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FOUNDATION DESIGN SECTION

foundation investigation and design report

ENGINEERING MATERIALS OFFICE

FOUNDATION DESIGN SECTION

CONT 94-53

WP 624-90-01/02 DIST 4

HWY Q.E.W. STR SITE 18-20

Q.E.W. Crossing at 18 Mile Creek
Westbound and Eastbound Lanes

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GEOCRES 30M3-194 DATE JAN 27 1993

FOUNDATION INVESTIGATION REPORT
For
Q.E.W. Crossing at 18 Mile Creek
W.P. 624-90-01 Westbound Lane
W.P. 624-90-02 Eastbound Lane
Site No. 18-20
District 4, Burlington

INTRODUCTION

This report summarizes the information obtained from a foundation investigation carried out at the above mentioned site where three span four bridge structures are proposed to carry the existing Q.E.W. and South and North Service Roads Crossing at 18 Mile Creek.

The field works for the foundation investigation were carried out at the above mentioned site during the period of December 2 to December 20, 1991 and May 11 to May 29, 1992. Ten boreholes (BH 91-1 to BH 91-9 inclusive, plus BH 91-5A) for the proposed original large twin culverts (5.9 m X 5.9 m X 137 m) were advanced and sampled between December 2 and December 20, 1991 to replace the existing twin culverts.

It should be noted that the original design scheme was found to be not environmentally viable. Therefore, a new proposal brought forth to replace the existing culverts with four (4) bridge structures. Additional nine boreholes (BH 92-1 to BH 92-9) were advanced and sampled as part of this project between May 11 and May 29, 1992. These boreholes extended down to depths between 14.2 m and 30.5 m below the existing ground surface.

Total of nineteen (19) boreholes were drilled for four bridge structures. Among them, eleven (11) boreholes are located within the Q.E.W. eastbound and westbound lanes, while four (4) boreholes are situated within South Service Road structure and North Service Road structure, respectively. The information from these boreholes is utilized in this report.

This report contains factual information obtained from these investigations pertaining to structure foundations, approach embankments and related earthworks for the Q.E.W. bridge structures, eastbound and westbound lanes, as shown on Dwg. No. 6249001/02-A and B.

SITE DESCRIPTION AND GEOLOGY

The site is located on the existing alignment of Q.E.W. where it crosses the Eighteen Mile Creek in the Town of Lincoln, Regional Municipality of Niagara. The proposed structures are located approximately 2.5 km east of Jordan Harbour. The topography in the area is gently undulating with a valley. Land use in the vicinity of the site is primarily agricultural known as the Niagara Fruit Belt.

Physiographically, the site is located in the "Iroquois Plain" region (Ref: Chapman and Putnam, 1984). The general area was inundated by the Pleistocene Lake Iroquois. As the lake level receded much below the present level of Lake Ontario, the Eighteen Mile Creek cut a valley through the till. Underlying the glacial deposit is the red Queenston Shale from which the till's reddish colour is derived. Later, the rise in the Lake Ontario water level to approximately its present level, drowned the outlet of the creek and created a lagoon and marsh separated from the lake by a barrier beach. Water flow is to the north into Lake Ontario.

SUBSURFACE CONDITIONS

The subsoil conditions are generally consistent across the site. The Q.E.W crosses the Eighteen Mile Creek at this location. The road embankment fill of the existing Q.E.W. consists of bedding sand, mainly clayey silt and some crushed stone as much as 13.6 m in the middle of valley.

Underlying the fill is a layer of organics which was encountered at all borehole locations except at one borehole location (BH 92-7). The thickness of this layer ranges from 1.1 m at BH 91-1 to 5.6 m at BH 91-2.

Underneath this layer, clayey silt with some sand and trace of gravel was encountered. The thickness of this layer ranges from 6.1 m at BH 91-9 to 18.3 m at 92-7. A thin layer of silty sand and gravel was found at 6 borehole locations (BH's 91-2, 91-3, 91-5, 91-5A, 91-6, and 92-2) in between the organic material and clayey silt with a maximum thickness of about 1.2 m at BH 92-7.

Cohesive glacial till was encountered underneath the clayey silt at all boreholes locations. This material can be described as a heterogeneous mixture of clayey silt, sand and gravel. The maximum thickness of this deposit was found to be about 5.2 m at BH 92-9. This layer is underlain by shale and siltstone bedrock. A thin layer of non-cohesive glacial till, which can be described as a heterogeneous mixture of silt, sand and gravel, was found with a thickness of 2.4 m at BH 91-9.

Sound bedrock was proven in 14 borehole locations by obtaining up to 2.7 m of NQ rock cores. The bedrock surface ranges from an elevation of 56.4 m at BH 92-9 to an elevation of 60.0 m at BH 91-4 which corresponds to 29.0 m and 23.0 m below the existing ground surface, respectively. The upper portion of bedrock was slightly weathered for a maximum 1.2 m at BH 92-8 below the rock surface. The sound bedrock surface ranges from an elevation of 56.4 m at BH 92-9 to an elevation of 59.3 m at BH 91-4 which corresponds to 29.0 m and 23.7 m below the existing ground surface. The bedrock is known to be "SHALE and interbedded SILTSTONE of the Queenston Formation".

The boundaries between the various soil types, in situ and laboratory test results are shown on the attached Record of Borehole Sheets in the Appendix. The locations and elevations of the boreholes, along with a profile and sections, are shown on Dwg. No. 624901/02-A and B.

A detailed description of the subsurface conditions encountered is given below.

Embankment Fill

The embankment fill consists of bedding sand, mainly clayey silt and some crushed

stone. The thickness of this layer was found to range from 4.4 m at BH 92-7 to 13.6 m at BH's 91-6 and 92-9.

Atterberg Limit Tests were performed on clayey silt samples and the results are plotted on Figure 1 and summarized as follows:

Property	Range (%)
Natural Moisture Content (w)	8.5 - 24.5
Liquid Limit (w_L)	16.5 - 36.0
Plastic Limit (w_P)	13.0 - 17.5
Plasticity Index (Ip)	3.0 - 19.0

From the Plasticity Chart, it is evident that the layer can be classified as a clayey silt to silt, some sand and gravel with low plasticity (CL or CL-ML).

Grain Size Distribution tests were carried out on this fill material. Figure 2 in the Appendix shows the results in an envelope form. In this stratum, the "N" values range from 0 to over 31 blows/0.3 m indicating the consistency of this deposit described as very soft to hard. Some silty sand layers were found within this clayey silt fill as shown on Figure 3.

Organic Clayey Silt to Silty Clay, Some Sand

This deposit was encountered beneath the existing embankment fill in all boreholes except BH No's 91-4 and 92-7 which were on or near the edge of the valley. The thickness of this deposit ranges from 1.1 m at BH 91-1 to 5.6 m at BH 91-2 and this deposit gradually peters out near the valley's edge.

The material, as sampled, was highly organic with organic pieces generally visible, and well-decayed pieces of roots and wood were not uncommon. Occasional samples were fibres. Some sand and occasional gravel were noted as well as occasional sand seams.

Atterberg Limit tests were performed on these samples and the results are plotted on Figure 4 and summarized as follows:

Index Property	Range (%)
Natural Moisture Content (w)	19.0 - 70.0
Liquid Limit (w_L)	17.0 - 68.0
Plastic Limit (w_P)	14.0 - 45.0
Plasticity Index (Ip)	3.0 - 23.0

From the plasticity chart, it is evident that the layer can be classified as an organic clayey silt to silty clay with low to high plasticity (OL.OI and OH).

Grain Size Distribution tests were carried out on these materials. Figure 5 in the Appendix shows the results in an envelope form.

Undrained Shear Strength of the soil was determined by in situ vane tests and by laboratory tests, namely unconfined compression tests. The results are plotted on Figure 6 and the Record of Borehole log sheets in the Appendix and summarized as follows:

Undrained Shear Strength	Cu (kPa)	Sensitivity
In-Situ Vane Tests	15 - >115	1 - 6
Unconfined Compression Tests	28 - 98	

As shown on Figure 6, the vane strengths measured within organic layer varied from 15 kPa to greater than 115 kPa, indicating soft to very stiff consistency. This layer has a sensitivity varying from 1 to 6 based on the measured undisturbed and remoulded vane strengths. This would indicate that the organic clayey silt to silty clay is generally sensitive.

An oedometer test was carried out to investigate the consolidation characteristics of the organic clayey silt to silty clay. The sample tested is

considered representative of the organic deposit was selected from a Shelby tube sample obtained at about an elevation of 69 m in BH 91-8. The result of the consolidation test is shown on Figure 7. The preconsolidation pressure is estimated to be about 330 kPa, indicating an overconsolidation ratio of about 1.25 relative to the existing effective overburden stress. The compression index (Cc) was determined to be about 0.213.

Silty Sand With Gravel

This deposit was found at five (5) borehole locations underlying the organic stratum (BH 91-2, 91-3, 91-5, 91-5A and 92-7). The thickness of this layer ranges from 0.5 m at BH 91-3 to 1.1 m at BH's 91-5, 91-5A and 92-7. Figure 3 in the Appendix shows the result of Grain Size Distribution test.

In this stratum, the "N" values ranged from 9 to 22 blows/0.3 m indicating a state of compaction described as loose to compact.

Clayey Silt With Sand

This deposit was encountered in all boreholes, either beneath the organic clayey silt to silty clay or the silty sand deposit, and appeared to represent the original material into which the Creek Valley had been carved. Hence, the deposit varied in thickness from 18.3 m at BH 92-7 near the edge of the valley to a minimum of 6.1 m at BH 91-9 near the centre of the valley.

Atterberg Limit tests were performed on these samples and the results are plotted on Figure 8 and summarized as follows:

Index Property	Range (%)
Natural Moisture Content (w)	13.0 - 20.5
Liquid Limit (w_L)	19.0 - 32.0
Plastic Limit (w_P)	14.0 - 17.0
Plasticity Index (Ip)	4.0 - 15.0

From the plasticity chart, it is evident that the layer can be classified as an inorganic clayey silt, some sand with low plasticity (CL or CL-ML).

Grain Size Distribution tests were carried out on these materials. Figure 9 in the Appendix shows the results in an envelope form.

Undrained shear strength of the soil was obtained by in-situ vane tests and by laboratory unconfined compression tests. The results are plotted on Figure 6 and the Record of Borehole log sheets in the Appendix and summarized as follows:

Undrained Shear Strength	Cu (kPa)	Sensitivity
In-situ Vane Tests	61 - >115	1 - 3
Unconfined Compression Tests	69 - 285	

The field vane strengths obtained in this stratum varied from 61 kPa to greater than 115 kPa indicating a stiff to hard consistency. The sensitivity of this deposit varies from 1 to about 3 indicating this material being normal.

Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Cohesive Glacial Till)

This stratum was encountered underneath the clayey silt layer and immediately above the bedrock. The thickness of this layer ranges from 0.7 m at BH 91-4 to 5.2 m at BH 92-9.

Atterberg Limit tests were performed on these samples and the results are plotted on Figure 10 and summarized as follows:

Property	Range (%)
Natural Moisture Content (w)	7.0 - 13.0
Liquid Limit (w_L)	17.0 - 24.0
Plastic Limit (w_p)	12.0 - 14.0
Plasticity Index (Ip)	5.0 - 10.0

From the plasticity chart, it is evident that this deposit can be classified as a heterogeneous mixture of clayey silt, sand and gravel with low plasticity (CL or CL-ML).

Grain Size Distribution tests were carried out on the cohesive glacial till material. Figure 11 in the Appendix shows the results. An increasing frequency of fragments of weathered shale was encountered within the lower portion of this till.

In this stratum, the "N" value range from 30 to over 100 blows/0.3 m indicating the consistency of this deposit as hard.

Heterogeneous Mixture of Silt, Sand and Gravel (Non-Cohesive Glacial Till)

This layer was encountered between clayey silt and cohesive glacial till at a borehole location. The thickness of this layer was found to be about 2.3 m at BH 91-9.

A Grain Size Distribution test was carried out on this material as shown on Figure 12. This layer is basically non-cohesive. In this stratum, the "N" value is about 27 blows/0.3 m indicating a state of compaction described as compact.

Bedrock

Bedrock was cored in fourteen (14) boreholes by obtaining up to 2.7 m of NQ rock at BH 92-8. The top of the bedrock ranged from elevation 56.4 m to 60.0 m which correspond to 29.0 m and 23.0 m below the existing ground surface, respectively. The upper 0 to 1.2 m is in a slightly weathered state. The top of the sound bedrock ranged from 56.4 m to 59.3 m.

The bedrock is a red shale with interbedded green siltstone (approximately 85% shale, 15% siltstone) of the Queenston Formation. Detailed description of the rock is attached in the Appendix entitled "Rock Core Description".

The Core Recovery (CR) and Rock Quality Designation (RQD) values were determined in-situ and also in the laboratory to evaluate the competence and integrity of the rock. The Core Recoveries (CR) range between 73 and 100 percent and Rock Quality Designation (RQD) values range from 7 to 69 percent. Based on these results, the rock can be classified as weak to very weak and slightly to unweathered.

GROUNDWATER CONDITIONS

Groundwater conditions were observed by measurement of water levels in the open boreholes. The groundwater level was found to be at approximate elevation between 63.7 m at BH 92-7 and 74.6 at BH 91-4 which correspond to depths of 21.5 m and 8.4 m below the existing ground surface. However, it is likely that the groundwater level was the same as the creek level and is subject to seasonal fluctuations.

DISCUSSION AND RECOMMENDATIONS

The recommendations in this report apply to the bridge structures and related approaches.

It is proposed to construct four (4) three span bridge structures (19 m x 22 m x 19 m) which will replace the existing twin concrete culverts along the Q.E.W. crossing the Eighteen Mile Creek. It is understood that an increase in grade for the Q.E.W. embankment will be required to avoid some snow accumulation within the Q.E.W. during the winter season due to the ditch effect on the highway. This would involve the additional placement and compaction of up to 1.7 m fill for the permanent approach along the Q.E.W. to the same level with the existing South and North Service Roads.

Recommendations pertaining to the foundations of the two new bridges for the Q.E.W. eastbound and westbound lanes and related earth works are summarized as follows.

Structure Foundations

East and West Abutments

In view of the low shear strength and compressibility of the organic clayey silt to silt clay and the extensive clayey silt layers, conventional spread footing shallow foundations are not applicable at this site. It is recommended that the abutment may be supported on end-bearing steel "H" piles, equipped with reinforced tips in order to facilitate pile penetration through the basal glacial till and driven to sound bedrock.

In consideration of no additional load application underneath the pile cap at the both abutments, the following design parameters are suggested for the purpose of the O.H.B.D.C..

Pile Type	Factored Axial Capacity at U.L.S	Axial Capacity at S.L.S. Type II
HP 310 x 79	1150 kN	900 kN
HP 310 x 110	1600 kN	1150 kN

Pile tip elevations for estimating the pile lengths are given below.

Structure	East Abutment(Elevation)	West Abutment(Elevation)
Q.E.W. Eastbound and Westbound lanes	57.3 m - 58.3 m	58.7 m - 59.0 m

Battered piles should be installed, where required, to resist lateral load on abutments.

In view of the extreme denseness of the glacial till stratum located immediately above the bedrock, some piles may not penetrate this dense stratum. The pile should be equipped with standard MTO tip reinforcement. In such a case, the pile capacity should be controlled in the field using current MTO pile driving standards. However, attempts should be made in all cases to drive the piles to the bedrock surface. It should also be noted that the pile driving be controlled by maximum capacity of piles.

During pile driving, the steel "H" pile should be set to a termination of 8 blows for the last 12 millimetres of penetration using a hammer transferring about 60 kilojoules of energy per blow to the pile.

Provision should be made to restrike all piles to confirm the set after adjacent piles have been driven. Piles that do not meet the design set criteria on the first restrike would require additional restriking. A minimum of 48 hour should be allowed before restriking a pile.

In order to enhance pile driving, the fill material immediately below pile caps should not contain particle sizes greater than 75 mm.

Alternatively, caisson foundations can be considered for the both abutments. Details for caissons will be discussed in Pier Foundations.

East and West Piers

In consideration of the existence of weak and compressible organic clayey silt to silty clay and extensive clayey silt layers, conventional spread shallow foundations are not applicable for the piers at this site. It should be noted that during the construction, to avoid the problems associated with excavation through embankment toward longitudinal direction , it is recommended that the structural loading at the piers be transferred to the underlying sound bedrock by means of bored cast-in-place caissons installed through the embankment and overburden.

The caisson should have a minimum length to diameter ratio of 3 within the bedrock and should be socketed at least 0.5 metre into the sound shale bedrock. The caissons may be design using an end bearing factored capacity at Ultimate Limit States of 3500 kilopascals. Serviceability Limit States is not relevant to caissons founded on bedrock since the stresses required to produce detrimental settlements will be larger the value given for the factored bearing capacity at ULS.

The following caisson bottom elevations are suggested for estimating the caisson length.

Structure	East Pier (Elevation)	West Pier (Elevation)
Q.E.W. Eastbound and Westbound lanes	57.6 m - 58.0 m	57.8 m - 58.8 m

Caissons should be a minimum diameter of 900 mm to allow for both the clean out

of any basal debris and final evaluation of the rock surface in order to confirm the above-stated capacities.

Groundwater infiltration may have to be controlled by using drilling mud coupled with telescoping liners or other methods. However, regardless of the method used, during withdrawal of the innermost liner, it is recommended that, while pouring, a positive head of concrete should be maintained at all times to prevent intrusion of the surrounding soils, groundwater and/or bentonite slurry.

The proposed method of caisson installation be in accordance OPSS 903.07.03 and subject to review by this office.

It should be noted that to avoid the need for deep excavation of the existing embankment and frost protection, caisson cap for the piers should be placed immediately below the bridge decks.

