

GEOCRIS No:
31G-209



Golder Associates Ltd.
CONSULTING ENGINEERS

REPORT ON

FOUNDATION INVESTIGATION
PROPOSED CONCRETE CULVERTS

HIGHWAY 416 WP 373-89-01

DISTRICT 9 (OTTAWA) EASTERN REGION
GEOCRIS # 31G-209

Submitted to:

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901-2064B-4

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1.0 INTRODUCTION

Golder Associates Ltd. has been retained by McCormick Rankin, consultants to the Ministry of Transportation Ontario (MTO), to carry out subsurface investigations at the sites of proposed large concrete culverts along the proposed Highway 416 Southbound Lanes from north of Highway 43 and northerly to the Rideau River (see Key Plan, Figure 1). The purpose of the investigations was to determine and report on the general subsurface conditions at the designated culvert sites by means of a limited number of sampled boreholes.

The proposed concrete culverts are to be located where three major drainage channels cross the alignment of the proposed Highway 416 Southbound Lanes, as follows:

- approximate Station 11+780 SBL - Site 1
- approximate Station 12+520 SBL - Site 2
- approximate Station 14+335 SBL - Site 3

In addition, borings were put down at about Station 14+325 (Site 4) along an originally proposed CPR overpass alignment, prior to the finalization of the Southbound Lanes CPR at-grade alignment. The results of these borings (BH90-C4 to 90-C7) have been included with this report for record purposes only.

2. SITE DESCRIPTION AND GEOLOGY

The culvert sites are located immediately west of the existing Highway 16 between about Highway 43 and the Canadian Pacific Railway. The topography at each of the three culvert sites is low and flat, and the drainage channels are cut a further 1 to 2 metres below the general ground level. Ground cover at the culvert sites consists of either uncut grass or low brush. The existing Highway 16 in the site areas is constructed on about a 2 metre high earth fill embankment.

This area of the proposed Highway 416 is located within the physiographic region known as the North Gower Drumlin Field. The drumlins in this area are widely scattered, with the flat areas between the drumlins being underlain by silty sand, silt, and/or sensitive silty clay deposited by the Champlain Sea. Drainage in the culvert areas is to the north-west towards the Rideau River, and may generally be defined as poor to not well developed. As such, much of the surficial ground cover in this area consists of bog deposits and/or organic soils.

3.0 PROCEDURE

The field work for the culvert investigations was carried out on May 9 to 15, 1990 and March 15, 1991. During these periods, the following boreholes were put down:

- Site 1 - Borehole 90-C1 at Station 11+760 SBL, to a depth of 5.8 metres.
- Site 2 - Boreholes 90-C2 and 90-C3 at Stations 12+504 SBL and 12+530 SBL respectively, each to a depth of 5.2 metres.
- Site 3 - Boreholes 90-C8 and 90-C9 at Stations 14+321 SBL and 14+339 SBL respectively (CPR at-grade alignment), each to a depth of 5.2 metres.
- Site 4 - Boreholes 90-C4 to 90-C7 at Station 14+307 SBL to 14+335 SBL (originally proposed CPR overpass alignment), to depths of 3.5 to 3.7 metres.

The boreholes were put down using a track mounted hollow stem auger machine. Standard penetration tests were carried out at 0.75 to 1.5 metre depth intervals in the boreholes and samples of the soils encountered were recovered using drive open sampling equipment. As well, where applicable in-situ vane shear tests were carried out in cohesive strata. Groundwater levels were noted in the open borings on completion of the drilling. The field work was supervised throughout by members of our engineering staff.

Logs of the soil and groundwater conditions encountered in each of the borings are shown on the Record of Borehole sheets following the text of this report. The approximate locations of the borings are given on the Site Plans, Figures 2 to 5.

The soil samples recovered from the borings were taken to our laboratory for examination and classification testing. The results of the laboratory testing are given on the Record of Borehole sheets and on Figures 6 and 7.

The borehole locations were determined in the field by Golder Associates Ltd. with reference to survey chainage set by McCormick Rankin along the centreline of the proposed Highway 416 southbound lanes. Ground surface elevations at the borehole locations were determined by McCormick Rankin. The elevations shown are referenced to Geodetic datum.

4.0 SUBSURFACE CONDITIONS

The subsurface stratigraphy encountered in each borehole is shown on the Record of Borehole sheets. The boring logs indicate the subsurface conditions at the test locations only, and boundaries between the subsurface strata shown on the logs are often not distinct but rather are transitional and have been interpreted. Following is a summarized account of the subsurface conditions at each of the three culvert sites along the proposed at-grade Highway 416 southbound lanes.

4.1 Site 1 (Approximate Station 11+780 SBL)

Borehole 90-C1 indicates that this site, under a 300 millimetre topsoil layer, is underlain by some 600 millimetres of loose brown silty sand followed by an extensive deposit of sensitive silty clay. The upper approximately 2 metres of the silty clay at this site has been weathered to a grey-brown fissured crust which has a very stiff consistency as evidenced by standard penetration test N values of 9 to 4 blows per 0.3 metre (decreasing with depth). An Atterberg limit test carried out on a sample of the grey-brown silty clay crust gave a liquid limit value of 38 percent, a plasticity index value of 19 percent, and a corresponding natural water content of about 25 percent (see Figure 6).

Below the weathered crust the colour of the silty clay is grey and the consistency decreases to soft to firm based on in-situ vane shear strength values of about 25 to 30 kilopascals. Borehole 90-C1 was terminated within the grey silty clay at a depth of 5.8 metres below ground surface.

The groundwater level in the open borehole 90-C1 at the time of drilling on May 9, 1990 was at elevation 83.95 metres, or some 3.6 metres below ground surface. The water level in the adjacent drainage course was, at the same time, close to the level of the adjacent ground surface at about elevation 87.0 metres.

4.2 Site 2 (Approximate Station 12+520 SBL)

Boreholes 90-C2 and 90-C3 indicate that this site, under a surface cover of some 0.6 to 1.1 metres of sandy silt fill, is underlain by 200 to 300 millimetres of topsoil followed by (in borehole 90-C3) about 0.6 metres of loose brown silty sand.

Below these surficial deposits the site is underlain by an extensive deposit of sensitive silty clay, the upper 1 to 2 metres of which has been weathered to a grey-brown fissured crust. Standard penetration tests carried out in the grey brown silty clay crust gave N values of 5 to 1 blows per 0.3 metre (decreasing with depth), indicating a generally stiff consistency. A grading analysis carried out on a sample of grey-brown silty clay is shown on Figure 7 and indicates the fine-grained nature of this deposit. The natural water content of the grey-brown silty clay is about 20 percent based on one determination.

