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DIST. 9 REGION

W.P. No. 252-66

CONT. No.

W. O. No.

STR. SITE No. 3-264

HWY. No. 416

LOCATION OTTAWA QUEENSWAY

South to Jock River

No of PAGES -

=====

OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:

FOUNDATIONS COPY

Ontario
Department of Transportation and Communications
~~DEPARTMENT OF HIGHWAYS, ONTARIO~~
XXXXXXXXXXXXXXXXXXXX
MEMORANDUM

31Q5-75

TO: Mr. T. C. Kingsland,
Regional Bridge Planning Engineer,
Regional Office,
KINGSTON, Ontario.

FROM: Foundation Section,
Design Services Branch,
Room 107, Lab. Bldg.

ATTENTION:

DATE: July 20, 1971

OUR FILE REF.

IN REPLY TO **JUL 22 1971**

SUBJECT:

PRELIMINARY
FOUNDATION INVESTIGATION REPORT FOR
Structure and Related Crossings of
Hwy. #416, Ottawa Queensway Southerly
To the Jock River -- City of Ottawa
And Nepean Township, Regional Mun.
Of Ottawa-Carleton, Dist. 9 (Ottawa)
W.O. 71-11045 - W.P. 12-68 & 252-66

Attached, we are forwarding to you our Preliminary Foundation Investigation Report pertaining to the above ~~structure~~ sites. Presented in this report are the results of the investigation, together with our general comments pertaining to the stability of the approaches and recommendations regarding structure foundations at various crossings.

We believe that the information contained therein, will prove adequate for your immediate use. Should you require further data, or clarification of the report, please do not hesitate to contact this Office.

AGS/MdeF
Attach.

cc: Messrs. B. R. Davis
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Foundations Files ✓
Gen. Files

TABLE OF CONTENTS

1. INTRODUCTION.
 2. DESCRIPTION OF THE AREA AND GEOLOGY.
 3. FIELD AND LABORATORY WORK.
 4. SUBSOIL AND BEDROCK CONDITIONS:
 - 4.1) General.
 - 4.2) Fill.
 - 4.3) Sandy Silt to Silty Sand (Upper Deposit).
 - 4.4) Cohesive Strata:
 - 4.4.1) Clay to Silty Clay (Sensitive) - Grenfell Rd. Southerly to Woodroffe Ave.).
 - 4.4.2) Silty Clay to Clayey Silt - (Site No. 7 Southerly to Site No. 10).
 - 4.5) Silty Sand with some Gravel to Gravelly Sand - (Lower Deposit).
 - 4.6) Glacial Till.
 - 4.7) Bedrock.
 5. GROUNDWATER CONDITIONS.
 6. DISCUSSION AND RECOMMENDATIONS:
 - 6.1) General.
 - 6.2) Hwy. #416 Crossings - Proposed Alignment.
 - 6.3) Hwy. #416 Crossings - Possible Revision (Slack Road Southerly to Fallowfield Road).
 7. MISCELLANEOUS.
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PRELIMINARY
FOUNDATION INVESTIGATION REPORT FOR
Structure and Related Crossings of
Hwy. #416, Ottawa Queensway Southerly
To the Jock River -- City of Ottawa
And Nepean Township, Regional Mun.
Of Ottawa-Carleton, Dist. 9 (Ottawa)
W.O. 71-11045 - W.P. 12-68 & 252-66

1. INTRODUCTION:

The Foundation Section was requested to carry out a preliminary foundation investigation at the possible structure and related crossings to be situated within the aforementioned 9-1/2 mile stretch of Hwy. #416. The main purpose of the investigation is to provide sufficient information pertaining to foundation design to aid in the planning studies being carried out to assess the feasibility of adopting the proposed alignment.

The request for this foundation investigation was contained in a memo from Mr. T. C. Kingsland, Regional Bridge Planning Engineer, Eastern Region, dated April 21, 1971. An investigation was subsequently carried out by this Section to determine the subsoil, bedrock and groundwater conditions across this area.

This report presents all the factual information obtained from this investigation. Included are recommendations pertaining to foundation design at the various possible crossings, as well as the stability and settlement considerations associated with fills and cuts.

2. DESCRIPTION OF THE AREA AND GEOLOGY:

The area under investigation is bounded by the following:

2. DESCRIPTION OF THE AREA AND GEOLOGY: (cont'd.) ...

North - the Ottawa Queensway
South - Jock River
West - West of Woodroffe Avenue
East - 500 feet east of Merivale Road

It is therefore located partially within the City Limits of Ottawa and partially within the Township of Nepean.

The major portion of the area is gently undulating in relief between elevations 285 and 310. In the southern extremity, however, the terrain increases gradually in elevation (up to elevation 330).

North of Viewmount Drive the land is being heavily used for residential purposes, including commercial shops and factories as well as private residences. Along the southern part of the alignment the terrain is being cultivated and used for farming purposes.

Two southwest to northeast trending C.N.R. main lines traverse this area; these two lines eventually merge at a point about 1,000 feet east of the area under investigation.

The North-South flowing Rideau River is located approximately 1-1/2 miles east of the area investigated. This river, as well as the basically East-West flowing, 250 to 300 feet wide Jock River, control the drainage throughout this region. In addition, a number of creeks meander across the site; the major of these is the East-West running Black Rapids Creek, which is approximately 150 feet wide and 12 feet deep. This creek is located between Grenfell and Fallowfield Roads. The side slopes of the creek are of the order of 3:1; the water in this creek was about 4 feet deep at the time of the investigation.

The Ottawa River is entrenched within a low terrace which is bounded on either side by abrupt bluffs. Numerous faults

2. DESCRIPTION OF THE AREA AND GEOLOGY: (cont'd.) ...

have been discovered in this down-dropped block - i.e., in the area under consideration, there are many minor breaks and disconformities.

This area is situated in the physiographic region known as the "Ottawa Valley Clay Plains". The region is typified by deposits of clay interrupted by ridges of rock or sand. In the central portion of the area investigated, the predominant deposit is a sensitive marine clay laid down in the geologic past in Lake Champlain. This sensitive clay is generally overlain by a stiff mottled clay of non-marine origin. The overall thickness of the clay deposits is generally of the order of 25 to 30 feet. The clays are underlain by silt and glacial till.

In the northern and extreme southern portion of the area, however, the overburden is primarily composed of shallow deposits of glacial till (10 to 20 feet thick) derived from the underlying bedrock. These till sheets have been laid down in the form of ground moraines. At some random locations, interglacial granular deposits of either fluvial or alluvial origin are often complexly interbedded with the aforementioned strata. This is particularly the case in the general vicinity of Merivale and Slack Roads, here sand deposits up to 60 feet thick, are known to exist.

The overburden is underlain by bedrock. In the northern portion of the area investigated, the bedrock is composed of limestone and dolomite of the Trenton formation, Ordovician Period. In the southern portion, however, the bedrock is composed basically of dolomite of the Beekmantown formation of the same period.

3. FIELD AND LABORATORY WORK:

Nineteen boreholes were put down, using conventional diamond drill rigs adapted for soil sampling purposes, during the recent investigation.

3. FIELD AND LABORATORY WORK: (cont'd.) ...

Samples of the overburden were obtained, at specified intervals, in a 2-inch O.D. split-spoon sampler, which was hammered into the soil in accordance with the specifications for the Standard Penetration Test. Where cohesive deposits were encountered, the split-spoon sampling was supplemented by taking 2-inch I.D. Shelby tubes, which were manually pushed into the soil. In addition, field vane tests were carried out, where possible, to determine the undrained shear strength of the clay strata. Bedrock was proven in 16 of the borings by obtaining either AXT or BX size rock core samples.

Groundwater level observations were carried out, during the period of the investigation, in the open boreholes. An artesian water pressure was encountered at the borehole put down at Site No. 14. This head was completely sealed off following the sampling and drilling operations.

The soil, bedrock and groundwater conditions encountered at the boring locations, are presented on the Record of Borelog sheets, appended to this report. The location and elevation of the various boreholes were provided by personnel from the Eastern Region Engineering Surveys Section. The elevations in this report are referenced to a Geodetic datum. Boring locations and elevations are shown on Drawing No. W.O. 71-11045A. An estimated stratigraphical profile, along the proposed alignment, is also plotted on the drawing.

All the samples were subjected to a careful visual examination in the field, and subsequently in the laboratory. Following this examination, laboratory testing was carried out on selected representative samples to determine the following engineering properties of the overburden:

3. FIELD AND LABORATORY WORK: (cont'd.) ...

Bulk Density
Natural Moisture Content
Atterberg Limits
Grain-size Distribution
Undrained Shear Strength
Consolidation Characteristics

The results of this testing are plotted on the Record of Borelog sheets and summarized on Figures No. 1 to 9, inclusive, all contained in Appendix I of this report.

4. SUBSOIL AND BEDROCK CONDITIONS:

4.1) General:

The extent and composition of the overburden, within the area under investigation, varies markedly. In the central portion of the area, a firm to very stiff sensitive silty clay to clay stratum is present at a shallow depth below ground surface. The thickness of this stratum varies from 3 to 23 feet, being most extensive between Grenfell Road and Woodroffe Avenue. In the latter area the cohesive stratum is generally underlain by a 7 to 15 foot thick deposit of loose silt. This sequence is underlain by a thin (5 to 9 foot thick) glacial till sheet, which, in turn, is followed by bedrock.

From Viewmount Drive southerly to Slack Road, the cohesive strata are complexly interbedded with granular deposits of fluvial as well as alluvial origin. In some instances, the cohesive strata are absent. In this area the granular deposits vary from silty fine sand to gravelly sand. The thickness of the compact to very dense granular deposits vary randomly from 4 to 55 feet.

From Viewmount Drive northerly to the Ottawa Queensway, as well as in the extreme southern portion of the area under investigation, the glacial till protrudes to within a few feet

4. SUBSOIL AND BEDROCK CONDITIONS: (cont'd.) ...

4.1) General: (cont'd.) ...

of existing ground surface. In these areas the glacial till varies anywhere from 2 to 35 feet in thickness. The till sheet is again underlain by bedrock.

The stratigraphical sequence encountered in the borings is plotted on the Record of Borelog sheets. The stratigraphical profile, along the proposed alignment of Hwy. #416, which is plotted on Drawing No. W.O. 71-11045A, has been inferred from this data. The subsoil and bedrock encountered from ground surface downward, is presented in the sub-sections to follow.

4.2) Fill:

A number of borings were put down along existing roadways. At these locations between 2 and 6 feet of fill was encountered. The composition of the fill ranged from a silty sand to sandy silt with a trace of gravel. Grain-size distribution tests were performed on two samples obtained within the fill; the results are plotted on Figure No. 1 in Appendix I of this report. Standard penetration testing carried out within the fill, gave 'N' values which range from 5 to 25 blows/ft. These values would indicate that the fill has been subjected to a moderate degree of compaction.

4.3) Sandy Silt to Silty Sand (Upper Deposit):

A granular deposit, composed of a brown sandy silt to silty sand with occasional gravel sizes, was encountered within the area extending from Site No. 7 (south of Viewmount Drive) southerly to Site No. 11 (Slack Road). At Sites No. 7 and 10 the granular subsoil underlies a thin cohesive deposit, while at Site No. 8, it overlies a cohesive deposit. At Sites No. 9 and 11, however, it was encountered at the original ground surface - i.e., the cohesive deposit is absent. The thickness of the deposit ranges from 4 feet (Site No. 8) to 41 feet (Site No. 11). Occasional clayey silt layers, up to 3 inches thick, were encountered within the deposit at Site No. 8.

4. SUBSOIL AND BEDROCK CONDITIONS: (cont'd.) ...

4.3) Sandy Silt to Silty Sand (Upper Deposit): (cont'd.) ...

Further, boulders up to 8 inches in size were present below elevation 273 at the boring put down at Site No. 11. Grain-size distribution testing, carried out for samples of the granular deposit, are plotted on Figure No. 2.

Standard penetration testing was carried out within this deposit; the results are shown on the Record of Borelog sheets. This testing gave 'N' values which range from 10 to 72 blows/ft., being typically of the order of 15 to 25 blows/ft. Based on these results, it is estimated that the relative density of this granular deposit varies from compact to very dense, being generally in the compact range.

4.4) Cohesive Strata:

A major clay plain exists within the area extending from Grenfell Road (Site No. 12) southerly to Woodroffe Avenue (Site No. 17). The clay in this region is known to be of marine origin. A secondary clay area exists in the general area where the C.N.R. crosses Merivale Road (Sites No. 7 to 10). The cohesive deposit in this latter area is of glacial origin. The characteristics of these depositionally different deposits will be discussed separately below.

4.4.1) Clay to Silty Clay (Sensitive) -
(Grenfell Rd. Southerly to Woodroffe Ave.):

The overall thickness of the grey marine clay in this area varies from 12 to 23 feet. The upper 4 to 11.5 feet of the stratum is mottled grey-brown in colour, which is an indication that this zone has been subjected to desiccation. Occasional silt partings are present throughout the stratum.

4. SUBSOIL AND BEDROCK CONDITIONS: (cont'd.) ...

4.4) Cohesive Strata: (cont'd.) ...

4.4.1) Clay to Silty Clay (Sensitive) -

(Grenfell Rd. Southerly to Woodroffe Ave.): -
(cont'd.) ...

In addition, clayey silt seams, up to 1/4 inch thick, are present at random locations.

The engineering properties of the cohesive subsoil are summarized in the following table:

<u>Identity Tests</u>		<u>Upper Desiccated Zone</u>	<u>Lower Zone</u>
		<u>Range</u> <u>(Average)</u>	<u>Range</u> <u>(Average)</u>
Bulk Density (p.c.f.)	(γ)	120 and 123 - 2 Tests	104 - 119 (110)
Liquid Limit (%)	(W_L)	39 - 46 (41)	38 - 85 (72)
Plastic Limit (%)	(W_P)	25 - 29 (27)	22 - 34 (30)
Natural Moisture Content (%)	(W)	34 - 45 (40)	52 - 67 (60)
Liquidity Index	(I_L)	0.5 - 0.9 (0.7)	0.5 - 0.9 (0.8)

Compressibility Characteristics

Void Ratio	(e_o)	-	Tests (1.1 - 1.7
Compression Index	(C_c)	-	(0.8 - 1.4
Degree of Preconsolidation ($P_c - P_o'$) (p.s.f.)		-	5 (2000 - 3,400

Undrained Shear Strength (C_u)
(p.s.f.)

In Situ Field Vane Tests	>2,000	700 - 1,300
Laboratory Tests	1,800 - >2,000	650 - 1,100

Standard Penetration Resistance ('N')

(Blows/ft.) 7 - 19 -

4. SUBSOIL AND BEDROCK CONDITIONS: (cont'd.) ...

4.4) Cohesive Strata: (cont'd.) ...

4.4.1) Clay to Silty Clay (Sensitive) -

(Grenfell Rd. Southerly to Woodroffe Ave.): -
(cont'd.) ...

The Atterberg limit test results, given in the table, are also summarized on the Plasticity Chart, Figure No. 3. The testing indicates the clay is inorganic. In the upper desiccated zone the plasticity is in the intermediate range; in the lower zone, however, it varies from intermediate to high. The natural moisture content, in both zones, is generally at about the liquid limit as indicated by the liquidity indices recorded (average 0.7 to 0.8).

The field and laboratory undrained shear strength results are plotted on the Record of Borelog sheets. The results indicate that the consistency of the upper desiccated zone is typically very stiff, while the lower zone is in the firm to stiff range.

The consolidation characteristics of this cohesive stratum were determined by carrying out a series of laboratory consolidation tests, the results of which are shown as Void Ratio vs. Pressure plots on Figures No. 4 and 5. The testing indicates that the lower zone is preconsolidated by anywhere from 2,000 to 3,400 p.s.f. in excess of the existing overburden pressure. The upper desiccated zone is, however, preconsolidated to a degree in excess of this range. The values for the Initial Void Ratio (e_0) and Compression Index (C_c) are typical for results obtained on this sensitive marine clay deposit.

The cohesive deposit, in this area only, is generally underlain by a loose to compact ('N' values between 4 to 13 blows/ft.) grey silt, whose thickness ranges from 7 to 15 feet. Numerous clayey silt layers, up to 3 inches thick, are present throughout this deposit. Grain-size distribution testing, carried out on samples from the silt, are plotted on Figure No. 6.