Other Considerations

Lateral Earth Pressures

Free draining material such as Granular "A" or Granular "B" is recommended as an appropriate backfill material to prevent hydrostatic pressure build-up on the abutment walls. Design parameters of the soil are given below for the purpose of the O.H.B.D.C.

	Granular "A"	Granular "B"
Angle of Internal Friction (ϕ)	35^0	30^0
Unit Weight (kN/m^3), γ	22.8	21.2
Coefficient of Active Earth Pressure (Ka)	0.27	0.33
Coefficient of Earth Pressure at Rest (Ko)	0.43	0.5

The earth pressure coefficient at rest is to be used when the design of abutment walls are rigid and unyielding.

Dewatering

No major dewatering difficulties are anticipated for footing excavation in consideration of lower groundwater levels and the relatively low permeability of the clayey silt fill. However, if localized seepage or surface water to accumulates in excavations, it can be controlled by perimeter ditches and pumping from corner sumps.

Frost Protection

The pile caps should be placed so as to have a minimum earth cover of 1.2 m to allow for frost protection.

Settlement of Approach Embankments

Based on currently available information, it is our understanding that the proposed grade of the roadway at the approach embankments will be raised by up to 1.7 m. Consequently, the additional fill will act as a surcharge and induce settlement within the underlying organic clayey silt to silty clay.

To minimize settlement, total embankment loading should not exceed the preconsolidation pressure, σ'_p, of the organic clayey silt to silty clay. Based on the results of the consolidation test and our previous experience with similar organic deposits, it is estimated that σ'_p, is about 330 kPa. Since the field vane shear strengths were found to be reasonably constant with this deposit, it is anticipated that σ'_p, would not vary significantly with depth. Accordingly, the organic clayey silt to silty clay at mid-level of the stratum is considered to be preconsolidated by about 66 kPa in excess of the existing effective overburden stress. Assuming that the unit weight of compacted granular

fill is about 21 kN/m^3, 1.7 m of such fill would correspond to a surcharge of 36 kPa. As such, the proposed additional embankment loading will not result in stresses higher than σ'_p. Based on the compression index, Cc, obtained from the consolidation test, the magnitude of settlement of the approach embankment will be modest, being in the order of 40 mm. Consideration should be given to placing and compacting the additional fill well in advance of bridge construction to allow some settlement to take place prior to final road paving.

Stability of Approach Embankment

The stability analyses were carried out based on a minimum design underdrained shear strength of 50 kPa for the organic clayey silt to silty clay, as established by field vane tests. Since no additional fill will be placed on the South and North Service Road, the existing slope will be stable in the transverse direction.

However, since additional earth fill of 1.7 m will be placed within Q.E.W. Lanes and the existing embankment fill of about 11 m will be cut down to creek level, stability analyses were carried out to evaluate the overall stability of the approach fill in the longitudinal direction and also the internal stability of the fills were examined. Based on the "Total Stress" analyses, the forward slope for the Q.E.W. structures and North and South Service Road Structures will require a 3 m wide mid-height beam with a 2H to 1V side slope to meet a minimum factor of safety of 1.3 as shown on Figure 13.

Construction Consideration

Prior to raising the existing embankment, topsoil, organics and other foreign materials should be removed from the fill placement area. Such locations, should be excavated and backfilled with an approved, compacted fill material. Clean earth fill at suitable water contents should be used as embankment fill.

The additional fill should be placed in thin layers and compacted as per MTO standards. The fill should be keyed into the pre-existing slope in accordance

with current MTO standards and practice.

Excavations for abutments, pile-caps construction may be carried out in temporary open cuts with side slopes maintained at gradients not steeper than 1.5H:1V through the clayey silt fill. All excavations should be carried out according to the guidelines contained in the latest edition of the Ontario Occupational Health and Safety Act. To prevent softening of the exposed clayey silt fill, it is recommended that Granular "A" material be place on the excavation base to provide protection to the founding stratum as soon as the base of the excavation has been inspected.

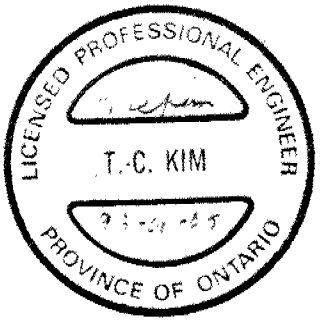
Excavation cut of the forward slope toward 18 Mile Creek should be delayed until the four bridge structures are completed in order to avoid expensive roadway protection scheme such as very high temporary shoring system.

For erosion protection purposes, the embankment forward slopes should be covered with a layer of topsoil and properly seeded in order to enhance adequate vegetation cover. Suitable protection measures should also be provided to the creek banks adjacent the abutments. Such measures may include appropriately sized rip-rap underlain by suitable granular filter.

MISCELLANEOUS

The initial fieldwork for this investigation was carried out during the period of December 2 to December 20, 1991 under the supervision of R. Ng, Trainee Engineer and Tae C. Kim, Sr. Foundation Engineer. The equipment was owned and operated by Master Soil Investigation Ltd., Toronto. Additional fieldwork for this investigation was carried out during the period of May 11 to May 29, 1992 under the supervision of M. Iampietro, Student Engineer, and Tae C. Kim, Sr. Foundation Engineer. The equipment was owned and operated by Malone's Soil Samples Co. Ltd., Toronto.

This report was written by Tae C. Kim, Senior Foundation Engineer and reviewed by M. Devata, Chief Foundation Engineer.

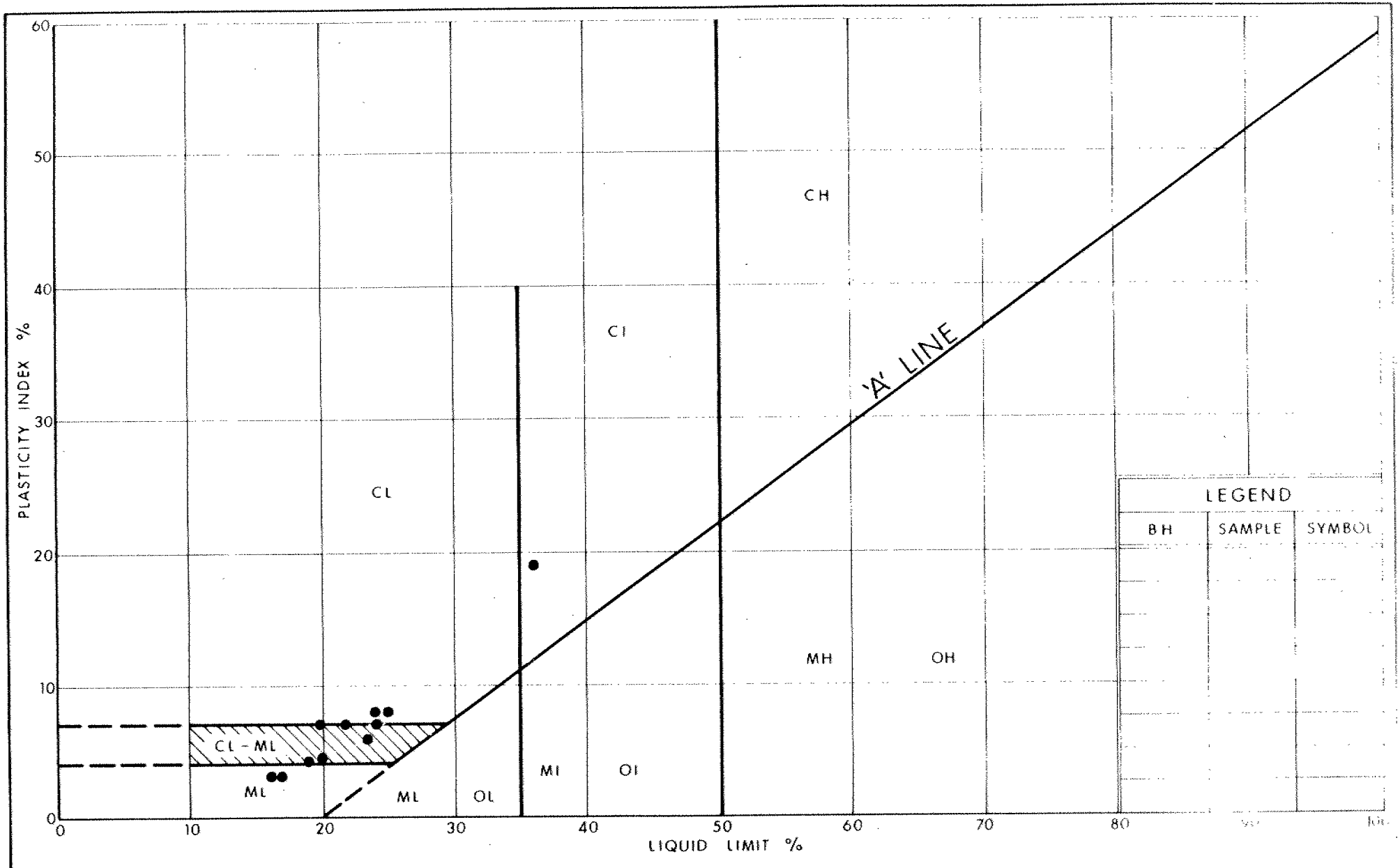


Tae C. Kim, P. Eng.
Sr. Foundation Engineer

M. Devata, P. Eng.
Chief Foundation Engineer

APPENDIX

Oct 75, FF-S-21



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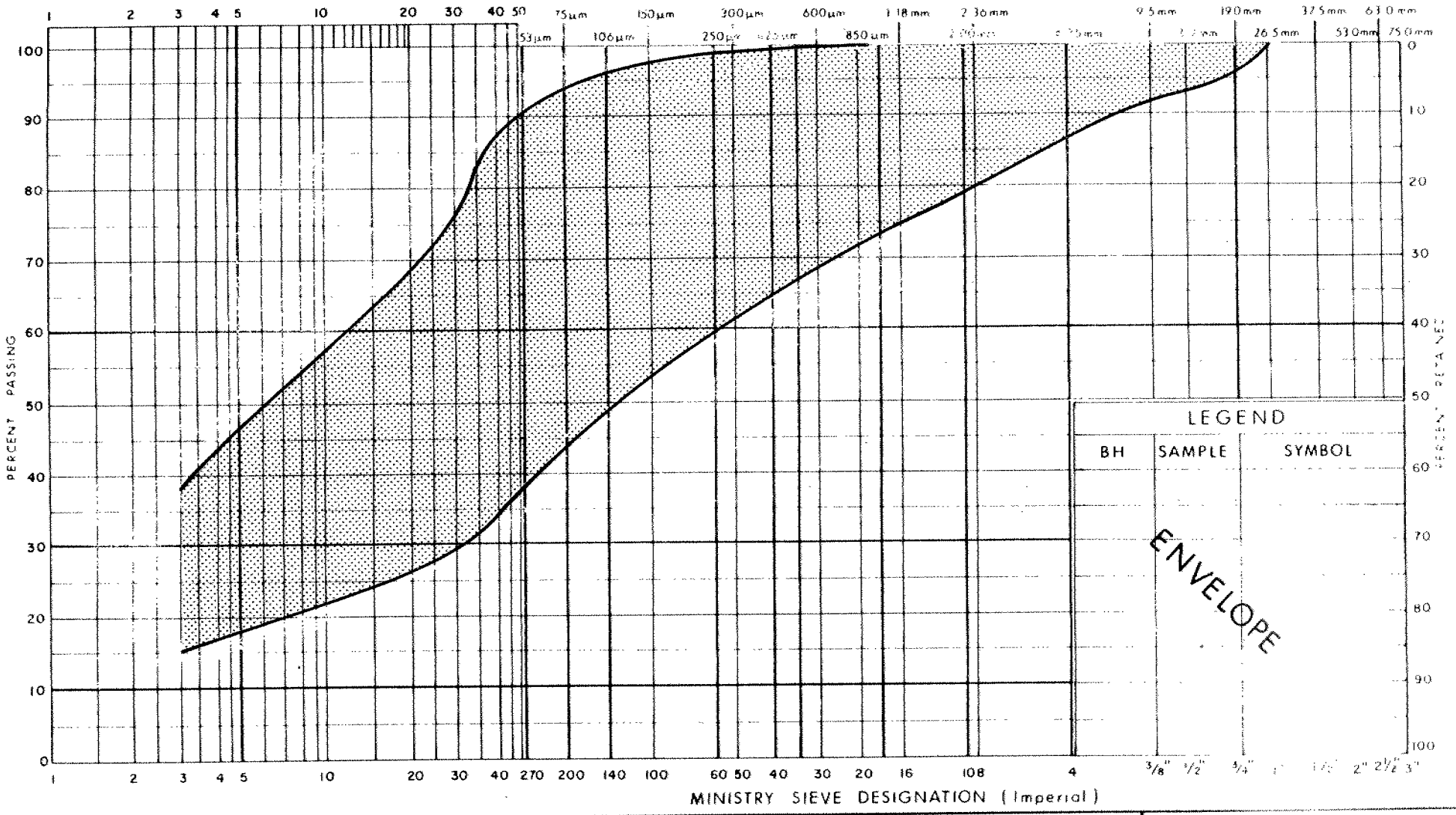
PLASTICITY CHART
CLAYEY SILT TO SILT
(Fill)

FIG No 1
WP 624-90-01/02

78 12 M

UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT	SAND			GRAVEL	
	Fine	Medium	Coarse	Fine	Coarse



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GRAIN SIZE DISTRIBUTION
CLAYEY SILT TO SILT
(Fill)

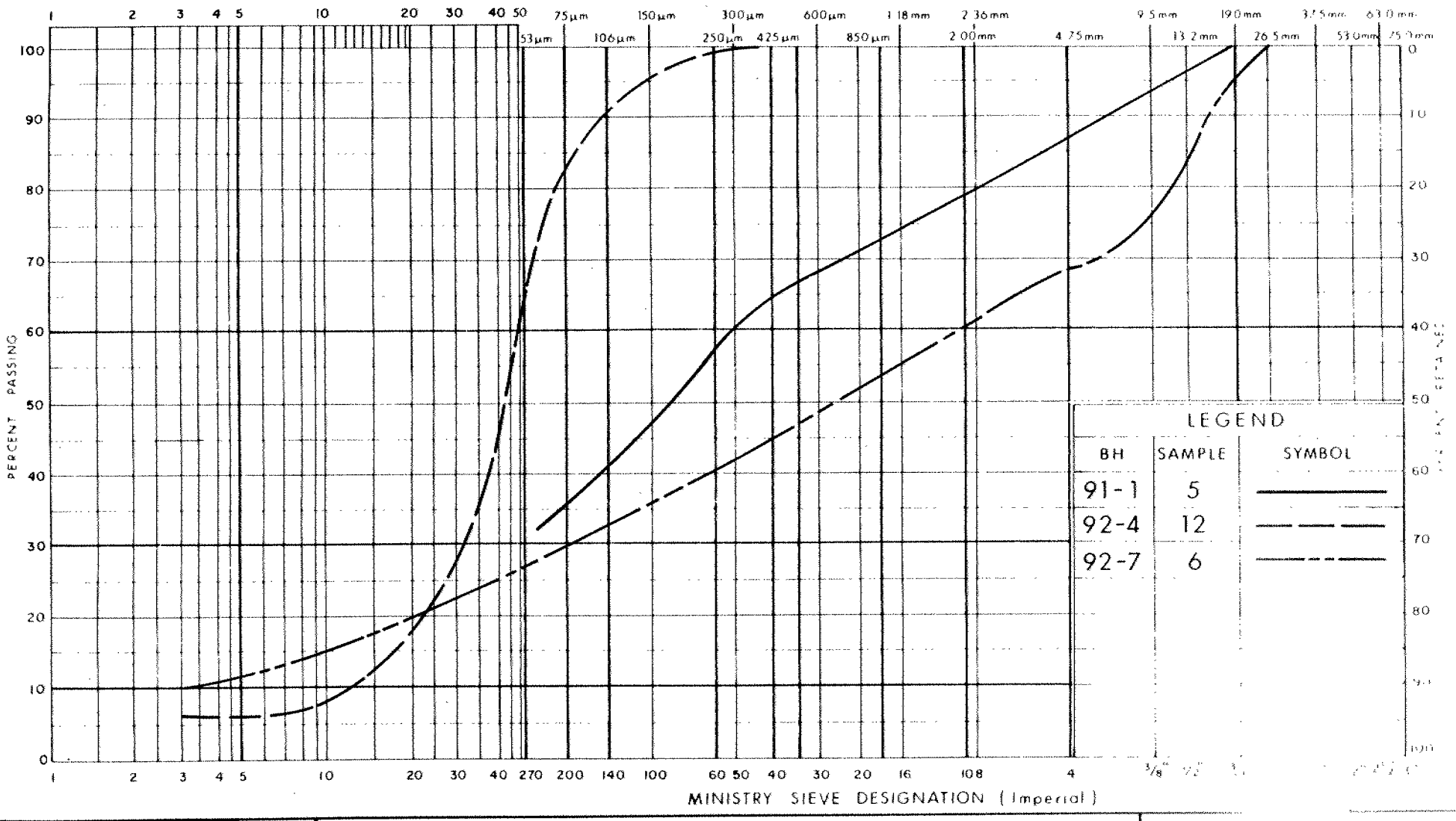
FIG No 2

W P 624-90-01/02

78 12 M

UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT	SAND			GRAVEL	
	Fine	Medium	Coarse	Fine	Coarse



