

OAKVILLE-HAMILTON SECTION
ENGINEERING MATERIALS OFFICE
FOUNDATION DESIGN SECTION

WO 82-26025 DIST 4
HWY GO-ALRT STR SITE

Oakville Project - West Extension
- Oakville Creek Bridge
- Oakville Creek Elevated Section
- Oakville Creek West Bridge

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FOUNDATION INVESTIGATION REPORT

FOR

W.O. 82-26025

District 4, Hamilton

GO-ALRT, West Extension, Oakville Project

- Oakville Creek Bridge
- Oakville Creek Elevated Section - Special Structure
- Oakville Creek West Bridge

INTRODUCTION

This report summarizes the results of the foundation investigation for the proposed structures.

The fieldwork was conducted during the period from 83 11 18 to 83 12 12 utilizing a continuous flight auger machine equipped with hollow-stem and solid-stem augers and a BXL core barrel, and a modified diamond drill equipped with NX and BX casings and a BXL core barrel.

This work consisted of:

- 12 dynamic cone penetration tests/sampled boreholes/rock cores,
- 3 test pits.

SITE DESCRIPTION

This site is located at Oakville Creek in the Town of Oakville, approximately 650 m south of the QEW. The GO-ALRT alignment is on the existing Ontario Hydro right-of-way, with the CNR to the south.

The area is described physiographically by Chapman and Putnam (1969) as the South Slope, which, in the vicinity of the site, consists generally of a shale plain overlain by a veneer of glacial drift. These soils have originated, to a large extent, from the underlying bedrock, although some imported glacial material is also present.

Topographically, this site consists of a flat plain, dissected by the valley of Oakville Creek. The valley is approximately 170 m wide and 25 m deep. It crosses the site with a N-S orientation at Oakville Creek Bridge and also encroaches on the north side of the GO-ALRT alignment at Oakville Creek West Bridge. At Oakville Creek Bridge, the existing valley slopes are approximately 1.6 horizontal to 1 vertical. At Oakville Creek West Bridge, the existing south bank slopes at approximately 1 horizontal to 1 vertical.

The land use in the area is institutional / commercial / residential.

SUBSURFACE CONDITIONS

General

The Record of Borehole Sheets, (Appendix) illustrate the conditions at the borehole locations. Detailed logs for the test pits are also included in the Appendix. The locations and elevations of the boreholes, and stratigraphical profiles based on the borehole data, are shown on the Borehole Locations & Soil Strata Drawing for Oakville Creek and Oakville Creek West.

Outside the Oakville Creek Valley, 1.5 to 3.7 m of stiff to hard silty clay overlies the sedimentary bedrock at the borehole locations. At the east bank, the bedrock is Georgian Bay Formation shale containing limestone layers up to 30 cm thick - the upper 1.5 ± m being weathered. At the west bank and along the south bank slope of Oakville Creek, the Queenston Formation shale grades into the Georgian Bay Formation at 97 ± m. Here, the weathered bedrock zone varies from 0.7 to 3.7 m at the borehole locations. However, the weathered bedrock is generally 1.5 ± m thick.

Along valley slopes, the overburden cover is:

- 1.5 ± m at Oakville Creek,
- 1.0 ± m at Oakville Creek West, south bank slope.

Within Oakville Creek Valley, the overburden material is variable (fill, alluvium, till), although for the most part cohesive. In the previous and existing stream channels, the overburden is composed of a large proportion of boulders, and limestone slabs up to 0.5 m in thickness. These conditions will affect Oakville Creek Bridge Piers 3, 4, and 5. The overburden thickness at the proposed pier locations ranges from 4.4 to 13.0 m. The bedrock is Georgian Bay Formation shale containing occasional limestone layers. Upstream of the proposed GO-ALRT alignment, Oakville Creek has been realigned from its previous course along the east bank of the valley, to its present course through the central-west part of the valley. Cross Avenue has been constructed on a fill along the east bank of the valley.

Overburden

SILTY CLAY (CL to CI)

This firm to hard material is cohesive.

It contains occasional shaly layers, traces to with sand, and traces to with gravel.

The material within Oakville Creek valley, much of which is fill, is more variable (with higher sand and gravel contents) than the material outside the valley.

At the borehole locations, the thickness of this material varies from:

- 1.5 to 3.7 m outside the valley,
- 3.5 to 4.4 m within the valley.

