

GEOCRES No. 30M5-185

DIST. 4 REGION

W.P. No. 199-77-09

CONT. No.

W. O. No.

STR. SITE No. 10-483

HWY. No. 403

LOCATION Hwy 403 W.B.L
OVER North SERVICE RD
BRIDGE #31

OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:



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FOUNDATION DESIGN SECTION

foundation investigation and design report

ENGINEERING MATERIALS OFFICE
FOUNDATION DESIGN SECTION

WP 199-77-09 DIST 4

HWY 403 STR SITE 10-483

Proposed Bridge No. 31 at
North Service Road-Hwy. 403/QEW Interchange

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FOUNDATION INVESTIGATION REPORT
For
Proposed Bridge No. 31 at
North Service Road-Hwy. 403/QEW Interchange
Highway 403, Site 10-483
W.P. 199-77-09
District 4, Burlington

INTRODUCTION

A foundation investigation was carried out at the above-mentioned site, between 91 09 17 and 91 09 24, for proposed Bridge No. 31, to be constructed across the existing, recently constructed, North Service Road, which is located immediately to the west of the Highway 403/Brant Street interchange.

During this investigation, six boreholes were advanced to depths of 2.6 to 16.2 m.

This report contains the factual information, obtained from these six boreholes, as well as from two relevant boreholes, which were drilled simultaneously, for a similar structure located immediately to the east (ie. Bridge No. 32 - Ref. No. W.P. 199-77-10).

SITE DESCRIPTION

The existing North Service Road, is located to the north of the QEW, within an open cut, at an elevation approximately 5 m lower than the prevailing ground surface. South of the cut, the prevailing ground surface slopes rapidly to the south towards the QEW and Lake Ontario.

PROCEDURES

The fieldwork, for this project, was carried out by this office between 91 09 17 and 91 09 24. Six (6) boreholes, were advanced to depths of 2.6 to 12.2 m using continuous-flight hollow stem augers driven by a truck-mounted drilling rig equipped with standard soil sampling equipment.

Four of the boreholes were then extended to depths of up to 16.2 m, using conventional diamond drilling (BXL and NQ) techniques, in order to prove bedrock.

Upon completion of the coring, a piezometer was installed in one of the boreholes, in order to measure the long term groundwater conditions. This was supplemented by piezometers, which were installed in the two other boreholes, drilled under Ref. No. W.P. 199-77-10.

The locations of the boreholes were staked out in the field, and their elevations determined by McCormick Rankin Consulting Engineers. However, due to difficulties in having the drilling rig gain access to most of these locations (ie. the boreholes were located on a slope), nearly all of the boreholes had to be moved. Slight changes in location and elevation of the boreholes were determined by representatives from this office by simple methods (ie. tape measure, compass and hand level).

The soil samples, which were obtained in the field, were examined in the laboratory by visual and tactile methods. Moisture content, Atterberg Limit and grain size distribution tests were conducted on several select soil samples. The results of this laboratory testing are included on the borehole log sheets and on Figures 1 to 3.

SUBSURFACE CONDITIONS

The subsurface conditions, given in the following sections are, based on the six boreholes drilled during this investigation, as well as BH's 32-B and 32-D, which were drilled specifically for Bridge No. 32 (Ref. No. W.P. 199-77-10), but are sufficiently close to Bridge No. 31 to apply to it as well.

General Conditions

Beneath a thin layer of fill, which was encountered at some locations, the subsoils at the site generally consist of a deposit of a cohesive heterogeneous mixture of clayey silt with some sand and gravel (glacial till) which is, in turn, underlain by a non-cohesive deposit of a heterogeneous mixture of sandy

silt with some gravel and clay (glacial till). The glacial till directly overlies slightly to moderately weathered, greyish red, Queenston shale bedrock. The groundwater table generally slopes from an elevation of about 108.3 m at the north end of the bridge to an elevation of 107.0 m at the south end.

Details of the soil and groundwater conditions are given on the borehole log sheets at the back of this report. The following paragraphs are intended to augment these data.

Silty Clay to Clayey Silt, trace of Organics (Fill or 'Possible Fill')

A thin, surficial layer of dark brown to brownish grey, silty clay to clayey silt up to 1.4 m thick, was encountered at some locations above the cut on the south side of North Service Road, and within the ditches directly adjacent to the road. Much of this material has been referred to as 'Fill', since it was found to contain traces of root fibres and/or occasional topsoil enclosures.

At some locations, the soil did not appear to contain any appreciable organics. However, the lack of any well-defined structure, within the soil, indicates that this material may have been disturbed or reworked, and therefore it has been referred to as 'Possible Fill'.

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

A deposit consisting of a cohesive, heterogeneous mixture of clayey silt containing some sand and gravel, was contacted at the ground surface or beneath a thin layer of fill (and/or 'Possible Fill') at depths of up to 1.4 m in all but one of the boreholes. The base of this deposit was found to extend to depths of up to 8.6 m or elevations of 107.5 to 108.7 m.

Atterberg Limits tests, carried out on three samples from this deposit, which were obtained from the boreholes, had liquid limits of 27 to 28 (average of 28) percent and plasticity indices of 12.5 to 13 (average of 13) percent. These results, which have been plotted on Figure 1, indicate that this soil can be classified as CL or a clayey silt of low plasticity. Moisture contents of samples, from this deposit, range from 8.5 to 16 (average of 13) percent.

A grain size distribution test, carried out on a sample of soil obtained from this deposit, and shown on Figure 2, indicates a relatively well-graded material consisting of 42 percent silt, 28 percent clay, 18 percent sand and 12 percent gravel-sized particles. These results, coupled with a visual examination of the soil, indicate that this material is of glacial origin and therefore, may be referred to as glacial till.

Standard Penetration resistances ('N' values) of 16 to 120 blows/0.3 m, which were measured in this deposit, indicate that the clayey silt till is of generally very stiff to hard consistency. It should be noted, that a somewhat weaker zone with an 'N' value of 7 blows/0.3 m was encountered in BH 31-E at a depth of 3.7 m to 4.4 m (ie. an elevation of 112.8 m to 113.5 m).

Heterogeneous Mixture of Sandy Silt, some Gravel and Clay (Glacial Till)

The cohesive clayey silt till, referred to in the previous section, was found to be immediately underlain by a non-cohesive, heterogeneous mixture of sandy silt containing some gravel and clay, at depths ranging from 0.6 m to 8.6 m. The base of this deposit was found to extend to depths of up to 10.2 m or elevations of 105.6 to 107 m at the borehole locations.

Moisture content tests, carried out on samples of soil obtained from this deposit, ranged from 7 to 10 (average of 9) percent.

Grain size distribution tests, carried out on two samples of soil obtained from this deposit and shown on Figure 3, indicate a generally well-graded soil with 21 to 26 percent gravel, 34 to 35 percent sand, 30 to 33 percent silt and 10 to 11 percent clay-sized particles. These results, coupled with a visual examination of the soil, indicate that this material is of glacial origin and therefore, may be referred to as glacial till.

Since the 'N' values, which were measured in this deposit, were all greater than 50 blows/0.3 m, this deposit is considered to be in a very dense state.

Shale Bedrock

All boreholes reached bedrock (or the assumed bedrock surface), at depths ranging from 2.6 m to 10.2 m, or elevations of 105.6 m to 107.0 m. The bedrock surface was found to generally slope to the south. In six of the boreholes, the underlying bedrock was cored to depths of 5.8 m to 16.2 m. Recoveries and RQD's ranged from 10 to 100 percent and 0 to 70 percent, respectively.

GROUNDWATER CONDITIONS

Measurements taken in the open boreholes, immediately prior to coring, were generally found to either be dry or with a slight amount of water at the bottom of the hole. However, water levels measured in two of the open boreholes (31-B and 31-D), at least 24 hours after their completion, were found to be at elevation of 107 and 108.3 m.

Piezometers were installed in three of the boreholes, immediately after coring, in order to measure the long term groundwater conditions. The water levels, measured in the piezometers, at least 24 hours after their installation, were found to be at elevations of 107.0 m to 107.7 m. Therefore, it appears that the groundwater table ranges from an elevation of 107 to 108.3 m, with a general reduction in elevation from north to south towards the QEW and Lake Ontario.

In any case, the groundwater table is subject to seasonal fluctuations and is expected to rise during the spring freshet and during and immediately following any periods of prolonged heavy rainfall.

DISCUSSION AND RECOMMENDATIONS

General

It is proposed to construct Bridge No. 31 across the open cut which carries the newly-constructed, single lane North Service Road. Bridge No.'s 32 and 36 (Ref. No.'s W.P. 199-77-10 and W.P. 199-77-11) will be located on the east and west sides of Bridge No. 31, respectively. All three bridges will be constructed to the west of Bridge No. 40, which is presently under construction (Contract No. 91-22).

Bridge No. 31 will consist of a three-span structure, with the inner span being supported by piers. Initially, the bridge will be used to accomodate two Highway 403 westbound lanes. Ultimately, however, it is proposed to widen the bridge, in order to accommodate one more additional lane.

