ENGINEERING MATERIALS OFFICE
FOUNDATION DESIGN SECTION

GWP 281-99-00 **REGION** Central
HWY QEW **SITE** N/A

High Mast Lighting
QEW and Glendale Avenue Interchange

DISTRIBUTION:
Central Region Highway Engineering (3)
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GEOCRES No: 30M03-224 **Date**: July 11, 2002

Foundation Investigation Report
for
High Mast Lighting
QEW and Glendale Avenue Interchange
QEW Widening between Glendale Avenue and Mountain Road
Regional Municipality of Niagara Falls
GWP 281-99-00

Introduction

This report summarizes the subsurface conditions encountered at the Glendale Avenue Interchange for high mast lighting.

Borehole information obtained from the Pavements and Foundations GeoCres Library was used to determine the representative subsurface conditions at the proposed high mast light pole footing locations.

Site Description

The site is located within the Niagara Escarpment region. The area around Glendale Avenue is generally flat. The QEW southbound follows the rise of the escarpment. The elevation of QEW at Glendale is approximately 116.5. The profile grade of Glendale Avenue at the QEW crossing is approximately El. 123.0.

Physiographically, the site is characterized by an extensive glacio-lacustrine deposit underlain by glacial till and shale bedrock.

Investigation Procedures

The subsurface information was obtained from an investigation carried out for the Glendale Avenue Underpass in 1960 (GeoCres 30M3-78) and a Foundation Investigation Report for high mast lighting prepared under WP 134-92-00 (GeoCres 30M3-211).

Subsurface Conditions

General

The site is underlain by a crust of cohesive very stiff to hard brown silty clay that extends for a depth of 6 to 10 m. The deposit overlies a lower stratum of silty clay that is stiff in consistency. The lower silty clay ranges in thickness from 8 to 13.6 m. It is underlain by a very dense glacial till deposit composed of sand, silt and clay. Shale bedrock is present at a depth of 28m, approximate El. 89.0.

Boreholes were dry upon completion of drilling. However, the groundwater level may be assumed at a depth of 7.5 m.

For the boundaries of the various deposits and field and laboratory test results, refer to the appended Record of Borehole sheets. The original ground elevations shown on the borehole logs may differ from present day elevation as a result of construction. A drawing showing the location of the borings in plan is appended.

Recommendations

The installation of fourteen high mast light poles is proposed within the Glendale Avenue interchange.

The caisson footings for the HML poles should be designed in accordance with the methods described by B.B. Broms in the following papers:

Broms, B.B.; Lateral Resistance of Piles in Cohesive Soils,
Journal of Soil Mechanics and Foundations Division,
ASCE, Vol. 90, No. SM2, Paper 3825, March 1964

Broms, B.B.; Lateral Resistance of Piles in Cohesionless Soils,
Journal of Soil Mechanics and Foundations Division,
ASCE, Vol. 90, No. SM3, Paper 3909, May 1964.

The following parameters are provided for the design of the high mast light pole footings, where:

q_u = unconfined compressive strength
ϕ = apparent angle of internal friction
γ = bulk unit weight; effective unit weight should be used below the water table

HML	BH No.	Soil Type	Elevation	q_u (kN/m^3)	ϕ	γ (kN/m^2)
P1, P2, P3	5 (30M3-78)	Upper Silty Clay Stiff Lower Silty Clay Very Stiff	116.9 - 106.8 106.8 – 98.9	300 130		19.5 19.0
P4, P5, P6, P10, P11	3 (30M3-78)	Upper Silty Clay Very Stiff Lower Silty Clay Stiff	113.4 – 105.6 105.6 – 100.0	220 130		19.5 19.0
P7, P8	6 (30M3-78)	Upper Silty Clay Hard Lower Silty Clay Stiff	118.1 – 109.6 109.6 – 99.2	300 130		19.5 19.0
P9, P12, P13, P14	5 (WP 134-92-00)	Non-cohesive Fill Compact Upper Silty Clay Very Stiff Lower Silty Clay Stiff	117.7 – 117.1 117.1 – 109.1 109.1 – 108.1	- 220 130	30° - -	22.0

Ground elevations obtained from the existing borehole data may differ from present elevations. In many cases, additional fill has been placed for the existing structure and roadway. A non-cohesive fill material may be assumed at these locations having an internal friction angle of 25° and a unit weight of 20 kN/m^3.