4. SUBSOIL AND BEDROCK CONDITIONS: (cont'd.) ...

4.4) Cohesive Strata: (cont'd.) ...

4.4.2) Silty Clay to Clayey Silt -
(Site No. 7 Southerly to Site No. 10):

A cohesive glacial deposit composed of a grey clayey silt with a trace of sand is generally present at a shallow depth below ground surface in this area. This cohesive soil, which has a plasticity in the low range, varies from 3 to 13.5 feet in thickness, being most extensive on the north side of the C.N.R. (refer to Site No. 8 - B.H. #1). Occasional sand seams, up to 3 inches in thickness, are present throughout this deposit. Two grain-size distribution curves, obtained on samples from this subsoil, are plotted on Figure No. 7.

The field and laboratory undrained shear strength results are plotted on the Record of Borelog sheets. The testing gave values for the undrained shear strength which range from 800 to 1,100 p.s.f. Based on these results, it is estimated that the consistency of the deposit ranges from firm to stiff.

One consolidation test was carried out on a sample from this deposit obtained at Site No. 8 - B.H. No. 1 (refer to Figure No. 4). This test indicated that the deposit was only slightly (400 p.s.f.) preconsolidated in excess of the existing overburden pressure. The Compression Index (C_c), however, was 0.28, which is low in comparison with the indices recorded in the area occupied by the marine clay. This is further indication that this particular deposit is not of marine origin.

4.5) Silty Sand with some Gravel to Gravelly Sand -
(Lower Deposit):

The clayey silt stratum at Site No. 8 is underlain by a granular deposit composed of a compact to very dense ('N' values 12 to 69 blows/ft.) brown gravelly sand grading with depth into a sand with some gravel. The thickness of this isolated deposit is

4. SUBSOIL AND BEDROCK CONDITIONS: (cont'd.) ...

4.5) Silty Sand with some Gravel to Gravelly Sand -
(Lower Deposit): (cont'd.) ...

about 55 feet thick. The lower zone of this subsoil is bouldery (below elevation 219); the boulders encountered were up to 7 inches in size. Grain-size distribution curves for samples of the deposit are plotted on Figure No. 8.

4.6) Glacial Till:

The overburden deposits, discussed in the previous sections, are generally underlain by a glacial till. From Viewmount Drive (Site No. 6) northerly, as well as in the extreme southern portion of the area under investigation (Site No. 18), the glacial till protrudes within a few feet of ground surface. The thickness of the till sheet, where encountered, varies from 2 feet (Site No. 2) to in excess of 35 feet (Sites No. 17 and 18); this would indicate that it is most extensive in the southern region. The composition of the till varies markedly. In the northern and central areas it is primarily composed of a clayey silt (of low plasticity) binding sand and gravel - i.e., it is cohesive in nature. In the vicinity of Sites 7 to 10, as well as in the southern area, however, the till is granular, having a matrix of silt and sand binding gravel. The lower portion of the glacial till is often bouldery; the bouldery zone ranges anywhere from 1 foot to up to 30 feet in those areas where the till is most extensive. Grain-size distribution testing was carried out on samples obtained from the two distinct zones within the till, using 2-inch O.D. sampling equipment. The gradational variations between the two are shown in envelope form on Figure No. 9.

Standard penetration testing was carried out within this deposit. This testing gave 'N' values which varied as follows:

Cohesive Zones	--	11 to 85 blows/ft.
Granular Zones	--	11 to 65 blows/ft.

4. SUBSOIL AND BEDROCK CONDITIONS: (cont'd.) ...

4.6) Glacial Till: (cont'd.) ...

Based on this testing, it is estimated that the consistency of the cohesive zones within the till range from stiff to hard, while the relative density of the granular zones varies from compact to very dense. It should be noted that the lower values were obtained in the upper portion of the deposit. It is inferred that these lower values were probably due to 'reworking' of the material in this area.

4.7) Bedrock:

Bedrock was proven at sixteen of the boring locations by obtaining between 8.5 and 13.5 feet of either AXT or BX size rock core samples. The surface of the bedrock was found to be very irregular in this area, varying from elevation 210 at Site No. 8 to 318 at Site No. 2. The variability of the bedrock topography may be due to the fact that this area has been intersected by faults and other minor breaks (refer to the discussion in Section No. 2). The most likely zone of faulting in this area would be in the vicinity of the intersection of the C.N.R. and Merivale Road, here the bedrock slope is quite steep (refer to Drawing No. W.O. 71-11045A).

The bedrock, in the northern portion of the area, is a grey dolomite and shaly dolomite of the Trenton formation, Ordovician Period. In the southern portion it is composed of a dolomite to sandy dolomite of the Beekmantown formation of the same period. In this latter formation, occasional gypsum seams and interbeds, up to 1/2 inch thick, are present. In general, the upper 2 to 4 feet of the bedrock is in a fractured and jointed condition, below this upper zone the rock is sound as evidenced by the high percentage of core recovery.

5. GROUNDWATER CONDITIONS:

Groundwater level observations have been carried out during the period of the investigation, by recording the water level

5. GROUNDWATER CONDITIONS: (cont'd.) ...

in the open borings. The observations are recorded on the borelog sheets and summarized on Drawing No. W.O. 71-11045A. The results of the measurements indicate that the groundwater level, within the overburden deposits, varies from 1 to 13 ft. below existing ground surface, being generally between 3 and 6 feet below ground surface. These depths correspond to groundwater levels which vary from elevation 253.5 (Site No. 1) to elevation 318.5 (Site No. 2).

An artesian water pressure head was encountered in the upper fractured zone of the bedrock at Site No. 14, put down in the vicinity of a tributary of Black Rapids Creek. Once this zone of the bedrock was penetrated, water rose instantaneously in the casing. The artesian head stabilized itself once it reached elevation 298.5, which is a head of about 7 feet above the existing ground level in the area. It is inferred that this fractured zone of the bedrock is acting as a confined aquifer; this zone is probably being charged with groundwater from the surrounding terrain, which is at a higher elevation.

6. DISCUSSION AND RECOMMENDATIONS:

6.1) General:

An alignment for the most northerly portion of Hwy. #416, extending from the proposed Ottawa Queensway intersection (east of Maitland Avenue) southerly to the Jock River, has been proposed. The purpose of this report is to provide preliminary information relating to the foundation engineering aspects associated with this particular area.

The proposed highway will incorporate 2 lanes in either direction, which will be separated by a wide median.

The subsoil, bedrock and groundwater conditions, encountered in the area under investigation, have been discussed previously in this report in Sections No. 4 and 5. An inferred stratigraphical profile, along the proposed alignment, is shown on Drawing No. W.O. 71-11045A.

6. DISCUSSION AND RECOMMENDATIONS: (cont'd.) ...

6.1) General: (cont'd.) ...

The following will be discussed in Sub-section 6.2) of this report:

- i) Highway and roadway structure crossings of Hwy. #416 (e.g., the Ottawa Queensway, Merivale Road and Woodroffe Avenue) - (a total of eleven in all);
- ii) C.N. Railway overhead structure crossings - (two);
- and
- iii) Creek crossings - (two).

These crossings are shown in plan on Drawing No. W.O. 71-11045A.

A minor westerly revision of the alignment is also being considered; this possible revision would extend from Slack Road southerly to Fallowfield Road. It is understood that, if this revision is adopted, then the following would be the case:

- a) Grenfell Rd. (Site No. 12) would be carried beneath Hwy. #416 in a cut approximately 20 feet deep - (Overpass structure);

and

- b) Hwy. #416 would be carried beneath the C.N.R. at Site No. 14 - (Subway structure). In this case, a cut approximately 20 feet deep would be required.

The revision will be discussed in Sub-section 6.3).

At this stage, the profile grades at the crossings, as well as other pertinent data, have not been finalized. A preliminary profile (unnumbered) has, however, been provided by the Functional Planning Section - (Eastern Region) for the proposed alignment.

6. DISCUSSION AND RECOMMENDATIONS: (cont'd.) ...

6.1) General: (cont'd.) ...

Preliminary design data, recommendations pertaining to foundation design of the various structures, as well as the stability and settlement considerations for the approach fills, will be presented in tabular form in the sub-sections previously mentioned.

6. DISCUSSION AND RECOMMENDATIONS: (cont'd.) ...

6.2) HWY. #416 CROSSINGS
- PROPOSED ALIGNMENT

<u>Site No.</u>	<u>Crossing</u>	<u>Type</u>	<u>Page No.</u>
1	Ottawa Queensway	- Overpass Structures (Twin)	17
2	Base Line Road	- Underpass Structure	18
3	Merivale Road	- Underpass Structure	19
5	Meadowlands Drive	- Underpass Structure	20
6	Viewmount Drive	- Underpass Structure	21
7	Proposed Western Parkway	- Overpass Structures (Twin)	22
8	C.N.R.	- Overhead Structures (Twin)	23
9	Merivale Road	- Overpass Structures (Twin)	24
10	Creek	- Culvert, Fill	25
11	Slack Road	- Underpass Structure	26
13	C.N.R.	- Overhead Structures (Twin)	27
15	Black Rapids Creek	- Culvert, Fill	28
16	Fallowfield Road	- Underpass Structure	29
17	Woodroffe Avenue	- Underpass Structure	30
18	County Road No. 13	- Underpass Structure	31

FOUNDATION RECOMMENDATIONS - SITE # 1
Overpass Structures (Twin) - Hwy. #416 and O.Q.W.

Approx. Existing Ground Elev. (Approx. Grade of Hwy. #416)	Predominant Overburden Strata Approx. Thickness (Ft.)	R E C O M M E N D A T I O N S		Remarks
		<u>Structure(s)</u>	<u>Approaches</u>	
			Fill Heights - 30' to 32' (Estimated)	
255 + Hwy. #416 grade not established (yet)	Glacial Till - Cohesive - Very Stiff to Hard (9.5') Underlain by Dolomite Bedrock.	<u>Piers:</u> Spread footings founded at or below elev. 250, within the glacial till stratum. Allowable bearing pressure up to 2.5 t.s.f. <u>Abutments:</u> 'Perched' on spread footings in the approach fills, within a zone composed of well compacted granular material, using an allowable bearing value of 2.0 t.s.f. Alternatively, end-bearing piles driven to bedrock. - Estimated tip elev. 246. - designed for the max. allowable capacity for the pile section chosen. <u>Note:</u> Differential settlements between the abutments and adjacent piers will not exceed 1/2".	<u>Stability:</u> Fills up to 32' (with 2:1 slopes) will be stable. (F.S. \geq 1.3) <u>Probable Elastic</u> <u>Settlements:</u> 32' Fill (2:1 Slopes) - 1" (Max.)	-

FOUNDATION RECOMMENDATIONS - SITE #2

Underpass Structure - Hwy. #416 and Base Line Road

Approx. Existing Ground Elev. (Approx. Grade of Hwy. #416)	Predominant Overburden Strata Approx. Thickness (Ft.)	R E C O M M E N D A T I O N S		Remarks
		Structure(s)	Approaches	
			Fill Heights - 20' to 21' (Estimated)	
325 + (Not established at this time)	Silty Sand to Sandy Silt (<u>Fill</u>) (Loose to Compact) - (6') Glacial Till - Cohesive (Very Stiff) - (1.5') Underlain by Shaly Limestone Bedrock.	<u>Piers:</u> Spread footings founded on or within the bedrock - (at or below elev. 317.5). Allowable bearing pressure up to 20.0 t.s.f. <u>Abutments:</u> 'Perched' on spread footings, in the approach fills, within a zone composed of well compacted granular material, using an allowable bearing value of 2.0 t.s.f. Alternatively, end-bearing piles driven to bedrock. - Estimated pile tip elev. 317.5. - designed for the max. allowable capacity of the pile section chosen. <u>Note:</u> Differential settlements between the abutments and piers will not exceed 1/2".	<u>Stability:</u> Fills up to 21' (with 2:1 slopes) will be stable. (F.S. \geq 1.3) <u>Probable Elastic</u> <u>Settlement:</u> 21' fill (2:1 slopes) - 1" (Max.)	-

FOUNDATION RECOMMENDATIONS - SITE #3

Underpass Structure - Hwy. #416 and Merivale Road

Approx. Existing Ground Elev. (Approx. Grade of Hwy. #416)	Predominant Overburden Strata Approx. Thickness (Ft.)	R E C O M M E N D A T I O N S		Remarks
		Structure(s)	Approaches	
313.5 + Not established at this time)	Sand (Fill) (Loose to Compact) Glacial Till - Cohesive (Hard) (22') (Lower 11' bouldery - boulders up to 10" in size) Underlain by Shaly Limestone Bedrock.	<u>Piers:</u> Spread footings founded at or below elev. 308, within the cohesive glacial till stratum. Allowable bearing value up to 5.0 t.s.f. <u>Abutments:</u> 'Perched' on spread footings in the approach fills, with- in a zone composed of well compacted granular material, using an allowable bearing value of 2.0 t.s.f. Alternatively, end-bearing piles driven to practical refusal within the lower bouldery zone of the glacial till. - Estimated pile tip elev. 292. - designed for the max. capacity of the pile section chosen. <u>Note:</u> Differential settlements between the abutments and adjacent piers will not exceed 1/2".	<u>Stability:</u> Fills up to 21' (with 2:1 slopes) will be stable. (F.S. \geq 1.3) <u>Probable Elastic</u> <u>Settlement:</u> 21' Fill (2:1 Slopes) - 1" (Max.)	-

FOUNDATION RECOMMENDATIONS - SITE # 5

Underpass Structure - Hwy. #416 and Meadowlands Drive

Approx. Existing Ground Elev. (Approx. Grade of Hwy. #416)	Predominant Overburden Strata Approx. Thickness (Ft.)	R E C O M M E N D A T I O N S		Remarks
		<u>Structure(s)</u>	<u>Approaches</u>	
311 + - (Not established at this time)	Glacial Till - Cohesive (Very Stiff to Hard) (15.0') Underlain by Shaly Dolomite Bedrock	<u>Piers:</u> Spread footings founded at or below elev. 303, within the cohesive glacial till stratum. Allowable bearing pressure up to 5.0 t.s.f. <u>Abutments:</u> 'Perched' on spread footings in the approach fills, within a zone composed of well com- pacted granular material, using an allowable bearing value of 2.0 t.s.f. - Alternatively, end-bearing piles driven to bedrock. - Estimated pile tip elev. 295. - designed for the max. allowable capacity for the pile section chosen. <u>Note:</u> Differential settlements between the abutments and adjacent piers will not exceed 3/4 inch.	<u>Stability:</u> Fills up to 21' (with 2:1 slopes) will be stable. (F.S. \geq 1.3) <u>Probable Elastic</u> <u>Settlement</u> 21' Fill (2:1 slopes) - 1" (Max.)	-

cont'd. ... 21

FOUNDATION RECOMMENDATIONS - SITE # 6

Underpass Structure - Hwy. #416 and Viewmount Drive

Approx. Existing Ground Elev. (Approx. Grade of Hwy. #416)	Predominant Overburden Strata Approx. Thickness (Ft.)	R E C O M M E N D A T I O N S		Remarks
		<u>Structure(s)</u>	<u>Approaches</u> Height of Approaches - - Longitudinal - 22' - Transverse - 25'	
233.5 + (292)	Silty Sand (<u>Fill</u>) - (Compact) (4.5') Glacial Till (Cohesive) (Hard) (10.5') (Bouldery below elev. 280 - boulders up to 8" in size) Underlain by Shaly Dolomite Bedrock.	<u>Piers:</u> Spread footings founded at or below elev. 284, within the cohesive glacial till stratum. Allowable bearing pressure up to 4.5 t.s.f. <u>Abutments:</u> 'Perched' on spread footings in the approach fills, with- in a zone composed of well compacted granular material, using an allowable bearing value of 2.0 t.s.f. Alternatively, end-bearing piles driven to bedrock. - Estimated tip elev. 273.5 - - designed for the max. allowable capacity for the pile section chosen. <u>Note:</u> Differential settlements between the abutments and adjacent piers will not exceed 1/2".	<u>Stability:</u> Fills up to 25' (with 2:1 Slopes) will be stable. (F.S. \geq 1.3) <u>Probable Elastic</u> <u>Settlement:</u> Fills up to 25' (with 2:1 Slopes) - 1/2" to 1"	-

FOUNDATION RECOMMENDATIONS - SITE # 7

Overpass Structures (Twin) - Hwy. #416 and Proposed Western Parkway

Approx. Existing Ground Elev. (Approx. Grade of Hwy. #416)	Predominant Overburden Strata Approx. Thickness (Ft.)	R E C O M M E N D A T I O N S		Remarks
		<u>Structure(s)</u>	<u>Approaches</u> Fill Heights - Transverse Direction: - North Approach - 31')Max. - South Approach - 36')	
281 + (313 to 315)	Clayey Silt (Stiff) (4') Sandy Silt to Silty Sand (Compact to Very Dense) (26') Glacial Till - Granular (Dense to Very Dense) (16') - Bouldery Zone below elev. 243. Boulders up to 6" in size. Underlain by Dolomite Bedrock	<u>Piers:</u> Spread footings founded at or below elev. 276, within the granular stratum, using an allowable bearing value of 2.0 t.s.f. Alternatively, end-bearing piles driven to bedrock, as discussed below. <u>Abutments:</u> 'Perched' in the approach fills and supported on end- bearing piles driven to bedrock. - Estimated pile tip elev. 235 - designed for the max. allowable capacity for the pile section chosen. <u>Note:</u> Differential settlements between the pile-supported abutments and spread footing supported piers should not exceed 1/2".	<u>Stability:</u> Fills up to 36' (with 2:1 slopes) will be stable. (F.S. \geq 1.3) <u>Probable Elastic</u> <u>Settlements:</u> 36' Fill (2:1 slopes) - 1 to 1-1/2" (Max.)	-

FOUNDATION RECOMMENDATIONS - SITE # 8

Overhead Structures (Twin) - Hwy. #416 and C.N.R.