Outside the valley, this material extends from the ground surface to the bedrock surface except at BH #59 where it is overlain by 1.1 m of silty sand. Within the creek valley, conditions are more variable (refer to Record of Borehole Sheets).

Physical properties of the material, as determined from field and laboratory tests, are summarized as follows:

	<u>Range</u>	<u>Average</u>	<u>Median</u>
Natural Moisture Content (w)	4.5 - 23.0 %	11.9 %	13.8 %
Liquid Limit (W_L)	22.0 - 41.5 %	27.5 %	26.8 %
Plastic Limit (W_p)	13.5 - 19.5 %	15.9 %	15.5 %

Figure 1 illustrates a typical grain size distribution for this material.

SILTY SAND

This compact to dense material is non-cohesive.

It contains traces of clay and gravel and occasional lenses of silty clay.

This material was encountered within Oakville Creek valley at BH #48 where it extends from the surface to a depth of 1.4 m. Outside the creek valley, silty sand was encountered in a 0.15 m thick layer at elev. 101.2 ± at BH #56, and from the surface to a depth of 1.1 m at BH #59.

HETEROGENEOUS MIXTURE

This very dense material is composed of boulders, cobbles, gravel, sand, silt and clay. It is predominantly non-cohesive, with cohesive material in the spaces between the coarser particles.

This material was encountered at the present and previous creek channels. At BH #50 it extends from the creek bottom for a depth of 6.7 m. At BH #51, 1.4 m (thickness) of this material was encountered below 3.5 m of silty clay. At BH #48, 5.2 m (thickness) of this material was encountered at a depth of 5.8 m below the surface. At all these locations, the bouldery material directly overlies the bedrock.

Physical properties of the cohesive components of this material, as determined from field and laboratory tests, are summarized as follows:

	<u>Range</u>	<u>Average</u>	<u>Median</u>
Natural Moisture Content (w)	7.5 - 11.0 %	9.1 %	9.0 %
Liquid Limit (W_L)	20.5 - 23.5 %	22.3 %	22.5 %
Plastic Limit (W_p)	14.5 - 17.5 %	15.5 %	15.0 %

Figure 2 illustrates a typical grain size distribution for this material.

Bedrock

This site is underlain by bedrock of the Queenston and Georgian Bay (formerly Meaford Dundas) Formations. The Queenston Formation is present only in the vicinity of Boreholes 53 to 59 on the plateau to the west of the Oakville Creek. This formation consists predominantly of red shale containing occasional (approximately 5%) green shale and siltstone layers. Boreholes indicate that the Queenston shale at this site is extensively weathered (see Borehole logs). This is due to its shallow depth and proximity to the west and south slopes of the Oakville Creek, which have given rise to stress relief and weathering in this formation.

The contact between the Queenston and Georgian Bay Formations is a transitional zone consisting of alternating red and green shales. The exact depth of the contact is consequently difficult to define, but occurs between 4.7 and 6.7 m below ground surface in Boreholes 53 to 59.

The Georgian Bay Formation underlies the whole site, and consists of near-horizontally bedded green grey shale generally containing approximately 15 to 20% limestone layers ranging in thickness from approximately 10 to 300 mm. Boreholes 48, 50 and 51 in the river valley indicate the presence of a local higher concentration of limestone layers. The upper bedrock is weathered to varying degrees (see borehole logs). The sound bedrock is generally very thin to thin bedded intersected by occasional very widely spaced vertical joints (natural discontinuities). Unconfined compressive strength tests were undertaken on Georgian Bay shale samples from Boreholes 56 and 57 (see Tables 2 and 3 and Figures 3, 4, and 5). These strengths ranged from 6.6 to 14.6 MPa with an average of 10.8 MPa. The interbedded limestone layers are considerably stronger than the shale and are estimated to be of high strength (50 - 200 MPa).

Refer to Table 1 (Appendix) for descriptions of the rock core that was recovered at this site.

Groundwater

Stabilized groundwater conditions were difficult to establish because of the impermeable nature of the overburden and the generally intact nature of the bedrock. At the time of the field investigation, the groundwater elevation was estimated at elevation 99 ± m at the east bank; between the surface and elevation 77.5 ± m (creek level) in Oakville Creek Valley; at elevation 102 ± m at the west bank and west along the GO-ALRT alignment towards Kerr Street. Slight fluctuations in this level are expected to occur seasonally.

DISCUSSION AND RECOMMENDATIONS

It is proposed to construct a 5-span bridge to carry the proposed GO-ALRT over Oakville Creek at a grade of $107.5 \pm$ m.