Below the weathered crust, the silty clay becomes grey in colour and the consistency decreases to soft to firm. In situ vane tests carried out in the grey silty clay gave shear strength values ranging from about 28 to 42 kilopascals. The natural water content of the grey silty clay ranges from about 40 to 50 percent. Boreholes 90-C2 and 90-C3 were terminated at a depth of 5.2 metres within the grey silty clay.

Groundwater level measurements taken in the open boreholes 90-C2 and 90-C3 at the completion of drilling indicate a groundwater level at about elevation 86.2 to 86.4 metres, or some 0.8 metres below ground surface on May 10, 1990. The water level in the adjacent drainage course was at about the same level on May 10, 1990.

4.3 Site 3 (Approximate Station 14+335 SBL)

Boreholes 90-C8 and 90-C9 indicate that this site is underlain by surficial deposits of topsoil, fine sand to silty sand fill, silty sand, sandy silt, and clayey silt to depths

of about 2.0 to 2.1 metres below ground surface. Standard penetration tests carried out in these surficial deposits indicate relative densities of loose (fill, silty sand) and/or consistencies of stiff (clayey silt).

Below these surficial deposits this site is underlain by an extensive deposit of sensitive silty clay. The upper 0.4 to 1.0 metres of the silty clay at this site has been weathered to a grey-brown fissured crust. Atterberg limit tests carried out on samples of the grey-brown silty clay gave liquid limit values of about 41 to 45 percent and plasticity index values of about 23 to 25 percent (see Figure 6). The corresponding natural water content of the grey-brown silty clay at this site is about 30 to 50 percent.

Below the weathered crust, the colour of the silty clay changes to grey and the consistency decreases to firm based on in-situ vane shear strength values of about 25 kilopascals. Boreholes 90-C8 and 90-C9 were terminated within the grey silty clay at a depth of 5.2 metres below ground surface.

The groundwater level at this site, as measured in the open borings at the time of the investigation on March 15, 1991 ranges from about ground surface to 1.3 metres below ground surface (elevation 86.0 to 86.7 metres). The water level in the adjacent drainage course at the time of the investigation in mid-March 1991 was at about elevation 86.5 metres.

5.0 PROPOSED CONCRETE CULVERTS

5.1 General

This section of the report provides engineering guidelines on the geotechnical aspects of the project based on our interpretation of the borehole information and project requirements. It is stressed that the information in this portion of the report is provided for the guidance of the design engineers only.

Details regarding the size and founding level of the proposed concrete culvert structures at the three sites investigated have not been finalized as of the date of this report. It is understood, however, that present planning calls for closed box non rigid frame type structures similar to the existing structures under Highway 16 adjacent to each site, i.e. approximately 3 metre wide by 2 metre high, 30 to 50 metre long skewed concrete culverts founded near the level of the bottom of the drainage courses.

5.2 Foundations

The significant founding stratum at each of the three culvert sites is the stiff weathered crust of grey brown silty clay and/or the stiff clayey silt (borehole 90-C8). However, since the stiff grey brown silty clay and clayey silt are underlain at relatively shallow depths at each site by soft to firm grey silty clay, allowable bearing pressures for culvert foundation design will be limited by the capacity of the soft grey silty clay to support the load without undergoing excessive settlement. Some consolidation of the soft silty clay may be expected, however, due to the proposed 2 metre high roadway embankment loading. As such, the relatively flexible, low contact pressure, box culverts presently being proposed are considered to be suited for these sites. Either cast in place or precast segmental closed box types would be suitable alternatives.

All surficial fill, topsoil, and loose silty or sandy deposits (as well as any alluvium which may exist in the bed of the drainage courses) should be sub-excavated at the culvert locations to expose undisturbed grey-brown silty clay crust material and/or stiff clayey silt. The closed concrete box culverts should then be founded on a compacted pad of crushed stone, a minimum of 300 millimetres thick and consisting of Ontario Provincial Standard Specification (OPSS) Granular B, Type II compacted in place to at least 95 percent of the maximum standard Proctor dry density value.

Provided the contact pressure of the culvert structures with the grey-brown silty clay/clayey silt subgrade does not exceed about 100 kilopascals under Ultimate Limit State (ULS) conditions and 70 kilopascals under Serviceability Limit State (SLS) Type II conditions, performance should be adequate with settlements unlikely to exceed about 25 millimetres.

If the depth of water/ice within each culvert during the winter months is less than 1.0 metre, or the depth of water plus granular pad thickness is less than 1.8 metres, the silty clay subgrade should be protected from frost action by providing a 50 millimetre thickness of rigid insulation (such as DOW HI-40) beneath the floor of each box culvert.

To prevent scouring, concrete cut-off walls extending at least 1.4 metres below culvert invert level should be provided at both ends of the culverts, in accordance with the Ontario Highway Bridge Design Code (OHBDC). The stem of the cut-off walls should be cast in place without the use of forms.

5.3 Backfill

Backfill to each concrete culvert should be in accordance with the appropriate Ontario Provincial Standard Drawing OPSD-803.01. For normal frost protection, the walls of each culvert should be backfilled a minimum of 1.5 metres horizontally with

non-frost susceptible granular material meeting OPSS Granular B Type I. The granular backfill materials should be placed in maximum 300 millimetre thick loose lifts and compacted to 95 percent of the standard Proctor dry density using suitable vibratory equipment.

Concrete box culverts backfilled with free draining granular material should be designed to resist lateral earth pressures calculated using a coefficient of earth pressure at rest, K_o , of 0.58 (ULS) and 0.50 (SLS) and a total unit weight of 21 kilonewtons per cubic metre. Positive drainage of the granular fill should be provided by weep holes in the walls of the culverts.

5.4 Construction Considerations

Excavation slopes at the culvert locations should be no steeper than 1 horizontal to 1 vertical in order to avoid sloughing of the loose surficial materials into the excavation and potential instability of the excavation slopes.

The silty clay/clayey silt founding material will be sensitive to disturbance from ponded water, construction traffic, and frost. In order to minimize disturbance, construction should be carried out in the dry during the summer months. Water inflow into the excavation areas can be minimized by the construction of earth dykes both upstream and downstream of the construction areas. Water flow could then be handled by either pumping or redirecting the drainage courses around the dyke system. The earth dykes could be constructed of relatively impermeable earth material such as the native silty clay at the site. Care should be taken to remove all soft, loose or disturbed material from the bed of drainage courses prior to placing the dyke material. Seepage water within the dyked area may then be handled by pumping from suitably filtered sumps.