Approx. Existing Ground Elev. (Approx. Grade of Hwy. #416)	Predominant Overburden Strata Approx. Thickness (Ft.)	R E C O M M E N D A T I O N S		Remarks
		<u>Structure(s)</u>	<u>Approaches</u> Heights of Fill - 40' (Max.)	
230 to 234 (320 ±)	<ul style="list-style-type: none"> - Sandy Silt to Silty Sand (Compact) (5.5') - Clayey Silt (Firm to Stiff) (North side of tracks - 13.5' South side of tracks - 5') - Gravelly Sand to Sand with some Gravel (Compact to Very Dense) (55.5') (Bouldery zone below elev. 219 - boulders up to 7" in size). Underlain by Dolomite to Sandy Dolomite Bedrock. 	<p><u>Piers and Abutments:</u> Supported on end-bearing piles driven to practical refusal, within the lower bouldery zone of the glacial till.</p> <ul style="list-style-type: none"> - Estimated pile tip elev. 212 to 215. - Designed for the max. capacity of the pile section chosen at the pier locations. <p><u>Note:</u> Capacity of piles supporting the abutments may have to be reduced in order to allow for negative skin frictional effects. - Refer to "Remarks" column.</p> <p>Alternatively, found the structure elements on Franki or caisson type foundations, the base of which could be formed in the lower granular stratum. Allowable capacity will be based on the size of the installations, which will be determined in the design stage.</p>	<p><u>Stability:</u></p> <ul style="list-style-type: none"> - <u>South Approach</u> - 40' fills (with 2:1 slopes) will be stable. (F.S. ≥ 1.3) - <u>North Approach</u> - <ul style="list-style-type: none"> i) 30' fill (with 2:1 slopes) will be stable. (F.S. ≥ 1.3) ii) 40' fill - mid-height berm 25' long required to ensure stability. (F.S. ≥ 1.3) <p>All slopes 2:1.</p> <p><u>Probable Consolidation Settlement:</u></p> <ul style="list-style-type: none"> - <u>South Approach</u> - <ul style="list-style-type: none"> 1" to 1-1/2" - 12 months. 2" to 3" - 5 years (Max.) - <u>North Approach</u> - <ul style="list-style-type: none"> 40' fill - 25' long mid-height berms - (with 2:1 slopes) 4" to 5" - 18 months 8" to 10" - 10 years (Max.) 	<p>Consideration should be given to constructing the approach fills prior to construction of the structure foundations, in order to:</p> <ul style="list-style-type: none"> i) minimize post-construction settlements; and ii) to minimize the negative skin frictional effects on the piles supporting the abutments.

FOUNDATION RECOMMENDATIONS - SITE # 9
Overpass Structures (Twin) - Hwy. #416 and Merivale Road

Approx. Existing Ground Elev. (Approx. Grade of Hwy. #416)	Predominant Overburden Strata Approx. Thickness (Ft.)	R E C O M M E N D A T I O N S		Remarks
		<u>Structure(s)</u>	<u>Approaches</u> Height of Fills - 20' to 22'	
289 + - (310 + -)	- Sand (<u>Fill</u>) (Loose) (3') - Sand (Compact to Very Dense) (25') Glacial Till - Granular (Very Dense) (5') Underlain by Dolomite Bedrock	<u>Piers:</u> Spread footings located at or below elev. 285 within the granular stratum. Allowable bearing value up to 3.0 t.s.f. <u>Abutments:</u> 'Perched' within the approach fills, within a zone of well compacted granular material, using an allowable bearing value of 2.0 t.s.f. Alternatively, end-bearing piles driven to bedrock. - Estimated pile tip elev. 256 - designed for the max. capacity for the pile section chosen. <u>Note:</u> Differential settlements between the abutments and adjacent piers will not exceed 1/2".	<u>Stability:</u> 22' high fills (with 2:1 slopes) will be stable. (F.S. \geq 1.3) <u>Probable Elastic</u> <u>Settlements:</u> 1" (Max.)	-

FOUNDATION RECOMMENDATIONS - SITE #10

HWY. #416 CROSSING OF CREEK

Predominant Overburden strata - Approx. Thickness (Ft.)	Approx. Height of Fill Proposed (2:1 Slopes)	Stability and Settlement Considerations	R e m a r k s
<p>Clayey Silt (Stiff) (4.5')</p> <p>Silty Sand (Compact) (9.5')</p> <p>Glacial Till - Granular (Very Dense) (12')</p> <p>(Bouldery below Elev. 266 - Boulders up to 6" in size)</p> <p>Underlain by Dolomite Bedrock</p>	<p>8' to 10'</p>	<p>1) No stability problems anticipated.</p> <p><u>Probable Settlement:</u> 1/2" (Max.)</p>	<p>C.S.P. culvert could be placed beneath the fill in order to allow the creek to flow through this area.</p>

FOUNDATION RECOMMENDATIONS - SITE # 11

Underpass Structure - Hwy. #416 and Slack Road

Approx. Existing Ground Elev. (Approx. Grade of Hwy. #416)	Predominant Overburden Strata Approx. Thickness (Ft.)	R E C O M M E N D A T I O N S		Remarks
		<u>Structure(s)</u>	<u>Approaches</u> Height of Fills - 19' to 20'	
311 + (312 -)	Silty Sand to Sandy Silt (Compact to Very Dense) (41') (Bouldery zone below elev. 273 - boulders up to 8" in size) Underlain by Dolomite Bedrock	<u>Piers:</u> Spread footings founded at or below elev. 308, within the granular stratum. Allowable bearing pressure 2.5 t.s.f. <u>Abutments:</u> 'Perched' on spread footings in the approach fills, within a zone composed of well compacted granular material, using an allowable bearing value of 2.0 t.s.f. Alternatively, end-bearing piles driven to bedrock. - Estimated tip elev. 269 - Designed for the maximum capacity of the pile section chosen. <u>Note:</u> Differential settlements between the piers and abutments should not exceed 1/2".	<u>Stability:</u> 20' high fills (with 2:1 slopes) will be stable (F.S. = 1.3) <u>Probable Elastic</u> <u>Settlement:</u> 20' Fill (2:1 slopes) - 1" (Max.)	

FOUNDATION RECOMMENDATIONS - SITE #13

Overhead Structures (Twin) - Hwy. #416 and C.N.R.

Approx. Existing Ground Elev. Approx. Grade of Hwy. #416)	Predominant Overburden Strata Approx. Thickness (Ft.)	R E C O M M E N D A T I O N S		Remarks
		<u>Structure(s)</u>	<u>Approaches</u> Height of Fills - 29' to 30'	
298 ± (327 ±)	Clay (Sensitive) (Firm to Very Stiff) (23') (Upper 11' Desic- cated) Silt - (Loose) (15') Glacial Till Cohesive (Hard) (2') Underlain by Dolomite Bedrock	<u>Piers and Abutments:</u> - Supported on End-bearing piles driven to bedrock - Estimated tip elev. 257 - Designed for the max. capacity of the pile section chosen at the pier locations. <u>Note:</u> Capacity of piles supporting the abutments may have to be reduced in order to allow for negative skin frictional effects - refer to "Remarks" column.	<u>Stability:</u> Fills up to 30' (with 2:1 slopes) will be stable. (F.S. ≥ 1.3) <u>Probable Consolidation</u> <u>Settlements:</u> 30' fill (with 2:1 slopes) 4" to 5" in 3 to 4 years 8" to 10" in 20 years - (Max.)	Consideration should be given to constructing the approach fills prior to construction of the structure foundations, in order to: i) minimize post-construction settlements; and ii) to minimize the negative skin frictional effects on the piles supporting the abutments.

FOUNDATION RECOMMENDATIONS - SITE #15

HWY. #416 CROSSING OF BLACK RAPIDS CREEK

Predominant Overburden Strata - Approx. Thickness (Ft.)	Approx. Height of Fill Proposed (2:1 Slopes)	Stability and Settlement Considerations	R e m a r k s
<p>Clay (Sensitive) (Firm to Very Stiff) (20')</p> <p>(Upper 9' Desiccated)</p> <p>Silt - (Loose) (13')</p> <p>Glacial Till - Granular (Compact) (7.5')</p> <p>Underlain by Dolomite Bedrock</p>	<p>35' to 38'</p>	<p><u>Stability:</u></p> <p>Fills up to 38' (with 2:1 slopes) will be stable.</p> <p align="center">(F.S. \geq 1.3)</p> <p><u>Probable Consolidation Settlements:</u></p> <p>2" to 3" - 2 years</p> <p>5" to 7" - 15 years (Max.)</p>	<p>A multi-plate pipe arch culvert could be used at this location.</p> <p>No major construction problems are anticipated.</p> <p>- The culvert should be provided with a 6" camber in order to allow for the differential settlement expected along its length.</p>

FOUNDATION RECOMMENDATIONS - SITE #16

Underpass Structure - Hwy. #416 and Fellowfield Road

Approx. Existing Ground Elev. (Approx. Grade of Hwy. #416)	Predominant Overburden Strata Approx. Thickness (Ft.)	R E C O M M E N D A T I O N S		Remarks
		<u>Structure(s)</u>	<u>Approaches</u> Height of Fills - Longitudinal - 19' Transverse - 21'	
300 ± (302 ±)	<ul style="list-style-type: none"> - Silty Sand (<u>Fill</u>) (Compact) (5.5') - Clay (Sensitive) (Firm to Very Stiff) (12') (Upper 5' desiccated) - Silt - (Loose) (7') Glacial Till Granular (Compact) (9') Underlain by Dolomite Bedrock 	<u>Piers and Abutments:</u> Supported on end-bearing piles driven to bedrock. - Estimated tip elev. 267. - Designed for the max. capacity of the pile section chosen.	<u>Stability:</u> Fills up to 21' (with 2:1 slopes) will be stable. (F.S. \geq 1.3) <u>Probable Consolidation Settlement:</u> 21' Fill (with 2:1 slopes) 1" to 2" - 2 years 3" to 4" - 10 years (Max.)	-

cont'd. ... 30

FOUNDATION RECOMMENDATIONS - SITE # 17

Underpass Structure - Hwy. #416 and Woodroffe Avenue

Approx. Existing Ground Elev. (Approx. Grade of Hwy. #416)	Predominant Overburden Strata Approx. Thickness (Ft.)	R E C O M M E N D A T I O N S		Remarks
		<u>Structure(s)</u>	<u>Approaches</u> Height of Fills - 21' to 22'	
303 + - (304 +)	- Sand (Fill) (Compact) (2') - Clay (Sensitive) (Firm to Stiff) (17') (Upper 6.5' Dislocated) - Glacial Till (Granular) (Dense to Very Dense) (35'±) (Bouldery through- out - boulders up to 18" in size)	<u>Piers and Abutments:</u> Supported on end-bearing piles driven to practical refusal within the bouldery glacial till stratum. - Estimated tip elev. 260 to 265. - Designed for the max. capacity of the pile section chosen.	<u>Stability:</u> Fills up to 22' (with 2:1 slopes) will be stable. (F.S. ≥ 1.3) <u>Probable Consolidation Settlement:</u> 22' Fill (with 2:1 slopes) 1" to 1½" - 3 years 2" to 3" - 15 years (Max.)	

cont'd. ... 31

FOUNDATION RECOMMENDATIONS - SITE #18

Underpass Structure - Hwy. #416 and County Road #13

Approx. Existing Ground Elev. Approx. Grade of Hwy. #416)	Predominant Overburden Strata Approx. Thickness (Ft.)	R E C O M M E N D A T I O N S		Remarks
		<u>Structure(s)</u>	<u>Approaches</u> Fill Heights - 22' (Max.)	
325 + (325 +)	Silty Sand (Fill) (Compact) (3.5') Glacial Till Granular (Very Dense) (32' ±) (Bouldery zone below elev. 306 - boulders up to 10" in size)	<u>Piers:</u> Spread footings founded at or below elev. 321, within the glacial till deposit. Allowable bearing pressure up to 5.0 t.s.f. <u>Abutments:</u> 'Perched' on spread footings in the approach fills, within a zone composed of well compacted material, using an allowable bearing value of 2.0 t.s.f. - Alternatively, end-bearing piles driven to practical refusal in the lower bouldery zone of the glacial till - Estimated tip elev. 300. - Designed for the max. allowable capacity for the pile section chosen.	<u>Stability:</u> 22' high fills - (with 2:1 slopes) will be stable. (F.S. ≥ 1.3) <u>Probable Elastic</u> <u>Settlement:</u> 22' Fills (2:1 slopes) negligible.	-

6. DISCUSSION AND RECOMMENDATIONS: (cont'd.) ...

6.3) HWY. #416 CROSSINGS

- POSSIBLE REVISION

(Slack Road Southerly to Fallowfield Road)

<u>Site No.</u>	<u>Crossing</u>	<u>Type</u>	<u>Page No.</u>
12	Grenfell Road	- Overpass Structure (Twin)	33
14	C.N.R. & Black Rapids Creek	- Subway Structure (Twin)	34

FOUNDATION RECOMMENDATIONS - SITE # 12

Overpass Structures (Twin) - Hwy. #416 and Grenfell Road

Approx. Existing Ground Elev. (Approx. Grade of Hwy. #416)	Predominant Overburden Strata Approx. Thickness (Ft.)	R E C O M M E N D A T I O N S		Remarks
		<u>Structure(s)</u>	<u>Cut</u> Along Grenfell Road ≈ 20' (Max.) (in clay)	
302 ± (302 ±)	<ul style="list-style-type: none"> - Clay (Sensitive) (Firm to Stiff) (25') (Upper 13' Desiccated) - Silt (Loose to compact) (8') - Glacial Till Cohesive (Very Stiff) (6') <p>Underlain by Dolomite Bedrock.</p>	<p><u>Piers and Abutments:</u></p> <p>Founded on end-bearing piles driven to bedrock.</p> <ul style="list-style-type: none"> - Estimated tip elev. 262. - Designed for the max. capacity of the pile section chosen. 	<p><u>Stability:</u></p> <p>20' cut - extending into sensitive clay stratum.</p> <ul style="list-style-type: none"> - The slopes should be cut and maintained at 3:1. - The clay slopes should be protected against surficial erosion and seepage forces by: <ul style="list-style-type: none"> i) blanketing the slopes with a 12" thick layer of Granular 'A' material. This blanket then should be sodded; and ii) provide drainage measures, including interceptor ditches and buried, properly filtered drainage pipe, where necessary. iii) A permanent pumping system may be required to relieve both the surface and subsurface drainage water inflow into the cut sections. 	<ul style="list-style-type: none"> - A dewatering scheme will be required during construction, in order to reduce the unbalanced hydrostatic pressure head existing in the silt deposit underlying the clay stratum. Such a scheme would prevent this material from 'boiling up' into the base of the excavation. - Permanent relief wells will be required beneath the roadway, in order to depress the water level below this surface. These wells should extend into the bedrock.