On the south side of Bridge No. 31, it is proposed to raise the grade by up to 5.0 m, within 50 m of its south abutment. However, the grade on the north side of the bridge will be slightly lowered.

Design Considerations

Abutments

The loads, at the abutment areas for the bridge, may be supported by spread footings placed either on undisturbed clayey silt till or on granular fill. The recommendations for the north and south abutments for the bridge will be dealt with below.

South Abutment

The loads from the south abutment area, may be supported by conventional shallow spread footing foundations. The foundations must be taken below any fill, organic or otherwise unsuitable soil to bear on the undisturbed, very stiff, glacial till. For such footings, a design value of 600 kPa may be used for the factored bearing capacity at U.L.S. or 300 kPa for the bearing capacity at S.L.S. Type II at a maximum elevation of 114.5 m (assuming that they are less than or equal to 3.0 m wide).

Where subexcavation is required, the excavated soil should be replaced by well-compacted Granular 'A'.

North Abutment

The north abutment may be supported on conventional shallow spread footing foundations. The foundations should be located at or below elevation 116.6 m, below any surficial fill or organics encountered in this area. However, a somewhat weaker zone was encountered at about elevation 113 m, within the generally very stiff to hard clayey silt till, in the north abutment area. To prevent overstressing the above-mentioned weaker zone, it is recommended that the foundations are located above elevation 115 m. Footings placed on native clayey silt till, as discussed above, shall be designed using a factored U.L.S. capacity of 400 kPa and an S.L.S. Type II capacity of 200 kPa (assuming that they are less than or equal to 3.0 m wide).

Alternatively, the north abutment foundations may be designed as a spread footing located on a well-compacted Granular 'A' pad. For a 3 m wide footing resting on a minimum 1.2 m thick granular pad, placed and compacted above elevation 115 m, the factored U.L.S. and S.L.S. Type II capacities will be 850 kPa and 300 kPa, respectively.

Piers

From the drawings provided to us, it appears that the proposed piers, for Bridge No. 31, will be located close to the bottom of the existing cut (ie. immediately adjacent to the North Service Road). In this case, spread footings should be placed on either the very hard clayey silt till or the very dense sandy silt till. For such footings, a design value of 750 kPa may be used for the factored bearing capacity at U.L.S. Assuming that the footings are less than 3 m wide, this value may be assumed at or below the following elevations.

<u>Structure</u>	<u>North Pier (m)</u>	<u>South Pier (m)</u>
Bridge No. 31	108.1	108.3

The bearing capacity at S.L.S. Type II will not govern the design, in this case.

Placement of the footings on the underlying shale was not considered, since the footing excavations would extend well below the elevation of the existing roadway and the groundwater table.

Resistance to Lateral Forces

For design purposes, an unfactored coefficient of friction of 0.45 may be assumed to apply between the base of the footing and either the hard clayey silt till or the very dense sandy silt till, at the pier locations. At the abutments, however, the unfactored coefficient of friction should be reduced to 0.35 between the base of the footing and the somewhat weaker clayey silt till. Finally, for footings placed on a pad of compacted Granular 'A', an unfactored coefficient of friction of 0.50 may be assumed.

Approach Areas

Embankment slopes, for approaches less than 8 m high, may be designed at 2H:1V, assuming they are comprised of borrow materials as per MTO specifications.

Backfill Against Abutments

Free-draining granular fill, such as Granular 'A' or Granular 'B', must be used against the abutment walls to prevent the buildup of hydrostatic pressure behind them. The following design parameters, for these granular fills, may be used in accordance with the O.H.B.D.C.:

	<u>Granular 'A'</u>	<u>Granular 'B'</u>
Angle of Internal Friction (ϕ)	35°	30°
Unit Weight (kN/m^3), γ	22.8	21.2
Coefficient of Active Earth Pressure (K_a)	0.27	0.33
Coefficient of Earth Pressure at Rest (K_o)	0.43	0.5

If the abutment walls are rigid and unyielding, then the earth pressures acting on them should be computed using the earth pressure coefficients at rest. However, if some movement of the abutment walls can be tolerated, then the earth pressures acting on them may be computed using the active pressure coefficients.

Care should be taken to avoid the development of large horizontal pressures, when compacting the backfill behind the abutments. Vibratory compaction equipment, for use behind retaining structures, must be restricted in size, as per current M.T.O. specifications.

Frost Protection

All foundations should have a minimum cover of 1.2 m for frost protection.

Construction Considerations

Excavation and Dewatering

Temporary excavations, through the clayey silt till, to depths of up to 4.0 m, will be temporarily stable at slopes of 1:1.

It is expected that any surface water entering the excavation or perched water in any sandy zones, within the cohesive (ie. clayey silt) till may be controlled by gravity drainage and/or properly filtered sumps. If, however, the excavations must extend through the coarser underlying till (ie. sandy silt till) below the groundwater table, and seepage becomes excessive, more extensive groundwater control measures may be required, for even temporary excavations.

Construction of Approaches and Abutment Areas

All of the existing organic-stained fill or other unsuitable soils must be stripped throughout the full-width of the proposed abutment and approach areas.

The subgrade preparation, the selection of the fill material and its placement and compaction, should be carried out according to OPSS Standards and MTO practice.

Concluding Remarks

As an alternative to spread footing foundations, deep foundations may be considered at the abutments. If this option is favoured, we would be pleased to provide detailed recommendations for their design and construction.

MISCELLANEOUS

The field investigation was supervised by A. Hildebrand, Engineering Trainee, M. Michalek, Project Foundation Engineer, and J. Blair, Project Foundation Engineer, using equipment owned and operated by Master Soil Investigation Inc.

The project was carried out by J. Blair, Project Foundation Engineer, under the general supervision of B. Iyer, Senior Foundation Engineer.

This report was written by J. Blair, reviewed by B. Iyer, Senior Foundation Engineer and approved by M. Devata, Chief Foundation Engineer.



John A. Blair

J. Blair, P.Eng.
Project Foundation Engineer

M. Devata

M. Devata, P.Eng.
Chief Foundation Engineer

APPENDIX

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 kg, 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 \bar{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 (RQD), FOR MODIFIED RECOVERY, IS:

RQD (%)	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

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 = $\frac{c_u}{\tau_r}$

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

PHYSICAL PROPERTIES OF SOIL

ρ_s	kg/m^3	DENSITY OF SOLID PARTICLES	e	1, %	VOID RATIO	e_{\min}	1, %	VOID RATIO IN DENSEST STATE
γ_s	kN/m^3	UNIT WEIGHT OF SOLID PARTICLES	n	1, %	POROSITY	I_D	1	DENSITY INDEX = $\frac{e_{\max} - e}{e_{\max} - e_{\min}}$
ρ_w	kg/m^3	DENSITY OF WATER	w	1, %	WATER CONTENT	D	mm	GRAIN DIAMETER
γ_w	kN/m^3	UNIT WEIGHT OF WATER	S_r	%	DEGREE OF SATURATION	D_n	mm	n PERCENT - DIAMETER
ρ	kg/m^3	DENSITY OF SOIL	w_L	%	LIQUID LIMIT	C_u	1	UNIFORMITY COEFFICIENT
γ	kN/m^3	UNIT WEIGHT OF SOIL	w_p	%	PLASTIC LIMIT	h	m	HYDRAULIC HEAD OR POTENTIAL
ρ_d	kg/m^3	DENSITY OF DRY SOIL	w_s	%	SHRINKAGE LIMIT	q	m^3/s	RATE OF DISCHARGE
γ_d	kN/m^3	UNIT WEIGHT OF DRY SOIL	I_p	%	PLASTICITY INDEX = $w_L - w_p$	v	m/s	DISCHARGE VELOCITY
ρ_{sat}	kg/m^3	DENSITY OF SATURATED SOIL	I_L	1	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$	i	1	HYDRAULIC GRADIENT
γ_{sat}	kN/m^3	UNIT WEIGHT OF SATURATED SOIL	I_C	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$	k	m/s	HYDRAULIC CONDUCTIVITY
ρ'	kg/m^3	DENSITY OF SUBMERGED SOIL	e_{\max}	1, %	VOID RATIO IN LOOSEST STATE	j	kN/m^2	SEEPAGE FORCE
γ'	kN/m^3	UNIT WEIGHT OF SUBMERGED SOIL						