For proposed fill, the following design parameters should be used, taking into consideration that only 60% if the proposed fill height will provide lateral support, $\phi = 30°$, $\gamma = 20$ kN/m^3. Any organic or soft material should be removed within the plan limits of the fill before placing. The fill should consist of acceptable earth, free of organic material. It should be placed and compacted as per MTO standard.

It should be assumed that soil in the zone of frost penetration does not provide any lateral resistance. The depth of frost penetration at this site is 1.2m.

For proposed fill, the following design parameters should be used, taking into consideration that only 60% if the proposed fill height will provide lateral support, $\phi = 30^{\circ}$, $\gamma = 20$ kN/m^3. Any organic or soft material should be removed within the plan limits of the fill before placing. The fill should consist of acceptable earth, free of organic material. It should be placed and compacted as per MTO standard.

It should be assumed that soil in the zone of frost penetration does not provide any lateral resistance. The depth of frost penetration at this site is 1.2m.

For HML poles placed on or near slopes, the calculation of lateral resistance should be reduced as per Figure 1.

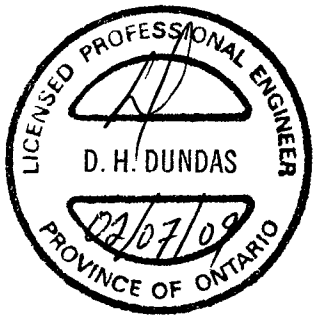
Groundwater levels were not established in the representative borings. It should be assumed that the water table is present at a depth of 7.5m.

Reference should be made to Special Provision 631S01 – Construction Specification for Concrete Footings for High Mast Light Poles.

Miscellaneous

The report was prepared by B. Bennett, Foundation Engineer, Pavements and Foundations Section. The report was reviewed and approved by D. Dundas, Senior Foundation Engineer.

Betty Bennett, P.Eng.
Foundation Engineer



David Dundas, P.Eng.
Sr. 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 63.5kg, 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 (R Q D), 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

STRESS AND STRAIN

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

MECHANICAL PROPERTIES OF SOIL

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

PHYSICAL PROPERTIES OF SOIL

ρ_s	kg/m^3	DENSITY OF SOLID PARTICLES
γ_s	kN/m^3	UNIT WEIGHT OF SOLID PARTICLES
ρ_w	kg/m^3	DENSITY OF WATER
γ_w	kN/m^3	UNIT WEIGHT OF WATER
ρ	kg/m^3	DENSITY OF SOIL
γ	kN/m^3	UNIT WEIGHT OF SOIL
ρ_d	kg/m^3	DENSITY OF DRY SOIL
γ_d	kN/m^3	UNIT WEIGHT OF DRY SOIL
ρ_{sat}	kg/m^3	DENSITY OF SATURATED SOIL
γ_{sat}	kN/m^3	UNIT WEIGHT OF SATURATED SOIL
ρ'	kg/m^3	DENSITY OF SUBMERGED SOIL
γ'	kN/m^3	UNIT WEIGHT OF SUBMERGED SOIL

e	1,%	VOID RATIO
n	1,%	POROSITY
w	1,%	WATER CONTENT
S_r	%	DEGREE OF SATURATION
w_L	%	LIQUID LIMIT
w_P	%	PLASTIC LIMIT
w_S	%	SHRINKAGE LIMIT
I_P	%	PLASTICITY INDEX = $w_L - w_P$
I_L	1	LIQUIDITY INDEX = $\frac{w - w_P}{I_P}$
I_C	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_P}$
e_{max}	1,%	VOID RATIO IN LOOSEST STATE

e_{min}	1,%	VOID RATIO IN DENSEST STATE
I_D	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
D	mm	GRAIN DIAMETER
D_n	mm	n PERCENT - DIAMETER
C_U	1	UNIFORMITY COEFFICIENT
h	m	HYDRAULIC HEAD OR POTENTIAL
q	m^3/s	RATE OF DISCHARGE
v	m/s	DISCHARGE VELOCITY
i	1	HYDRAULIC GRADIENT
k	m/s	HYDRAULIC CONDUCTIVITY
j	kN/m^3	SEEPAGE FORCE