In order to reduce disturbance of the silty clay/clayey silt subgrade, the crushed stone pad should be placed as soon as possible following excavation.

The bearing surfaces for the new culvert structures should be inspected by geotechnical personnel prior to placement of the crushed stone pad in order to confirm that suitable founding material has been reached and properly prepared. Inspection of the placing of the culvert bedding and backfill materials should be carried out to ensure that specifications are met from both a grading and compaction point of view.

Final design drawings for the new culvert structures should be reviewed and accepted by the geotechnical consultant prior to construction.

GOLDER ASSOCIATES LTD.

A handwritten signature in black ink, appearing to read 'R. A. Montgomery', with a large, stylized initial 'R' and a checkmark-like flourish at the end.

R.A. Montgomery, P.Eng.

Principal

RAM:cp:cn

Disk 26

EXPLANATION OF TERMS USED IN REPORT

N VALUE: THE STANDARD PENETRATION TEST (SPT) N VALUE IS THE NUMBER OF BLOWS REQUIRED TO CAUSE A STANDARD 51mm O.D SPLIT BARREL SAMPLER TO PENETRATE 0.3m INTO UNDISTURBED GROUND IN A BOREHOLE WHEN DRIVEN BY A HAMMER WITH A MASS OF 63.5kg, FALLING FREELY A DISTANCE OF 0.76m. FOR PENETRATIONS OF LESS THAN 0.3m N VALUES ARE INDICATED AS THE NUMBER OF BLOWS FOR THE PENETRATION ACHIEVED. AVERAGE N VALUE IS DENOTED THUS \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_l	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^3	SEEPAGE FORCE
γ'	kN/m^3	UNIT WEIGHT OF SUBMERGED SOIL						

METRIC

W P 373-89-01 LOCATION Station 11+760 SBL -9.5 m Rt C/L ORIGINATED BY DWM
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY RAM
DATUM Geodetic DATE May 9, 1990 CHECKED BY RAM

[illegible]

OFFICE REPORT ON SOIL EXPLORATION

+3, x5 : Numbers refer to Sensitivity

20
15 ϕ 5 (%) STRAIN AT FAILURE
10



METRIC

W P 373-89-01 LOCATION Station 12+504 SBL - 8.5m Lt C/L ORIGINATED BY DWM
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY RAM
DATUM Geodetic DATE May 10, 1990 CHECKED BY RAM

[illegible]

OFFICE REPORT ON SOIL EXPLORATION

x^3, x^5 : Numbers refer to Sensitivity

20
15 ϕ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 90-C3

METRIC

W P 373-89-01 LOCATION Station 12+530 SBL - 11.5 Rt C/L ORIGINATED BY DWM
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY RAM
DATUM Geodetic DATE May 10, 1990 CHECKED BY RAM

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										SHEAR STRENGTH kPo			WATER CONTENT (%)		
																		O UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE					
87.2	Ground Surface																						
0.0	Fill, sandy silt some gravel		1	SS	12		87	Water level in open hole at elev. 85.4 metres, May 10, 1990										0 49 39 12					
86.1	Compact Brown		2	SS	12		86																
1.1	Topsoil																						
1.4	Silty clay, some sand seams (weathered crust)	3	SS	5																			
85.0	Stiff Grey brown						85																
2.2	Silty clay, some black organic mottling	4	SS	2			84																
		5	SS	PM			83																
82.0	Soft to firm Grey					82																	
5.2	End of Borehole						81																

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 90-C4

METRIC

W P 373-89-01 LOCATION Station 14+307 SBL - 5 m Rt C/L - CPR Overpass Alignment ORIGINATED BY DWN
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY RAM
DATUM Geodetic DATE May 14, 1990 CHECKED BY RAM

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 ^o VALUES			20	40	60	80	100					
86.9	Ground Surface																
0.0	Topsoil, sandy		1	SS	1												
86.1	Loose Dark brown																
0.8	Silty Sand																
0.9	Loose Brown		2	SS	4												
	Silty clay, some thin sand seams (weathered crust)		3	SS	2												
84.0	Very stiff to stiff Grey brown																
2.9	Silty clay, some fine sand																
83.2	Firm Grey		4	SS	PM												
3.7	End of Borehole																

METRIC

W P 373-89-01 LOCATION Station 14+322 SBL - 3 m Lt C/L - CPR Overpass Alignment ORIGINATED BY DWM
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY RAM
DATUM Geodetic DATE May 15, 1990 CHECKED BY RAM

[illegible]

OFFICE REPORT ON SOIL EXPLORATION



METRIC

W P 373-89-01 LOCATION Station 14+323 NBL - 5 m Lt C/L- CPR Overpass Alignment ORIGINATED BY DWM
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY RAM
DATUM Geodetic DATE May 14, 1990 CHECKED BY RAM

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										SHEAR STRENGTH kPo					WATER CONTENT (%)
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE															
86.8	Ground Surface																GR SA SI CL						
86.5	Topsoil, sandy Very loose Dark brown		1	SS	1		Bentonite																
0.3	Sand, fine to medium																						
86.0	Very loose Grey brown																						
0.8	Silty clay, some fine sand seams (weathered crust)		2	SS	3		86																
								Water level in standpipe at elev. 85.7 metres on July 19, 1990															
				3	SS	1		85															
							Native backfill																
84.0	Stiff Grey brown										+ s=8												
2.8	Silty clay, some fine sand lenses						84				+ s=4												
							Standpipe																
83.1	Firm to soft Grey										+ s=8												
3.7	End of Borehole										+ s=4												
							83																
							82																


+3, x5: Numbers refer to Sensitivity

20
15 ϕ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 90-C7

METRIC

W P 373-89-01 LOCATION Station 14+335 NBL - 1 m Rt C/L - CPR Overpass Alignment ORIGINATED BY DWM
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY RAM
DATUM Geodetic DATE May 15, 1990 CHECKED BY RAM