ROCK CORE DESCRIPTION

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CORE RECOVERY					CORE DESCRIPTION	
BH#	RC#	DEPTH (m)	% CR*	% RQD*	DEPTH (m)	DESCRIPTION
31-B	14	13.11-14.63	96	72	13.11-16.15	SHALE, greyish red, with interbedded greenish grey SILTSTONE (21%); very fine grained; weak to very weak; unweathered to slightly weathered; fractures moderately close to extremely close spaced, flat to near vertical, planar to undulating, smooth.
	15	14.63-16.15	100	77		
31-D	6	3.35-4.88	92	47	3.35-6.40	SHALE, greyish red, with interbedded greenish grey SILTSTONE (18%); very fine grained; weak to very weak; unweathered to slightly weathered; fractures moderately close to extremely close spaced, flat to near vertical, planar to undulating, smooth.
	7	4.88-6.40	100	70		
31-E	11	10.16-11.68	10	0	10.16-16.21	SHALE, greyish red, with interbedded greenish grey SILTSTONE (20%); very fine grained; weak to very weak; unweathered to slightly weathered (moderately weathered, 10.16-11.76 m); fractures moderately close to extremely close spaced, flat to near vertical, planar to undulating, smooth.
	12	11.68-13.21	80	27		
	13	13.21-14.68	83	37		
	14	14.68-16.21	70	24		
31-G	6	2.82-4.32	94	47	2.82-5.79	SHALE, greyish red, with interbedded greenish grey SILTSTONE (15%); very fine grained; weak to very weak; unweathered to slightly weathered; fractures moderately close to extremely close spaced, flat, planar to undulating, smooth.
	7	4.32-5.79	68	43		

*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

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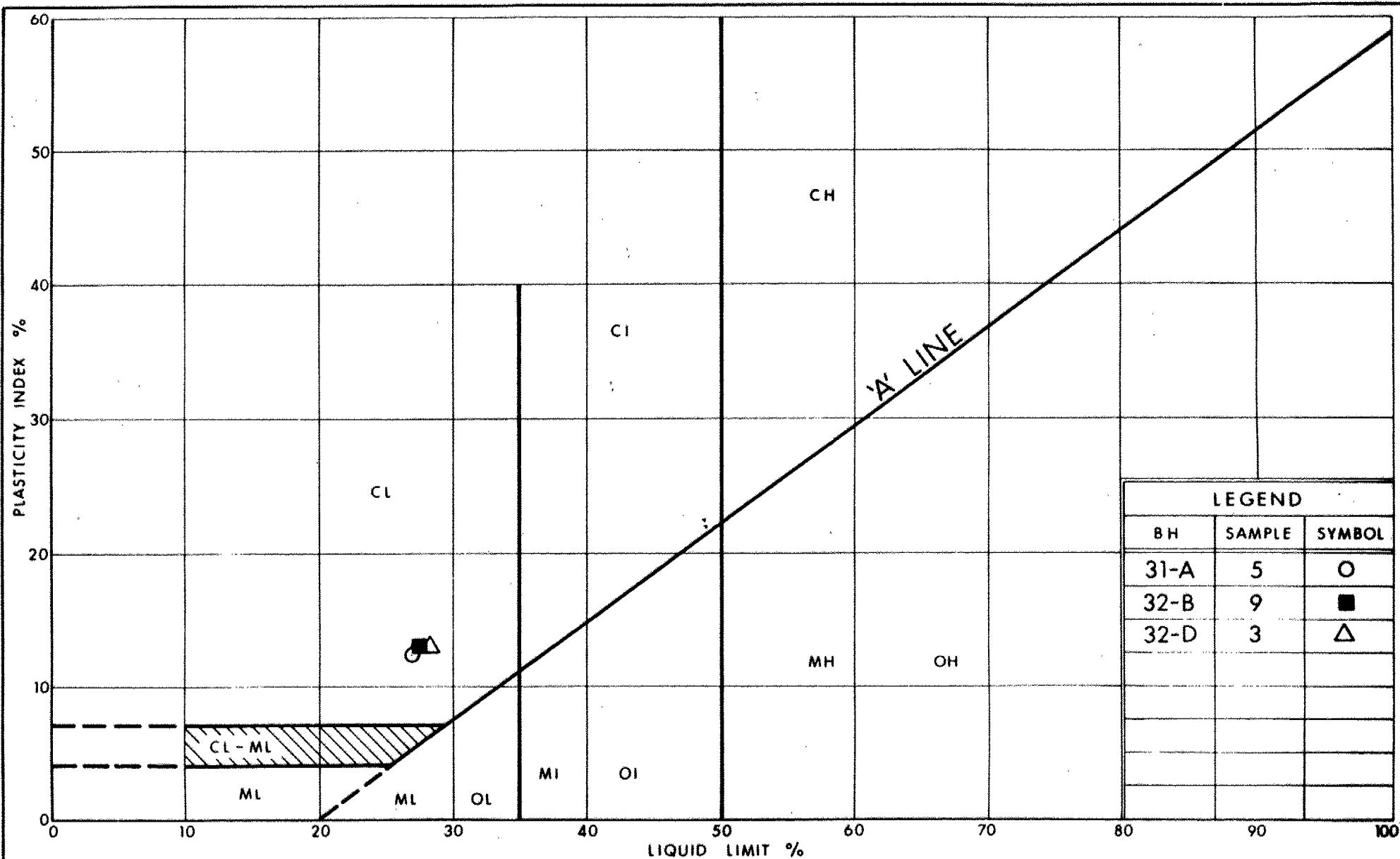
CORE RECOVERY					CORE DESCRIPTION	
BH#	RC#	DEPTH (m)	% CR*	% RQD*	DEPTH (m)	DESCRIPTION
32-B	12	9.91-11.43	83	67	9.91-12.95	SHALE, greyish red, with interbedded greenish grey SILTSTONE (18%); very fine grained; weak to very weak; unweathered to slightly weathered (moderately weathered, 9.91-9.98 m); fractures moderately close to extremely close spaced, flat to near vertical, planar to undulating, smooth.
	13	11.43-12.95	95	81		
32-C	6	3.96-5.43	57	0	3.96-6.81	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.
	7	5.43-6.81	89	0		
32-D	7	3.51-4.90	60	17	3.51-6.43	SHALE, greyish red, with interbedded greenish grey SILTSTONE (16%); very fine grained; weak to very weak; unweathered to slightly weathered (moderately weathered, 3.51-3.83 m); fractures moderately close to extremely close spaced, flat to near vertical, planar to undulating, smooth.
	8	4.90-6.43	100	80		
32-E	12	10.90-12.34	100	45	10.90-13.87	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.
	13	12.34-13.87	92	33		

*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



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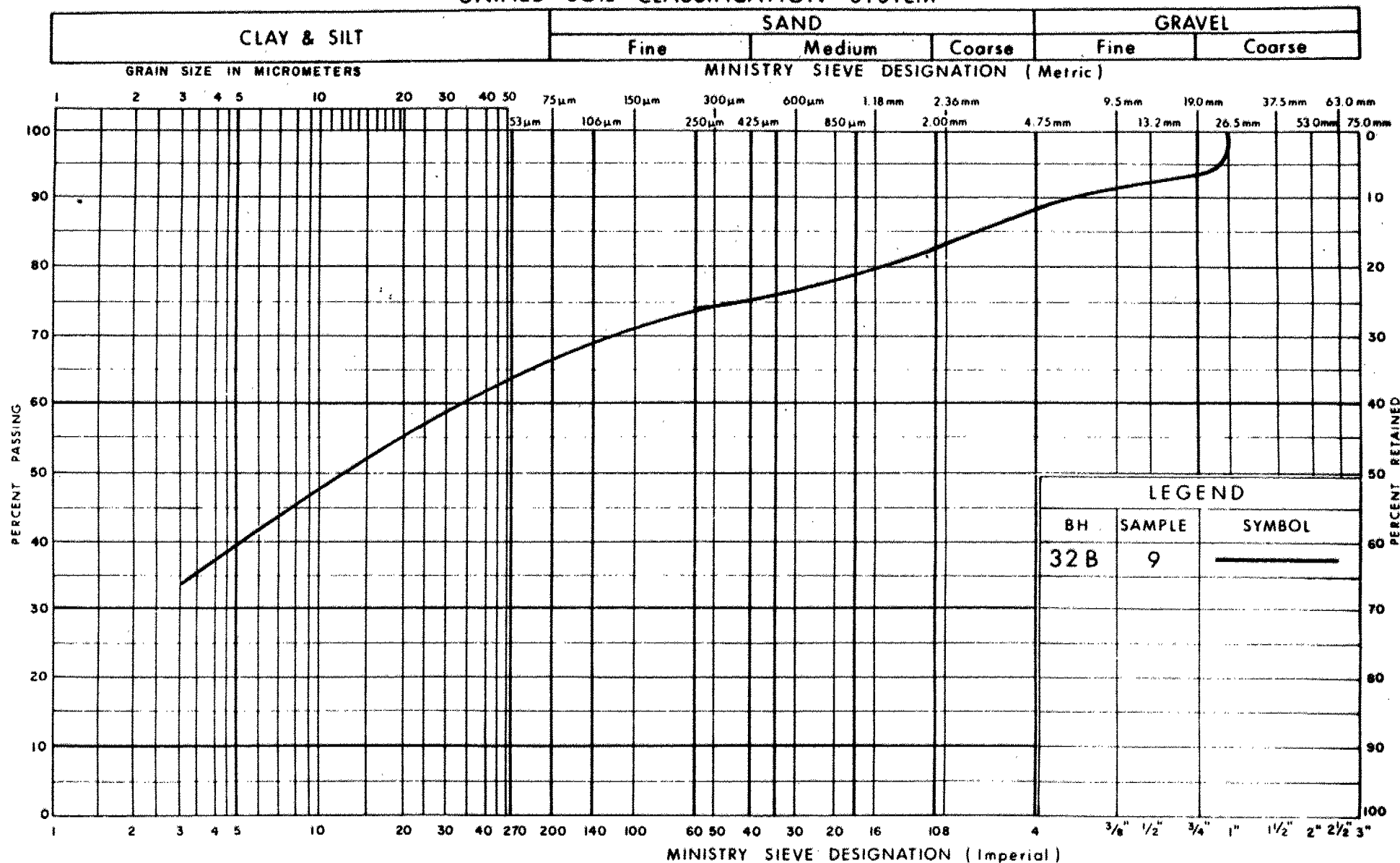
Ontario