General Recommendations (Applicable to all proposed structures)

- Earth pressure acting on abutments and retaining walls should be computed as per Subsection 6.6.1.2.2 of the O.H.B.D.C. assuming a non-yielding foundation with $K_o = 0.43$ and $\gamma = 22.0 \text{ kN/m}^3$ for Granular A backfill; $K_o = 0.5$ and $\gamma = 21.2 \text{ kN/m}^3$ for Granular C backfill.
- For frost protection, cover should be greater than 1.2 m.
- The minimum cover required for scour protection should be determined from hydrological data.
- No stability problems are anticipated for embankments or cuts with slopes of 2:1 or flatter. If steeper slopes are required please contact this Section for recommended slope angles and erosion protection.
- The existing valley slopes at Oakville Creek Bridge are acceptable provided that any disturbance during construction is restored and erosion protection is provided. However, at Oakville Creek West Bridge, active undercutting and erosion is occurring. At this location, suitable protection should be provided to control erosion. As a minimum requirement, it is recommended that erosion protection be provided for at least 10 m on each side of the centre line of Pier 2 (Sta.10 + 648 \pm) and Pier 3 (Sta.10 + 690 \pm).
- Differential settlements in the structures will be negligible.
- Outside of the valley and on the valley slopes, dewatering is not anticipated to be a major problem because of the impermeable nature of the overburden and the generally intact nature of the bedrock. In most cases, it is believed that groundwater entering excavations can be controlled by conventional pumping techniques. However, due to the variable nature of the sediments within the valley, a dewatering scheme will be required if piers are to be constructed in the dry.

- Excavations in bedrock may be accomplished without blasting techniques although the limestone layers (up to 30 cm thick) in the Georgian Bay Formation will present some difficulties.
- At all spread footing locations, all soft or loose material should be removed, and the foundation surface should be covered, within 12 hours of exposure, with a 15 cm pad of mass concrete. Where trenches (e.g. underground utilities) are encountered within the footing areas, they should be excavated to bedrock and backfilled, within 12 hours of exposure, with mass concrete.
- For resistance to lateral forces for footings on bedrock;
 - a) key footing into bedrock a minimum of 0.5 m and use a friction coefficient of 0.25 between the bedrock and the footing,
 - or b) dowel into sound bedrock a minimum of 1.5 m (as a design example a 5 cm diameter dowel installed as recommended will provide a safe shearing resistance of approximately 20 kN per dowel).
- For resistance to lateral forces for footings on overburden;
 - a) on heterogeneous mixture of boulders, cobbles, gravel, sand, silt and clay (proposed Oakville Creek Bridge Piers 4 and 5), use a friction coefficient of 0.5,
 - b) on silty clay with occasional shaly layers (proposed Oakville Creek Elevated Section - Special Structure piers at Sta. 10 + 549 ± and at Sta. 10 + 579 ±) use a friction coefficient of 0.25.

Design Details

Five foundation proposals have been recommended at various pier locations at this site;

- i) spread footings in Zone 1
- ii) spread footings in Zone 2
- iii) spread footings in Zone 3
- iv) steel H-piles (310x110) equipped with reinforced tips and driven to bedrock
- v) concrete caissons in Zone 3

Design details for these foundation proposals are provided below, followed by specific design details for each proposed pier location. The proposals which lead to the least expensive design should be adopted.

SPREAD FOOTINGS (PROPOSALS i, ii, iii)

For the spread footing proposals, the following design values are recommended for foundations within the indicated zones;

- net safe bearing pressure
 - for Zone 1 = 400 kPa
 - for Zone 2 = 670 kPa
 - for Zone 3 = 1000 kPa

and for the purposes of the O.H.B.D.C.;

- Factored Bearing Capacity at U.L.S.
 - for Zone 1 = 600 kPa
 - for Zone 2 = 1000 kPa
 - for Zone 3 = 1500 kPa
- Bearing Capacity at S.L.S. Type II
 - for Zone 1 = 400 kPa
 - for Zone 2 will not govern design
 - for Zone 3 will not govern design

STEEL H - PILES (PROPOSAL iv)

For 310x110 steel H-piles equipped with reinforced tips in accordance with structural standard DD-3301, and driven to bedrock, the following design values are recommended;

- safe capacity = 1150 kN

and for the purposes of the O.H.B.D.C.;

- Factored Capacity at U.L.S. = 1600 kN
- Capacity at S.L.S. Type II = 1150 kN

The load on the pile should at no time exceed 1150 kN.