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										WATER CONTENT (%)		
								SHEAR STRENGTH kPo										20 40 60		
							○ UNCONFINED + FIELD VANE													
							● QUICK TRIAXIAL x LAB VANE													
87.3	Ground Surface																GR SA SI CL			
	Fill, sand, medium, some silt		1	SS	4		87										Water level in open hole at elev. 85.2 metres, May 15, 1990			
			2	SS	3															
85.8	Very loose Grey brown						86													
1.5	Peat, silty, fibrous																			
85.3	Very loose Black		3	SS	4															
2.0	Silty Clay Grey brown																0 37 54 9			
2.3			4	SS	4		85													
	Silty clay, some sand seams																			
83.8	Stiff Grey						84													
3.5	End of Borehole																			
							83													

METRIC

W P 373-89-01 LOCATION Station 14+321 SBL - 13 m Rt c/L CPR At grade Alignment ORIGINATED BY IIC
DIST 9 HWY 417 BOREHOLE TYPE Hollow Steam Auger COMPILED BY RAM
DATUM Geodetic DATE March 15, 1991 CHECKED BY RAM

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 (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100										WATER CONTENT (%)		
								SHEAR STRENGTH kPa										W _p W W _L		
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE												
86.7	Ground Surface																			
86.4	Topsoil Silty Dark Brown						Water	level in open hole at elev.	86.7	metres,	March	15, 1991								
0.3	Silty Sand Brown																			
0.5	Clayey silt and sand		1	SS	3		86						O							
84.6	Stiff Grey Brown		2	SS	1		85													
2.1	Silty clay, some sand (weathered crust)		3	SS	WH		84						10							
83.6	Stiff Grey Brown																			
3.1	Silty clay, some fine sand seams		4	SS	PM		83													
			5	SS	PM															
81.5	Firm Grey		6	SS	PM		82													
5.2	End of Borehole						81													

RECORD OF BOREHOLE No 90-C9

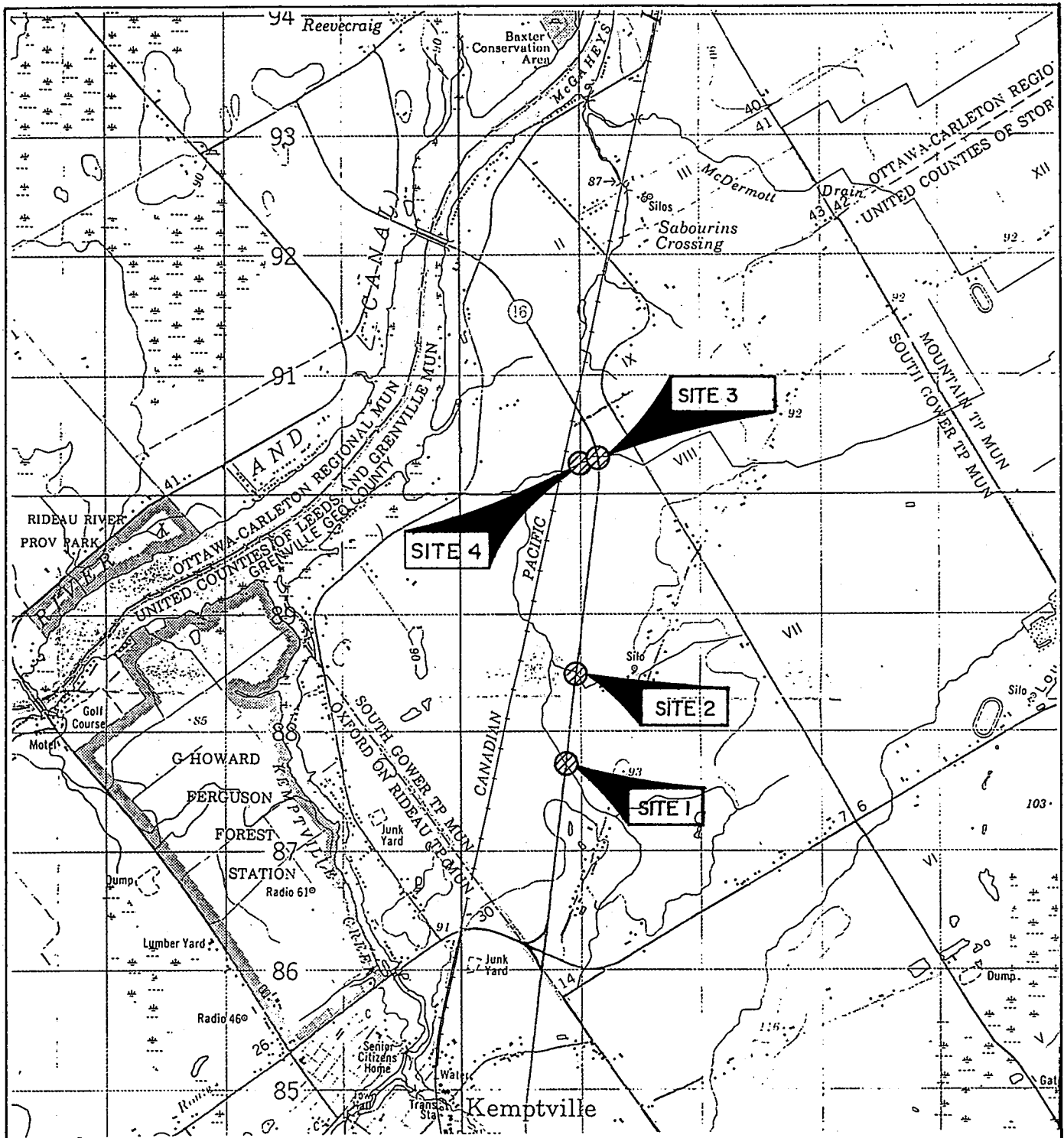
METRIC

W P 373-89-01 LOCATION Satation 14+339 SBL - 9.5m Lt c/L - CPR Overpass Alignment ORIGINATED BY HC
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY RAM
DATUM Geodetic DATE March 15, 1991 CHECKED BY RAM

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 (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	SHEAR STRENGTH kPo					
87.3	Ground Surface													
0.1	Topsoil, Silty Dark Brown													
86.5	Fill, fine sand, some organic material Brown													
0.8	Fill, silty sand, some organic material		1	SS	3									
85.9	Loose Dark Brown		2	SS	6									
1.4	Topsoil, sandy													
85.5	Loose Dark Brown		3	SS	4									
1.8	Sandy silt, some clay Grey													
2.0	Loose													
84.9	Silty clay, with sand (weathered crust)		4	SS	WH									
2.4	Stiff Grey Brown		5	SS	2									
	Silty clay, some sand		6	SS	2									
			7	SS	1									
82.1	Stiff to firm Grey		8	SS	WH									
5.2	End of Borehole													