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

FIG No 1

W P 199-77-09

UNIFIED SOIL CLASSIFICATION SYSTEM



Ontario

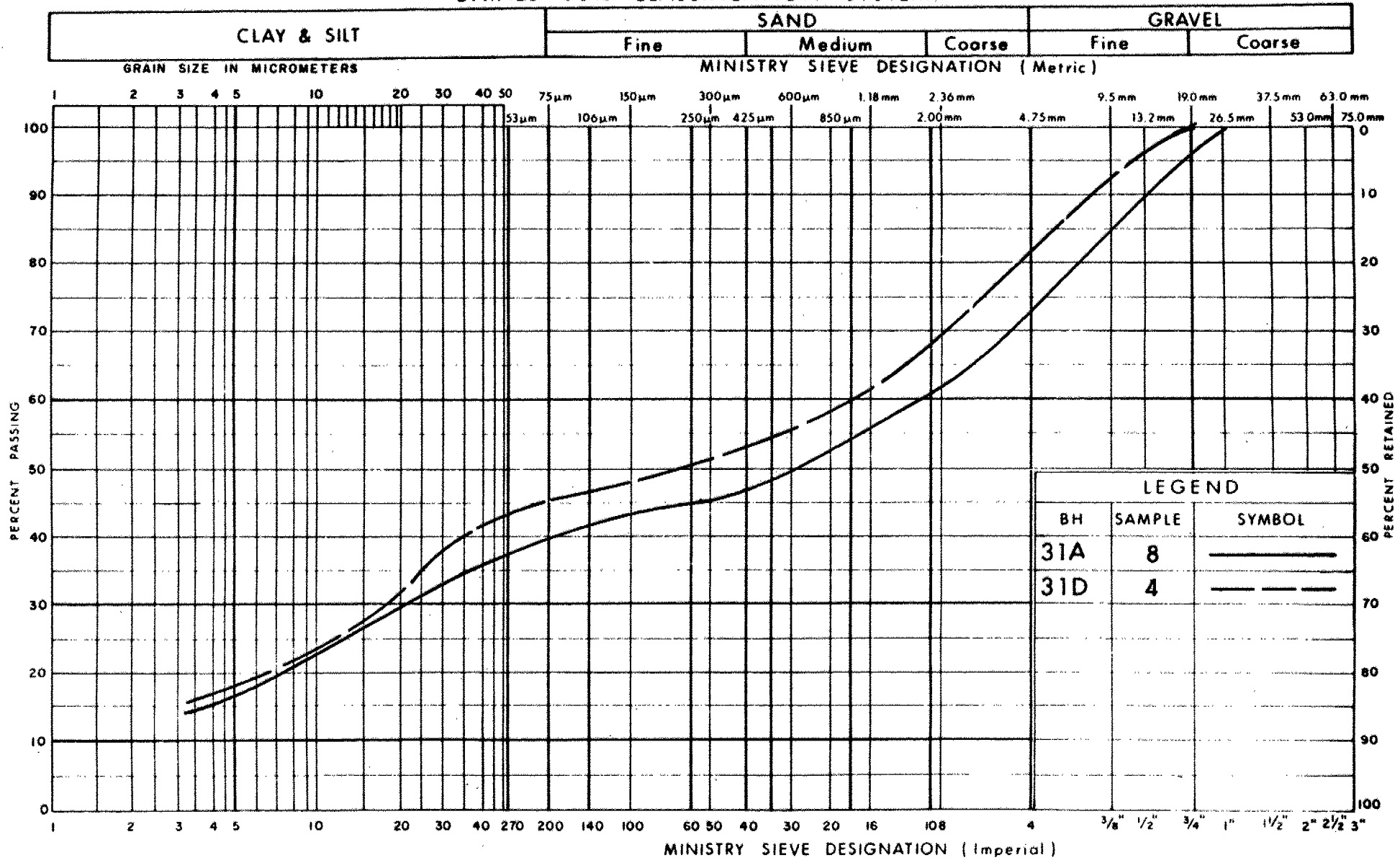
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GRAIN SIZE DISTRIBUTION
HETEROGENEOUS MIXTURE OF CLAYEY SILT
SOME SAND & GRAVEL (GLACIAL TILL)

FIG No 2

W P 199-77-09

UNIFIED SOIL CLASSIFICATION SYSTEM



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GRAIN SIZE DISTRIBUTION
HETEROGENEOUS MIXTURE OF SANDY SILT
SOME GRAVEL & CLAY (GLACIAL TILL)

FIG No 3

W P 199-77-09

RECORD OF BOREHOLE No 31-A 1 OF 1 METRIC

W.P. 199-77-09 LOCATION Co-ords: N 4 799 815; E 277 928 ORIGINATED BY MM
 DIST 4 HWY 403 BOREHOLE TYPE S.S. Auger COMPILED BY JB
 DATUM Geodetic DATE September 18, 1991 CHECKED BY BI

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
114.0	Ground Surface																
0.0	Heterogeneous Mixture of Clayey Silt, Some Sand and Gravel (Glacial Till) Very Stiff to Hard		1	SS	49		112										
			2	SS	20												
			3	SS	16												
			4	SS	17												
			5	SS	78		110										
			6	SS	120												
108.2	Brownish Gray Brown to Greyish Red		7	SS	78		108										
5.8	Heterogeneous Mixture of Sandy Silt Some Gravel and Clay (Glacial Till) Very Dense		8	SS	120/1	10cm											26 34 30 10
105.6			9	SS	94/62	10cm	106										
8.4	Bedrock																
104.8	Shale Containing Siltstone Interbeds		10	SS	120/20	10cm											
9.2	* Water level not established.																

RECORD OF BOREHOLE No 31-B 1 OF 1 METRIC

W.P. 199-77-09 LOCATION Co-ords: N 4 799 856; E 277 927 ORIGINATED BY AH
 DIST 4 HWY 403 BOREHOLE TYPE S.S. Auger / BXL Coring COMPILED BY JB
 DATUM Geodetic DATE September 17, 1991 CHECKED BY BI

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT 7 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
116.0	Ground Surface																
0.0	0.1m Fill Clayey Silt, Some Sand (Possible Fill) Containing Root Fibres		1	SS	25												
114.6			2	SS	20												
1.4	Brownish Grey		3	SS	22		114										
	Heterogeneous Mixture of Clayey Silt, Some Sand, Trace of Gravel (Glacial Till)		4	SS	19												
			5	SS	20		112										
	Very Stiff		6	SS	24												
	Hard		7	SS	80		110										
			8	SS	60/80m												
			9	SS	65												
			10	SS	60/10m		108										
107.5	Brownish Grey																
8.5	Heterogeneous Mixture of Greyish Red Sandy Silt, Some Gravel and Clay (Glacial Till) Very Dense		11	SS	60/12m		106										
106.0																	
10.0	Bedrock Shale						104										
	Weathered Sound						102										
	Containing Siltstone Interbeds		14	RC	REC 96%												RQD 72%
			15	RC	REC 100%												RQD 70%
99.8							100										
16.2	End of Borehole																
	The water level was measured in the open borehole on September 24, 1991.																

RECORD OF BOREHOLE No 31-C 1 OF 1 METRIC

W.P. 199-77-09 LOCATION Co-ords: N 4 799 885; E 277 944 ORIGINATED BY JB
 DIST 4 HWY 403 BOREHOLE TYPE S.S. Auger COMPILED BY JB
 DATUM Geodetic DATE September 19, 1991 CHECKED BY BJ

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT 7 KN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100					
109.1	Ground Surface																
108.5	0.08m Topsoil Clayey Silt, Root Fibres	Dark Grey to Reddish Brown Greyish Red	1	SS	17												
0.6	Heterogenous Mixture of Sandy Silt, Some Gravel and Clay (Glacial Till) Very Dense		2	SS	55/13cm		108										
			3	SS	60/12cm												
106.5	Refusal - Possible Bedrock		4	SS	60/14cm												
2.6	End of Borehole • Water level not established.																