CONCRETE CAISSONS (PROPOSAL v)

For 1 m diameter concrete caissons founded as recommended on sound bedrock the following design values are recommended;

- safe capacity = 5.0 MN

and for the purposes of the O.H.B.D.C.;

- Factored Capacity at U.L.S. = 7.5 MN
- Capacity at S.L.S. Type II = 5.0 MN

The load on the caisson should at no time exceed 5.0 MN.

Larger capacities are possible for caissons with diameters larger than 1.0 m.

Specific Design Details

Refer to the Bore Hole Locations and Soil Strata drawings and the Record of Borehole Sheets for subsurface conditions at the proposed pier locations.

OAKVILLE CREEK BRIDGE

It is recommended that consideration be given to altering the spans of Oakville Creek Bridge to avoid anticipated difficulties associated with construction for proposed Piers 1 and 6 on the valley slopes and proposed Pier 4 in the creek.

PIER 1, STA. 10 + 370 ±

Pier 1 should be founded on a spread footing on sound bedrock with the entire footing located within Zone 3 as shown on Figure A-2.

PIER 2, STA. 10 + 400 ±

Pier 2 may be founded on;

- a) a spread footing on weathered bedrock within Zone 2, at or below elev. 76.5 m.

or b) steel H-piles (size 310x110) equipped with reinforced tips and driven to bedrock. The bedrock elevation at the borehole location at this pier is $76.5 \pm$ m.

PIER 3, STA. 10 + 430 \pm

Pier 3 may be founded on steel H-piles (size 310x110) equipped with reinforced tips and driven to bedrock. The bedrock elevation at the borehole location at this location is $69.7 \pm$ m.

PIER 4, STA. 10 + 460 \pm

Pier 4 may be founded on;

a) a spread footing on overburden within Zone 1, at or below elev. 73.6 m.

or b) a spread footing on weathered bedrock at or below elev. 70.2 m. For this option, Zone 3 recommendations apply.

The selection of foundation type for this pier will be influenced by the size and footing elevation of the adjacent CNR pier. A scheme to protect the CNR pier may be required.

A de-watering scheme will be required if the footing is to be constructed in the dry. For this purpose, a cofferdam may be constructed using either sheeting or a prefabricated box. However, due to the subsurface conditions at this location, developing a seal will be difficult. Therefore, it would be advantageous to construct a portion (i.e. at least enough to balance the hydrostatic head) of the footing by employing tremie concrete techniques. The remainder of the footing and pier should be constructed in the dry.

PIER 5, STA. 10 + 490 \pm

Pier 5 may be founded on;

a) a spread footing on overburden within Zone 1, at or below elev. 77.2 m

or b) a spread footing on weathered bedrock at or below elev. 75.8 m. For this option, Zone 3 recommendations apply.

or c) steel H-piles (size 310x110) equipped with reinforced tips and driven to bedrock. The bedrock elevation at the borehole location at this pier is elev. 75.8 ± m.

PIER 6, STA. 10 + 520 ±

Pier 6 should be founded on a spread footing on sound bedrock with the entire footing located within Zone 3 as shown on Figure A-1.

OAKVILLE CREEK ELEVATED SECTION - SPECIAL STRUCTURE

PIER AT STA. 10 + 549 ±

This pier may be founded on;

a) a spread footing on overburden within Zone 1, at or below elev. 101.5 m (estimated)

or b) a spread footing on weathered bedrock within Zone 2, at or below elev. 100.1 m (estimated)

or c) a spread footing on sound bedrock within Zone 3, at or below elev. 98.1 m (estimated)

Note that due to utility constraints, the borehole for this pier was located some 18m right of the GO-ALRT centre line. Subsurface conditions, specifically bedrock elevation, may vary at the proposed pier location.

PIER AT STA. 10 + 579 ±

This pier may be founded on;

a) a spread footing on overburden within Zone 1, at or below elev. 100.5 m.

or b) a spread footing on weathered bedrock within Zone 2, at or below elev. 99.1 m

or c) a spread footing on sound bedrock within Zone 3, at or below elev. 97.2 m

OAKVILLE CREEK WEST BRIDGE

Subsurface conditions along the south bank slope at Oakville Creek West are illustrated in Figure B.