KEY PLAN

FIGURE 1
WP 373-89-01



SCALE
1:50,000

SPECIAL NOTE
THIS DRAWING IS TO BE READ IN CONJUNCTION
WITH ACCOMPANYING REPORT

Date APRIL 4, 1991
Project 901-2064B-4

Golder Associates

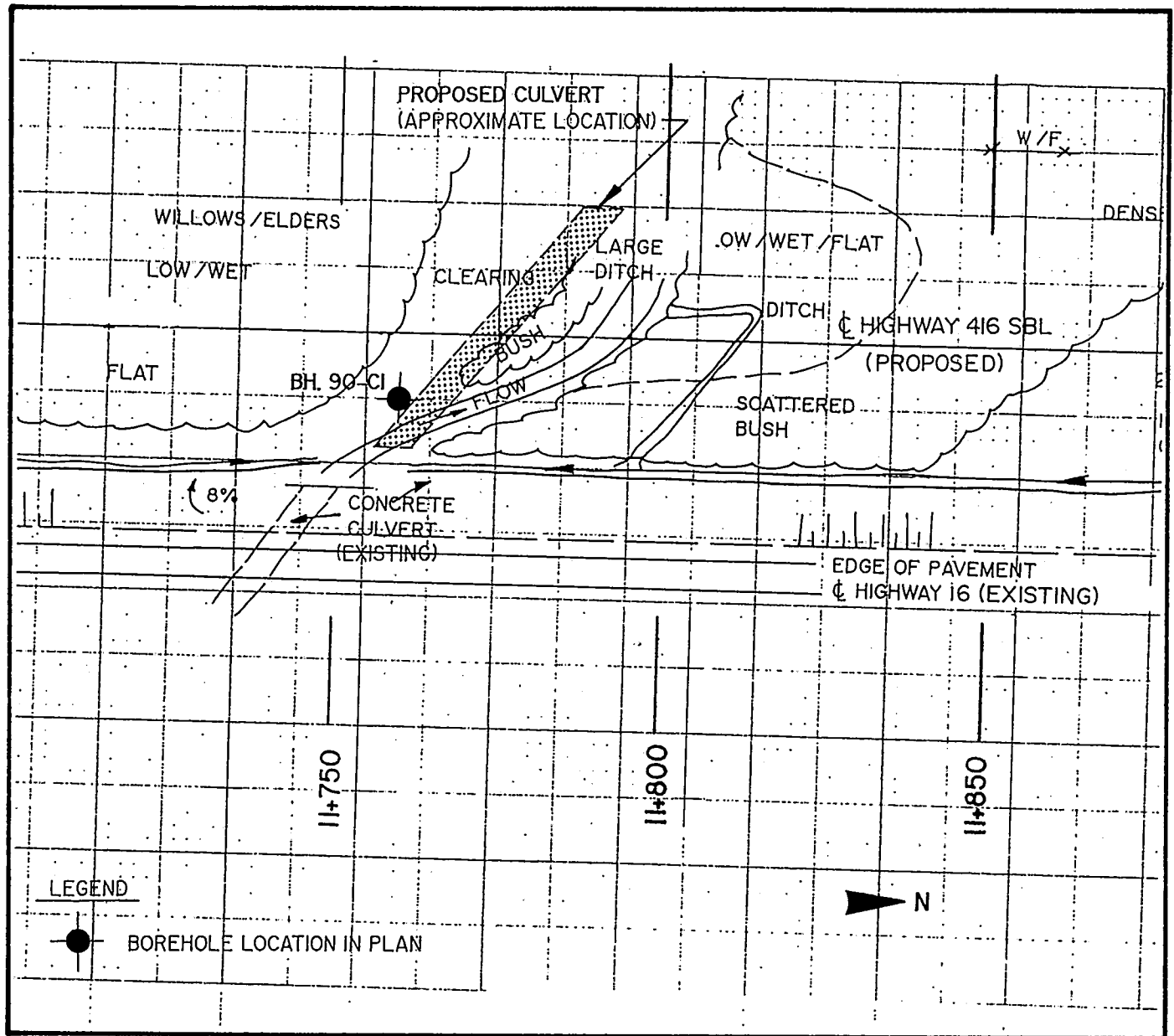
Drawn JC
Chkd. PR

SITE I PLAN

CONCRETE CULVERT - STATION 11+780 SBL (APPROXIMATELY)