RECORD OF BOREHOLE No 31-D 1 OF 1 METRIC

W.P. 199-77-09 LOCATION Co-ords: N 4 799 900; E 277 928 ORIGINATED BY AH
 DIST 4 HWY 403 BOREHOLE TYPE S.S. Auger / BXL Coring COMPILED BY JB
 DATUM Geodetic DATE September 19, 1991 CHECKED BY BI

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT 7 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				
109.2	Ground Surface							20 40 60 80 100									
0.0	Heterogeneous Mixture of Silty Clay, Some Sand, Trace of Gravel (Glacial Till)		1	SS	16												
107.8	Trace of Root Fibres Brownish Grey		2	SS	84												
1.4	Heterogeneous Mixture of Greyish Red Sandy Silt, Some Gravel and Clay (Glacial Till)		3	SS	60/12 cm												
106.5	Very Dense		4	SS	60/12 cm											21 35 33 11	
2.7	Weathered Sand		5	SS	60/12 cm												
	Bedrock Shale		6	RC	REC											RQD 47%	
102.8	Containing Siltstone Interbeds		7	RC	100%											RQD 70%	
6.4	End of Borehole																
* The water level was measured in the open borehole on September 24, 1991.																	

RECORD OF BOREHOLE No 31-E 1 OF 1 METRIC

W.P. 199-77-09 LOCATION Co-ords: N 4 799 930; E 277 941 ORIGINATED BY AH
DIST 4 HWY 403 BOREHOLE TYPE S.S. Auger / NQ Coring COMPILED BY JB
DATUM Geodetic DATE September 24, 1991 CHECKED BY BI

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC UNIT W _p	NATURAL MOISTURE CONTENT W	LIQUID UNIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
117.2	Ground Surface																
0.0			1	SS	20		116										
			2	SS	16												
			3	SS	17												
			4	SS	18		114										
			5	SS	7												
			6	SS	32												
			7	SS	29		112										
			8	SS	94												
			9	SS	103		110										
108.6	Greyish Brown		10	SS	81/5cm		108										
8.6	Heterogeneous Mixture of Sandy Silt, Some Gravel and Clay (Glacial Till) Very Dense		11	RC	REC		106										RQD 0%
107.0	Brown		12	RC	REC												RQD 27%
10.2	Weathered Sound		13	RC	REC		104										RQD 37%
	Bedrock Shale		14	RC	REC		102										RQD 24%
	Containing Siltstone Interbeds																
101.0																	
18.2	End of Borehole * Groundwater Elevation not Established																

RECORD OF BOREHOLE No 31-G

1 of 1

METRIC

W.P. 199-77-09 LOCATION Co-ords: N 4 799 878; E 277 925 ORIGINATED BY JB
DIST 4 HWY 403 BOREHOLE TYPE S.S. Auger / NO Coring COMPILED BY JB
DATUM Geodetic DATE September 19, 1991 CHECKED BY BI

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT 7 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
108.8	Ground Surface																
0.0	150mm Dark Grey Clayey Silt Fill Root Fibres Heterogeneous Mixture of Sandy Silt to Clayey Silt Some Gravel Brown to Grayish Red (Glacial Till) Very Dense to Hard		1	SS	55		108										
			2	SS	50/20												
			3	SS	50/15												
			4	SS	72/18												
106.3	Weathered Sound		5	SS	100/1		106										
2.5	Bedrock Shale		6	RC	REC 94%												RQD 47%
	Containing Siltstone Interbeds																
	Grayish Red		7	RC	REC 68%		104										RQD 43%
103.0																	
5.8	End of Borehole																
	1991 09 24																
	* GROUND WATER CONDITIONS																
	PIEZO. NO.																
	GROUND WATER ELEVATION (Metres)																
	1																
	107.7																

RECORD OF BOREHOLE No 32-B

1 OF 1

METRIC

W.P. 199-77-10 LOCATION Co-ords: N 4 799 887; E 277 948 ORIGINATED BY AH
DIST 4 HWY 403 BOREHOLE TYPE S.S. Auger / BXL coring COMPILED BY JB
DATUM Geodetic DATE September 18, 1991 CHECKED BY BI

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT 7 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100					
115.8	Ground Surface																
0.0	Topsoil/Clayey Silt Fill Traces of Root Fibres		1	SS	41												
114.4	Clayey Silt, Some Sand (Possible Fill)		2	SS	28												
1.4	Heterogeneous Mixture of Clayey Silt Some Sand and Gravel (Glacial Till) Very Stiff Hard		3	SS	22		114										
			4	SS	25												
			5	SS	23												
			6	SS	28		112										
			7	SS	23												
			8	SS	39		110										
			9	SS	82												
108.7	Brownish Grey Greyish Red		10	SS	80/100m		108										12 18 42 28
7.1	Heterogeneous Mixture of Sandy Silt Some Gravel and Clay (Glacial Till) Very Dense		11	SS	80/100m												
106.2	Weathered Sound		12	RC	83%		106										RQD 87%
9.8	Bedrock Shale Containing Siltstone Interbeds		13	RC	85%		104										RQD 81%
102.8																	
13.0	End of Borehole																
	1991 09 24																
	• GROUND WATER CONDITIONS																
	PIEZO. NO.																
	GROUND WATER ELEVATION (Metres)																
	1																
	107.2																

RECORD OF BOREHOLE No 32-D 1 OF 1 METRIC

W.P. 199-77-10 LOCATION Co-ords: N 4 799 808; E 277 945 ORIGINATED BY AH
 DIST 4 HWY 403 BOREHOLE TYPE S.S. Auger/BXL Coring COMPILED BY JB
 DATUM Geodetic DATE September 20, 1991 CHECKED BY BJ

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT 7 KN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
109.6	Ground Surface																
0.0	0.6m Silty Clay Fill - Trace of Root Fibres Heterogeneous Mixture of Clayey Silt Some Sand and Gravel (Glacial Till)		1	SS	21												
108.2	Hard Brown to Brownish Clay Grayish Red		2	SS	85												
1.4	Heterogeneous Mixture of Sandy Silt, Some Gravel and Clay (Glacial Till) Very Dense		3	SS	107/12m												
108.5			4	SS	89/18m												
3.1	Weathered Sound		5	SS	89/18m												
	Bedrock Shale		6	SS	89/18m												
103.2	Containing Siltstone Interbeds		7	RC	REC 60%												RQD 17%
			8	RC	REC 100%												RQD 80%
6.4	End of Borehole																
	1991 09 24 * GROUND WATER CONDITIONS																
	PIEZO. NO.																
	GROUND WATER ELEVATION (Metres)																
	1																
	107.0																

METRIC

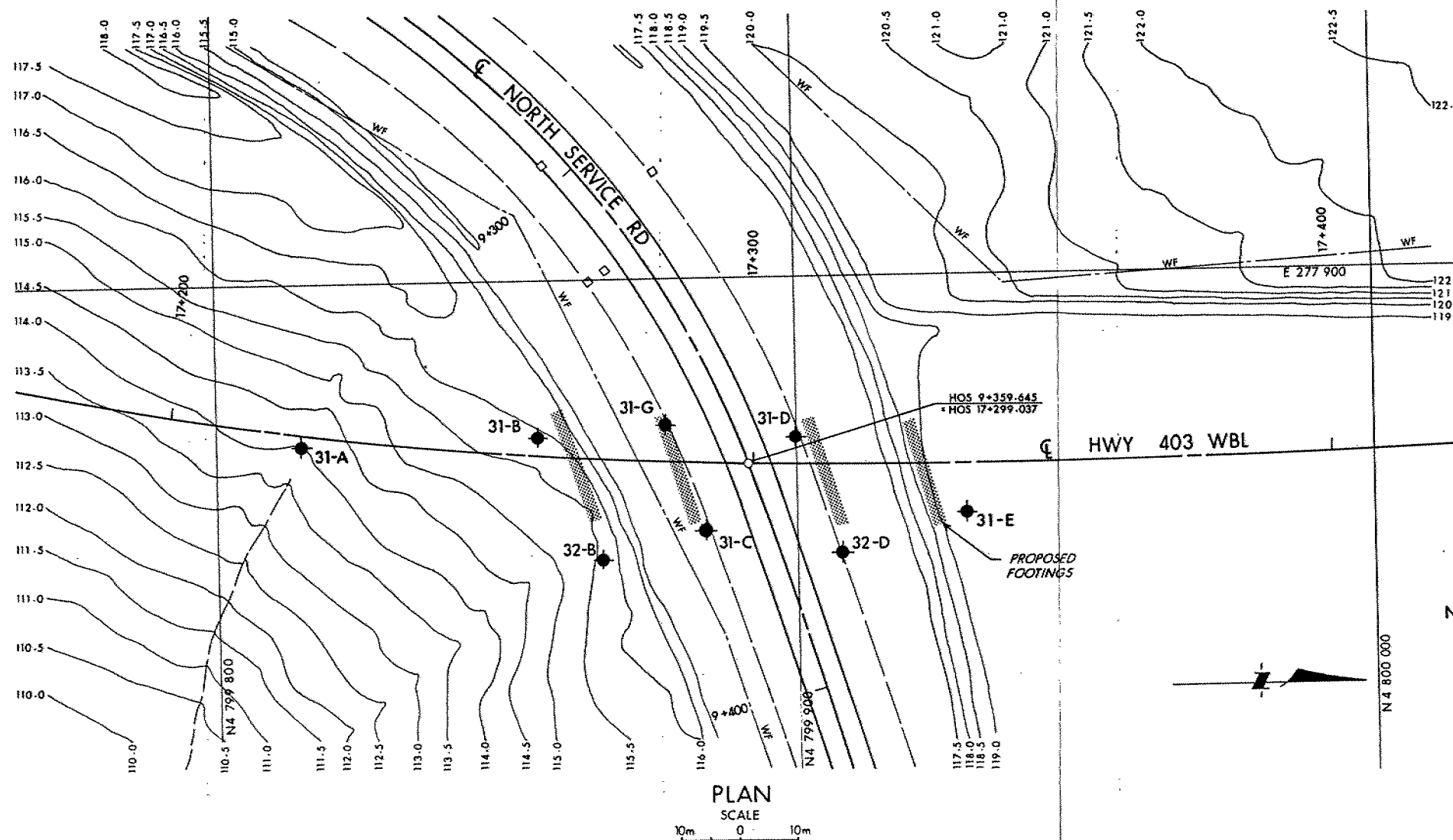
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES UNLESS
OTHERWISE SHOWN. STATIONS
IN KILOMETRES + METRES.