FOUNDATION RECOMMENDATIONS - SITE # 14

Subway Structure - Hwy. #416 and C.N.R. (Black Rapids Creek)

Approx. Existing Ground Elev. (Approx. Grade of Hwy. #416)	Predominant Overburden Strata Approx. Thickness (Ft.)	R E C O M M E N D A T I O N S		Remarks
		Structure(s)	Cut Beneath C.N.R. \approx 20' (Max.) (Through clay into silt)	
291.5 + (271.5 +)	- Clay (Sensitive) (Firm to Stiff) (15') (Upper 6' Desiccated) - Silt (Loose) (10') - Glacial Till Cohesive (Very Stiff) (3.5') Underlain by Dolomite Bedrock <u>Note:</u> Artesian Groundwater pressure in the upper fractured zone of the bedrock. Artesian head is 7' above existing ground surface.	<u>Piers:</u> Founded on spread footings located on or within bedrock (at or below elev. 262.5). Allowable bearing pressure up to 20.0 t.s.f. <u>Abutments:</u> Supported on end-bearing piles driven to bedrock. - Estimated tip elev. 262.5 - Designed for the max. capacity of the pile section chosen.	<u>Stability:</u> 20' cut - extending into silt deposit. - the slopes should be cut and maintained at 3:1. - The composite clay-silt slopes should be protected against surficial erosion and seepage forces by: i) blanketing the slopes with a 12" thick layer of Granular 'A' material. This blanket then should be sodded; and ii) Provide drainage measures, including interceptor ditches and buried, properly filtered drainage pipe, where necessary. iii) A permanent pumping system may be required to relieve both the surface and subsurface drainage water inflow into the cut sections.	- A dewatering scheme will be required during construction, in order to reduce the unbalanced hydrostatic pressure head existing in the silt - till - bedrock seq- uence. Such a scheme would prevent 'boiling' of the base of the excavation. - Permanent relief wells will be re- quired beneath the roadway, in order to depress the water level below this surface. These wells should extend into the bedrock.

6. DISCUSSION AND RECOMMENDATIONS: (cont'd.) ...

6.3) Hwy. #416 Crossings -

- Possible Revision (Slack Road Southerly to Fallowfield Road): (cont'd.) ...

As indicated in the two previous tables, major dewatering complications will arise if the possible revision is adopted and the grade of Hwy. #416 and Grenfell Road are depressed below the existing ground level in this area. This is due to the fact that the base of the clay cuts are underlain by a granular deposit (silt) which will be subjected to a relatively large unbalanced hydrostatic head. In addition, an artesian water pressure head exists in the upper fractured zone of the bedrock at the proposed C.N.R. crossing (Site #14). Further, past experience in this area has indicated that it is difficult to: i) cut and maintain slopes, and ii) construct a pavement which will perform satisfactorily in the sensitive marine clay located in this area.

No major foundation problems are anticipated at the corresponding crossings along the proposed alignment (refer to Sites #13 and 15 in Sub-section 6.2).

Based on the aforementioned, it would appear that the revision to the proposed alignment (Subway Scheme) is impractical and uneconomical, from a foundation point of view, when compared with the proposed alignment.

It should be stressed that the recommendations, given in this report, are of a preliminary nature. A complete foundation investigation will be required at all the sites, once the alignment for this portion of Hwy. #416 has been selected and the design details become available for the various sites.

7. MISCELLANEOUS:

The field work, performed during the period of May 17 to June 2, 1971, was carried out under the supervision of Mr. B. T. Darch, Senior Foundation Engineer, who was assisted by Mr. A. E. Dyer, Student Technician (Field).

The drilling equipment was owned and operated by the F. E. Johnston Drilling Company Ltd., Ottawa.

This report was written by Mr. B. T. Darch, and reviewed by Mr. M. Devate, Supervising Foundation Engineer.

July, 1971

APPENDIX I

MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE SITE No. 1

FOUNDATION SECTION

JOB 71-11045

LOCATION

Hwy. 416 & Ottawa Queensway

ORIGINATED BY B. T. D.

W.F. 12-688-252-66

BORING DATE May 22, 1971

COMPILED BY B. T. D.

DATUM GEOMETRIC

BOREHOLE TYPE Wash Poring-Nr. 3x. Casing-3x. Rock Core

CHECKED BY

[illegible]

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE		LIQUID LIMIT ——— w_L PLASTIC LIMIT ——— w_p WATER CONTENT ——— w			BULK DENSITY γ P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		SHEAR STRENGTH P.S.F. ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB. VANE		WATER CONTENT % w_p ——— w ——— w_L 20 40 60				
325.5	Ground Level												
0.0	Silty sand to ss. silt (Fill) (Brown) loose to compact		1	ss	25	320							▼ 318.5 W.L. in open B.H. June 1971
319.5			2	ss	9								
317.8	Clsc. till V. stiff Fractured		3	ss	12								
7.7	Shaley Limestone Bedrock, Irr. Shale Seams (grey)		4	ss	94%								
307.9	Sound		5	ss	100%								
17.6	End of Borehole					310							
						300							

DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE SITE No.3

FOUNDATION SECTION

JOB 71-11045

LOCATION Hwy. 416 & Merivale Road

ORIGINATED BY B T D

W.P. 12-68 & 252-66

BORING DATE May 27, 28, and 31, 1971

COMPILED BY B.T.D.

DATUM Geodetic

BOREHOLE TYPE WashBoring-Fx, Bx, Ax Casing-Bx&AXT Rock

CHECKED BY 

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT						LIQUID LIMIT ——— w_L PLASTIC LIMIT ——— w_p WATER CONTENT ——— w				BULK DENSITY γ P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FOOT		SHEAR STRENGTH P.S.F. ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB. VANE						WATER CONTENT % 20 40 60					
313.7	Ground Level																	
0.0	Sand some silt & gravel (Fill)		1	SS	10	330										3 81 (16) ▽ 307.7		
308.2	Loose to Compact		2	SS	7													
5.5	Clayey silt with sand and gravel (Glacial Till) (Grey) Hard		3	SS	52													
			4	SS	60	300										17 38 31 11 W.L. in open BH. June 1, 71		
			5	SS	66													
			6	SS	56													
	Bouldery Zone (Boulders up to 10 in size)		7	BXTC	30%	290												
			8	BXTC	39%													
286.2			9	BARC	72%													
275	Fractured Shaley Limestone Bedrock (Grey) Sound		10	AXT-RC	51%	280												
275.6			11	AXT-RC	70%													
38.1	End of Borehole					270												

DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE SITE No.4

FOUNDATION SECTION

JOB 71-11045

LOCATION Hwy. 116 & West of Meadowlands Drive.

ORIGINATED BY B.T.D.

W.P. 12-68 & 252-66

BORING DATE May 28 and 29 1971

COMPILED BY B. T. D.

DATUM Geodetic

BOREHOLE TYPE WashPoring-Nx, Bx Casing-Bx Rock Core

CHECKED BY

[illegible]

DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE SITE No.5

FOUNDATION SECTION

JOB 71-11045 LOCATION Hwy. 416 & Meadows Drive ORIGINATED BY B.T.D.
W.P. 12-68 & 252-66 BORING DATE May 27 1971 COMPILED BY B.T.D.
DATUM Geodetic BOREHOLE TYPE Wash Boring-Bx, Bx Casing- Bx Rock Core CHECKED BY JK

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE					LIQUID LIMIT — w_L			BULK DENSITY γ P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		BLOWS / FOOT					PLASTIC LIMIT — w_p				
							SHEAR STRENGTH P.S.F.					WATER CONTENT — w				
310.8	Ground Level															
0.0	Topsoil		1	ss	11	310										
1.0	Clayey silt with some sa. & gra. (Glac. till) (mottled brown to gray) V. stiff to hard.		2	ss	11											
			3	ss	12											
			4	ss	85											
295.8	-----Boulders-----					300										
15.0	-----Fractured-----		5	BXRC	90%											
	Shaley Dolomite Bedrock numerous shaley seams (GREY)		6	BXRC	97%	290										
284.7	Sound		7	BXRC	93%											
26.1	End of Borehole					280										

34 42 16
304.8

W.L. in open BH.
May 28/71

DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE SITE No.6

FOUNDATION SECTION

JOB 71-11065

LOCATION Hwy. 416 & Viewmount Drive

ORIGINATED BY A.E.D.

W.P. 12-68 & 252-66

BORING DATE May 17 and 18 1971

COMPILED BY B. D. T.

DATUM ~~Coodet: 10~~

BOREHOLE TYPE WashPoring 2x 2x Casing-2x & AXT

CHECKED BY

[illegible]

DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE SITE No.7

FOUNDATION SECTION

JOB 71-11045

LOCATION Hwy. 416 & Creek

ORIGINATED BY A.E.D.

W.P. 12-68 & 252-66

BORING DATE May 20 and 21 1971

COMPILED BY B.T.D.

DATUM Geodetic

BOREHOLE TYPE Washboring- Nx Casing-Bx-Rock Core

CHECKED BY *[Signature]*

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE						LIQUID LIMIT ——— w_L PLASTIC LIMIT ——— w_p WATER CONTENT ——— w			BULK DENSITY γ P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		SHEAR STRENGTH P.S.F.						WATER CONTENT %				
							○ UNCONFINED ● QUICK TRIAXIAL			+ FIELD VANE x LAB. VANE			w_p ——— w ——— w_L				
							400	800	1,200	1,600	2,000						
281.0	Ground Level																
0.0	Topsoil		1	ss	11	280											
1.1	Clayey Silt Trace of Sa. Silt		2	TV	PM												
276.9	Sandy Silt to Silty Sand, trace of Gra. (Brown to grey) Compact		3	ss	21												
4.1			4	ss	18												
			5	ss	23	270											
			6	ss	18												
	Silty Sand with Gravel (Grey) Dense to V. Dense		7	ss	32	260											
			8	ss	48/10"												
251.0																	
30.0	Heterogeneous Mixture of Silt, Sa. & Gra. (Glacial Till) Boulders up to 6" in size below elev. 243) (Grey) Dense to V. Dense		9	ss	41	250											
			10	ss	153												
			11	BXRC	10%	240											
			12	ss	44												
235.2			13	ss	100%												
45.8	Fractured Dolomite Bedrock irregular shale interbeds (Grey) Sound		14	BXRC	94%	230											
226.0			15	BXRC	94%	220											
55.0	End of Borehole.																

DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No.1 SITE No.8 FOUNDATION SECTION

JOB 71-11045 LOCATION Hwy. 416 & C.N.R. ORIGINATED BY A.E.D.
 W.P. 12-68& 252- 66 BORING DATE May 24, 26, 27, 28, & 29 1971 COMPILED BY B.T.D.
 DATUM Geodetic BOREHOLE TYPE Washboring-1x 3x Ax Casing - Art Rock Core CHECKED BY [Signature]

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE						LIQUID LIMIT ——— w_L PLASTIC LIMIT ——— w_p WATER CONTENT ——— w			BULK DENSITY γ P.C.F.	REMARKS	
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		SHEAR STRENGTH P.S.F.						WATER CONTENT %					
							O UNCONFINED			+ FIELD VANE			● QUICK TRIAXIAL					x LAB. VANE
						400	800	1,200	1,600	2,000	20			40	60			
284.5	Ground Level		1	ss	12	280										116	GR. SA. SL. CL.	
279.0	Sandy Topsoil		2	ss	12													
1.5	Sandy Silt to Silt		3	TP	PM													
5.5	Clayey Silt		4	TP	PM	270										124	Open BH May 29/71	
	Trace of sand		5	TP	PM													
	Grey		6	ss	24													
265.3	Firm to Stiff		7	ss	36	260										14 58 (20)	33 62 (5)	
19.2	Gravelly sand trace of silt Grey		8	ss	31													
	compact to dense		9	ss	45													
	Sand, trace to some silt and gravel		10	SS	12	250										9 84 (3)		
	Grey		11	SS	64													
			12	SS	69													
	Compact to Very Dense		13	SS	61	240										8 89 (3)		
			14	SS	45													
			15	SS	50													
			16	SS	69	230										7 71 (22)		
			17	WS														
			18	AXRT	22%													
210.0	Bouldery Zone Boulders up to 7" in size		19	AXTRC	66%	210												
74.5	Fractured Dolomite to sandy dolomite bedrock, irr. sandstone		20	AXTRC	100%													
201.4	incl. s., Grey, Sound		21	AXRTC	100%													
83.1	End of Borehole					200												

DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No.2 SITE No.8 FOUNDATION SECTION

JOB 71-11045 LOCATION Hwy. 116 & C.N.R.

ORIGINATED BY B.T.D.

W.P. 12-68-252-66 BORING DATE May 31, 1971

COMPILED BY B. T. D.

DATUM Geodetic BOREHOLE TYPE WashBoring-Nx Casing

CHECKED BY

[illegible]

DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE SITE No.9

FOUNDATION SECTION

JOB W.O. 71-11045

LOCATION Hwy. 416 & Marivale Road

ORIGINATED BY A.E.D.

W.P. 12-68 & 252-66

BORING DATE May 17 and 18 1971

COMPILED BY B.D.T.

DATUM Goodale

BOREHOLE TYPE Washboring - Drilling - Rock Core

CHECKED BY

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE						LIQUID LIMIT — w_L PLASTIC LIMIT — w_p WATER CONTENT — w			BULK DENSITY γ P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		SHEAR STRENGTH P.S.F.						WATER CONTENT %				
							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB. VANE						w_p — w — w_L 20 40 60				
289.0	Ground Level																
286.1	Fill Loose		1	ss	5	280											
3.0	Sand with some silt and occasional gravel sizes		2	ss	72												
	Brown to Grey		3	ss	43												
	Compact to V. Dense		4	ss	18												
			5	ss	19	270											
261.1			6	ss	30	260											
28.0	Het. Mixt. of si. sa. & gra. (Glacial Till) Very dense.		7	ss	65												
32.9	Fractured		8	BXRC	87%												
247.1	Dolomite Bedrock Grey Sound		9	BXRC	97%	250											
42.0	End of Borehole																

3.83 (14)
Open B.H.
May 19,
1971

8.89 (3)

15.64 (21)

DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE SITE No.11

FOUNDATION SECTION

JOB 71-11045 LOCATION Hwy. 416 & Slack Road ORIGINATED BY A.E.D.
W.P. 12-68 & 252-66 BORING DATE May 18 & 19 1971 COMPILED BY K.W.
DATUM Geodetic BOREHOLE TYPE Wash Boring- Hx & Bx Casing Bx Rock Core CHECKED BY [Signature]

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT						LIQUID LIMIT ——— w_L PLASTIC LIMIT ——— w_p WATER CONTENT ——— w			BULK DENSITY γ P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		SHEAR STRENGTH P.S.F.						w_p ——— w ——— w_L WATER CONTENT % 20 40 60				
310.8	Ground Level																
0.0	Silty fine sand to sandy silt (brown to grey)		1	SS	14	310											
			2	ss	15												
			3	SS	21												
			4	SS	10	300											
			5	ss	37												
			6	ss	18	290											
	Compact to Dense		7	ss	35												
			8	ss	12	280											
			9	ss	22												
269.6	Boulders up to 8" in size		10	BXTC	—	270											
41.2	Fractured Dolomite Bedrock (Grey) Sound		11	HYRC	100												
			12	HYRC	100												
			13	"	100												
260.0			14	"	100	260											
50.8	End of Borehole																

54 (40)
302.4

W.L. in open B.H. May 20, 1971.

0 43 (57)

0 31 (69)

FOUNDATION SECTION

ORIGINATED BY A. E. D.

COMPILED BY K.W.

CHECKED BY

[illegible]

MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE SITE No.13

FOUNDATION SECTION

JOB 71-11045

LOCATION Hwy. 116 & C.N.R.

ORIGINATED BY B.T.D.

W.P. 12-68 252-66

BORING DATE May 21, 26, & 27 1971

COMPILED BY K.W.