FIGURE 2

WP 373-89-01



SCALE
1:1000

SPECIAL NOTE
THIS DRAWING IS TO BE READ IN CONJUNCTION
WITH ACCOMPANYING REPORT

Date APRIL 4, 1991
Project 90I-2064B-4

Golder Associates

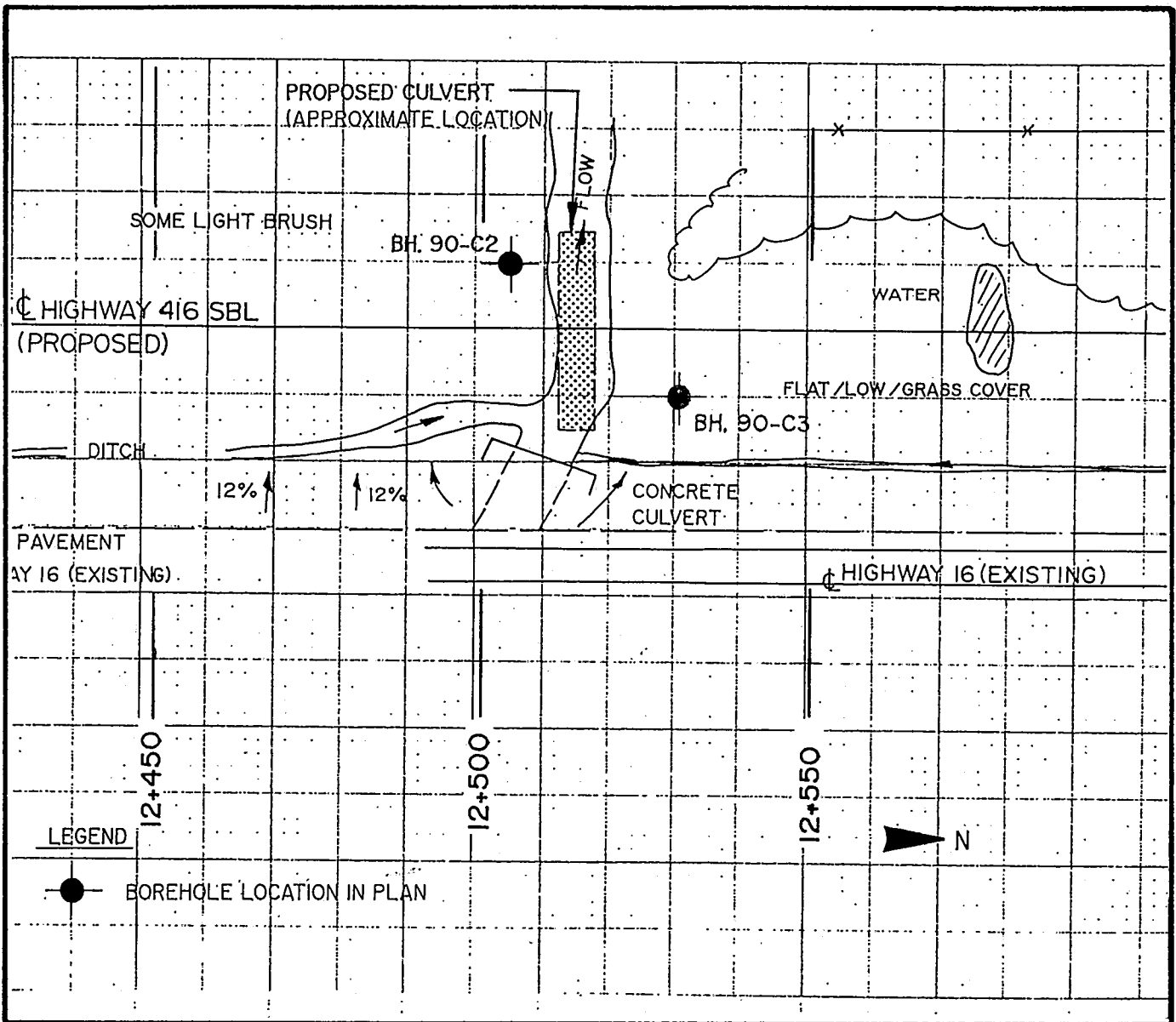
Drawn JC
Chkd. Pay

SITE 2 PLAN

CONCRETE CULVERT - STATION 12+520 SBL (APPROXIMATELY)

FIGURE 3

WP 373-89-01



SCALE
1:1000

SPECIAL NOTE
THIS DRAWING IS TO BE READ IN CONJUNCTION
WITH ACCOMPANYING REPORT

Date APRIL 5, 1991
Project 90I-2064B-4

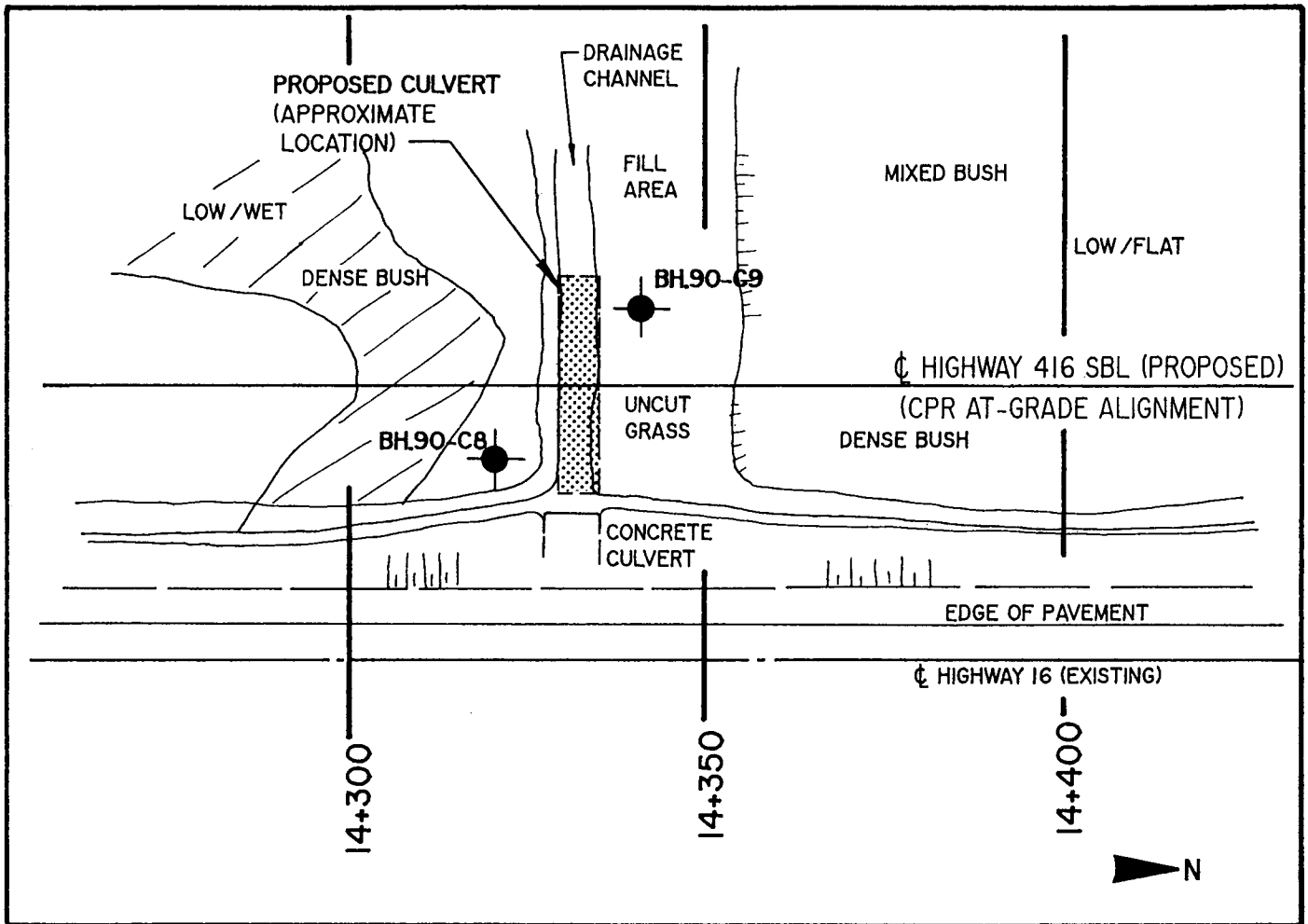
Golder Associates

Drawn JC
Chkd. Per

SITE 3 PLAN

CONCRETE CULVERT - STATION 14+335 (APPROXIMATELY)
(CPR AT GRADE ALIGNMENT)