CONT No
WP No 199-77-09

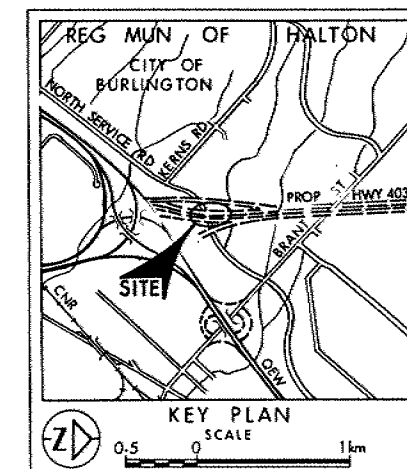
NORTH SERVICE RD
HWY 403 / QEW INTERCHANGE
(BRIDGE-31)
BORE HOLE LOCATIONS & SOIL STRATA



SHEET



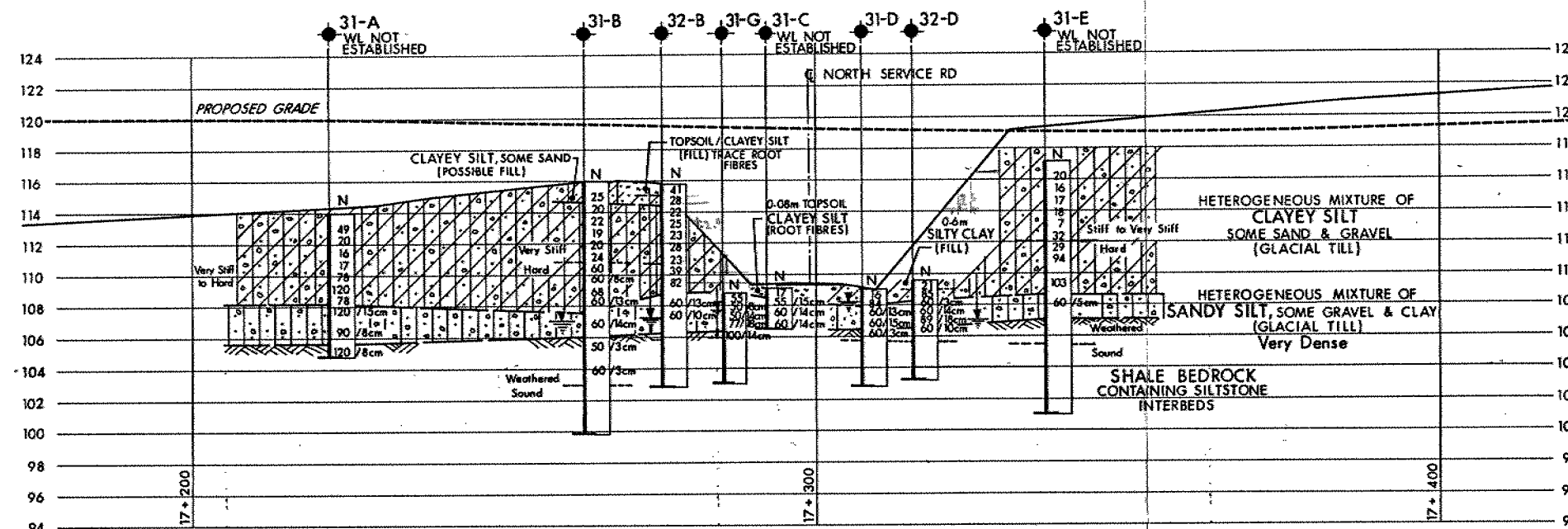
Note:
Contour Lines on the North side
of the proposed bridge do not
represent current conditions at
site due to excavation for Hwy 403



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)
- ≡ WL at time of investigation 91 09
- ≡ WL in Piezometer
- ≡ Piezometer

No	ELEVATION	CO-ORDINATES	
		NORTH	EAST
31-A	114.0	4 799 815.0	277 928.0
31-B	116.0	4 799 856.0	277 927.0
31-C	109.1	4 799 885.0	277 944.0
31-D	109.2	4 799 900.0	277 928.0
31-E	117.2	4 799 930.0	277 941.0
31-G	108.8	4 799 878.0	277 925.0
32-B	113.1	4 799 867.0	277 948.0
32-D	109.6	4 799 908.0	277 948.0



PROFILE HWY 403 WBL

SCALE
10m 0 10m Hor
4m 0 4m Vert

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 102-2 of Form 100.

REV	DATE	BY	DESCRIPTION

Geocres No 30M5-185

HWY No 403	DIST 4
SUBMD JB	CHECKED DATE 91 12 10 SITE 10-483
DRAWN DT	CHECKED APPROVED DWG 1997709-A

memorandum



To: Mr. V.F. Boehnke
Head, Structural Section
Central Region

Date: 1991 10 06

Attn: Mr. M.D. Bendayan

From: Foundation Design Section
Room 315, Central Building

Re: Foundation Investigation
W. P. 199-77-09/10/11
Highway 403, Sites 10-482/10-483/10-484
North Service Road and Kerns Road, Burlington, Ontario
District 4, Burlington

INTRODUCTION

A foundation investigation was carried out at the above-captioned site, between 1991 09 17 and 1991 09 23, 1991 for three bridges to be constructed across the existing, recently-constructed North Service Road, immediately to the west of the Highway 403/Brant Street interchange.

During this investigation, a total of 15 boreholes were advanced to depths of 2.6 to 16.2 m.

This memorandum contains the factual information obtained from the fieldwork, and provides interim recommendations for the three proposed bridges. Final reports for each bridge will follow shortly.

SITE DESCRIPTION

The existing North Service Road, is located to the north of the QEW within a cut, at an elevation approximately 5 m lower than the prevailing ground surface. South of the cut, the prevailing ground slopes rapidly to the south towards the QEW and Lake Ontario.

It is proposed to construct Bridge #'s 31, 32 and 36 (Site No.'s 10-483, 10-484, 10-482) across the cut carrying the newly-constructed North Service Road. The three bridges are to be located immediately to the west of Bridge #40 (Contract No. 91-22), which is presently under construction.

PROCEDURES

The fieldwork, for this project, was carried out by this office between 1991 09 17 and 1991 09 23. A total of 15 boreholes, were advanced to depths of 2.6 to 12.2 m using continuous-flight hollow stem augers driven by a truck-mounted drilling rig equipped with standard soil sampling equipment.

Most of the boreholes were then extended to depths of up to 16.2 m using conventional diamond drilling (BXL and NQ) techniques to prove bedrock and, in some cases, to penetrate boulders and/or pieces of rafted bedrock.

Groundwater levels were measured in most of the open boreholes immediately upon completion of sampling (or prior to coring). Upon completion of coring, piezometers were then installed in several of the boreholes, in order to measure the long term groundwater conditions.

The locations of the boreholes were staked out in the field, and their elevations determined by McCormick Rankin Consulting Engineers. However, due to difficulties in having the drilling rig gain access to most of these locations (ie. the boreholes were located on a slope), nearly all of the boreholes had to be moved. Slight changes in location and elevation of the boreholes were determined by representatives from this office by simple methods (ie tape measure, compass and hand level).

The soil samples, which were obtained in the field, were examined in the laboratory by visual and tactile methods. Moisture content, Atterberg Limits and grain size distribution tests were conducted on several select soil samples. The results of this laboratory testing will be included in the final report for each site.

SUBSURFACE CONDITIONS

The stratigraphy at the site generally consists of a cohesive, heterogeneous mixture of clayey silt with some sand and gravel (glacial till) which is, in turn, underlain by a non-cohesive, heterogeneous mixture of sandy silt with some gravel and clay (glacial till). The cohesionless till directly overlies the bedrock surface. A thin surficial layer of fill was also encountered at some locations above cut on the south side of North Service Road and, at several places, within the ditches directly adjacent to the road.

All boreholes reached bedrock (or the assumed bedrock surface) at depths ranging from 2.0 to 12.4 m, or elevations of 105 to 107.5 m. The bedrock surface was found to generally slope from north to south.