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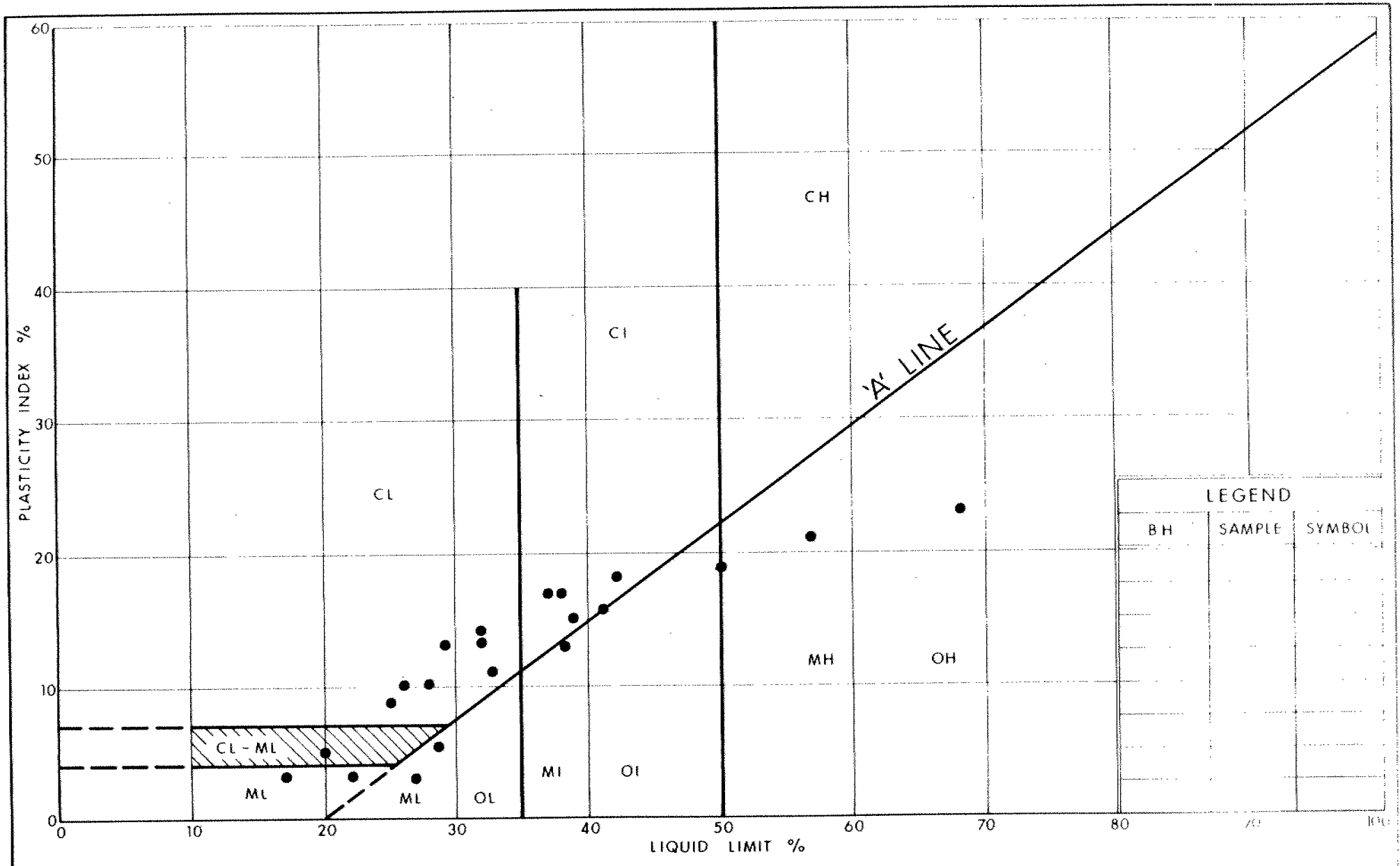
GRAIN SIZE DISTRIBUTION
SILTY SAND TO SANDY SILT

FIG No
WP 624-90-01/02

Oct 75, FF-S-21



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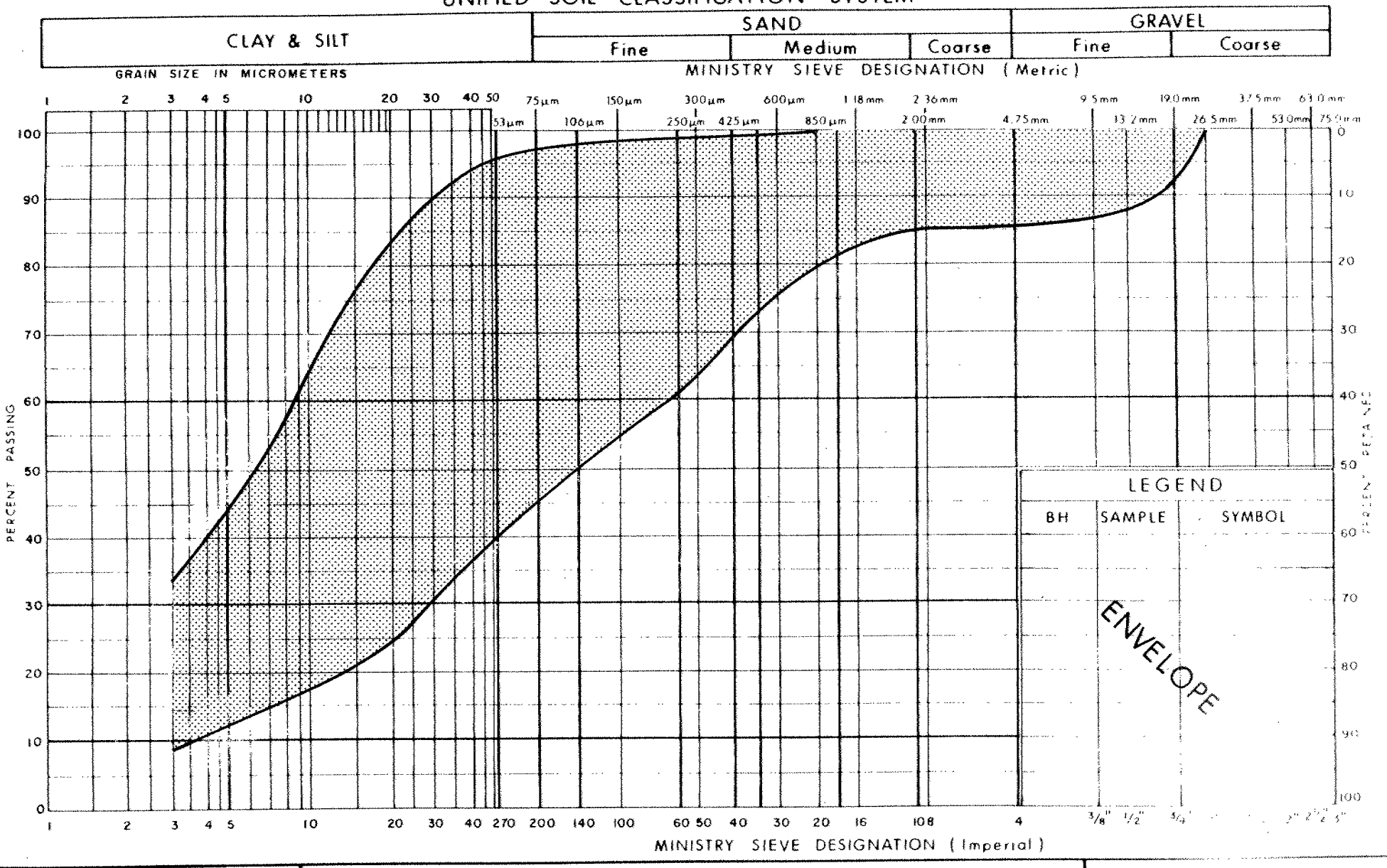
PLASTICITY CHART
ORGANIC CLAYEY SILT TO SILTY CLAY

FIG No 4
WP 624-90-01/02

UNIFIED SOIL CLASSIFICATION SYSTEM



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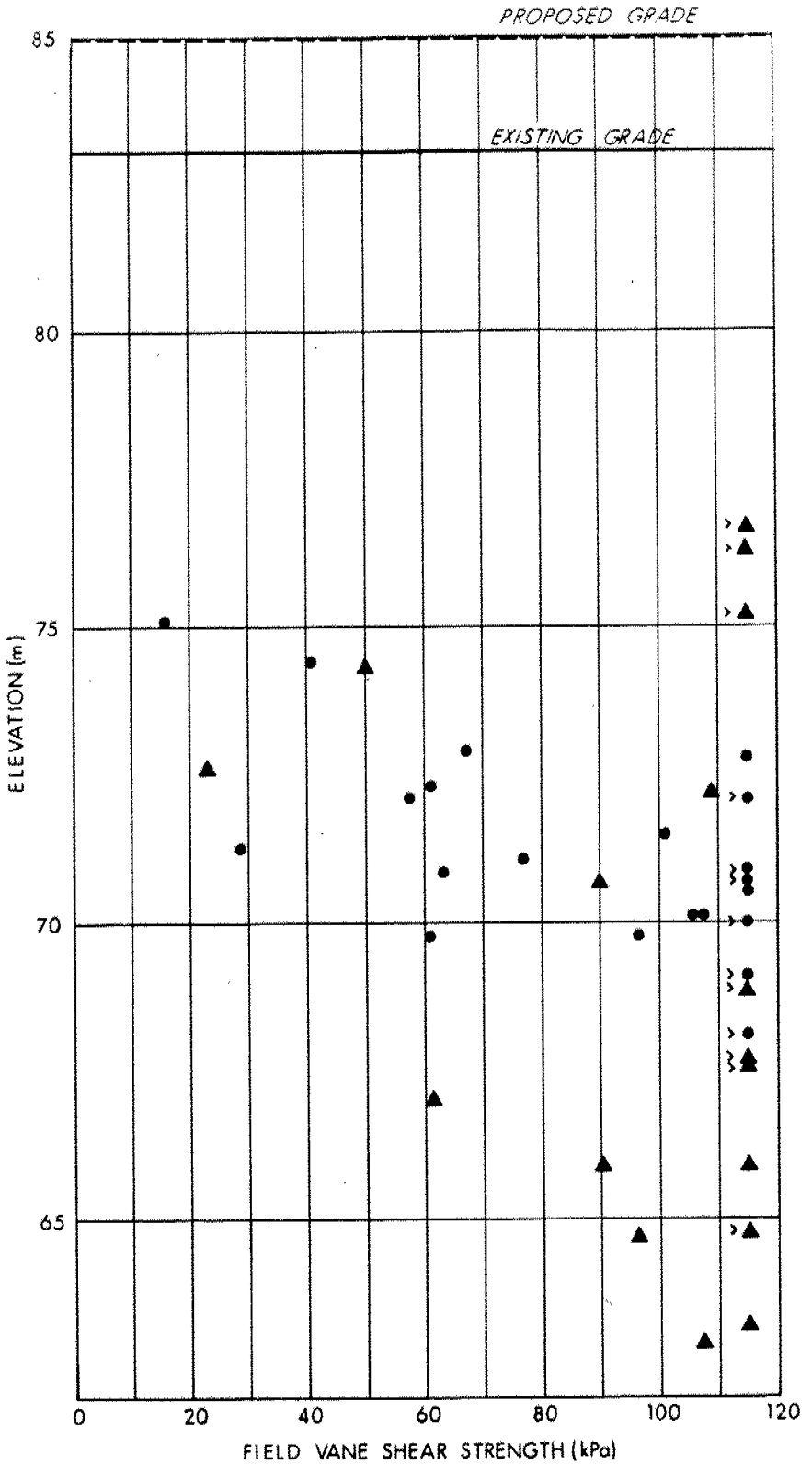
GRAIN SIZE DISTRIBUTION
ORGANIC CLAYEY SILT TO SILTY CLAY

FIG No 5
W P 624-90 01/02



PROFILE OF FIELD VANE TESTS

ORGANIC CLAYEY SILT TO SILTY CLAY

● ORGANIC CLAYEY SILT TO SILTY CLAY
▲ CLAYEY SILT

Fig No 6
WP 624-90-01/02

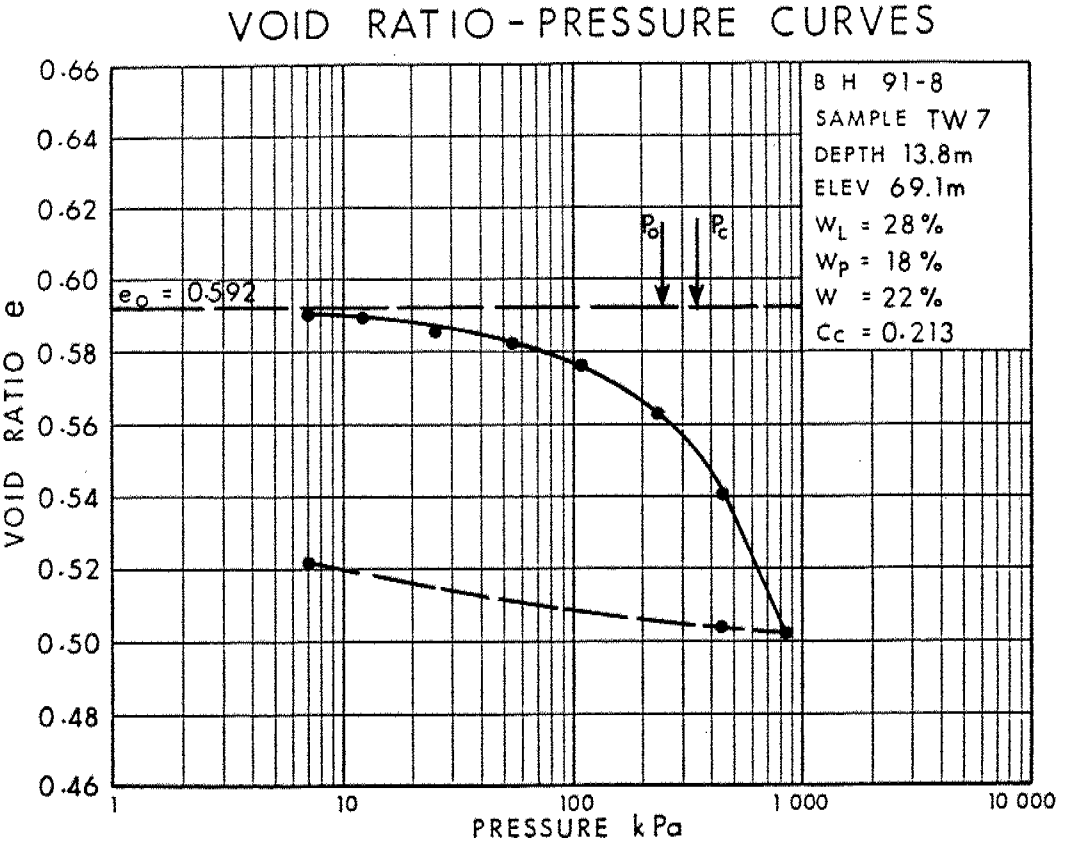
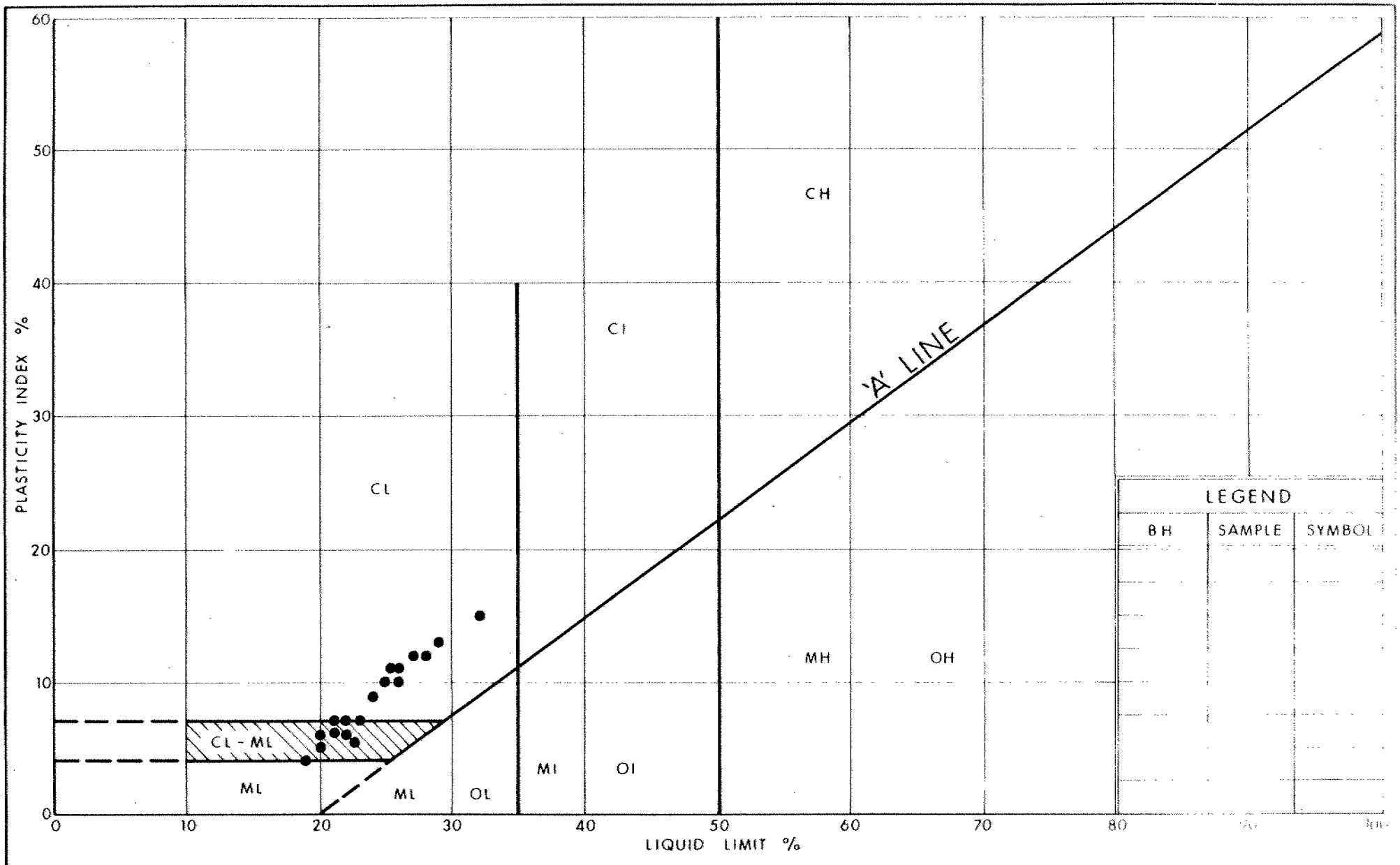