FIGURE 4
WP 373-89-01



SCALE
1:1000

SPECIAL NOTE
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WITH ACCOMPANYING REPORT

Date APRIL 5, 1991
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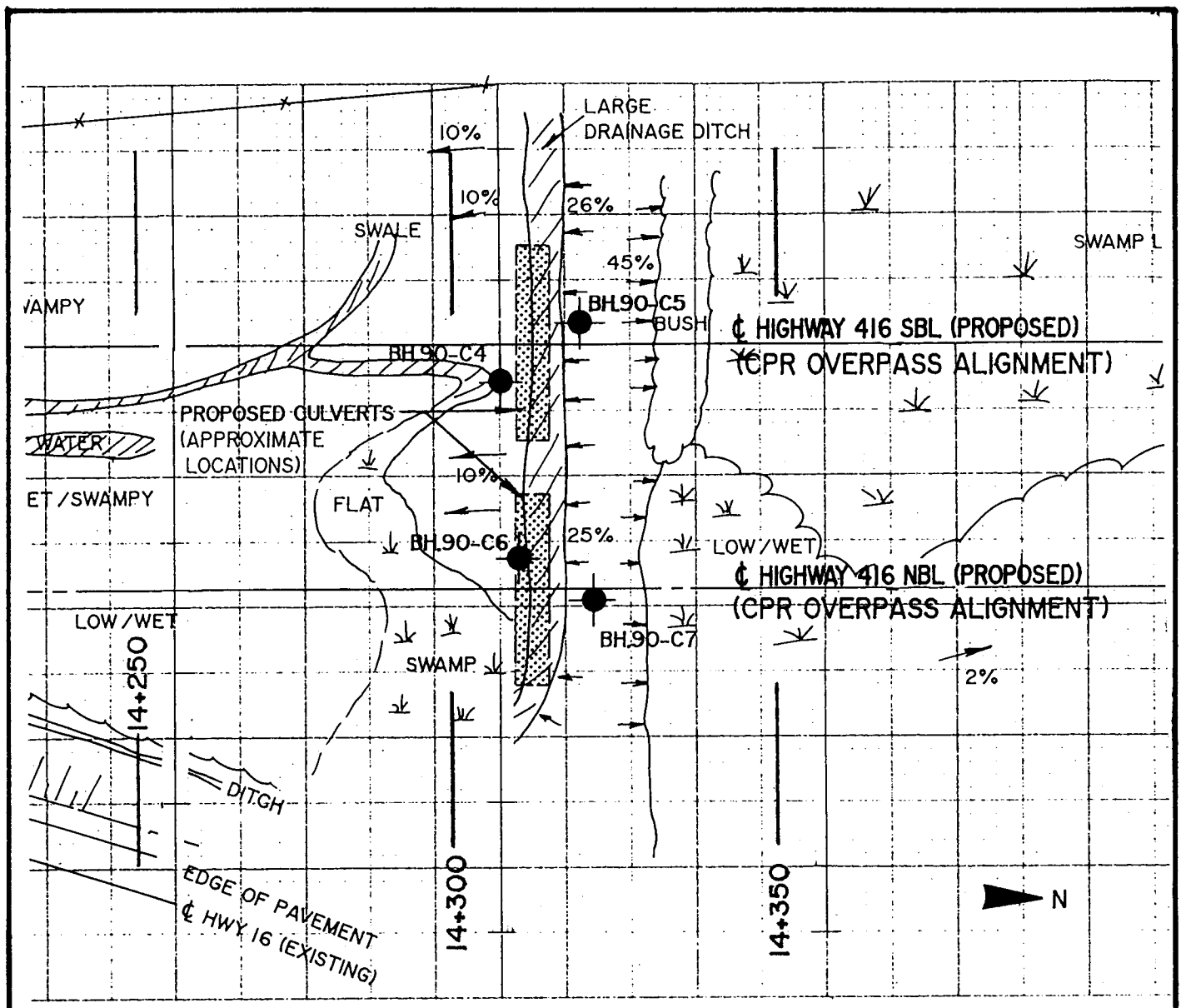
Drawn JC
Chkd. PM

SITE 4 PLAN

CONCRETE CULVERTS - STATION 14+325 SBL & NBL (APPROXIMATELY)
(CPR OVERPASS ALIGNMENT)