DATUM Geodetic

BOREHOLE TYPE WashBoring- NX Casing - Bx Rocky Core

CHECKED BY 

[illegible]

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT	LIQUID LIMIT ——— w _L PLASTIC LIMIT ——— w _p WATER CONTENT ——— w			BULK DENSITY P.C.F.	REMARKS Art. Head GR.SA.SI.CL.
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		SHEAR STRENGTH P.S.F. ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB. VANE 400 800 1200 1600 2000	w _p ——— w ——— w _L WATER CONTENT % 20 40 60				
291.1	Ground Level											▽298.5
0.0	Clayey Silt Topsoil		1	ss	6	290						▼289.4
2.0	Desiccated Zone Very Stiff		2	ss	2							WL.inopen
	Clay to silty clay Trace of sand. Sensitive Grey.		3	TW	FR	280	xS 14	+S 5.5				B.H. May 28/71
276.1	Firm to stiff.		4	TW	PM		+S 5	+S 3				
15.0	Silt trace of clay and sand (occasional clayey silt layers up to 3 inches thick Grey loose)		5	ss	4	270	+S 3					
266.1			6	ss	II							0 1 90 9
25.0	Het. mix. of si & gra. (Glacial till) Very stiff.		7	BXR	100%							47 37 (16
262.7	Fractured Dolomite Bedrock irregular Clayey shaley seams grey Sound		8	RC	100%	260						▽ Art head encounter elev.261
251.6			9	BXR	100%							
39.8	End of Borehole					250						

FOUNDATION SECTION

ORIGINATED BY B.T.D.
COMPILED BY K.W.
CHECKED BY [Signature]

[illegible]

DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE SITE No. 17

FOUNDATION SECTION

JOB 71-11045

LOCATION Hwy. 416 & Woodroffe Avenue

ORIGINATED BY B.T.D.

W.P. 12-68 & 252-66

BORING DATE May 18, 19 & 20, 1971

COMPILED BY K.W.

DATUM Geodetic

BOREHOLE TYPE Washboring NX, BX Casing

CHECKED BY

BX Rock Core

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE					LIQUID LIMIT ——— W _L PLASTIC LIMIT ——— W _P WATER CONTENT ——— W			BULK DENSITY γ P.C.F.	REMARKS	
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		BLOWS / FOOT					SHEAR STRENGTH P.S.F.					WATER CONTENT %
							20	40	60	80	100	○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB. VANE					
							400	800	1200	1600	2000	20 40 60					
302.1	Ground Level														GR. SA. SI. CL.		
302.1	Sa. with some gra. Compact, Fill.	X													El. 301		
2.0	Desiccated crust.		1	SS	7	300											
	Mottled grey and brown.		2	TW	PM										W.L. in open B.H.		
	Clay to silty clay														May 20/71		
	Trace of sand. (Sensitive), (occ. layers of clayey si. up to 2" thick below el. 287)		3	TW	PM	290								109			
283.1	Firm to stiff.		4	TW	PM												
19.0	Heterogeneous mixture of silt, sand and gravel. Trace of clay. Glacial Till. (Boulders up to 18" in size throughout) Grey Dense to very dense.		5	SS	34	280											
			6	BX RC	59% Rec												
			7	BX RC	53% Rec												
			8	BX RC	21% Rec	270											
			9	SS	36												
			10	SS	128										42 51 (7)		
			11	SS	140	260											
			12	BX RC	61% Rec												
			13	SS	173										57 37 (6)		
			14	BX RC	58% Rec	250											
248.3			15	SS	9076"												
53.8	End of Borehole.					240											

DEPARTMENT OF HIGHWAYS- ONTARIO

MATERIALS & TESTING OFFICE

JOB 71-11045

LOCATION

Hwy. 416 & Regional Road No. 13

ORIGINATED BY

B.T.D.


W.P. 12-68 & 252-66











BORING DATE May 18, 19 1971

COMPILED BY K.W.

DATUM Geodetic

BOREHOLE TYPE Washboring Nx&BX Casing Bx Rock Core

CHECKED BY 

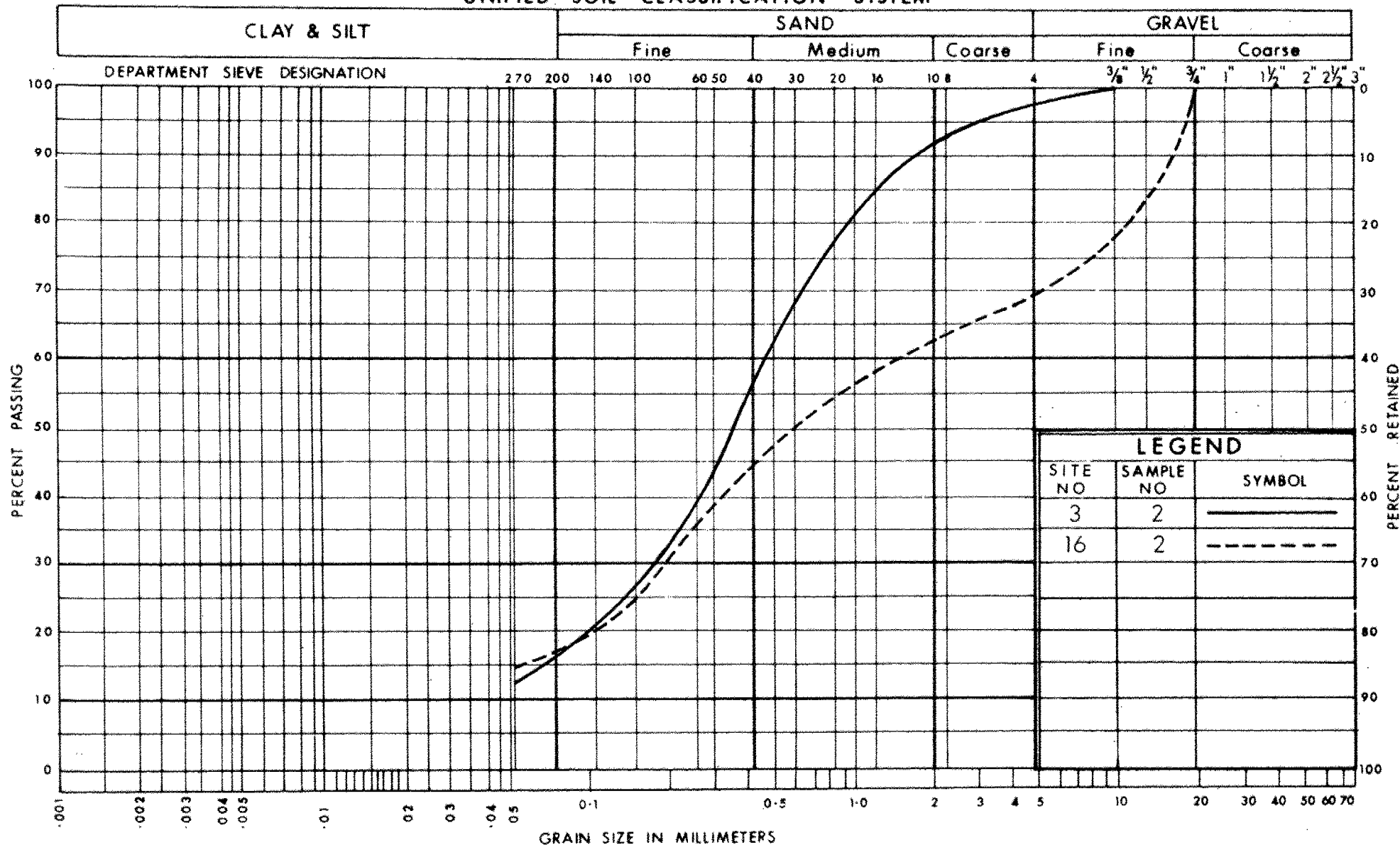
SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE				LIQUID LIMIT — w_L PLASTIC LIMIT — w_p WATER CONTENT — w			BULK DENSITY γ P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		SHEAR STRENGTH P.S.F.				WATER CONTENT %				
							<div>○ UNCONFINED</div> <div>● QUICK TRIAXIAL</div>	<div>+ FIELD VANE</div> <div>x LAB. VANE</div>							
325.0	Ground Level														
321.5	Silty Sand with some Grav. Fill Compact.		1	ss	17										8 45 30 7
317.5	Heterogeneous Mix of Silt Sand & Gr. Trace of clay (Glac. till) sand seems up to 1" thick Through boulders up to 10" in size below elevation 306 Brown to Grey		2	ss	90/11	320									
			3	ss	55										
			4	ss	73/9	310									
			5	BXRC	52%										
			6	BXRC	75%										
			7	BXRC	52%										
			8	"	59%										
			9	ss	110										
289.7			10	ss	130	290									
35.3	End of Bore hole					280									

18 41 30 1

312

WL in open BH May 20/7

UNIFIED SOIL CLASSIFICATION SYSTEM



DEPARTMENT OF HIGHWAYS
MATERIALS and
TESTING
DIVISION

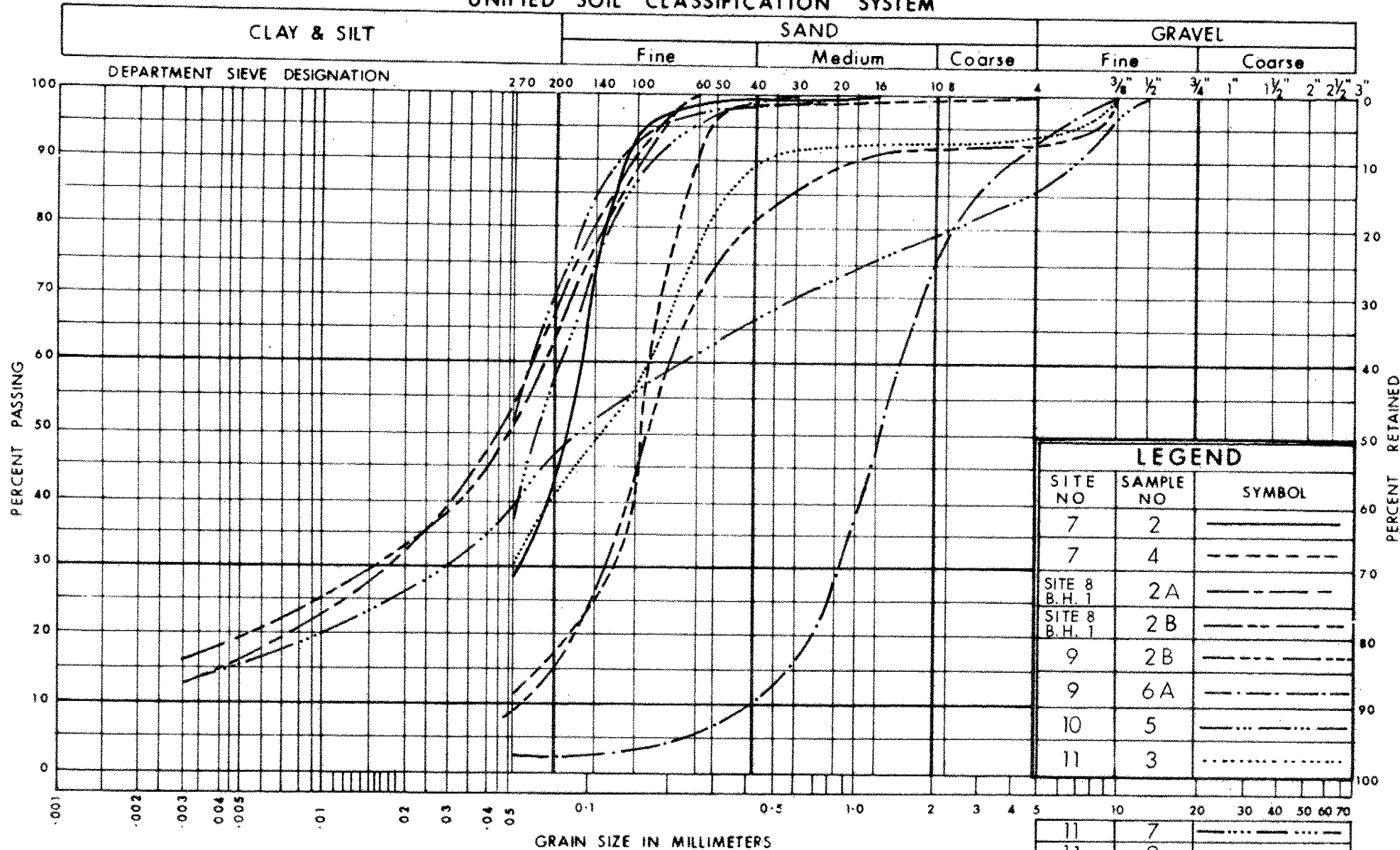
GRAIN SIZE DISTRIBUTION
FILL
(SAND TO SILTY SAND WITH GRAVEL)

W.P. No. 12-68 & 252-66

JOB No: 71-11045

FIG. 1

UNIFIED SOIL CLASSIFICATION SYSTEM



DEPARTMENT OF HIGHWAYS
MATERIALS and
TESTING
DIVISION

GRAIN SIZE DISTRIBUTION

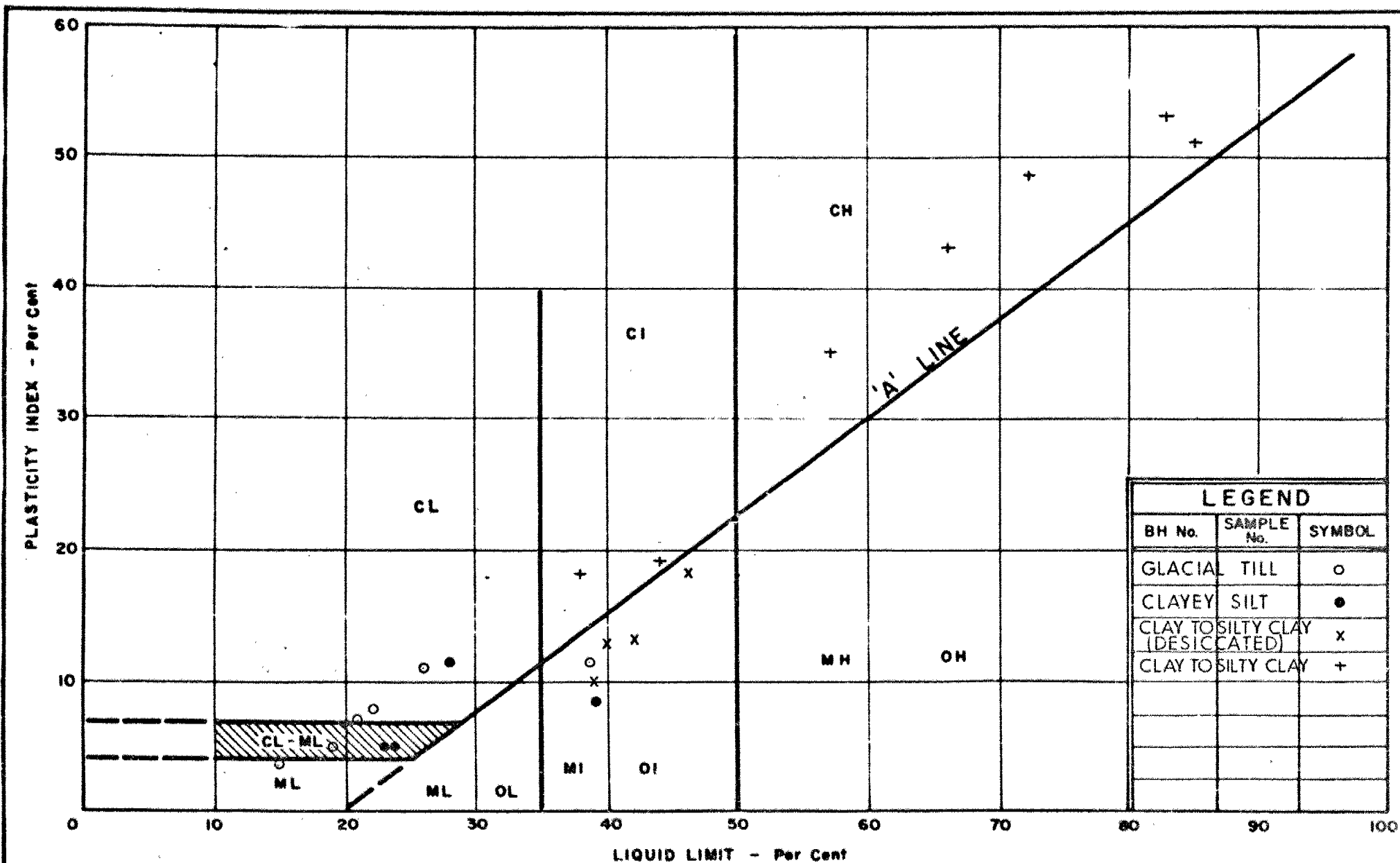
SILTY SAND TO SANDY SILT

OCC. GRAVEL SIZES (UPPER DEPOSIT)