Fig 7 WP 624-90-01/02



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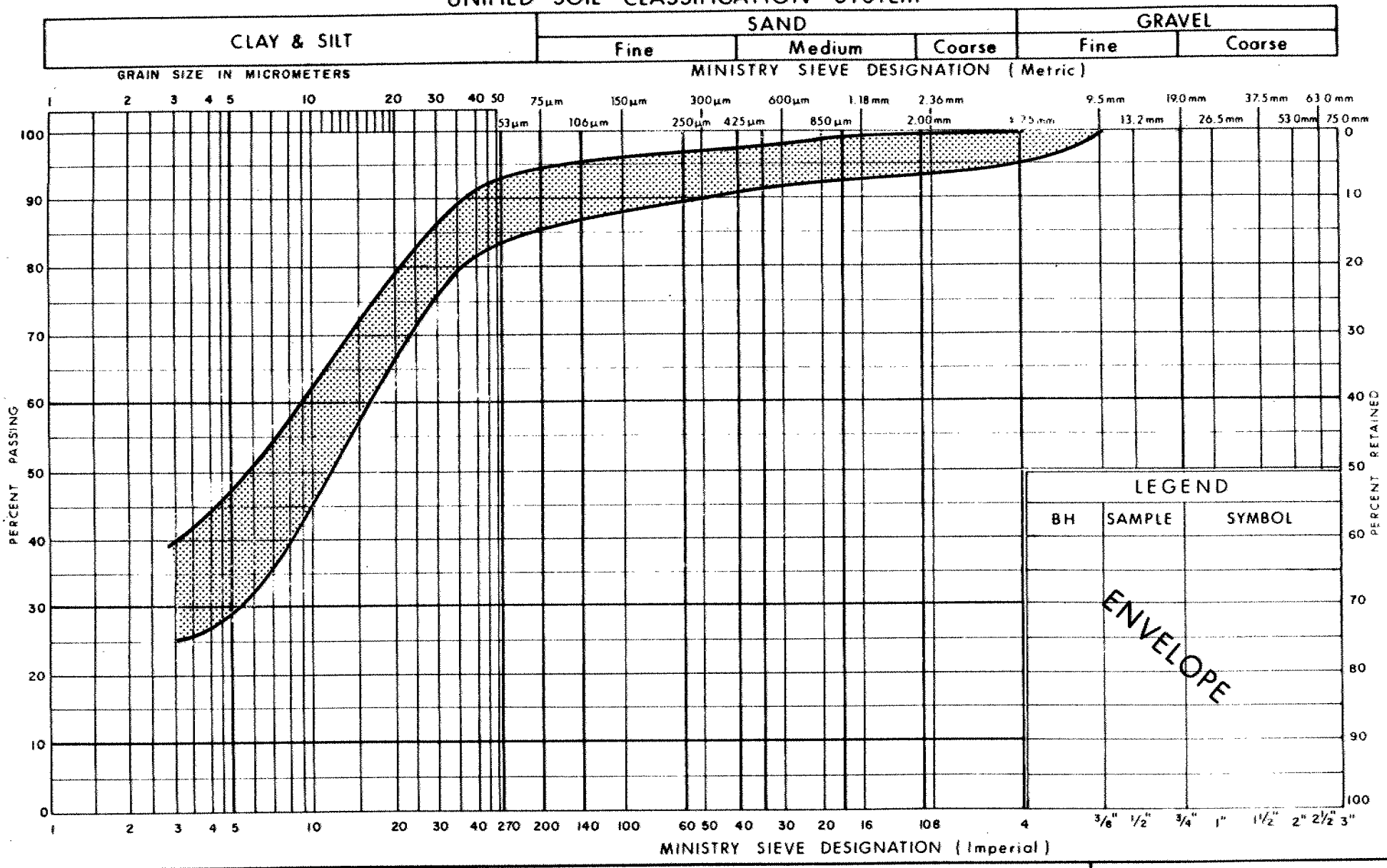
PLASTICITY CHART
CLAYEY SILT
WITH SOME SAND AND TRACE OF GRAVEL

FIG No 8
W P 624-90-01/02

UNIFIED SOIL CLASSIFICATION SYSTEM



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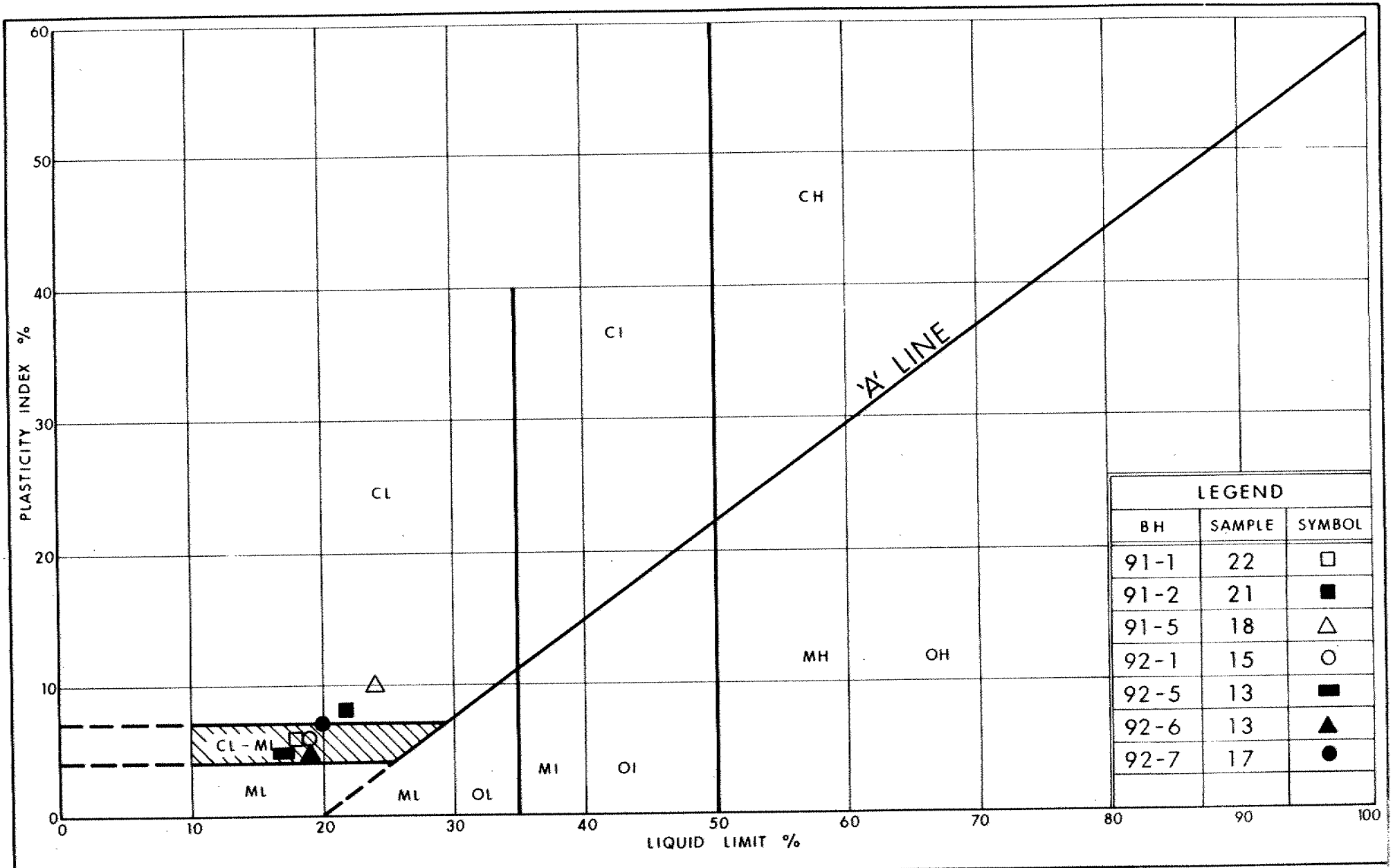
GRAIN SIZE DISTRIBUTION
CLAYEY SILT
WITH SOME SAND AND TRACE OF GRAVEL

FIG No 9

W P 624-90-01/02

Oct 75, FF-S-21



LEGEND		
BH	SAMPLE	SYMBOL
91-1	22	□
91-2	21	■
91-5	18	△
92-1	15	○
92-5	13	▬
92-6	13	▲
92-7	17	●

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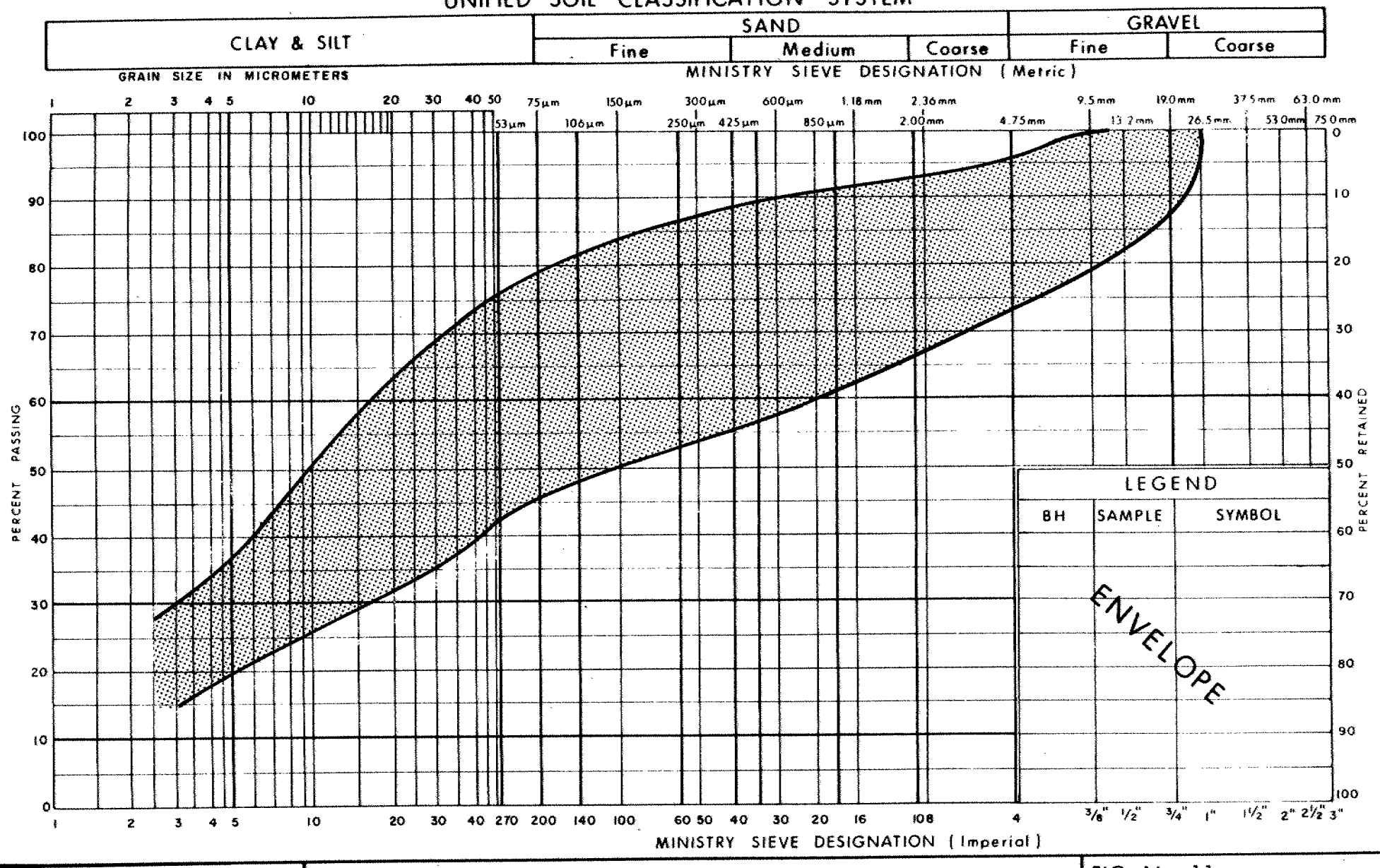
PLASTICITY CHART
HETEROGENEOUS MIXTURE OF CLAYEY SILT, SAND & GRAVEL (COHESIVE GLACIAL TILL)

FIG No 10

W P 624-90-01/02

UNIFIED SOIL CLASSIFICATION SYSTEM



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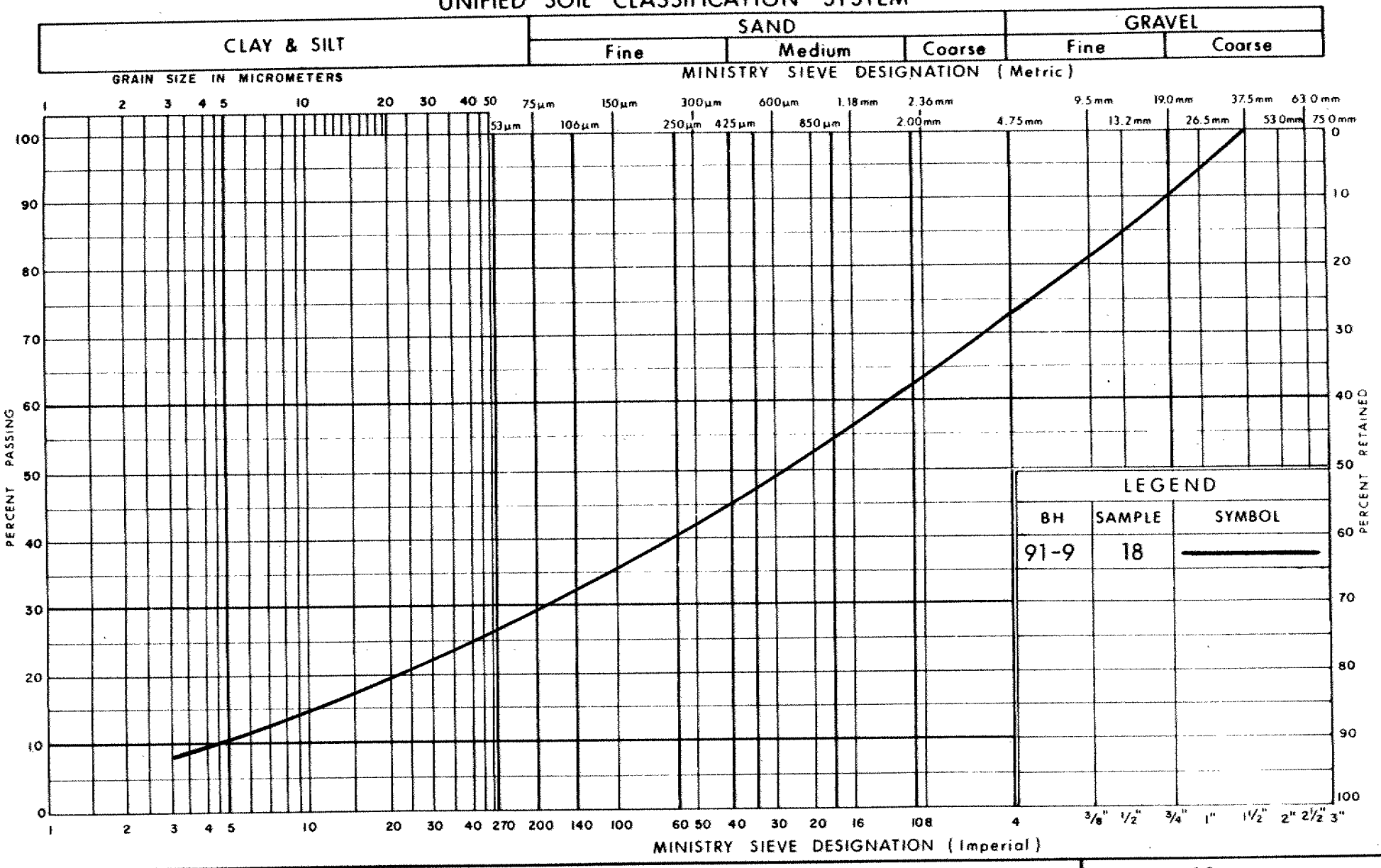
GRAIN SIZE DISTRIBUTION

HETEROGENEOUS MIXTURE OF CLAYEY SILT, SAND & GRAVEL
(COHESIVE GLACIAL TILL)