Geocres No: 30M3-211

Borehole #: 5

Project No: TG98050

W.P. No 134-92-00

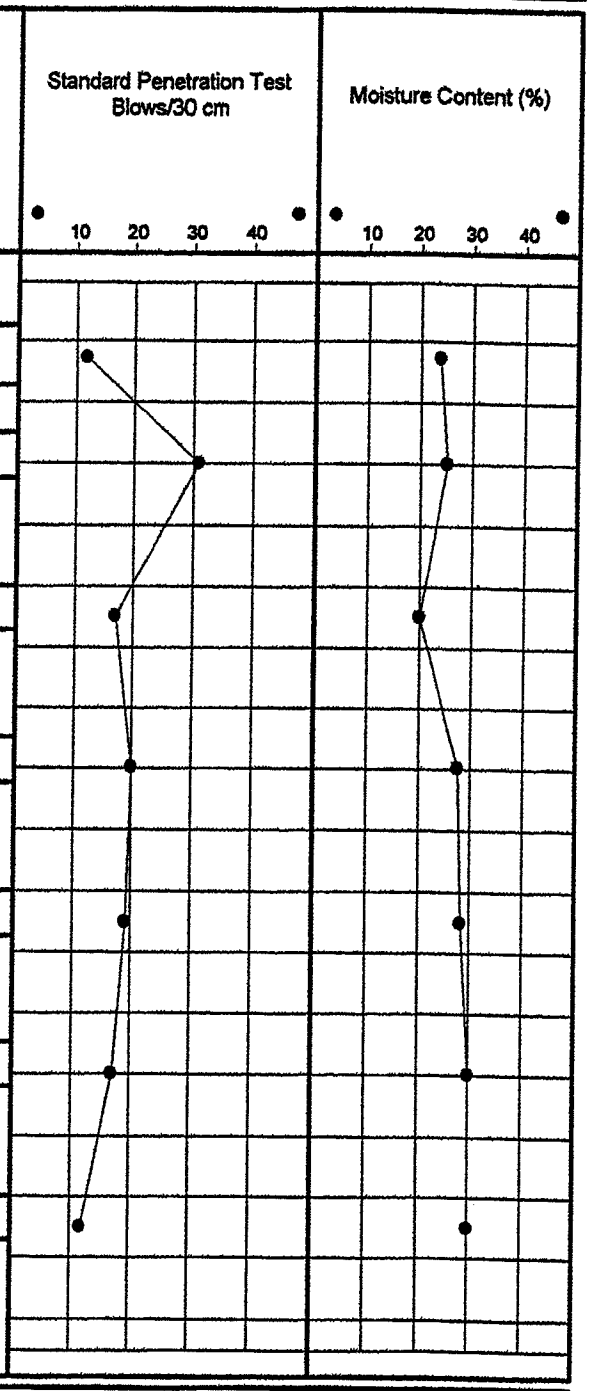
Coordinates: N 4 779 515, E 332 113

Client: Marshall Macklin Monaghan

Location: QEW/405, Niagara-On-The-Lake

Prepared By: M. Leitch

Depth (m)	Description	Elevation (m)	Number	Type	Blows/30 cm
0	Ground Surface	117.7			
	FILL 14 cm Asphalt over 46 cm Crushed Limestone.	117.1			
1			1	SS	12
2			2	SS	31
3			3	SS	17
4	***CLAY*** Brown changing to grey at 9.1 m, fissured, laminated, traces of gravel, some silt pockets, sdtpl to swtpl, hard to stiff, Wl=51.6%, Wp=22.1%, Ip=29.5%.		4	SS	20
5			5	SS	19
6			6	SS	17
7			7	SS	12
8		108.1			
9					
10	Borehole Terminated				



Drilled by: Elite Drilling

Drill Method: Solid Stem Augers

Upon Completion: Borehole dry and open.

AGRA Earth and Environmental
3300 Merrittville Hwy. Unit #5
Thorold, Ontario
L2V 4Y6

Hole Size: 150 mm

Datum: Local Geodetic

Drill Date: 98 03 25

OFFICE REPORT ON SOIL EXPLORATION

Geocres No: 30M3-78

DEPARTMENT OF HIGHWAYS - ONTARIO

MATERIALS AND RESEARCH SECTION

W.P. 254-60-1 — BORE HOLE NO. 3

JOB 60-F-74 — STATION 318+45 (150' Rt)

DATUM 372.0' — COMPILED BY B.K.

BORING DATE Aug. 15/60 — CHECKED BY V.K.