W.P. No. 12-68 & 252-66

JOB No: 71-11045

FIG. 2



DEPARTMENT OF HIGHWAYS
MATERIALS and
TESTING
DIVISION

PLASTICITY CHART

WP. No. 12 - 68 & 252 - 66

JOB No. 71 - 11045

FIG. 3

VOID RATIO-PRESSURE CURVES

JOB NO. 71 - 11045

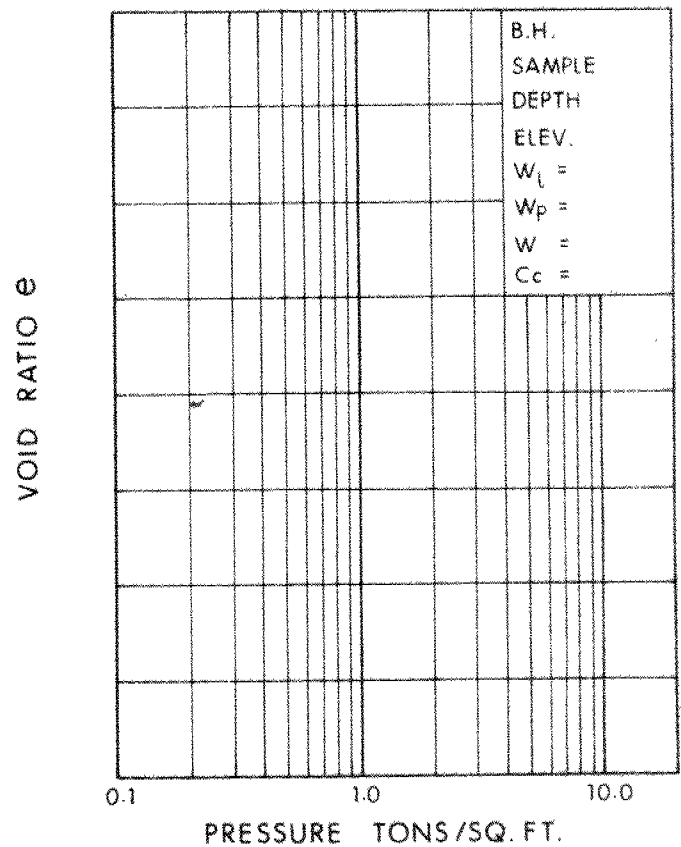
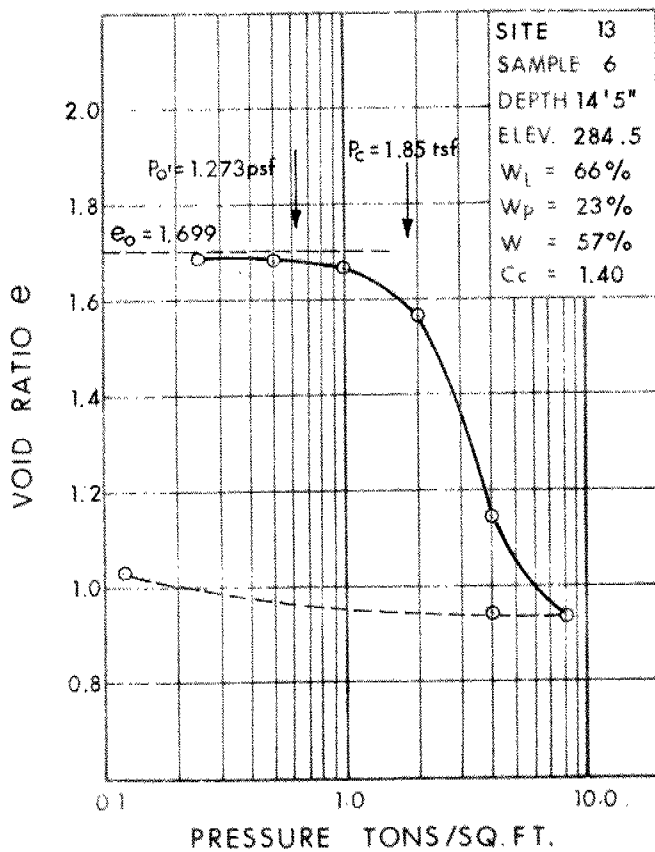
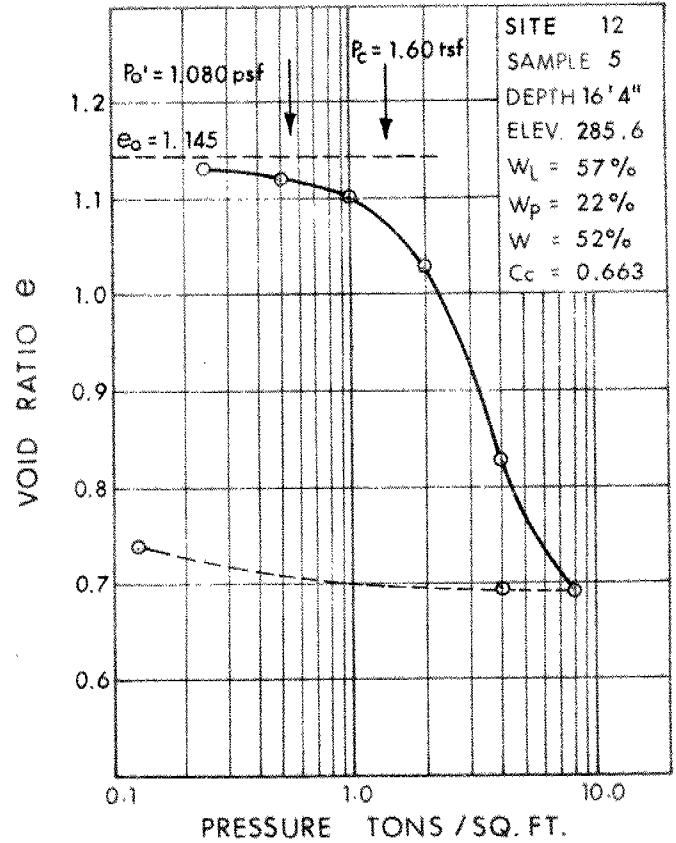
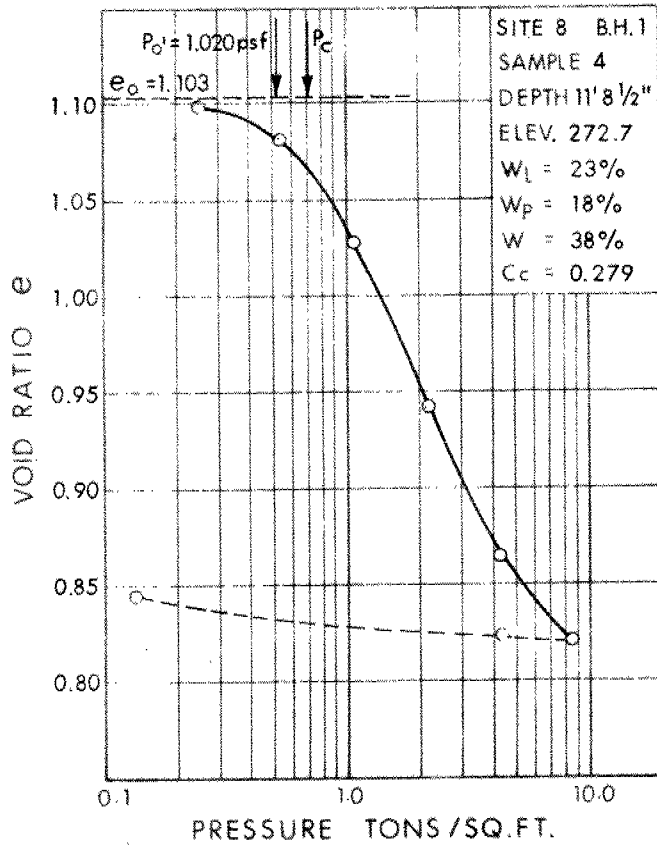


FIG. 4

VOID RATIO - PRESSURE CURVES

JOB NO. 71 - 11045

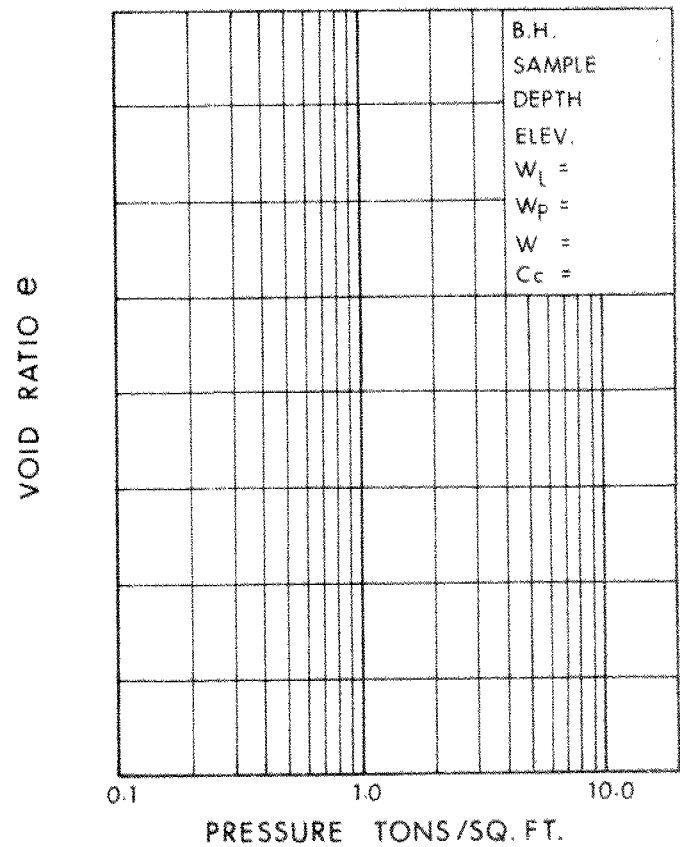
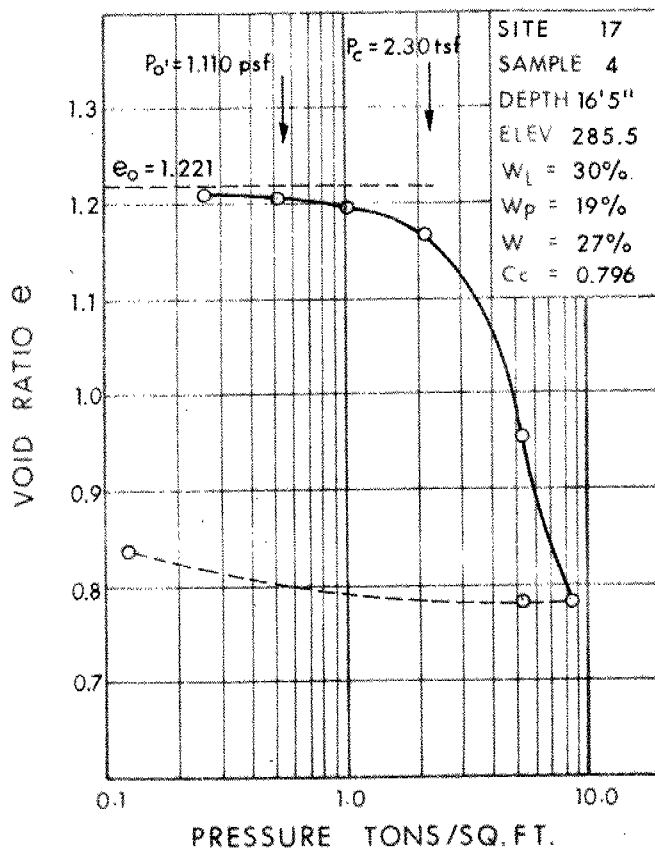
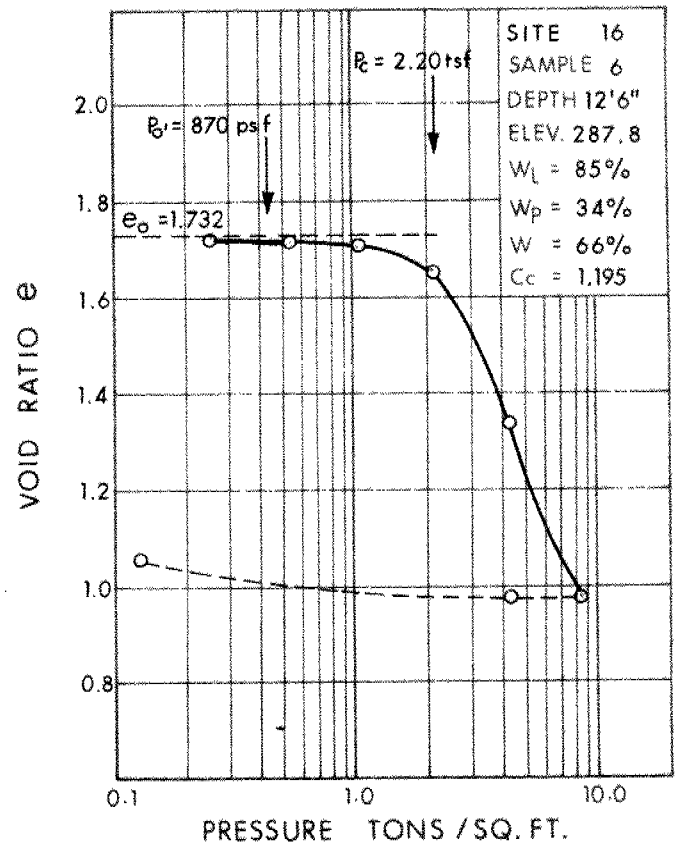
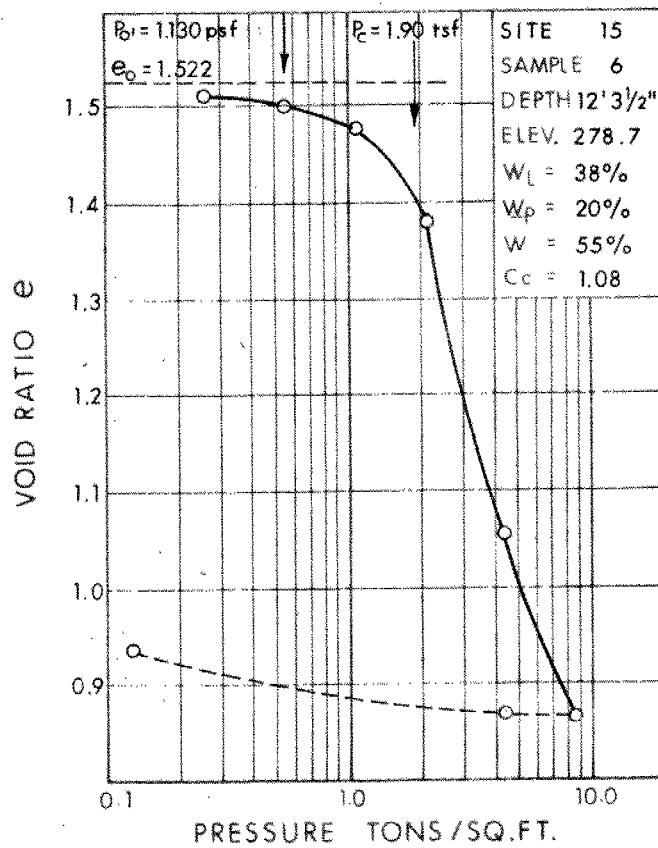
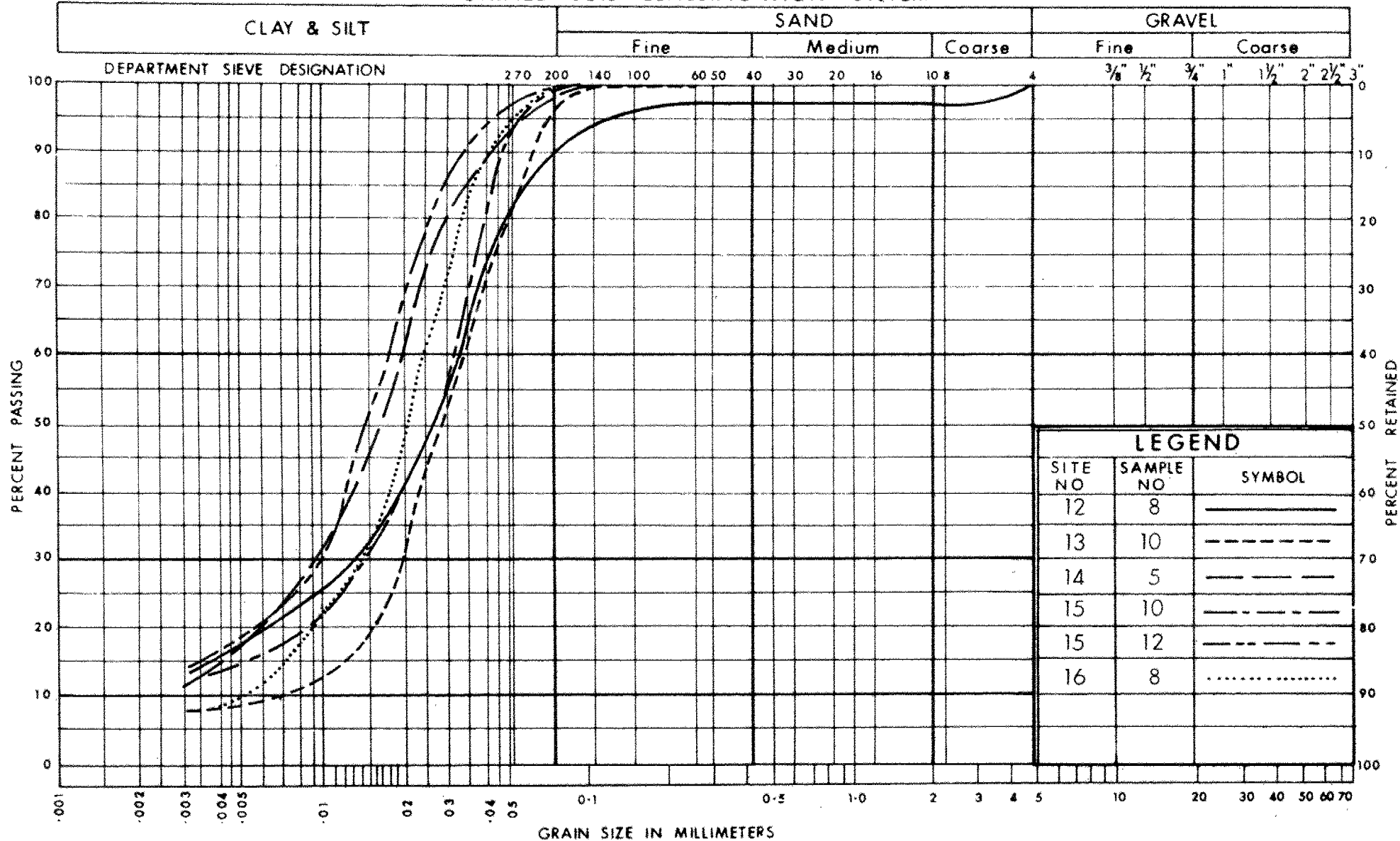