FIG No 11

W P 624-90-01/02

UNIFIED SOIL CLASSIFICATION SYSTEM



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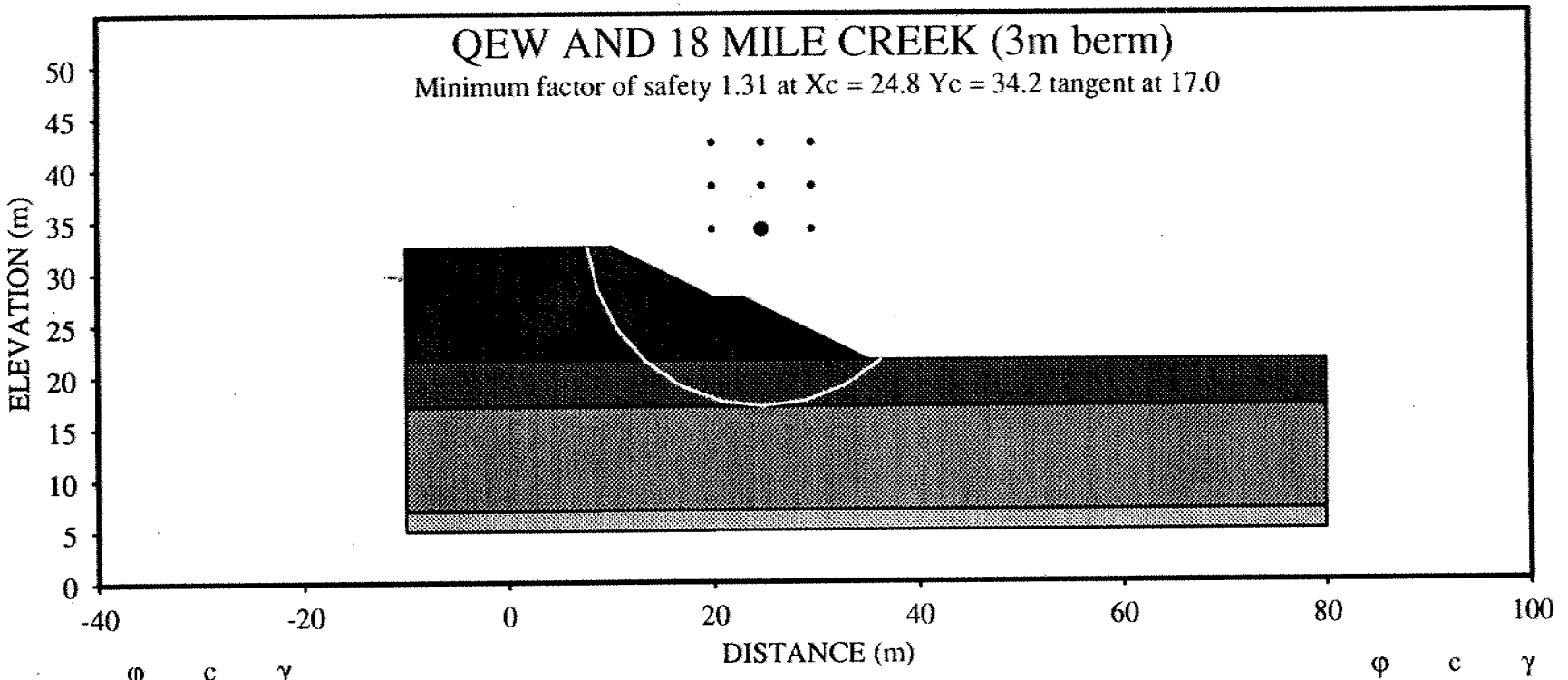
GRAIN SIZE DISTRIBUTION
HETEROGENEOUS MIXTURE OF SILT, SAND & GRAVEL
(NON-COHESIVE GLACIAL TILL)

FIG No 12

W P 624-90-01/02

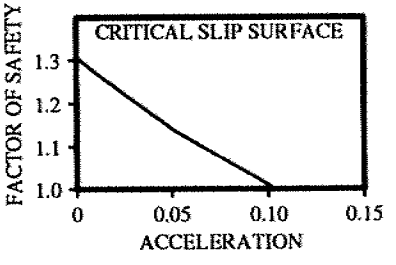


φ	c	γ	
30.0	0.0	21.0	CLAYEY SILT (FILL)
0.0	50.0	18.0	ORGANIC SILT

	φ	c	γ
CLAYEY SILT	0.0	92.0	21.3
COHESIVE TILL	35.0	0.1	22.0

CRITICAL ACCELERATIONS

0.090	0.105	0.165
0.087	0.100	0.173
0.097	0.104	0.204



FACTORS OF SAFETY

1.362	1.348	1.496
1.332	1.311	1.498
1.348	1.308	1.588

WP 624-90-01/02
Fig 13

RECORD OF BOREHOLE No 91-1 1 OF 1 METRIC

W.P. 624-90-01/02/03/04 LOCATION Co-ord. N 4782 027.9 E 317 883.7 ORIGINATED BY T.C.K.

DIST 4 HWY Q.E.W. BOREHOLE TYPE H.S. Auger, Cone Tests, Vane Tests, NQ Rock Core COMPILED BY R.N.

DATUM Geodetic DATE Dec. 5 & 9, 1991 CHECKED BY T.C.K.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE
85.2	Ground Surface						
0.0	Sand and gravel (Fill) Brown						
0.6 / 83.7	Granular 'A' (Fill) Grey / Grey						
1.5	Brown		1	SS	14		
			2	SS	21		
			3	SS	15		
	Clayey silt to silt, some sand and trace of gravel, occ. silty sand layers (Fill) Firm to very stiff						
			4	SS	19		
	Silty sand layer Compact		5	SS	26		
			6	SS	6		
75.1			7	SS	10		
10.1			8	SS	9	▼	
	Crushed Stone with sand (Fill) Loose to compact		9	SS	7		
			10	SS	0		
			11	SS	7		
70.1	Brown		12	SS	10		
15.1 / 69.0	Organic clayey silt, some sand and gravel Grey Very stiff		13	SS	16		
16.2			14	SS	18		
			15	SS	22		
			16	TW	PH		
	Clayey silt with some sand trace of gravel Very stiff to hard						
			17	SS	32		
			18	SS	27		
			19	SS	24		
			20	TW	PH		
			21	SS	35		
60.1	Grey						
25.1	Reddish Brown		22	SS	101		
	Het. mixture of clayey silt sand and gravel (Glacial till) occ. shale fragments		23	SS	109	/28cm	
58.4	Hard Reddish brown		24	SS	60	/13cm	
26.8	Red						
	Queenston shale bedrock		25	RC	REC	77%	
56.9							
28.3	End of Borehole						

DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100)

SHEAR STRENGTH kPa
o UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × LAB VANE
(20 40 60 80 100)

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

WATER CONTENT (%) (10 20 30)

UNIT WEIGHT γ kN/m³

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

ELEV	UNIT WEIGHT	GR	SA	SI	CL
82		1	35	43	21
78		13	51	(36)	
70	2.2 % (a.c.)	15	7	72	6
68		1	4	76	19
68	21.4	1	10	65	24
60		26	29	35	10
		RQD 23%			

120/28cm

3115 kPa

150.9 kPa

$+^3$, $\times^5$: Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No 91-2 1 OF 1 METRIC

W.P. 624-90-01/02/03/04 LOCATION Co-ord. N 4782 009.5 E 317 869.7 ORIGINATED BY T.C.K.

DIST 4 HWY Q.E.W. BOREHOLE TYPE H.S. Auger, Cone Tests, Vane Tests COMPILED BY R.N.

DATUM Geodetic DATE Dec. 13 & 16, 1991 CHECKED BY T.C.K.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
82.7	Ground Surface						
0.0 / 81.1	Brown Silty sand with gravel (Fill)						
1.6	Clayey silt to silt, some sand trace of gravel occ. silty sand layers (Fill) Soft to stiff		1	SS	10		
			2	SS	6		5 26 51 18
			3	SS	2		
			4	SS	6		
75.7	Brown		5	SS	5		
7.0	Dark grey		6	SS	5		
	Organic Clayey silt to silty clay trace of sand soft to very stiff		7	TW	PH		
			8	SS	4		
			9	TW	PH		2 7 70 21
	Dark grey		10	SS	8		
	Grey		11	SS	9	▼	
			12	SS	12		0 0 87 13
69.1	Grey		13	SS	3		
13.6 / 68.4	Silty sand with gravel Loose Brown		14	SS	9		
14.3	Grey		15	SS	21		
			16	SS	27		
	Clayey silt with some sand trace of gravel Stiff to very stiff		17	SS	10		
			18	SS	16		
			19	SS	24		
			20	SS	29		
60.4	Grey						
22.3	Reddish brown Het. mix. of clayey silt, sand and gravel (Glacial till) occ. shale fragments		21	SS	50/	/5cm	6 25 45 24
58.3	Hard Probable bedrock at 24.4m		22	SS	50/	/3cm	
24.4	End of Borehole						

ELEVATION SCALE: 82, 80, 78, 76, 74, 72, 70, 68, 66, 64, 62, 60

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100

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

PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L
WATER CONTENT (%) 10 20 30

UNIT WEIGHT γ kN/m³

68 4.8
w=70 10.4 % (o.c.)
41 17.4
0.9 % (o.c.)

>115
>115
100/ 25cm

+3, ×5 : Numbers refer to Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 91-3 1 OF 1 METRIC

W.P. 624-90-01/02/03/04 LOCATION Co-ord. N 4782 010.1 E 317 884.9 ORIGINATED BY T.C.K.

DIST 4 HWY Q.E.W. BOREHOLE TYPE H.S. Auger, Cone Tests, Vane Tests, NQ Rock Core COMPILED BY R.N.

DATUM Geodetic DATE Dec. 16 & 17, 1991 CHECKED BY T.C.K.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE
82.8	Ground Surface						
0.0	Brown Silty sand with gravel (Fill)						
81.3			1	SS	19		
1.5	Clayey silt to silt some sand occ. silty sand layers (Fill) Soft to very stiff		2	SS	6		
			3	SS	6		
			4	SS	9		
75.6	Brown		5	SS	0		
7.2	Dark grey		6	SS	15		
	Dark grey		7	SS	10		
	Grey		8	TW	PH		
	Organic Clayey silt to silty clay some sand Stiff to very stiff		9	SS	13		
			10	SS	11		
			11	SS	16		
70.8	Grey		12	SS	11	▼	
12.0	Silty sand with gravel, compact Brown		13	SS	22		
12.5	Grey						
	Clayey silt with some sand trace of gravel Very stiff to hard		14	SS	31		
			15	SS	24		
			16	SS	21		
			17	SS	31		
			18	SS	25		
60.5	Grey						
22.3	Reddish brown Het. mix. of clayey silt, sand and gravel (Glacial Till) occ. shale fragments Hard		19	SS	50/15cm		
58.4	Reddish brown						
24.4	weathered Red sound Queenston shale bedrock		20	RC	REC 88%		
56.0			21	RC	REC 83%		
26.8	End of Borehole						

DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100)

SHEAR STRENGTH kPa (20 40 60 80 100)
o UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × LAB VANE

PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L
WATER CONTENT (%) (10 20 30)

UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
3.2 % (o.c.)	0 10 67 23
19.9	0 8 69 23
1.0 % (o.c.)	0 12 66 22
	RQD 17%
	RQD 69%

+3, ×5 : Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No 91-4 1 OF 1 METRIC

W.P. 624-90-01/02/03/04 LOCATION Co-ord. N 4781 970.3 E 317 876.4 ORIGINATED BY T.C.K.

DIST 4 HWY Q.E.W. BOREHOLE TYPE H.S. Auger, Cone Tests, Vane Tests, NQ Rock Core COMPILED BY R.N.

DATUM Geodetic DATE Dec. 10 & 11, 1991 CHECKED BY T.C.K.

ELEV / DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (o UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
83.0	Ground Surface										
0.0 / 81.3	Silty sand with gravel (Fill)		1	SS	13		82				
1.7	Clayey silt to silt, some sand, trace of gravel. Occ. silty sand layers (Fill). Soft to stiff		2	SS	5		80				
			3	SS	5		78				
			4	SS	0		76				
			5	SS	0	▼	74				0 25 59 16
72.9			6	SS	4						
10.1 / 71.0	Sand and gravel with crushed stone (Fill). Compact. Brown		7	SS	20		72				
12.0	Grey		8	TW	PH					20.8	0 12 59 29
	Clayey silt, some sand, trace of gravel. Very stiff		9	SS	22		70				
			10	SS	25		68				
			11	SS	19		66				
			12	SS	29		64				
60.7	Grey		13	SS	28		62				
22.3 / 60.6	Het. mix of clayey silt, sand and gravel, occ. shale (Glacial Till) Reddish Brown		14	SS	60	/15cm	60				
23.0	Red weathered sound		15	RC	REC 85%						RQD 19%
58.6	Queenston shale bedrock										
24.4	End of Borehole										

+³, ×⁵: Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No 91-5 1 OF 1 METRIC

W.P. 824-90-01/02/03/04 LOCATION Co-ord. N 4781 971.0 E 317 892.1 ORIGINATED BY T.C.K.

DIST 4 HWY Q.E.W. BOREHOLE TYPE H.S. Auger, Cone Tests, Vane Tests, NQ Rock Core COMPILED BY R.N.

DATUM Geodetic DATE Dec. 10 & 11, 1991 CHECKED BY T.C.K.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
82.9	Ground Surface							
0.0 / 81.5	Brown Silty sand (Fill)							
1.4	Silty sand layer Loose		1	SS	6			
			2	SS	4			
			3	SS	5			
	Clayey silt to silt, some sand, trace of gravel (Fill) Occ. silty sand layers Firm to stiff		4	SS	10			
			5	SS	5			0 10 70 20
72.8	Brown		6	SS	8			
10.1	Grey		7	SS	8		1.3 % (o.c.)	0 3 65 32
	Organic Clayey Silt to Silty Clay trace of sand Soft to stiff		8	SS	0	▼		
69.7								
13.2 / 68.6	Silty sand with gravel		9	TW	PH			
14.3			10	SS	17			
			11	TW	PH		21.7	2 10 68 20
			12	SS	15			
	Clayey silt with some sand, trace of gravel Stiff to very stiff		13	SS	42			
			14	SS	23			
			15	SS	21			
			16	SS	28			
			17	TW	PH			
60.6	Grey							
22.3	Het. mix. of clayey silt, sand and gravel (Glacial Till) occ. shale fragments Brown		18	SS	60	/8cm		7 20 48 25
	Hard Brown / Reddish brown		19	SS	60	/15cm		
58.5								
24.4	Red							
	Queenston shale bedrock		20	RC	REC 91%			RQD 23%
57.0								
25.9	End of Borehole							

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100

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

PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L
WATER CONTENT (%) 10 20 30

ELEVATION SCALE 82 80 78 76 74 72 70 68 66 64 62 60 58

100/ 28cm
142.5 kPa
ρ
+3

+3, ×5 : Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 91-5A 1 OF 1 METRIC

W.P. 624-90-01/02/03/04 LOCATION Co-ord. N 4781 969.2 E 317 892.1 ORIGINATED BY T.C.K.

DIST 4 HWY Q.E.W. BOREHOLE TYPE H.S. Auger, Vane Tests COMPILED BY R.N.

DATUM Geodetic DATE Dec. 12, 1991 CHECKED BY T.C.K.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
82.9	Ground Surface								
0.0 / 81.4	Silty sand (Fill)								
1.5	Clayey silt to silt, some sand trace of gravel Occ. silty sand layers (Fill)								
72.6	Brown		1	SS	10				
10.3	Grey		2	SS	11				
	Organic clayey silt to silty clay some sand, trace of gravel Stiff to very stiff		3	TW	PH			1.9 % (a.c.)	2 41 46 11
69.5			4	SS	8	▼			
			5	TW	PH				
13.4 / 68.4	Silty sand with gravel Compact		6	SS	15				
14.5	Clayey silt with some sand trace of gravel Very stiff to hard		7	SS	26				
			8	SS	21				
			9	TW	PH			22.1	3 9 68 20
			10	SS	13				
			11	SS	21				
64.2			12	SS	37				
18.7	End of Borehole								

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100

SHEAR STRENGTH kPa
o UNCONFINED + FIELD VANE
• QUICK TRIAXIAL × LAB VANE
20 40 60 80 100

PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L
WATER CONTENT (%) 10 20 30

ELEVATION SCALE 82 80 78 76 74 72 70 68 66

+3, ×5 : Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 91-6 1 OF 1 METRIC

W.P. 524-90-01/02/03/04 LOCATION Co-ord. N 4781 952.3 E 317 899.1 ORIGINATED BY T.C.K.

DIST 4 HWY Q.E.W. BOREHOLE TYPE H.S. Auger, Cone Tests, Vane Tests, NQ Rock Core COMPILED BY R.N.

DATUM Geodetic DATE Dec. 2 & 4, 1991 CHECKED BY T.C.K.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
85.3	Ground Surface							
84.7	Granular 'A' (Fill) Grey							
0.6	Brown		1	SS	18			
			2	SS	25			
	Clayey silt to silt, some sand trace of gravel Occ. silty sand layers (Fill) Very stiff		3	SS	29			
	Granular 'A' Dense		4	SS	31			
76.8			5	SS	16			
8.5			6	SS	17			
	Crushed stone or subgrade material (Fill) Compact to very dense		7	SS	8			
73.4			8	SS	50/4cm	▼		
11.9	Clayey silt to silt, trace of sand (Fill) Stiff to very stiff		9	SS	20			0 4 62 34
71.7	Brown		10	SS	14			
13.6	Grey		11	SS	13			
	Organic clayey silt to silty clay some sand, trace of gravel Very stiff		12	SS	12			3 48 34 15
69.1			13	SS	54			0 5 70 25
16.2			14	TW	PH			
			15	SS	35			
	Clayey silt, trace of sand and gravel, occ. silt layers Very stiff to hard		16	SS	34			
			17	TW	PH		20.9	
			18	SS	22			
61.4	Grey							
23.9	Reddish brown		19	SS	60/15cm			
	Het. mix. of clayey silt, sand and gravel (Glacial Till) occ. shale fragments		20	SS	60/8cm			
	Hard							
57.9	Reddish brown weathered sound Red		21	SS	60/10cm			
27.4	Queenston shale bedrock		22	RC	REC 98%			RQD 9%
56.6								
28.7	End of Borehole							

ELEVATION SCALE: 84, 82, 80, 78, 76, 74, 72, 70, 68, 66, 64, 62, 60, 58

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

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

PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L

WATER CONTENT (%): 10 20 30

+2

122.5 kPa

+3

+3, ×5 : Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No 91-7 1 OF 1 METRIC

W.P. 624-90-01/02/03/04 LOCATION Co-ord. N 4782 013.2 E 317 903.7 ORIGINATED BY T.K.