PIER 1, STA. 10 + 609 ±

This pier may be founded on;

a) a spread footing on weathered bedrock at or below elev. 99.5 m. For this option Zone 3 recommendations apply.

or b) concrete caissons (1 m diameter) on sound bedrock at or below elev. 95 m.

PIER 2, STA. 10 + 648 ±

This pier may be founded on concrete caissons (1 m diameter) on sound bedrock at or below elev. 94 m.

PIER 3, STA. 10 + 690 ±

This pier may be founded on concrete caissons (1 m diameter) on sound bedrock at or below elev. 94 m.

PIER 4, STA. 10 + 729 ±

This pier may be founded on;

a) a spread footing on sound bedrock within Zone 3, at or below elev. 100.5 m

or b) concrete caissons (1 m diameter) on sound bedrock at or below elev. 95 m

MISCELLANEOUS

The fieldwork for this project was carried out under the supervision of Mr. P. Dempsey, Student Specialist, and Mr. D. H. Dundas, Foundations Engineer. The description and evaluation of the bedrock was carried out by Mr. E. Magni, Geologist.

The report was written by Mr. Dempsey and Mr. Dundas, and reviewed by Mr. K. G. Selby, Senior Foundations Engineer.

The equipment used was owned and operated by Atcost Soil Drilling Inc.



D. H. Dundas
D. H. Dundas, P.Eng.
Foundations Engineer

K. G. Selby
K. G. Selby, P.Eng.
Senior Foundations Engineer

APPENDIX

RECORD OF BOREHOLE No 46 **METRIC**

Oakville Creek Bridge

WO 82-26025 LOCATION Co-ords. N 4 812 220.0, E 289 715.0 ORIGINATED BY PD

DIST 4 HWY GO-ALRT BOREHOLE TYPE Cone Test, S.S. Auger, BXL Core COMPILED BY DD

DATUM Geodetic DATE 83 11 18 CHECKED BY SO

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					
100.1	Ground Surface														
0.0	Silty Clay (CL) occ. shaly layers trace/some sand trace/some gravel Stiff to Hard		1	SS	31										
			2	SS	29										
98.0			3	SS	72/15	15 cm									
2.1			4	SS	91/20	20 cm									
	weathered sound		5	RC BXL	98%										
	Bedrock Georgian Bay Formation Shale 15% limestone layers		6	RC BXL	86%										
94.0															
6.1	End of Borehole														

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to Sensitivity 20
15 \diamond 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 47 **METRIC**

Oakville Creek Bridge

WO 82-26025 LOCATION Co-ords. N 4 812 176.0, E 289 690.0 ORIGINATED BY PD

DIST 4 HWY GO-ALRT BOREHOLE TYPE Cone Test, S.S. Auger, BXL Core COMPILED BY DD

DATUM Geodetic DATE 83 11 21 CHECKED BY SO

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
80.9 0.0	Ground Surface													
76.5 4.4	Silty Clay (CL) occ. shaly layers trace/with sand trace/with gravel Stiff to Hard		1	SS	8									
			2	SS	17									
			3	SS	8									55 14 21 10
			4	SS	22									31 18 39 12
			5	SS	57									45 20 28 7
71.2 9.7	Bedrock Georgian Bay Formation Shale 15% limestone layers		6	SS	60	10 cm								
			7	SS	60	8 cm								21 27 39 13
			8	RC BXL	98%									
			9	RC BXL	100%									
			10	RC BXL	95%									
71.2 9.7	End of Borehole													

OFFICE REPORT ON SOIL EXPLORATION

+³, x⁵: Numbers refer to Sensitivity 20
15 ϕ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 48 **METRIC**