FIGURE 5

WP 373-89-01



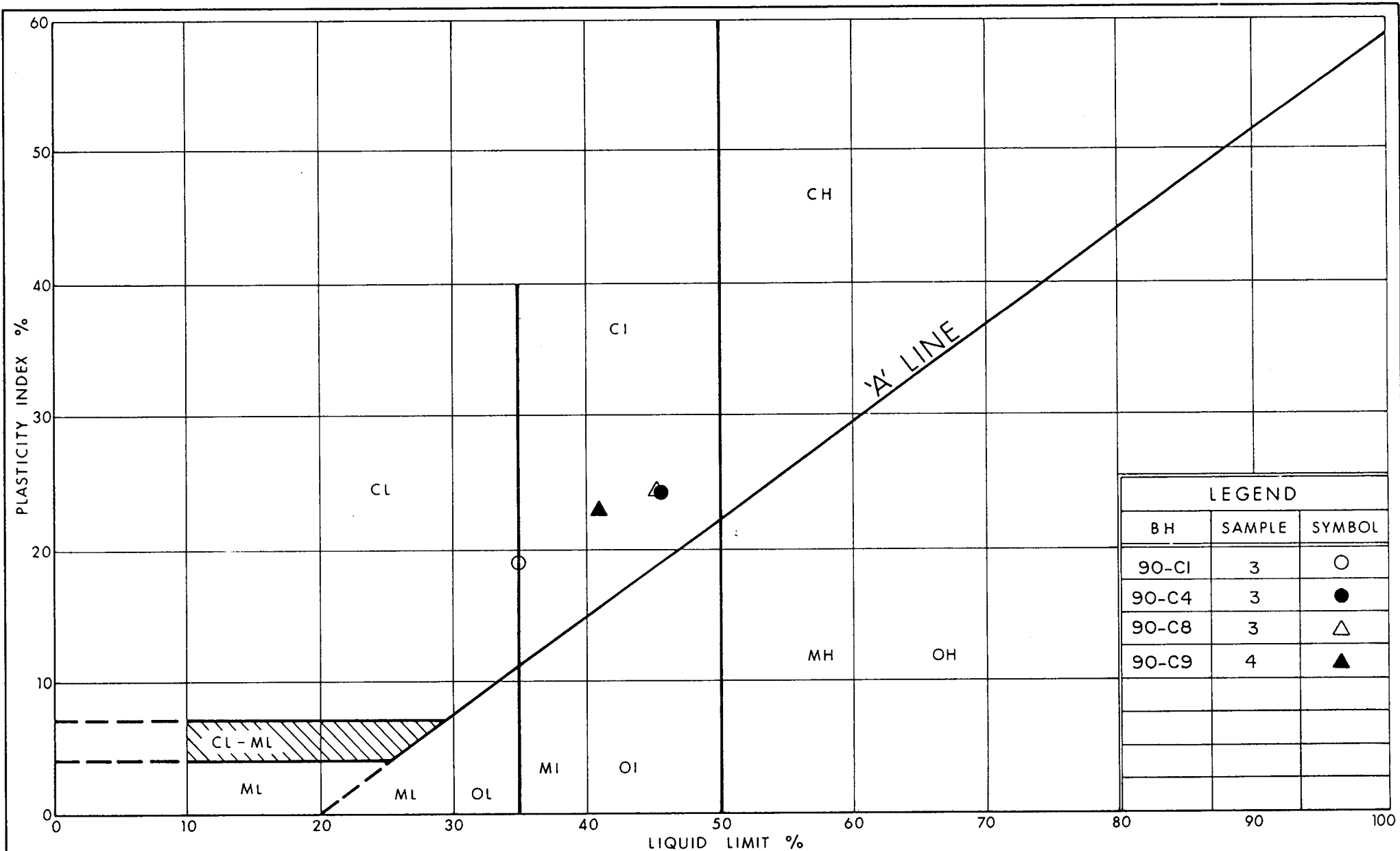
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SPECIAL NOTE
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WITH ACCOMPANYING REPORT

Date APRIL 5, 1991
Project 90I-2064B-4

Golder Associates

Drawn JC
Chkd. *[Signature]*



LEGEND

BH	SAMPLE	SYMBOL
90-C1	3	○
90-C4	3	●
90-C8	3	△
90-C9	4	▲



Ministry of
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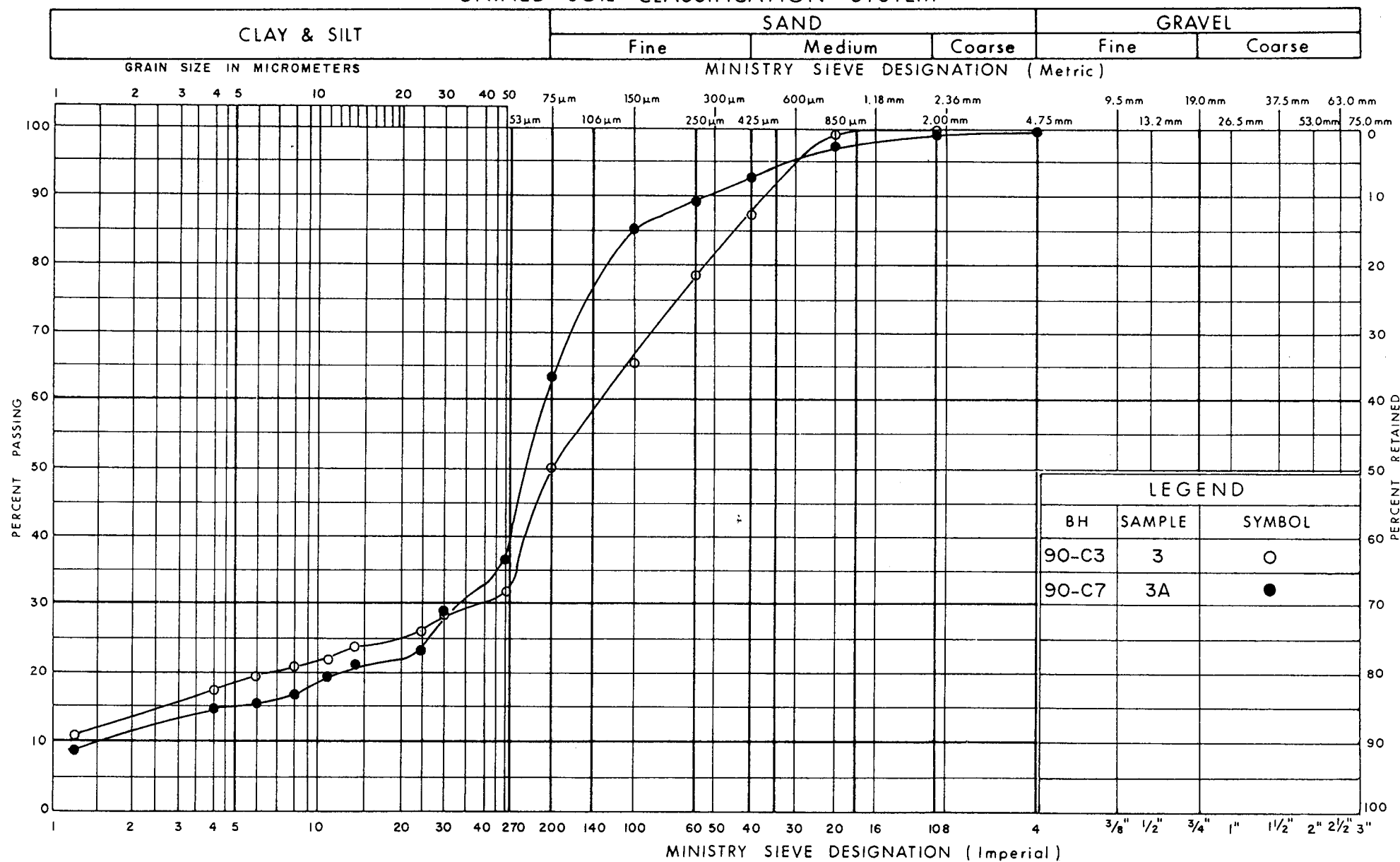
Ontario

PLASTICITY CHART SILTY CLAY

FIG No 6

W P 373-89-01

UNIFIED SOIL CLASSIFICATION SYSTEM



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Ontario

GRAIN SIZE DISTRIBUTION
SILTY CLAY

FIG No 7

W P 373-89-01