DIST 4 HWY Q.E.W. BOREHOLE TYPE H.S. Auger, Vane Tests COMPILED BY R.N.

DATUM Geodetic DATE Dec. 18, 1991 CHECKED BY T.C.K

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, × LAB VANE; 20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
82.8	Ground Surface										
0.0	Clayey silt to silt, some sand trace of gravel occ. silty sand layers (Fill) Firm to Stiff		1	SS	5		82				
			2	SS	10		80				
							78				
73.0	Brown		3	SS	7		76	+3			
9.8	Grey		4	SS	15		74			6.0 % (o.c)	0 3 80 17
	Organic clayey silt to silty clay trace of sand Stiff to Very Stiff (3+6)		5	SS	14		72	+2			
			6	SS	19					1.5 % (o.c.)	0 3 70 27
69.4			7	SS	16		70	+2			
13.4 68.6	Clayey silt with some sand Stiff		8	SS	12						
14.2	End of Borehole										

+³, ×⁵ : Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No 91-8 1 OF 1 METRIC

W.P. 624-90-01/02/03/04 LOCATION Co-ord. N 4781 994.2 E 317 903.7 ORIGINATED BY T.C.K.

DIST 4 HWY Q.E.W. BOREHOLE TYPE H.S. Auger, Vane Tests COMPILED BY R.N.

DATUM Geodetic DATE Dec. 20, 1991 CHECKED BY T.C.K.

ELEV / DEPTH	SOIL PROFILE: DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, × LAB VANE; 20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
82.9	Ground Surface										
82.8 / 0.0	Granular 'A'										
0.3	Brown										
	Clayey silt to silt, some sand and gravel Occ. silty sand layers (Fill) Soft to Stiff		1	SS	13		82				
			2	SS	5		80				
			3	SS	3		78				0 20 57 23
			4	SS	4		76				
	Brown / Grey		5	TW	PH		74				
71.2						▼	72				
11.7	Silty sand		6	TW	PH		70			18.8 2.7 % (o.c.)	0 8 73 19
	Organic clayey silt to silty clay some sand occ. silty sand layers Stiff to Hard		7	TW	PH		68	>115		20.0 1.3 % (o.c.)	0 11 69 20
			8	SS	38						
66.7											
16.2 / 65.7	Silt with some sand and gravel Very Dense		9	SS	59		66				
17.2	End of Borehole										

+3, ×5 : Numbers refer to Sensitivity

15 20/10 5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 91-9 1 OF 1 METRIC

W.P. 624-90-01/02/03/04 LOCATION Co-ord: N 4781 971.0 E 317 932.1 ORIGINATED BY T.C.K

DIST 4 HWY Q.E.W. BOREHOLE TYPE H.S. Auger, Cone Tests, Vane Tests COMPILED BY R.N.

DATUM Geodetic DATE Dec. 12 & 13, 1991 CHECKED BY T.C.K

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
82.5	Ground Surface						82		
0.0 / 81.1	Silty sand (Fill)								
1.4	Clayey silt to silt, some sand, trace of gravel occ. silty sand layers (Fill) Soft to Stiff		1	SS	5		80		
			2	SS	15		78		
			3	SS	2				
			4	SS	1		76		0 14 67 19
			5	SS	3		74		
			6	TW	PM	▼			
			7	SS	2		72		
71.6	Brown / Grey		8	SS	10				
10.9	Organic clayey silt to silty clay some sand Stiff to Very Stiff		9	SS	12		70		
			10	TW	PH			19.9	0 3 67 30
			11	SS	11			1.3 % (a.c.)	6 51 36 7
68.2			12	TW	PH		68		
14.3	Clayey silt, some sand, trace of gravel Compact to Dense		13	SS	30				
			14	SS	24		66		1 11 61 27
			15	SS	35				
			16	SS	0		64		
			17	SS	27				
62.1	Grey / Brown						62		
20.4	Het. mix. of silt, sand and gravel (Glacial Till) Compact		18	SS	27				26 43 23 8
59.8			19	SS	75 /15cm		60		
22.7	End of Borehole								

Het. mix. of clay silt, sand and gravel occ. shale fragments (Glacial Till)

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100

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

PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L
WATER CONTENT (%) 10 20 30

$+^3$, $\times^5$: Numbers refer to Sensitivity

$\frac{20}{15}\diamond\frac{5}{10}$ (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 92-1 1 OF 1 METRIC

W.P. 624-90-01/02/03/04 LOCATION Co-ord. N 4782 027.8 E 317 844.3 ORIGINATED BY MI

DIST 4 HWY QEW BOREHOLE TYPE HS Auger, Vane Tests, NQ Rock Core COMPILED BY MI

DATUM Geodetic DATE May 15, 1992 CHECKED BY TCK

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa o UNCONFINED + FIELD VANE • QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
85.0	Ground Surface										
0.0	Clayey Silt to Silt, some sand and trace of gravel occ. silty sand layers (Fill) Firm to Very Stiff		1	SS	19		84				
			2	SS	19		82				
			3	SS	14		80				
			4	SS	12		78	o			13 41 28 18
			5	SS	7		76				
			6	SS	7		74				
73.3	Brown		7	SS	7	▼					
11.7	D.Grey Organic Clayey Silt to Silty Clay trace of sand Firm to Stiff		8	SS	5		72	+2			
			9	TW	PH						
69.9	D.Grey		10	SS	5		70	>115 +		3.4 % (O.C.)	0 5 70 25
15.1	Grey		11	SS	15		68				
	Silty Sand		12	SS	20		66				
	Clayey Silt, some sand, trace of gravel occ. silty sand layers Stiff to Very Stiff		13	SS	21		64				
61.5	Grey		14	SS	15		62				
23.5	Reddish Brown Het. Mixture of Clayey Silt, Sand and Gravel occ. shale fragments Hard (Glacial Till)		15	SS	100		60	o			24 20 41 15
59.0	Reddish Brown		16	SS	100	/8cm					
26.0	Red Queenston Shale Bedrock		17	RC	REC 97%		58				RQD 25%
57.5											
27.5	End of Borehole										

$+^3$, $\times^5$: Numbers refer to Sensitivity

$15 \overset{20}{\diamond}_{10} 5$ (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 92-2 1 OF 1 METRIC

W.P. 624-90-01/02/03/04 LOCATION Co-ord. N 4782 028.6 E 317 865.3 ORIGINATED BY MI

DIST 4 HWY QEW BOREHOLE TYPE HS Auger, Vane Tests, NQ Rock Core COMPILED BY MI

DATUM Geodetic DATE May 19, 1992 CHECKED BY TCK

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
85.0	Ground Surface										
0.0	Clayey Silt to Silt, some sand and trace of gravel occ. silty sand layers (Fill) Firm to Stiff		1	SS	10		84				
			2	SS	13		82				
			3	SS	14		80				
			4	SS	14		78				
			5	SS	8						
			6	SS	7		76				
74.9											
10.1	Sand and Gravel with crushed stone (Fill) Brown		7	SS	9	▼	74				
73.3											
11.7	D.Grey Organic Clayey Silt to Silty Clay trace of sand Very Stiff		8	SS	4		72	>115 +	57 w=48.5	6.0 % (O.C.)	0 4 76 20
			9	SS	4			>115 +			
			10	TW	PH		70				
69.2	D.Grey		11	SS	4						
15.8	Grey Clayey Silt, some sand and trace of gravel Stiff		12	SS	8		68				1 8 68 23
			13	SS	13						
			14	TW	PH		66	+			
			15	SS	8		64	+1			
60.4	Grey										
24.6	Het. Mixture Clayey Silt, Reddish Brown Sand and Gravel (Glacial Till) occ. Shale Fragments, Hard		16	SS	33		60				
58.0	Reddish Brown Weathered Red Sound		17	SS	100	/28cm					
26.0	Queenston Shale Bedrock		18	RC	REC 93%		58				RQD 7%
57.3											
27.7	End of Borehole										

+3, ×5 : Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No 92-3 1 OF 1 METRIC

W.P. 624-90-01/02/03/04 LOCATION Co-ord. N 4782 030.1 E 317 904.3 ORIGINATED BY MI

DIST 4 HWY QEW BOREHOLE TYPE HS Auger, Vane Tests, NQ Rock Core COMPILED BY MI

DATUM Geodetic DATE May 13, 1992 to May 14, 1992 CHECKED BY TCK

ELEV / DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa o UNCONFINED + FIELD VANE • QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
85.3	Ground Surface										
0.0			1	SS	25		84				
			2	SS	22		82				
	Silty Sand		3	SS	26		80				
	Silty Sand		4	SS	12		78				
	Clayey Silt to Silt, some sand, trace of gravel occ. silty sand layers (Fill) Firm to Very Stiff Brown		5	SS	6		76				
75.2			6	SS	7						
10.1	Organic Clayey Silt to Silty Clay trace of sand		7	SS	3					5.6 % (O.C.)	0 8 72 20
74.0	Soft D.Grey		8	TW	PH		74	285 kPa		20.4	1 11 56 32
11.3	Grey		9	SS	20						
			10	SS	13		72				
			11	SS	13		70				
			12	SS	9		68	>115			
	Clayey Silt, with sand, trace of gravel Very Stiff		13	SS	10		66				
			14	SS	16	▼	64				
			15	SS	19		62				
60.7	Grey										
24.6	Reddish Brown		16	SS	100	/25cm	60				
	Het. Mixture of Clayey Silt, Sand and Gravel occ. shale fragments (Glacial Till)										
57.7	Hard Reddish Brown		17	SS	100	/18cm	58				
27.6	weathered Red / sound		18	RC	REC	100%					RQD 50%
56.2	Queenston Shale Bedrock										
29.1	End of Borehole										

+3, ×5 : Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No 92-4 1 OF 1 METRIC

W.P. 624-90-01/02/03/04 LOCATION Co-ord. N 4781 992.0 E 317 850.7 ORIGINATED BY MI

DIST 4 HWY QEW BOREHOLE TYPE HS Auger, Vane Tests, NQ Rock Core COMPILED BY MI

DATUM Geodetic DATE May 27, 1992 to May 28, 1992 CHECKED BY TCK

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa o UNCONFINED + FIELD VANE • QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
83.4	Ground Surface										
0.0	Clayey Silt to Silt, some sand, trace of gravel, occ. silty sand layers (Fill) Brown / Brownish Grey Very Soft to Soft		1	SS	3		82				
			2	SS	1		80				
			3	SS	2		78				
			4	SS	1		76				
74.8	Brownish Grey		5	SS	1						4 41 38 17
8.6 / 73.6	Organic Clayey Silt to Silty Clay trace sand, Firm D.Grey		6	SS	7		74				0 25 52 23
9.8	Brown		7	TW	PH						
			8	SS	21		72				
			9	SS	7						
	Brown / Grey		10	SS	7		70	>115 +			3 10 55 32
	Clayey Silt, some sand, trace of gravel, occ. sandy silt layers Firm to Very Stiff		11	SS	10	▼	68				
							66				
	Sandy Silt		12	SS	10		64				0 14 80 6
61.8	Grey										
21.6	Reddish Brown Het. Mixture Clayey Silt, Sand and Gravel, occ. shale fragments (Glacial Till) Hard		13	SS	115	/25cm	62				
58.9	Reddish Brown weathered Red sound		14	SS	100	/10cm	60				
24.5 / 57.3	Queenston Shale Bedrock		15	RC	REC 84%		58				RQD 27%
26.1	End of Borehole										

+3, ×5 : Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No 92-5 1 OF 1 METRIC

W.P. 624-90-01/02/03/04 LOCATION Co-ord. N 4781 988.3 E 317 910.9 ORIGINATED BY MI

DIST 4 HWY QEW BOREHOLE TYPE HS Auger, Vane Tests, NQ Rock Core COMPILED BY MI

DATUM Geodetic DATE May 26, 1992 to May 27, 1992 CHECKED BY TCK

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (o UNCONFINED, + FIELD VANE, • QUICK TRIAXIAL, × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
83.4	Ground Surface										
0.0 / 81.9	Granular "A" (Fill)										
1.5	Clayey Silt to Silt, some sand and gravel, occ. silty sand layers (Fill)		1	SS	9						
			2	SS	16						
			3	SS	7						
			4	SS	7						
			5	SS	1						
	Soft to Very Soft		6	SS	1						
			7	SS	2						
71.7	Brown										
11.7	D.Grey		8	SS	10						
	Organic Clayey Silt to Silty Clay some sand		9	TW	PH			28 kPa d; 2 o; 2 +	H o	20.0 1.2 % (O.C.)	0 43 45 12
	Stiff to Very Stiff										
68.3	D.Grey										
15.1	Grey		10	SS	15						
			11	TW	PH	▼		170 kPa o	⊢o⊣	21.3	1 11 53 35
	Clayey Silt, with some sand, trace of gravel										
	Stiff to Very Stiff		12	SS	12						
61.1	Grey										
22.3	Reddish Brown		13	SS	91				o ⊢		26 28 34 12
	Het. Mixture of Clayey Silt, Sand and Gravel, occ. shale fragments (Glacial Till) Hard		14	SS	100 /13cm						
58.2	Reddish Brown										
25.2	Red Queenston Shale Bedrock		15	RC	REC 92%						RQD 18%
56.7											
26.7	End of Borehole										

+³, ×⁵: Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No 92-6 1 OF 1 IMPERIAL

W.P. 624-90-01/02/03/04 LOCATION Co-ord. N 4781 971.4 E 317 914.5 ORIGINATED BY MI

DIST 4 HWY QEW BOREHOLE TYPE HS Auger, Vane Tests, NQ Rock Core COMPILED BY MI

DATUM Geodetic DATE May 28, 1992 CHECKED BY TCK

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH psf (o UNCONFINED, + FIELD VANE, • QUICK TRIAXIAL, × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ pcf	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
82.9	Ground Surface										
0.0	Sandy Silt (Fill) Compact		1	SS	10		82				
80.2											
2.7	Clayey Silt to Silt, some sand, trace of gravel, occ. silty sand layers (Fill) Firm		2	SS	4		80				
			3	SS	5		78				
			4	SS	5		76				
			5	SS	4	▼	74				
			6	SS	4						
72.8	Brown										
10.1	D.Grey Organic Clayey Silt to Silty Clay traces of sand		7	SS	8		72		42	4.4 % (o.c.)	0 8 67 25
71.2	Stiff D.Grey										
11.7	Grey Clayey Silt, with some sand, trace of gravel Firm to Hard		8	SS	4		70				
			9	SS	44						
			10	SS	22		68				
			11	SS	16		66				
61.4	Grey						64				
21.5	Reddish Brown Het. Mixture of Clayey Silt, Sand and Gravel, occ. shale fragments (Glacial Till) Hard		12	SS	30		62				
			13	SS	100 /28cm		60				4 18 57 21
58.4	Reddish Brown		14	SS	100 /13cm						
24.5	Red Queenston Shale Bedrock		15	RC	REC 100%		58				RQD 45%
56.9											
26.0	End of Borehole										

+3, ×5 ; Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No 92-7 1 OF 1 METRIC

W.P. 624-90-01/02/03/04 LOCATION Co-ord. N4781 950.4 E 317 861.3 ORIGINATED BY MI

DIST 4 HWY QEW BOREHOLE TYPE HS Auger, Vane Tests, NQ Rock Core COMPILED BY MI

DATUM Geodetic DATE May 11, 1992 CHECKED BY TCK

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
85.2	Ground Surface							20 40 60 80 100	10 20 30		
0.0	Clayey Silt to Silt, some sand and trace of gravel occ. silty sand layers (Fill) Stiff to Very Stiff		1	SS	18		84				
			2	SS	20				o H		11 44 30 15
			3	SS	17						
			4	SS	23		82				
80.8			5	SS	11						
4.4	Silty Sand, some gravel, trace of clay		6	SS	18				o H		31 39 23 7
79.6	Compact Brown						80				
5.6	Grey		7	SS	11						
			8	SS	11		78	>115 + >115 +			
			9	SS	7		76	>115 +			
			10	SS	9						
	Clayey Silt some sand, trace of gravel Stiff to Very Stiff		11	SS	10		74	1.4 +			
			12	SS	5		72	1.3 +			
			13	SS	11		70	>115 +	o H		5 9 61 25
			14	SS	11		68	>115 +			
			15	SS	10	▼*	66				
			16	SS	15		64				
61.3	Grey						62				
23.9	Reddish Brown Het. Mixture of Clayey Silt, Sand and Gravel occ. shale fragments (Glacial Till)		17	SS	100				o H		25 23 38 14
59.1	Hard Reddish Brown		18	SS	100	/20cm	60				
26.1	Red Queenston Shale Bedrock		19	RC	REC 89%						RQD 44%
57.6			20	RC	REC 100%		58				RQD 0%
27.6	End of Borehole										

* Water level not stabilized

+3, ×5 : Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No 92-8 1 OF 1 METRIC