Although, the water table was found to range from elevation 106.2 to 109.4 m, it is likely that some of the higher water levels recorded in the boreholes may not have represented the stabilized groundwater table, since water was used during coring operations. It is believed that the groundwater table varies from about elevation 106.2 to 108.2 m and generally slopes from north to south towards the QEW and Lake Ontario.

Detailed descriptions of both the soil and groundwater conditions which were encountered at the various borehole locations will be given in the final report for each site.

DISCUSSIONS and RECOMMENDATIONS

General

The existing North Service Road consists of a single lane road running in a generally east/west direction throughout the area of investigation.

Initially, Bridges 31 and 32 will be used to accomodate two Highway 403 Westbound and Eastbound Lanes, respectively. Ultimately, however, they will both be widened to accomodate an additional lane.

Bridge 36 will be used to accomodate two lanes for the ramp from the Highway 403 Eastbound lane to the QEW Southbound lane. However, we understand that, in this case, there will not be a need to widen this bridge.

All three bridges will consist of three-span structures, with the inner span being supported by piers.

It is proposed that, on the south side of Bridges 31 and 32, the grade will be raised by up to 5.0 and 7.5 m, respectively, within 50 m of their respective south abutments. However, the grade on the north side of both bridges will be slightly lowered.

At Bridge 36, the existing grade will be lowered by up to 2.0 m within 50 m of the abutments on both sides of the bridge.

Design Considerations

Abutments

The loads at the abutment areas, for the three bridges, may be supported by spread footings placed either on undisturbed clayey silt till or on granular fill. The recommendations for the north and south abutments for the three bridges will be dealt with below.

South Abutments

The loads from the south abutment areas may be supported by conventional shallow spread footing foundations. The foundations must be taken below any fill, organic or otherwise unsuitable soil to bear on the undisturbed, very stiff, glacial till. For such footings, a design value of 600 kPa may be used for the factored bearing capacity at U.L.S. or 300 kPa for the bearing capacity at S.L.S. Type II at the following elevations:

<u>Structure</u>	<u>South Abutment</u> <u>(m)</u>
Bridge 31	114.5
Bridge 32	114.4
Bridge 36	116.2

Where subexcavation is required, the excavated soil should be replaced by well-compacted Granular 'A'.

North Abutments

Bridge 31 and 32

The clayey silt till encountered beneath the north abutment areas for both Bridges 31 and 32 appears to be somewhat weaker than similar material encountered beneath either the south abutment areas of those bridges or both abutment areas of Bridge 36. In addition, it should be noted, that a particularly weak zone was found at a depth of about 4 m (ie. an elevation of about 113.2 m).

Conventional shallow spread footing foundations placed directly on the stiff to very stiff clayey silt till may be considered. However, in view of the soil conditions, encountered, a design value of only 400 kPa U.L.S. and 200 kPa S.L.S. Type II may be used for footings placed below any organic or otherwise unsuitable soils at an elevation of 116.6 m. In addition, in order to prevent overstressing of the weak zone referred to above, the footings should not be extended any lower than about 0.6 times the footing width of the footing (if the footing is square) above the weak zone or elevation 115.0 m (assuming a three m wide square footing).

Should additional allowable bearing pressures be required, it is recommended that the loads from the abutment areas of these two bridges be supported by conventional shallow spread footing foundations placed on a well-compacted pad of Granular 'A'. If this scheme is adopted, footings may be designed for factored bearing pressures of 850 kPa at U.L.S. and 300 kPa at S.L.S. Type

II. Based on a 3 m wide square footing, calculations indicate that the granular pad beneath the underside of the footings must be at least 0.4 times the footing width or a minimum of 1.2 m thick.

Once again, in order to prevent overstressing of the weak zone referred to above, the footings must be kept as high as possible and should not extend below elevation 116.8 m (assuming a 3 m wide square footing). However, should the geometry require that the footings must be extended below this elevation, then either the allowable bearing pressure must be reduced or, alternatively, pile foundations may have to be considered.

Bridge 36

The soils encountered at the north abutment area of Bridge 36 are somewhat more competent than those encountered for the two previous bridges. Therefore, in this case, it is recommended that the loads from the north abutment be supported by conventional shallow spread footing foundations. The foundations must be taken below any organic-stained or otherwise unsuitable soil to bear on undisturbed clayey silt till. For footings, placed at or below an elevation of 116.8 m, a design value of 600 kPa may be used for the factored bearing capacity at U.L.S. or 300 kPa for the bearing capacity at S.L.S. Type II.

It should be noted, however, that the soils appear to weaken somewhat below a depth of 5.2 m (elevation of 112.2). Therefore, in order to prevent overstressing this underlying zone (which would result in a reduction in the above-stated bearing capacities) the footings should not be placed lower than an elevation about 113.3 m (assuming a three m wide square footing).

Piers

From the drawings provided to us, it appears that the proposed piers for Bridges 31 and 32 will be located close to the bottom of the existing cut (ie. immediately adjacent to the North Service Road). In this case, spread footings should be placed on either the very hard clayey silt till or the very dense sandy silt till.

For Bridge 36, however, it appears that the proposed piers (and particularly the one to the south) will be located somewhat further up the existing slope. Spread footings may also be considered here. However, excavations to reach a suitably competent till will be somewhat greater and the excavated slopes may have to be cut back significantly. In this case, caissons socketed into the underlying bedrock may also be considered.

Recommendations for spread footings are given for the proposed piers at all three bridges and caissons for the piers at Bridge 36.

Spread Footings on Glacial Till

The piers for all of the bridges may be founded on shallow spread footings placed on either very hard clayey silt till or very dense sandy silt till. For such footings, a design value of 750 kPa may be used for the factored bearing capacity at U.L.S. This value may be assumed at or below the following elevations:

<u>Structure</u>	<u>North Pier</u> <u>(m)</u>	<u>South Pier</u> <u>(m)</u>
Bridge 31	108.1	108.3
Bridge 32	108.6	108.3
Bridge 36	109.8	110.1

The bearing capacity at S.L.S. Type II will not govern the design, in this case.

Placement of the footings on the underlying shale was not considered since the footing excavations would extend well below the elevation of the existing roadway and the groundwater table.

Piers Placed on Caissons

The structural loadings for the piers at Bridge 36, may be transferred to the underlying sound shale bedrock by means of bored cast-in-place concrete caissons. All caissons should be socketed at least 0.3 m into the underlying sound competent bedrock.

For the north and south piers, it is recommended that the following design parameters be used for caissons founded on sound shale bedrock at or below elevations of 106.0 and 105.5 m, respectively:

	Caisson Diameter	
	760 mm	915 mm
Factored Axial Capacity at U.L.S.	4400 kN	6300 kN

In both cases, the allowable capacities at S.L.S. Type II would not govern the design.

Caissons should be a minimum diameter of 760 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.

The caissons must be fully cased and socketed at least 0.3 m into the underlying sound bedrock. However, depending upon the desired degree of lateral resistance, the length of the socket may have to be increased.

Some groundwater infiltration should be expected, particularly when augering through the sandy silt till, below the groundwater table. It may be necessary to control groundwater by using drilling mud or other methods.

Resistance to Lateral Forces

For design purposes, an unfactored coefficient of friction of 0.45 may be assumed to apply between the base of the footing and the hard clayey silt till or very dense sandy silt till at the pier locations. At the abutments, however, the unfactored coefficient of friction should be reduced to 0.35 between the base of the footing and the very stiff clayey silt till.

Approach Areas

Slopes for the approaches and abutment areas may be designed at 2H:1V assuming they are comprised of borrow materials as per MTO specifications.

Frost Protection

All foundations should have a minimum cover of 1.2 m for frost protection.

Construction Considerations

Excavations and Dewatering

Temporary excavations through the clayey silt till to depths of up to 4.0 m will be temporarily stable at slopes of 1:1.

It is expected that any surface water entering the excavation or perched water in any sandy zones within the cohesive (ie. clayey silt till) may be controlled by gravity drainage and/or properly-filtered sumps. If, however, the excavations must extend through the coarser underlying till (ie. sandy silt till) below the

groundwater table, more extensive groundwater control measures may be required.

Construction of Approaches and Abutment Areas

All of the existing organic-stained fill or other unsuitable soils must be stripped throughout the full-width of the proposed abutment and approach areas.

The subgrade preparation, the selection of the fill material and its placement and compaction should be carried out according to OPSS Standards and MTO practice.

MISCELLANEOUS

The field investigation was supervised by Mr. Arthur Hildebrand and Mr. John Blair using equipment owned and operated by Master Soil Investigation Inc.

This memorandum was written by Mr. J. Blair, Project Foundation Engineer, reviewed by Messrs. B. Iyer, Senior Foundation Engineer and M. Devata, Chief Foundation Engineer.

We believe that this memorandum meets with your present requirements. However, should you have any questions regarding it, please do not hesitate to contact this office.

John A. Blair

John A. Blair, P.Eng.
Project Foundation Engineer

for

Balu Iyer, P.Eng.
Senior Foundation Engineer

#32, the face of the columns will be located 10.5 m away from the centreline of the North Service Road. For Bridge #36 this distance will be 11.5 m. These offsets are measured perpendicularly to the curved centreline of this roadway.