FIG. 5

UNIFIED SOIL CLASSIFICATION SYSTEM



DEPARTMENT OF HIGHWAYS
MATERIALS and
TESTING
DIVISION

GRAIN SIZE DISTRIBUTION

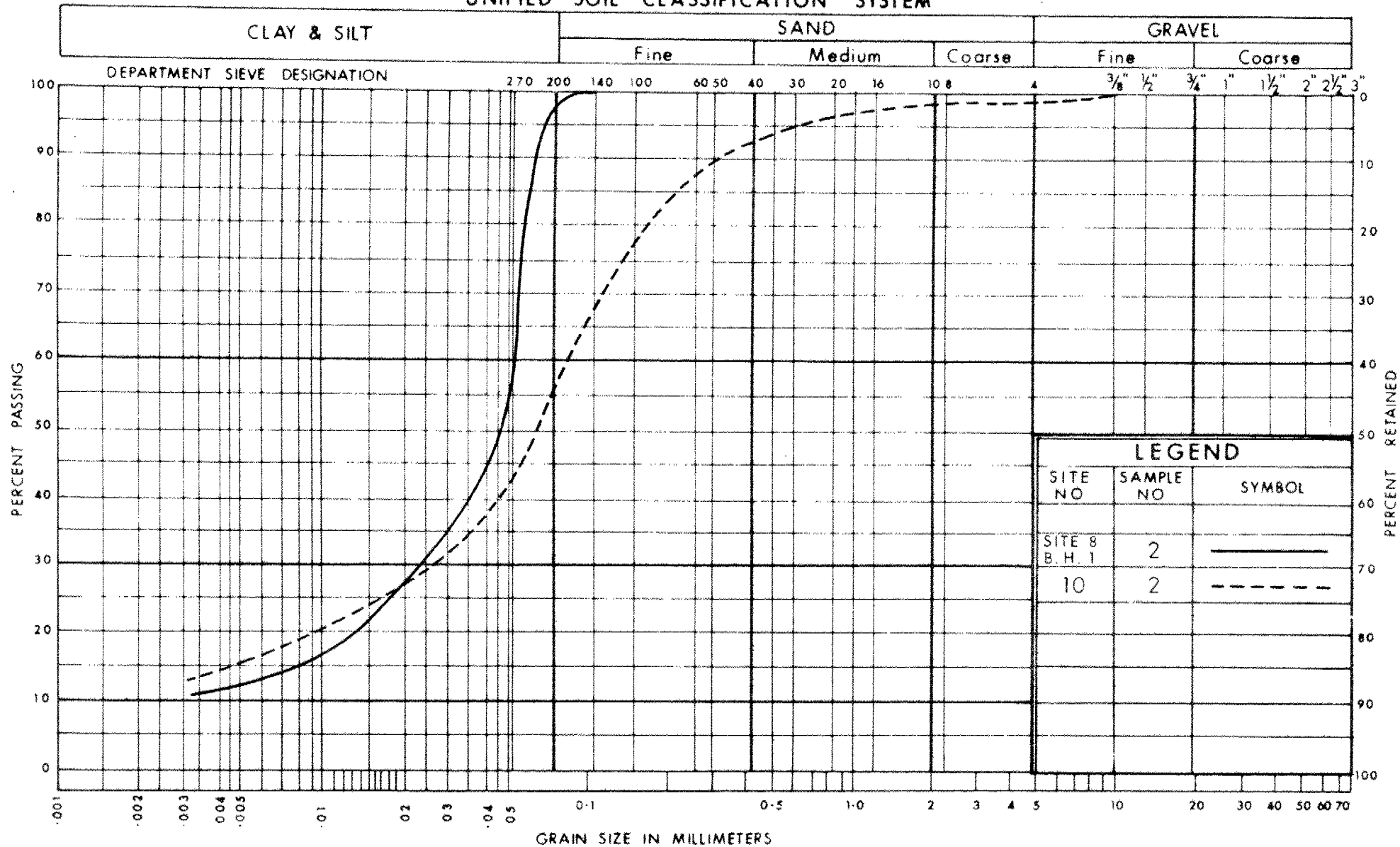
SILT

W.P. No. 12 - 68 & 252 - 66

JOB No: 71 - 11045

FIG. 6

UNIFIED SOIL CLASSIFICATION SYSTEM



DEPARTMENT OF HIGHWAYS
**MATERIALS and
TESTING
DIVISION**

GRAIN SIZE DISTRIBUTION

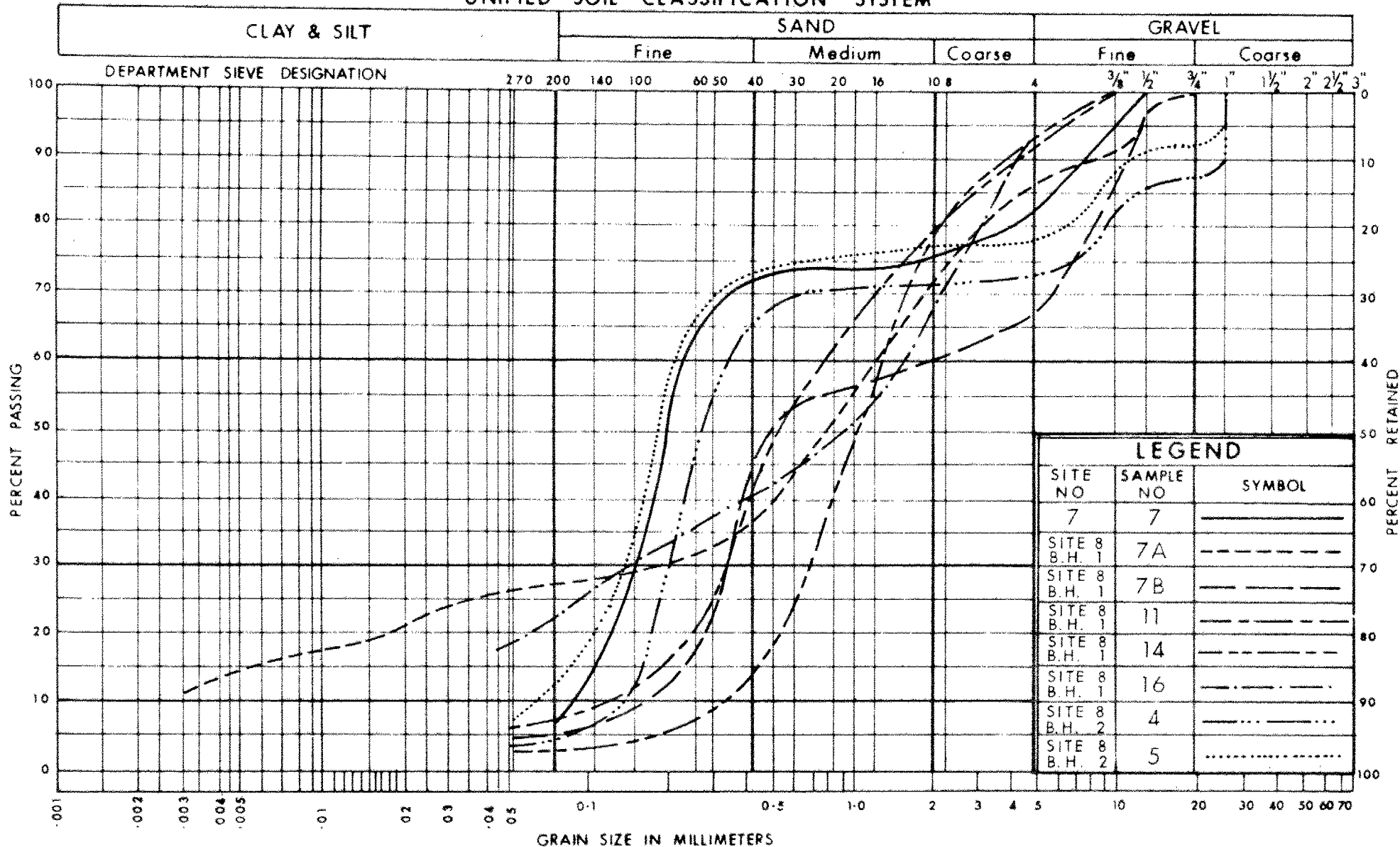
CLAYEY SILT

W.P. No. 12-68 & 252-66

JOB No. 71-11045

FIG. 7

UNIFIED SOIL CLASSIFICATION SYSTEM



DEPARTMENT OF HIGHWAYS
MATERIALS and
TESTING
DIVISION

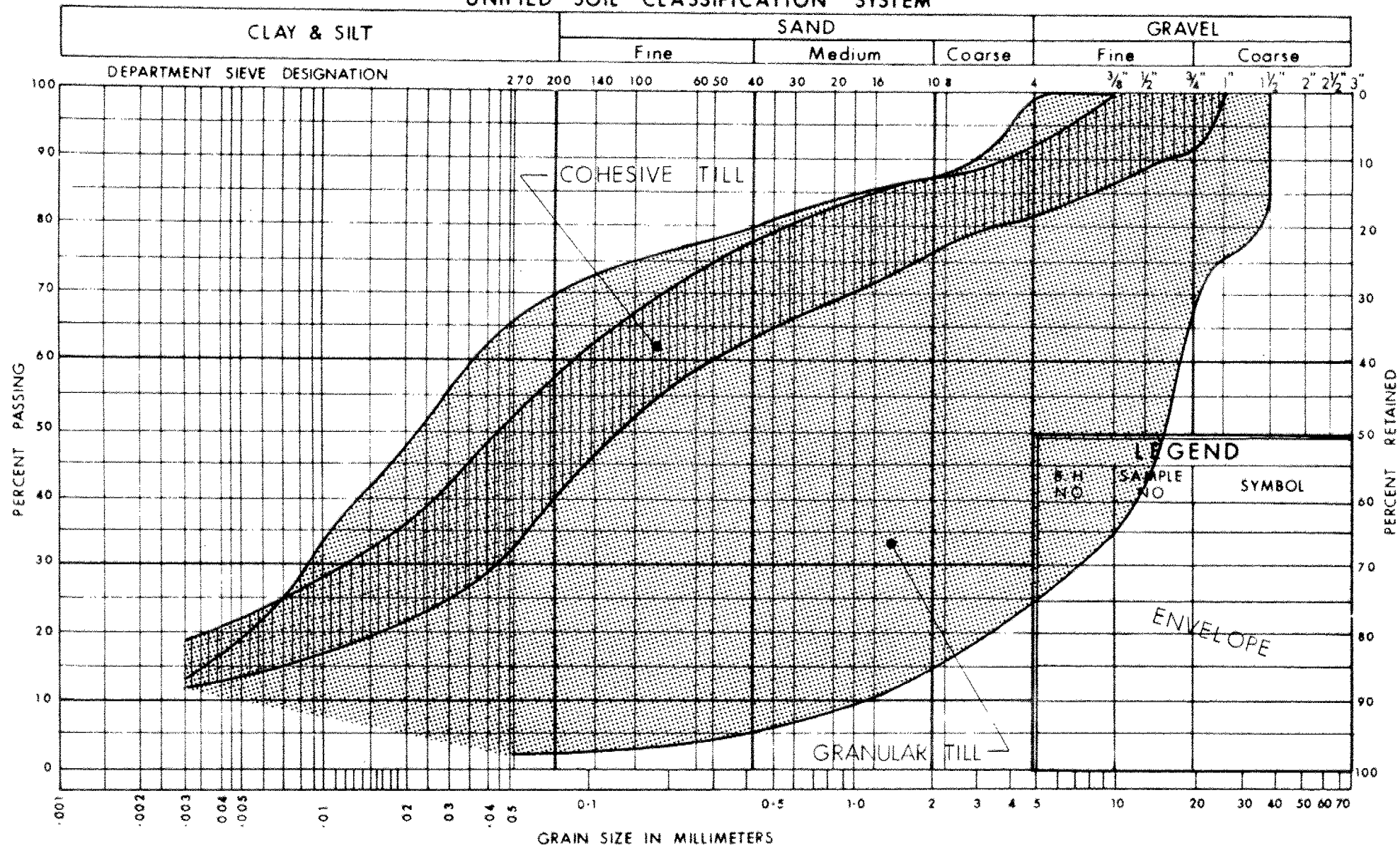
GRAIN SIZE DISTRIBUTION
SILTY SAND
WITH SOME GRAVEL TO GRAVELLY SAND (LOWER DEPOSIT)

W.P. No. 12-68 & 252-66

JOB No: 71-11045

FIG. 8

UNIFIED SOIL CLASSIFICATION SYSTEM



DEPARTMENT OF HIGHWAYS
MATERIALS and
TESTING
DIVISION

GRAIN SIZE DISTRIBUTION GLACIAL TILL

W.P. No. 12-68 & 252-66

JOB No. 71-11045

FIG. 9

ABBREVIATIONS USED IN THIS REPORT

PENETRATION RESISTANCE

STANDARD PENETRATION RESISTANCE 'N' - THE NUMBER OF BLOWS REQUIRED TO ADVANCE A STANDARD SPLIT SPOON SAMPLER 12 INCHES INTO THE SUBSOIL, DRIVEN BY MEANS OF A 140 POUND HAMMER FALLING FREELY A DISTANCE OF 30 INCHES.

DYNAMIC PENETRATION RESISTANCE - THE NUMBER OF BLOWS REQUIRED TO ADVANCE A 2 INCH, 60 DEGREE CONE, FITTED TO THE END OF DRILL RODS, 12 INCHES INTO THE SUBSOIL, THE DRIVING ENERGY BEING 350 FOOT POUNDS PER BLOW.