W.P. 624-90-01/02/03/04 LOCATION Co-ord. N4781 951.1 E 317 881.3 ORIGINATED BY MI

DIST 4 HWY QEW BOREHOLE TYPE HS Auger, NQ Rock Core COMPILED BY MI

DATUM Geodetic DATE May 20, 1992 CHECKED BY TCK

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, × LAB VANE; 20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
85.2	Ground Surface										
0.0	Clayey Silt to Silt some sand and gravel occ. silty sand to sandy silt layers (Fill) Stiff		1	SS	11		84				
			2	SS	13		82				
			3	SS	14		80				4 30 44 22
			4	SS	11		78				
76.6			5	SS	10						
8.6	Sand and Gravel with crushed stone (Fill)		6	SS	16		76				
75.1	Compact Brown										
10.1	Organic Clayey Silt to Silty Clay some sand		7	SS	4	▼					1 21 58 20
73.9	Firm D.Grey						74				
11.3	Grey		8	SS	22						
			9	SS	19						
	Silty Sand		10	SS	63		72				
			11	SS	19						
	Clayey Silt, some sand, trace of gravel occ. silty sand layers Stiff to Very Stiff						70				
			12	SS	15		68				
			13	SS	14		66				
61.3	Grey						64				
23.9	Reddish Brown Het. Mixture of Clayey Silt, Sand and Gravel occ. shale fragments (Glacial Till)		14	SS	78		62				
58.8	Hard Reddish Brown		15	SS	100	/25cm	60				
26.4	Red weathered sound		16	SS	100	/13cm	58				
	Queenston Shale Bedrock		17	RC	REC 73%						RQD 68%
56.1											
29.1	End of Borehole										

+³, ×⁵: Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No 92-9 1 OF 1 METRIC

W.P. 624-90-01/02/03/04 LOCATION Co-ord. N 4781 952.6 E 317 921.2 ORIGINATED BY MI

DIST 4 HWY QEW BOREHOLE TYPE HS, NQ Core COMPILED BY MI

DATUM Gedectic DATE May 12, 1992 to May 13, 1992 CHECKED BY TCK

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, × LAB VANE)	WATER CONTENT (%) w_P w w_L	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
85.4	Ground Surface										
0.0			1	SS	11		84				
			2	SS	14		82				
	Sandy Silt		3	SS	15		80				
			4	SS	10		78				
	Silty Sand		5	SS	13						
	Clayey Silt to Silt, some sand, trace of gravel occ. sandy silt to silty sand layers		Sandy Silt 6	SS	9		76				
	Stiff to Very Stiff		7	SS	9		74				
	(Fill)		8	SS	8						
71.8	Brown		9	SS	9		72				
13.6	D.Grey		10	SS	7						
	Organic Clayey Silt to Silty Clay trace of sand		11	TW	PH	▼				20.2	0 7 67 26
	Firm to Very Stiff		12	SS	3		70	>115+ 2			
69.2	D.Grey		13	SS	9						
16.2	Grey		14	SS	14		68				
	Clayey Silt, some sand, trace of gravel		15	SS	14		66	>115+			
	Stiff to Very Stiff						64	>115+			
61.6	Grey		16	SS	11						
23.8	Reddish Brown		17	SS	86		62				
	Het. Mixture of Clayey Silt, Sand and Gravel, occ. shale fragments						60				
	(Glacial Till)										
	Hard		18	SS	100	/23cm	58				
56.4	Reddish Brown		19	SS	100	/10cm					
29.0	Red						56				
	Queenston Shale Bedrock		20	RC	REC	97%					RQD 43%
54.9											

30.5 End of Borehole

+3, ×5 : Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

ROCK CORE DESCRIPTION
WP 624-90-01/02/03/04

CORE RECOVERY					CORE DESCRIPTION	
BH#	RC#	DEPTH (m)	% CR*	% RQD*	DEPTH (m)	DESCRIPTION
91-1	25	26.82-28.35	77	23	26.82-28.35	**SHALE**, greyish red, with interbedded greenish grey **SILTSTONE** (7%); very fine grained; weak to very weak; unweathered to slightly weathered (moderately weathered, 27.89-28.12 m); fractures close to extremely close spaced, flat to near vertical, planar to undulating, smooth.
91-3	19 20	24.38-25.91 25.91-26.82	88 83	17 69	24.38-26.82	**SHALE**, greyish red, with interbedded greenish grey **SILTSTONE** (14%); very fine grained; weak to very weak; unweathered to slightly weathered (moderately weathered, 24.38-24.71 m); fractures moderately close to extremely close spaced, flat to near vertical, planar to undulating, smooth.
91-4	15	23.01-24.38	85	19	23.01-24.38	**SHALE**, greyish red, with interbedded greenish grey **SILTSTONE** (7%); very fine grained; weak to very weak; unweathered to slightly weathered (moderately weathered, 23.01-23.72 m); fractures close to extremely close spaced, flat to near vertical, planar to undulating, smooth.
91-5	20	24.38-25.93	91	23	24.38-25.93	**SHALE**, greyish red, with interbedded greenish grey **SILTSTONE** (8%); very fine grained; weak to very weak; unweathered to slightly weathered; fractures close to extremely close spaced, flat to near vertical, planar to undulating, smooth.
91-6	22	27.43-28.68	98	9	27.43-28.68	**SHALE**, greyish red, with interbedded greenish grey **SILTSTONE** (14%); very fine grained; weak to very weak; unweathered to slightly weathered (moderately weathered, 27.43-27.51 m); fractures close to extremely close spaced, flat to near vertical, planar to undulating, smooth.

***CR** = CORE RECOVERY
***RQD** = ROCK QUALITY DESIGNATION

(NOTE: Depths are approximated where core recovery is less than 100%)

Logged by: DAW, Soils and Aggregates Section

ROCK CORE DESCRIPTION
WP 624-90-01/02/03/04

CORE RECOVERY					CORE DESCRIPTION	
BH#	RC#	DEPTH (m)	% CR*	% RQD*	DEPTH (m)	DESCRIPTION
92-1	17	25.98-27.51	97	25	25.98-27.51	**SHALE,** greyish red, with interbedded greenish grey **SILTSTONE** (5%); very fine grained; weak to very weak; unweathered to slightly weathered; fractures close to extremely close spaced, flat to near vertical, planar to undulating, smooth.
92-2	18	26.19-27.71	93	7	26.19-27.71	**SHALE,** greyish red, with interbedded greenish grey **SILTSTONE** (5%); very fine grained; weak to very weak; unweathered to slightly weathered; fractures close to extremely close spaced, flat to near vertical, planar to undulating, smooth.
92-3	18	27.61-29.13	100	50	27.61-29.13	**SHALE,** greyish red, with interbedded greenish grey **SILTSTONE** (15%); very fine grained; weak to very weak; unweathered to slightly weathered (moderately weathered, 27.61-28.04 m); fractures moderate to extremely close spaced, flat to near vertical, planar to undulating, smooth.
92-4	15	24.54-26.06	84	27	24.54-26.06	**SHALE,** greyish red, with interbedded greenish grey **SILTSTONE** (6%); very fine grained; weak to very weak; unweathered to slightly weathered (moderately weathered, 24.54-24.66 m); fractures close to extremely close spaced, flat to near vertical, planar to undulating, smooth.
92-5	15	25.15-26.67	92	18	25.15-26.67	**SHALE,** greyish red, with interbedded greenish grey **SILTSTONE** (7%); very fine grained; weak to very weak; unweathered to slightly weathered; fractures close to extremely close spaced, flat to near vertical, planar to undulating, smooth.

***CR** = CORE RECOVERY
***RQD** = ROCK QUALITY DESIGNATION

(NOTE: Depths are approximated where core recovery is less than 100%)

Logged by: DAW, Soils and Aggregates Section

ROCK CORE DESCRIPTION
WP 624-90-01/02/03/04

CORE RECOVERY					CORE DESCRIPTION	
BH#	RC#	DEPTH (m)	% CR*	% RQD*	DEPTH (m)	DESCRIPTION
92-6	15	24.51-26.04	100	45	24.51-26.04	**SHALE,** greyish red, with interbedded greenish grey **SILTSTONE** (7%); very fine grained; weak to very weak; unweathered to slightly weathered; fractures close to extremely close spaced, flat to near vertical, planar to undulating, smooth.
92-7	19 20	26.11-27.03 27.03-27.64	89 100	44 0	26.11-27.64	**SHALE,** greyish red, with interbedded greenish grey **SILTSTONE** (8%); very fine grained; weak to very weak; unweathered to slightly weathered; fractures close to extremely close spaced, flat to near vertical, planar to undulating, smooth.
92-8	17	27.56-29.08	73	68	27.56-29.08	**SHALE,** greyish red, with interbedded greenish grey **SILTSTONE** (13%); very fine grained; weak to very weak; unweathered to slightly weathered; fractures close to extremely close spaced, flat to near vertical, planar to undulating, smooth.
92-9	20	29.06-30.58	97	43	29.06-30.58	**SHALE,** greyish red, with interbedded greenish grey **SILTSTONE** (8%); very fine grained; weak to very weak; unweathered to slightly weathered; fractures close to very close spaced, flat to near vertical, planar to undulating, smooth.

***CR** = CORE RECOVERY
***RQD** = ROCK QUALITY DESIGNATION

(NOTE: Depths are approximated where core recovery is less than 100%)

Logged by: DAW, Soils and Aggregates Section

EXPLANATION OF TERMS USED IN REPORT

N VALUE: THE STANDARD PENETRATION TEST (SPT) N VALUE IS THE NUMBER OF BLOWS REQUIRED TO CAUSE A STANDARD 51mm O.D SPLIT BARREL SAMPLER TO PENETRATE 0.3m INTO UNDISTURBED GROUND IN A BOREHOLE WHEN DRIVEN BY A HAMMER WITH A MASS OF 63.5kg, FALLING FREELY A DISTANCE OF 0.76m. FOR PENETRATIONS OF LESS THAN 0.3m N VALUES ARE INDICATED AS THE NUMBER OF BLOWS FOR THE PENETRATION ACHIEVED. AVERAGE N VALUE IS DENOTED THUS $\tilde{N}$.

DYNAMIC CONE PENETRATION TEST: CONTINUOUS PENETRATION OF A CONICAL STEEL POINT (51mm O.D 60° CONE ANGLE) DRIVEN BY 475 J IMPACT ENERGY ON 'A' SIZE DRILL RODS. THE RESISTANCE TO CONE PENETRATION IS MEASURED AS THE NUMBER OF BLOWS FOR EACH 0.3m ADVANCE OF THE CONICAL POINT INTO THE UNDISTURBED GROUND.

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS

CONSISTENCY: COHESIVE SOILS ARE DESCRIBED ON THE BASIS OF THEIR UNDRAINED SHEAR STRENGTH (c_u) AS FOLLOWS:

c_u (kPa)	0 - 12	12 - 25	25 - 50	50 - 100	100 - 200	>200
	VERY SOFT	*SOFT*	*FIRM*	*STIFF*	*VERY STIFF*	*HARD*

DENSENESS: COHESIONLESS SOILS ARE DESCRIBED ON THE BASIS OF DENSENESS AS INDICATED BY SPT N VALUES AS FOLLOWS:

N (BLOWS/0.3m)	0 - 5	5 - 10	10 - 30	30 - 50	>50
	VERY LOOSE	*LOOSE*	*COMPACT*	*DENSE*	*VERY DENSE*

ROCKS ARE DESCRIBED BY THEIR COMPOSITION AND STRUCTURAL FEATURES AND / OR STRENGTH.

RECOVERY: SUM OF ALL RECOVERED ROCK CORE PIECES FROM A CORING RUN EXPRESSED AS A PERCENT OF THE TOTAL LENGTH OF THE CORING RUN.

MODIFIED RECOVERY: SUM OF THOSE INTACT CORE PIECES, 100mm+ IN LENGTH EXPRESSED AS A PERCENT OF THE LENGTH OF THE CORING RUN. THE ROCK QUALITY DESIGNATION (R Q D), FOR MODIFIED RECOVERY, IS:

R Q D (%)	0 - 25	25 - 50	50 - 75	75 - 90	90 - 100
	VERY POOR	*POOR*	*FAIR*	*GOOD*	*EXCELLENT*

JOINTING AND BEDDING:

SPACING	50mm	50 - 300mm	0.3m - 1m	1m - 3m	>3m
JOINTING	*VERY CLOSE*	*CLOSE*	*MOD. CLOSE*	*WIDE*	*VERY WIDE*
BEDDING	*VERY THIN*	*THIN*	*MEDIUM*	*THICK*	*VERY THICK*

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

S S	SPLIT SPOON	T P	THINWALL PISTON
W S	WASH SAMPLE	O S	OSTERBERG SAMPLE
S T	SLOTTED TUBE SAMPLE	R C	ROCK CORE
B S	BLOCK SAMPLE	P H	T W ADVANCED HYDRAULICALLY
C S	CHUNK SAMPLE	P M	T W ADVANCED MANUALLY
T W	THINWALL OPEN	F S	FOIL SAMPLE

STRESS AND STRAIN

u_w	kPa	PORE WATER PRESSURE
r_u	1	PORE PRESSURE RATIO
σ	kPa	TOTAL NORMAL STRESS
σ'	kPa	EFFECTIVE NORMAL STRESS
τ	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
ϵ	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS OF SHEAR DEFORMATION
μ	1	COEFFICIENT OF FRICTION

MECHANICAL PROPERTIES OF SOIL

m_v	kPa^{-1}	COEFFICIENT OF VOLUME CHANGE
C_c	1	COMPRESSION INDEX
C_s	1	SWELLING INDEX
C_α	1	RATE OF SECONDARY CONSOLIDATION
c_v	m^2/s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
T_v	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
σ'_{vo}	kPa	EFFECTIVE OVERBURDEN PRESSURE
σ'_p	kPa	PRECONSOLIDATION PRESSURE
τ_f	kPa	SHEAR STRENGTH
c'	kPa	EFFECTIVE COHESION INTERCEPT
ϕ'	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
c_u	kPa	APPARENT COHESION INTERCEPT
ϕ_u	-°	APPARENT ANGLE OF INTERNAL FRICTION
τ_R	kPa	RESIDUAL SHEAR STRENGTH
τ_r	kPa	REMOULDED SHEAR STRENGTH
S_t	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

PHYSICAL PROPERTIES OF SOIL

ρ_s	kg/m^3	DENSITY OF SOLID PARTICLES
γ_s	kN/m^3	UNIT WEIGHT OF SOLID PARTICLES
ρ_w	kg/m^3	DENSITY OF WATER
γ_w	kN/m^3	UNIT WEIGHT OF WATER
ρ	kg/m^3	DENSITY OF SOIL
γ	kN/m^3	UNIT WEIGHT OF SOIL
ρ_d	kg/m^3	DENSITY OF DRY SOIL
γ_d	kN/m^3	UNIT WEIGHT OF DRY SOIL
ρ_{sat}	kg/m^3	DENSITY OF SATURATED SOIL
γ_{sat}	kN/m^3	UNIT WEIGHT OF SATURATED SOIL
ρ'	kg/m^3	DENSITY OF SUBMERGED SOIL
γ'	kN/m^3	UNIT WEIGHT OF SUBMERGED SOIL
e	1,%	VOID RATIO
n	1,%	POROSITY
w	1,%	WATER CONTENT
S_r	%	DEGREE OF SATURATION
w_L	%	LIQUID LIMIT
w_P	%	PLASTIC LIMIT
w_S	%	SHRINKAGE LIMIT
I_P	%	PLASTICITY INDEX = $w_L - w_P$
I_L	1	LIQUIDITY INDEX = $\frac{w - w_P}{I_P}$
I_C	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_P}$
e_{max}	1,%	VOID RATIO IN LOOSEST STATE
e_{min}	1,%	VOID RATIO IN DENSEST STATE
I_D	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
D	mm	GRAIN DIAMETER
D_n	mm	n PERCENT - DIAMETER
C_U	1	UNIFORMITY COEFFICIENT
h	m	HYDRAULIC HEAD OR POTENTIAL
q	m^3/s	RATE OF DISCHARGE
v	m/s	DISCHARGE VELOCITY
i	1	HYDRAULIC GRADIENT
k	m/s	HYDRAULIC CONDUCTIVITY
j	kN/m^3	SEEPAGE FORCE

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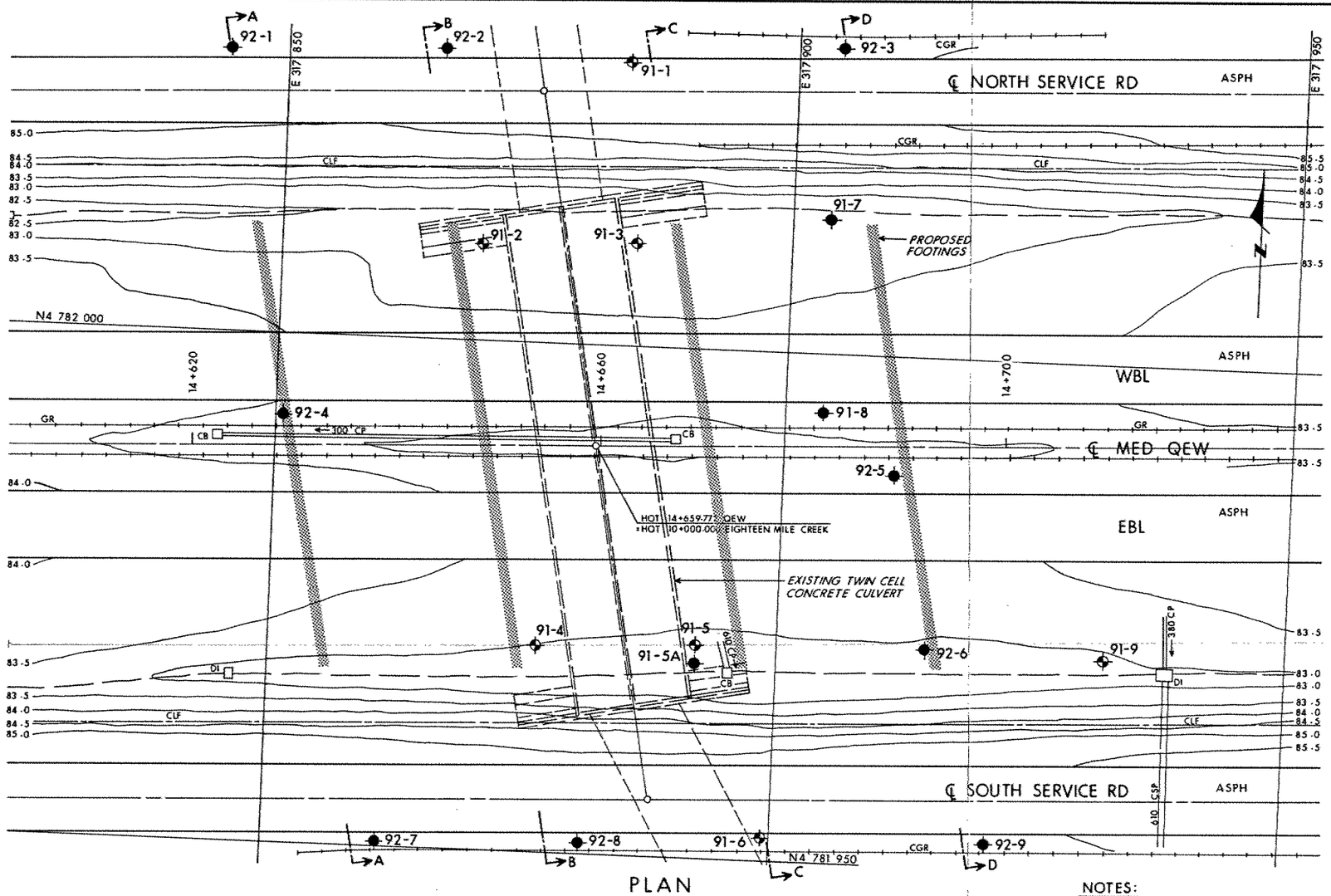
METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