Recent photos are included for the three sites under consideration. Access to all sites is easy by driving along the North Service Road (all property is within MTO R.O.W.). Any surveys support like staking the foundation locations, supplying elevations and co-ordinates etc. should be requested to Mr. J. Elliot, P. Eng. from McCormick Rankin, Consultant Engineers (telephone 823-8500).

We also include the Foundation Reconnaissance Report listing the utilities known to exist in subject general area.

Finally, please note that nearby bridge Site 10-339 (W.P. 199-77-12) is being built under Contract 91-22 with a start construction of August, 1991. Your Foundation Report prepared for this bridge (Ramp Q.E.W/S - 403/E,W over the North Service Road) could assist you in your studies.

To comply with present scheduling your Foundation Recommendations should be available by 91-09-12 and the Foundation Reports by 91-10-11.

As usual, please feel free to call if additional information/clarification is required.

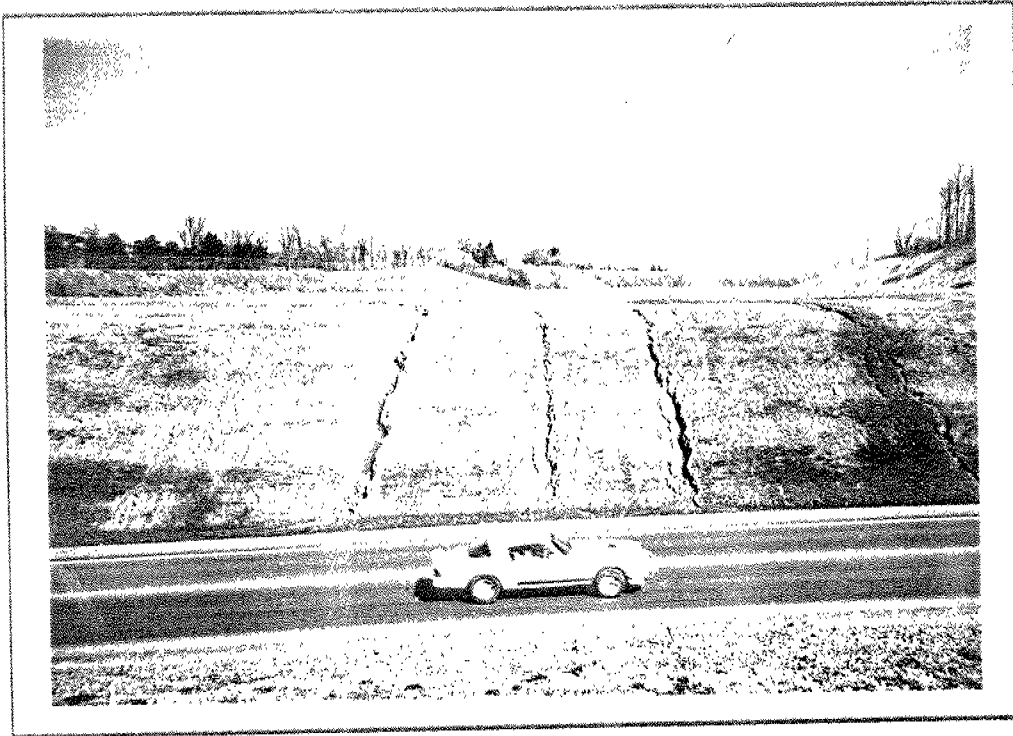


M. D. Bendayan
Sr. Structural Engineer
for:
V. F. Boehnke
Head, Structural Section

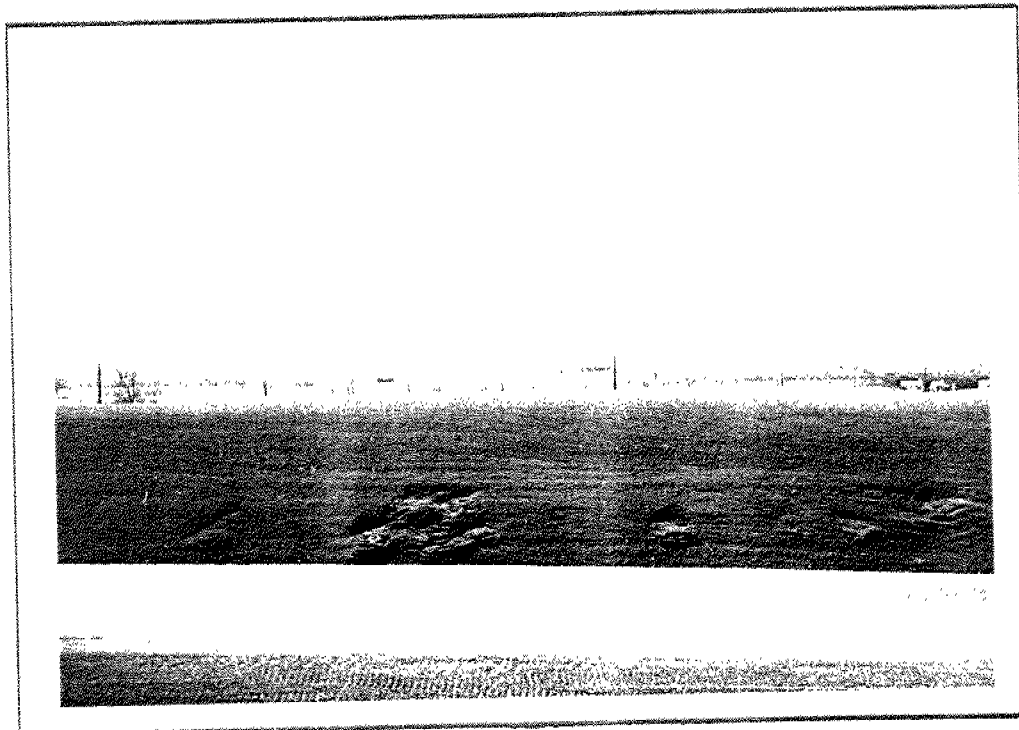
MB:dd
Encl.

cc: R. C. McCormick
I. Harrod
G. Cautillo
D. Riseboro
E. Salva

HWY. 403 W.D.L. OVER NORTH SERVICE ROAD (BRIDGE # 31)
W.P. 199-77-09 ; SITE 10-483
DISTRICT 4, BURLINGTON



LOOKING NORTH ACROSS NORTH SERVICE ROAD

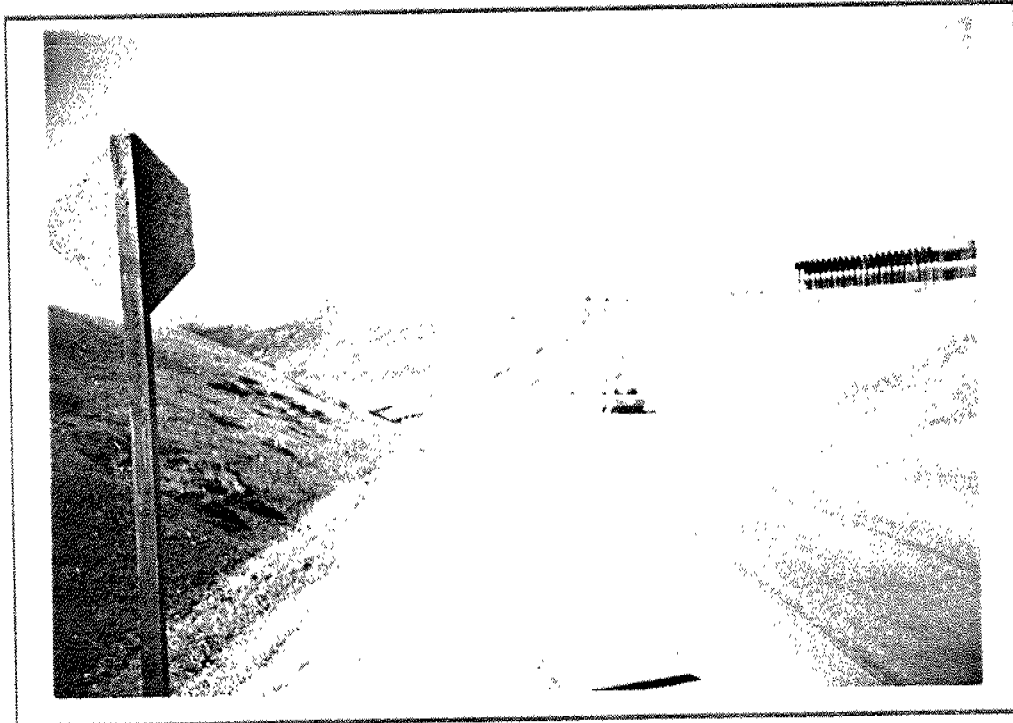


LOOKING SOUTH ACROSS NORTH SERVICE ROAD
(FREEMAN INTERCHANGE IN BACKGROUND)

BRIDGE SITE 10-483
BRIDGE # 31



LOOKING EAST ALONG NORTH SERVICE ROAD



LOOKING WEST ALONG NORTH SERVICE ROAD