2" DIA. SPLIT TUBE
2" SHELBY TUBE
2" SPLIT TUBE
2" DIA. CONE
2" SHELBY
CASING

LEGEND

1/2 UNCONFINED COMPRESSION (Qu)
VANE TEST (C) AND SENSITIVITY (S)
NATURAL MOISTURE AND LIQUIDITY INDEX
LIQUID LIMIT
PLASTIC LIMIT

SYMBOL	DESCRIPTION		ELEV. FEET	DEPTH FEET
	↓ Groundlevel	113.4	372.0	0
		0.3		
	Hard brown grey silty clay			10
				20
		125.6	346.5	
		7.8		
	Medium to stiff grey silty clay			30
				40
		100.0	328.0	
	Dense silty, sandy clay till	44.8	327.5	
	End of borehole			

STRENGTH AND PENETRATION RESISTANCE

P.S.F. 500 1000 1500 2000

BLOWS/FT. 25 50 75 100

Penetration ends @ elev. 351.0'

2.4

2.5

50 for 6"

CONSISTENCY

MOIST. CONTENT - % DRY WT. 15 30 45

SAMPLE	NATURAL UNIT WT. P.C.F.
S1	125
S2	-
S3	-
S4	-
T5	122
S6	-
T7	121
T8	132

Penetration resistance profile shown; obtained by driving a 2" dia cone from groundlevel to depth noted with an energy of 350 ft.lb. per

OFFICE REPORT ON SOIL EXPLORATION

Geocres No: 30M3-78

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS AND RESEARCH SECTION

W.P. 254-60-1 BORE HOLE NO. 5

JOB 60-F-74 STATION 318+05 (54' Lt)

DATUM 383.5' COMPILED BY B.K.

BORING DATE Aug. 24/60 CHECKED BY V.K.

2" DIA. SPLIT TUBE
2" SHELBY TUBE
2" SPLIT TUBE
2" DIA. CONE
2" SHELBY
CASING

LEGEND

½ UNCONFINED COMPRESSION (Qu) O
VANE TEST (C) AND SENSITIVITY (S) +S
NATURAL MOISTURE AND LIQUIDITY INDEX X
LIQUID LIMIT
PLASTIC LIMIT

SYMBOL	DESCRIPTION		ELEV. FEET	DEPTH FEET
	↓ Groundlevel	116.9	383.5	0
		0.0		
	Hard brown grey silty clay			
		106.8	350.5	
		10.1		
	Medium to stiff grey silty clay			
		98.9	324.5	
		18.0		
	Dense brown grey silty, sandy clay till			
		88.7	291.0	
		28.2		
	Bedrock (Queenston shale)	87.2	286.0	
	End of borehole	29.7		

STRENGTH AND PENETRATION RESISTANCE — P.S.F. 500 1000 1500 2000 — BLOWS/FT. 25 50 75 100

0 10 20 30 40 50 60 70 80 90 100

75 for 3"
45 for 6"
82 for 11"
50 for 6"

CONSISTENCY — MOIST. CONTENT - % DRY WT. 15 30 45

SAMPLE	NATURAL UNIT WT. P.C.F.
S1	123
S2	-
S3	-
S4	118
S5	-
S6	-
S7	-
S8	-
T9	118
T10	130
S11	-
S12	-
S13	-
S14	-
RC15	-

Geocres No: 30M3-78

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS AND RESEARCH SECTION

W.P. 254-60-1 BORE HOLE NO. 6

JOB 60-F-74 STATION 318/85 (62'Lt)

DATUM 387.5' COMPILED BY B.K.

BORING DATE Aug. 30/60 CHECKED BY V.K.

2" DIA. SPLIT TUBE
2" SHELBY TUBE
2" SPLIT TUBE
2" DIA. CONE
2" SHELBY
CASING

LEGEND

½ UNCONFINED COMPRESSION (Qu) — Q
VANE TEST (C) AND SENSITIVITY (S) — $+^S$
NATURAL MOISTURE AND LIQUIDITY INDEX — LI, X
LIQUID LIMIT — —O
PLASTIC LIMIT — |—