DESCRIPTION OF SOIL

THE CONSISTENCY OF COHESIVE SOILS AND THE RELATIVE DENSITY OR DENSENESS OF COHESIONLESS SOILS ARE DESCRIBED IN THE FOLLOWING TERMS:-

<u>CONSISTENCY</u>	<u>'N' BLOWS / FT.</u>	<u>c LB. / SQ. FT.</u>	<u>DENSENESS</u>	<u>'N' BLOWS / FT.</u>
VERY SOFT	0 - 2	0 - 250	VERY LOOSE	0 - 4
SOFT	2 - 4	250 - 500	LOOSE	4 - 10
FIRM	4 - 8	500 - 1000	COMPACT	10 - 30
STIFF	8 - 15	1000 - 2000	DENSE	30 - 50
VERY STIFF	15 - 30	2000 - 4000	VERY DENSE	> 50
HARD	> 30	> 4000		

TYPE OF SAMPLE

S.S.	SPLIT SPOON	T.W.	THINWALL OPEN
W.S.	WASHED SAMPLE	T.P.	THINWALL PISTON
S.B.	SCRAPER BUCKET SAMPLE	O.S.	OESTERBERG SAMPLE
A.S.	AUGER SAMPLE	F.S.	FOIL SAMPLE
C.S.	CHUNK SAMPLE	R.C.	ROCK CORE
S.T.	SLOTTED TUBE SAMPLE		
	P.H. SAMPLE ADVANCED HYDRAULICALLY		
	P.M. SAMPLE ADVANCED MANUALLY		

SOIL TESTS

Qu	UNCONFINED COMPRESSION	L.V.	LABORATORY VANE
Q	UNDRAINED TRIAXIAL	F.V.	FIELD VANE
Qcu	CONSOLIDATED UNDRAINED TRIAXIAL	C	CONSOLIDATION
Qd	DRAINED TRIAXIAL	S	SENSITIVITY

ABBREVIATIONS USED IN THIS REPORT

SOIL PROPERTIES

γ	UNIT WEIGHT OF SOIL (BULK DENSITY)
γ_s	UNIT WEIGHT OF SOLID PARTICLES
γ_w	UNIT WEIGHT OF WATER
γ_d	UNIT DRY WEIGHT OF SOIL (DRY DENSITY)
γ'	UNIT WEIGHT OF SUBMERGED SOIL
G	SPECIFIC GRAVITY OF SOLID PARTICLES $G = \frac{\gamma_s}{\gamma_w}$
e	VOID RATIO
n	POROSITY
w	WATER CONTENT
S_r	DEGREE OF SATURATION
w_L	LIQUID LIMIT
w_p	PLASTIC LIMIT
I_p	PLASTICITY INDEX
s	SHRINKAGE LIMIT
I_L	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$
I_c	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$
e_{max}	VOID RATIO IN LOOSEST STATE
e_{min}	VOID RATIO IN DENSEST STATE
I_D	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
	RELATIVE DENSITY D_r IS ALSO USED
h	HYDRAULIC HEAD OR POTENTIAL
q	RATE OF DISCHARGE
v	VELOCITY OF FLOW
i	HYDRAULIC GRADIENT
k	COEFFICIENT OF PERMEABILITY
j	SEEPAGE FORCE PER UNIT VOLUME
m_v	COEFFICIENT OF VOLUME CHANGE = $\frac{-\Delta e}{(1+e)\Delta\sigma}$
c_v	COEFFICIENT OF CONSOLIDATION
C_c	COMPRESSION INDEX = $\frac{\Delta e}{\Delta \log_{10} \sigma}$
T_v	TIME FACTOR = $\frac{c_v t}{d^2}$ (d, DRAINAGE PATH)
U	DEGREE OF CONSOLIDATION
τ_f	SHEAR STRENGTH
c'	EFFECTIVE COHESION INTERCEPT
ϕ'	EFFECTIVE ANGLE OF SHEARING RESISTANCE, OR FRICTION
c_u	APPARENT COHESION
ϕ_u	APPARENT ANGLE OF SHEARING RESISTANCE, OR FRICTION
μ	COEFFICIENT OF FRICTION
S_t	SENSITIVITY

GENERAL

π	= 3.1416
e	BASE OF NATURAL LOGARITHMS 2.7183
$\log_e a$ OR $\ln a$	NATURAL LOGARITHM OF a
$\log_{10} a$ OR $\log a$	LOGARITHM OF a TO BASE 10
t	TIME
g	ACCELERATION DUE TO GRAVITY
V	VOLUME
W	WEIGHT
M	MOMENT
F	FACTOR OF SAFETY

STRESS AND STRAIN

u	PORE PRESSURE
σ	NORMAL STRESS
σ'	NORMAL EFFECTIVE STRESS ($\bar{\sigma}$ IS ALSO USED)
τ	SHEAR STRESS
ϵ	LINEAR STRAIN
γ	SHEAR STRAIN
ν	POISSON'S RATIO (μ IS ALSO USED)
E	MODULUS OF LINEAR DEFORMATION (YOUNG'S MODULUS)
G	MODULUS OF SHEAR DEFORMATION
K	MODULUS OF COMPRESSIBILITY
η	COEFFICIENT OF VISCOSITY

EARTH PRESSURE

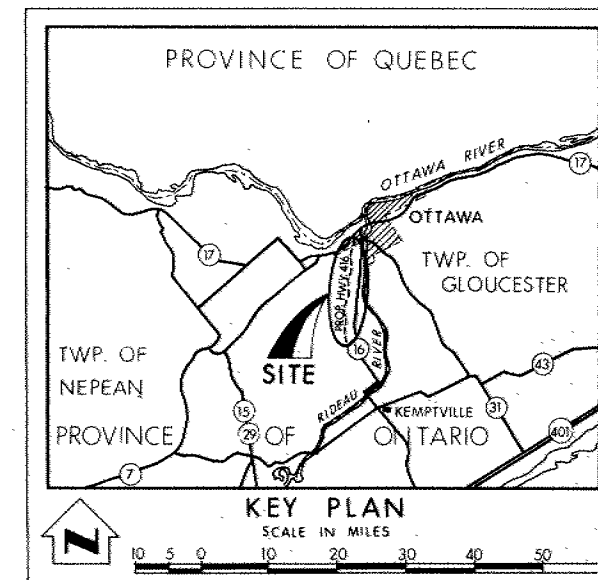
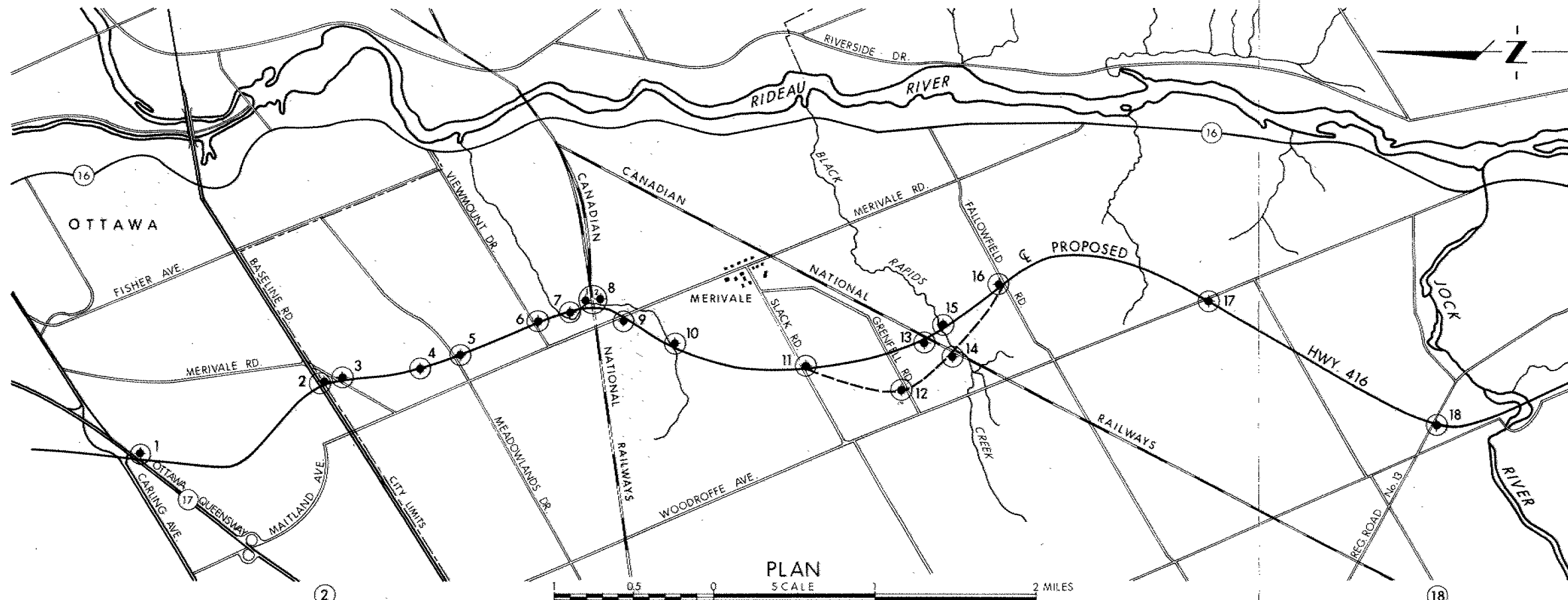
d	DISTANCE FROM TOP OF WALL TO POINT OF APPLICATION OF PRESSURE
δ	ANGLE OF WALL FRICTION
K	DIMENSIONLESS COEFFICIENT TO BE USED WITH VARIOUS SUFFIXES IN EXPRESSIONS REFERRING TO NORMAL STRESS ON WALLS
K_0	COEFFICIENT OF EARTH PRESSURE AT REST

FOUNDATIONS

B	BREADTH OF FOUNDATION
L	LENGTH OF FOUNDATION
D	DEPTH OF FOUNDATION BENEATH GROUND
N	DIMENSIONLESS COEFFICIENT USED WITH A SUFFIX APPLYING TO SPECIFIC GRAVITY, DEPTH AND COHESION ETC. IN THE FORMULA FOR BEARING CAPACITY
k_s	MODULUS OF SUBGRADE REACTION

SLOPES

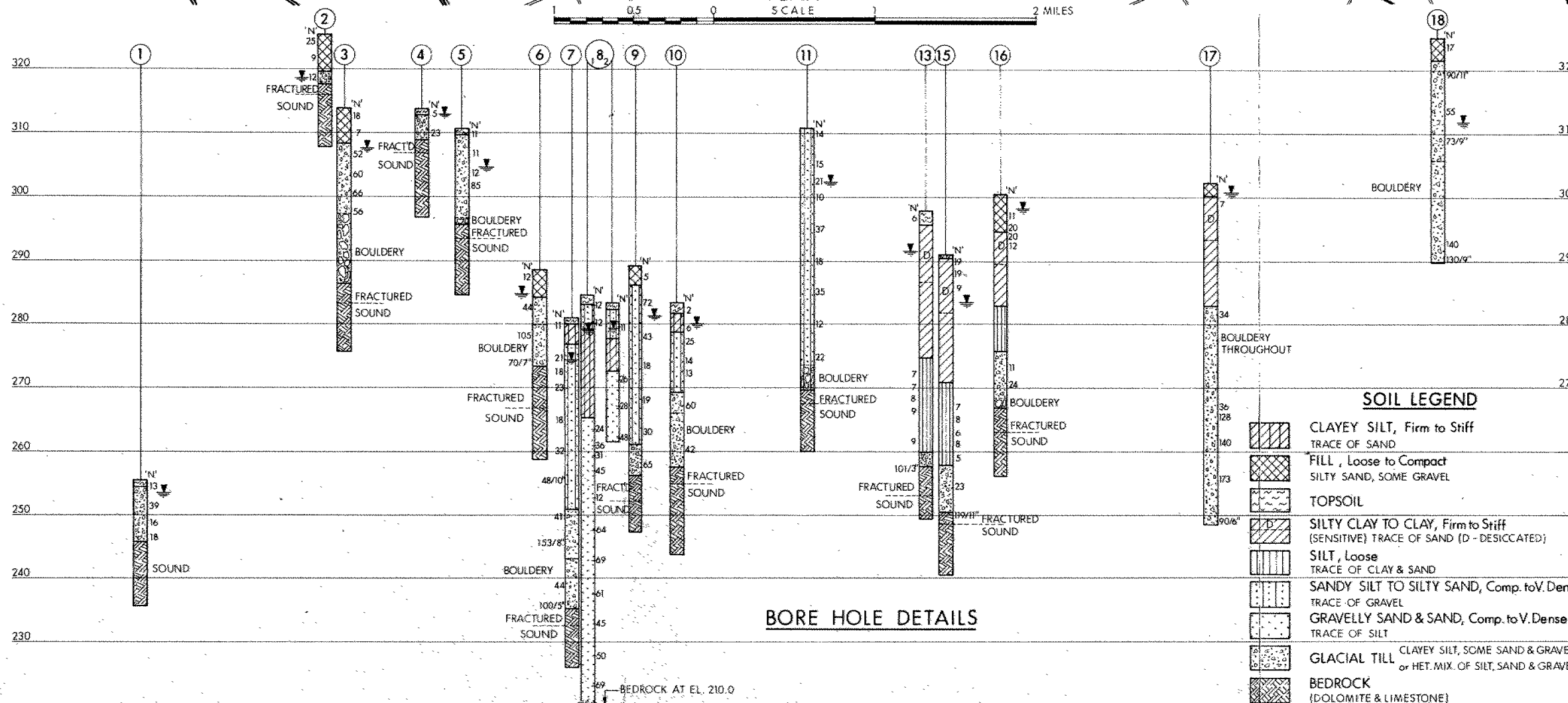
H	VERTICAL HEIGHT OF SLOPE
D	DEPTH BELOW TOE OF SLOPE TO HARD STRATUM
β	ANGLE OF SLOPE TO HORIZONTAL



LEGEND			
	Bore Hole		
	Cone Penetration Test		
	Bore Hole & Cone Test		
	Water Levels established at time of field investigation, May & June 1971		
	Site Locations		

NO.	ELEVATION	STATION	OFFSET
1	255.5		
2	325.5		
3	313.7		
4	313.9		
5	310.8		
6	288.6		
7	281.0		
8(1)	284.5		
8(2)	283.3		
9	289.1		
10	283.3		
11	310.8		
12	301.9		
13	297.9		
14	291.4		
15	291.0		
16	300.3		
17	302.1		
18	325.0		

NOTE
The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence and may be subject to considerable error.



SOIL LEGEND	
	CLAYEY SILT, Firm to Stiff
	TRACE OF SAND
	FILL, Loose to Compact
	SILTY SAND, SOME GRAVEL
	TOPSOIL
	SILTY CLAY TO CLAY, Firm to Stiff (SENSITIVE) TRACE OF SAND (D - DESICCATED)
	SILT, Loose
	TRACE OF CLAY & SAND
	SANDY SILT TO SILTY SAND, Comp. to V. Dense
	TRACE OF GRAVEL
	GRAVELLY SAND & SAND, Comp. to V. Dense
	TRACE OF SILT
	GLACIAL TILL CLAYEY SILT, SOME SAND & GRAVEL Stiff to Hard or HET. MIX. OF SILT, SAND & GRAVEL Comp. to V. Dense
	BEDROCK (DOLOMITE & LIMESTONE)

REVISIONS	DATE	BY	DESCRIPTION

DEPARTMENT OF TRANSPORTATION & COMMUNICATIONS DESIGN SERVICES BRANCH — FOUNDATION SECTION			
PRELIMINARY INVESTIGATION			
OTTAWA QUEENSWAY TO JOCK RIVER			
HIGHWAY NO. PROP. HWY. 416		DIST. NO. 9	
REGIONAL MUNICIPALITY OF OTTAWA - CARLETON			
TWP. NEPEAN & CITY OF OTTAWA			
BORE HOLE LOCATIONS & SOIL STRATA			
SUBMD. B.T.D.	CHECKED	WP NO. 12-68&252-66	DRAWING NO.
DRAWN S.R.	CHECKED	JOB NO. 71-11045	71-11045 A
DATE	JUNE 25, 1971	SITE NO.	BRIDGE DRAWING NO.
APPROVED		CONT. NO.	
PRINCIPAL FOUNDATION ENGINEER			