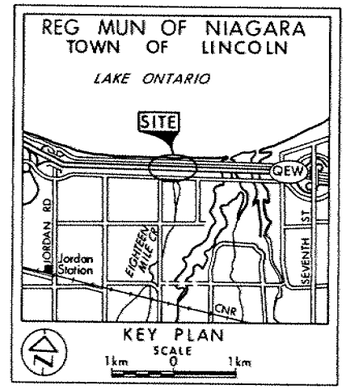
CONT No
WP No 624-90-01/02

SHEET

EIGHTEEN MILE CREEK
(QEW WBL & EBL)
BORE HOLE LOCATIONS & SOIL STRATA



PLAN
SCALE 5m 0 5m

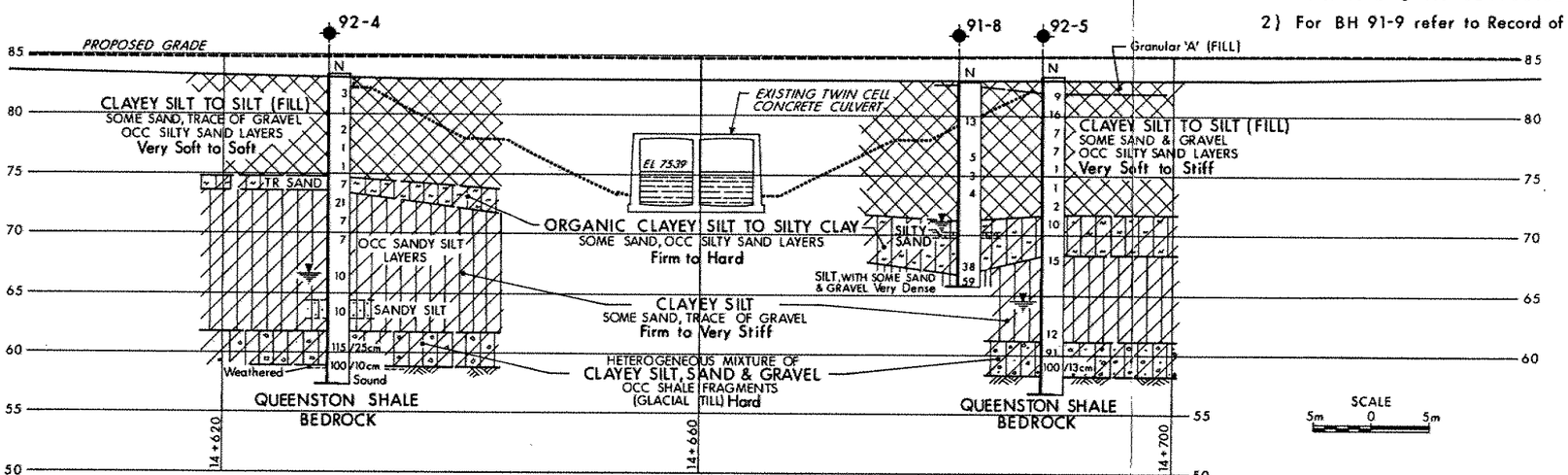


LEGEND

- Bore Hole
- Dynamic Cone Penetration Test (Cone)
- Bore Hole & Cone
- N Blows/0.3m (Std Pen Test, 475 J/blow)
- CONE Blows/0.3m (60° Cone, 475 J/blow)
- W L at time of investigation 1991 12 and 1992 05

	No	ELEVATION	CO-ORDINATES NORTH	EAST
1991-12	91-1	85.2	4 782 027.9	317 883.7
	91-2	82.7	4 782 009.5	317 869.7
	91-3	82.8	4 782 010.1	317 884.9
	91-4	83.0	4 781 970.3	317 876.4
	91-5	82.9	4 781 971.0	317 892.1
	91-5A	82.9	4 781 969.2	317 892.1
	91-6	85.3	4 781 952.3	317 899.1
	91-7	82.8	4 782 013.2	317 903.7
	91-8	82.9	4 781 994.2	317 903.7
	91-9	82.5	4 781 971.0	317 932.1
1992 05	92-1	85.0	4 782 027.8	317 844.3
	92-2	85.0	4 782 028.6	317 865.3
	92-3	85.3	4 782 030.1	317 904.3
	92-4	83.4	4 781 992.0	317 850.7
	92-5	83.4	4 781 988.3	317 910.9
	92-6	82.9	4 781 971.4	317 914.5
	92-7	85.2	4 781 950.4	317 861.3
	92-8	85.2	4 781 951.1	317 881.3
	92-9	85.4	4 781 952.6	317 921.2

NOTES:
1) For Sections A-A, B-B, C-C and D-D refer to Dwg No 624900102-B
2) For BH 91-9 refer to Record of Borehole Sheet



℄ PROFILE QEW

SCALE 5m 0 5m

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

NOTE: The complete foundation investigation and design report for this project and other related documents may be examined at the Engineering Materials Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with the conditions of Section GC 2.01 of OPS Gen Cond

REV.	DATE	BY	DESCRIPTION

Geocres No 30M3-194

HWY No QEW			DIST 4
SUBM'D TCK	CHECKED TK	DATE 1992 12 18	SITE 18-20
DRAWN DT	CHECKED	APPROVED	DWG 624900102-A

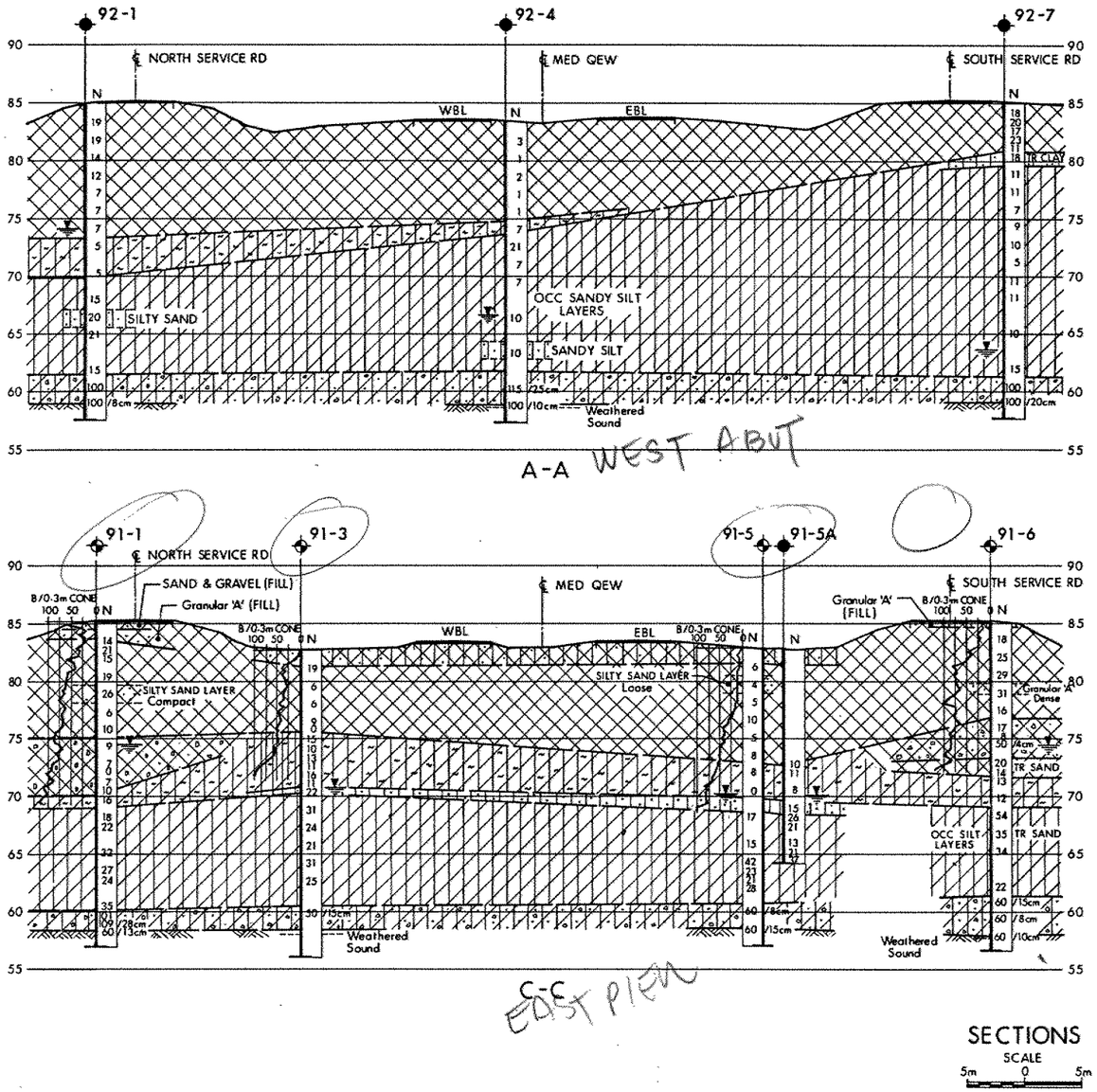
REF No B-138-QEW-4, 1986 09

METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

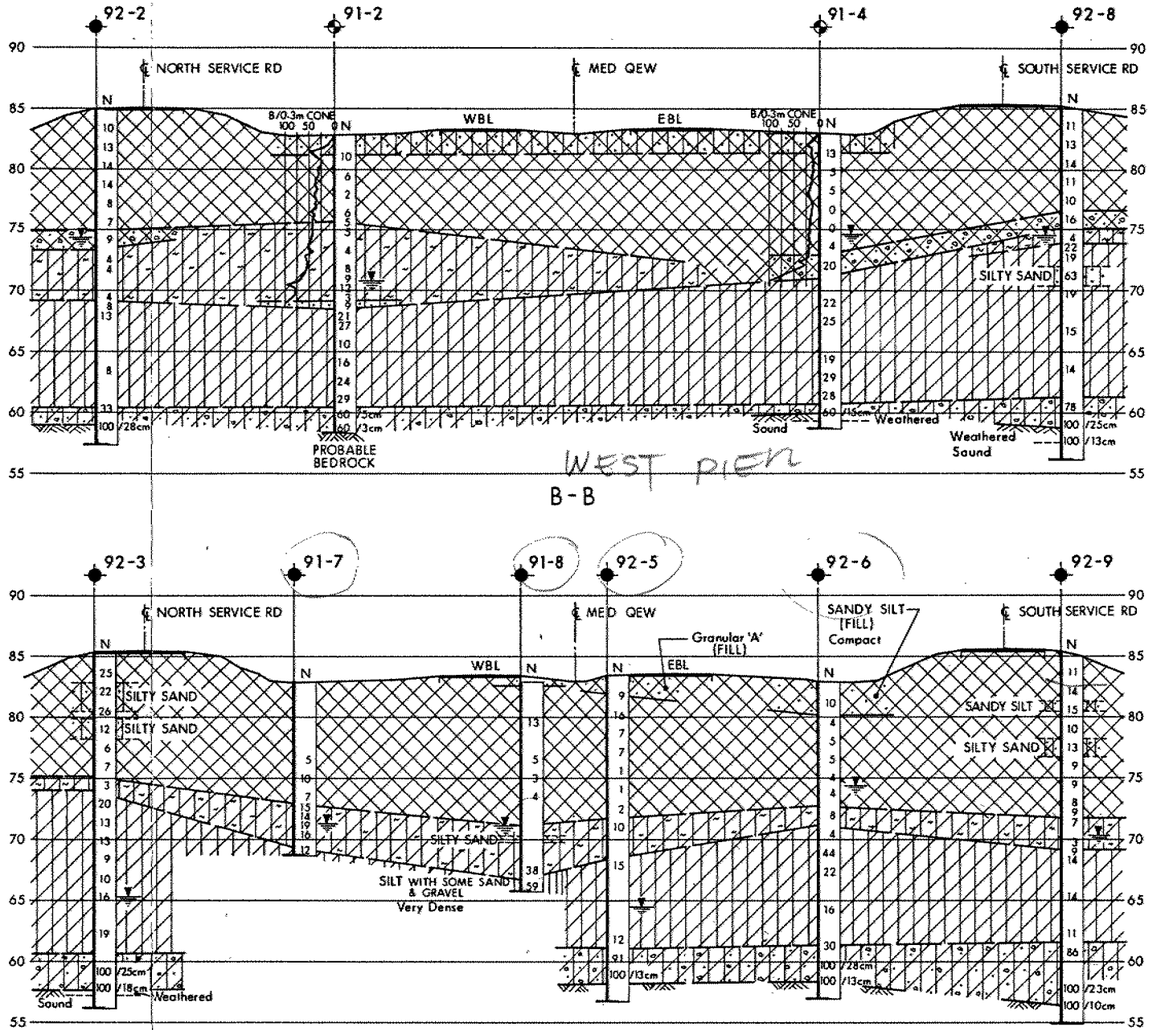
CONT No
WP No 624-90-01/02

EIGHTEEN MILE CREEK
(QEW WBL & EBL)
BORE HOLE LOCATIONS & SOIL STRATA

SHEET



A-A WEST ABUT



B-B WEST PIER

C-C EAST PIER

D-D E-ABUT

SECTIONS
SCALE
5m 0 5m

LEGEND	No	ELEVATION	CO-ORDINATES NORTH	CO-ORDINATES EAST	
Bore Hole	91-1	85.2	4 782 027.9	317 883.7	1991-12
Dynamic Cone Penetration Test (Cone)	91-2	82.7	4 782 009.5	317 869.7	
Bore Hole & Cone	91-3	82.8	4 782 010.1	317 884.9	
N Blows/0.3m (Std Pen Test, 475 J/blow)	91-4	83.0	4 781 970.3	317 876.4	
CONE Blows/0.3m (60° Cone, 475 J/blow)	91-5	82.9	4 781 971.0	317 892.1	
WL at time of investigation 1991 12 and 1992 05	91-5A	82.9	4 781 969.2	317 892.1	
	91-6	85.3	4 781 952.3	317 899.1	
	91-7	82.8	4 782 013.2	317 903.7	
	91-8	82.9	4 781 994.2	317 903.7	
	91-9	82.5	4 781 971.0	317 932.1	
	92-1	85.0	4 782 027.8	317 844.3	1992-05
	92-2	85.0	4 782 028.6	317 865.3	
	92-3	85.3	4 782 030.1	317 904.3	
	92-4	83.4	4 781 992.0	317 850.7	
	92-5	83.4	4 781 988.3	317 910.9	
	92-6	82.9	4 781 971.4	317 914.5	
	92-7	85.2	4 781 950.4	317 861.3	
	92-8	85.2	4 781 951.1	317 881.3	
	92-9	85.4	4 781 952.6	317 921.2	

SOIL STRATIGRAPHY LEGEND

- SILTY SAND (FILL)
- CLAYEY SILT TO SILT (FILL) SOME SAND, TRACE OF GRAVEL OCC SILTY SAND TO SANDY SILT LAYERS Very Soft to Very Stiff
- CRUSHED STONE (FILL) WITH SAND Loose to Very Dense
- SILTY SAND SOME/WITH GRAVEL Loose to Compact
- ORGANIC CLAYEY SILT TO SILTY CLAY TRACE/SOME SAND, TRACE GRAVEL Soft to Very Stiff
- CLAYEY SILT SOME/WITH SAND, TRACE GRAVEL OCC SILTY SAND LAYERS Firm to Hard
- HETEROGENEOUS MIXTURE OF CLAYEY SILT, SAND & GRAVEL OCC SHALE FRAGMENTS (GLACIAL TILL) Hard
- QUEENSTON SHALE BEDROCK

NOTE
For Plan and Profile refer to Dwg. No 624900102-A

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

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REV.	DATE	BY	DESCRIPTION

Geocres No 30M3-194

HWY No QEW			DIST 4
SUBM'D TCK	CHECKED TCK	DATE 1992 12 18	SITE 18-20
DRAWN DT	CHECKED	APPROVED	DWG 624900102-B