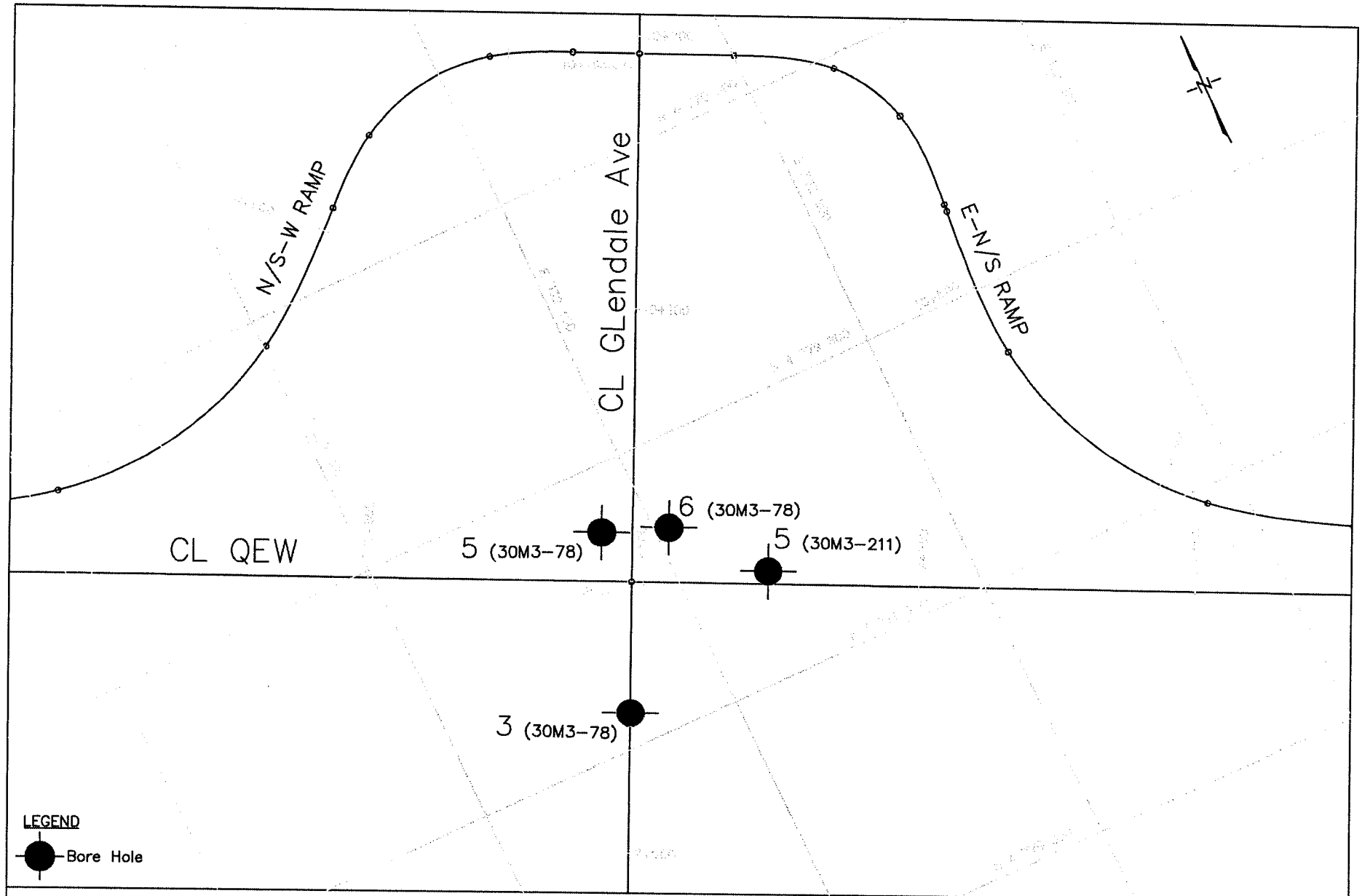
SYMBOL	DESCRIPTION	ELEV. FEET	DEPTH FEET
	↓ Groundlevel	387.5	0
	118.1 / 0.0		
	Hard brown grey silty clay		10
			20
	109.6 / 8.5	359.5	30
	Medium to stiff grey silty clay		40
			50
			60
	99.2 / 18.9	325.5	70
	Dense brown grey silty, sandy clay till		

STRENGTH AND PENETRATION RESISTANCE — P.S.F. — 500 1000 1500 2000 — BLOWS/FT. — 25 50 75 100

CONSISTENCY — MOIST. CONTENT - % DRY WT. — 15 30 45

SAMPLE	NATURAL UNIT WT. P.C.F.
S1	126
S2	-
S3	-
S4	-
T5	121
T6	120
T7	128
S8	-

3 for 4"
68 for 6"



PLAN

SCALE

25m 0 25m

NOTE
FOR SUBSOIL INFORMATION REFER TO RECORD OF BOREHOLE SHEETS

Borehole Locations
High Mast Lighting
QEW and Glendale Avenue Interchange
Geocres No: 30M03-224 GWP 281-99-00