Oakville Creek Bridge

WO 82-26025 LOCATION Co-ords. N 4 812 148.0, E 289 657.0 ORIGINATED BY PD

DIST 4 HWY GO-ALRT BOREHOLE TYPE Cone Test, S.S. Auger, BXL Core COMPILED BY DD

DATUM Geodetic DATE 83 11 22 CHECKED BY SO

ELEV DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	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
			NUMBER	TYPE	'N' VALUES			20	40					
80.7	Ground Surface													
0.0	Sand, Silt (CL) trace clay trace gravel occ. lenses of silty clay		1	SS	25									
79.3	Compact													
1.4	Silty Clay (CL) occ. shaly layers trace/some sand trace/with gravel		2	SS	13								0 7 68 25	
			3	SS	2								33 34 23 10	
			4	SS	6								39 26 24 11	
	Stiff to Firm trace organic Firm to Very Stiff		5	SS	5								25 32 31 12	
74.9														
5.8	Heterogeneous Mixture of Boulders, Cobbles, Gravel, Sand, Silt and Clay occ. shaly layers Very Dense		6	SS	108/18 cm									
			7	SS	80/25 cm									
			8	SS	74									
			9	SS	64									
			10	SS	44									
69.7														
11.0	weathered sand		11	SS	60/10 cm									
			12	RC BXL	90Z									
	Bedrock Georgian Bay Formation Shale 50Z-90Z limestone layers		13	RC BXL	92Z									
66.1														
14.6	End of Borehole													

OFFICE REPORT ON SOIL EXPLORATION

+3, x⁵: Numbers refer to Sensitivity 20
15
10 5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 50 **METRIC**

WO 82-26025 LOCATION Co-ords. N 4 812 128.0, E 289 647.0 ORIGINATED BY PD
 DIST 4 HWY GO-ALRT BOREHOLE TYPE Cone Test, NX & BX Casing, BXL Core COMPILED BY DD
 DATUM Geodetic DATE 83 11 23 - 30 CHECKED BY SO

SOIL PROFILE		STRAT PLOT	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		NUMBER	TYPE			'N' VALUES	20						40
77.5	Water Surface													
0.0	Water													
76.9	Creek Bottom					77								
0.6	Heterogeneous Mixture of Boulders, Cobbles, Gravel, Sand, Silt and Clay occ. shaly layers Very Dense		1	SS	65									
			2	SS	85									53 25 19 3
			3	SS	74									
			4	SS	90									
			5	RC	0%									63 21 12 4
			6	SS	150									
			7	RC BXL	75%									
			8	BXL RC	50%									
			9	BXL	33%									
			10	RC BXL	0%									
			11	SS	75									48 30 17 5
70.2		weathered sound Bedrock Georgian Bay Formation Shale 30% limestone layers (thickness 2-30 cm)		12	RC BXL	75%								
7.3				13	RC BXL	98%								
				14	RC BXL	100%								
66.2														
11.3	End of Borehole													

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to Sensitivity
 20
 15
 10
 5 (%) STRAIN AT FAILURE

Oakville Creek Bridge **RECORD OF BOREHOLE No 51** METRIC

WO 82-26025 LOCATION Co-ords. N 4 812 107.0, E 289 633.0 ORIGINATED BY PD

DIST 4 HWY GO-ALRT BOREHOLE TYPE Cone Test, NX Casing, BXL Core COMPILED BY DD

DATUM Geodetic DATE 83 12 02-05 CHECKED BY SO

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	SHEAR STRENGTH						WATER CONTENT (%)
80.7	Ground Surface						20 40 60 80 100						GR SA Si CL	
0.0	Silty Clay (CL to CI) occ. shaly layers trace/some sand trace/with gravel Very Stiff to Hard	[Strat Plot]	1	SS	17									
			2	SS	22									
			3	SS	33									3 5 52 40
			4	SS	48									5 7 50 38
77.2	Heterogeneous Mixture of Boulders, Cobbles, Gravel, Sand, Silt and Clay occ. shaly layers Very Dense	[Strat Plot]	5	SS	82								58 23 14 5	
3.5			6	SS	80								45 30 18 7	
75.8	weathered sound Bedrock Georgian Bay Formation shale 25% limestone layers (thickness 2-20 cm)	[Strat Plot]	7	SS	200/5 cm									
4.9			8	RC	79%									
			9	RC	100%									
			10	RC	100%									
72.3	End of Borehole	[Strat Plot]												
8.4														

OFFICE REPORT ON SOIL EXPLORATION

+³, x⁵: Numbers refer to Sensitivity

20
15 ϕ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 53

METRIC

WO 82-26026 LOCATION Co-ords. N 4 812 066.0, E 289 580.0 ORIGINATED BY PD
 DIST 4 HWY GO-ALRT BOREHOLE TYPE Cone Test, S.S. Auger, BXL Core COMPILED BY DD
 DATUM Geodetic DATE 83 11 25 CHECKED BY SO

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					
						○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE					WATER CONTENT (%)					
											10	20	30			
102.8	Ground Surface															
0.0	Silty Clay (CL) occ. shaly layers some/with sand some/with gravel Stiff to Hard		1	SS	83											
			2	SS	60	13 cm										
			3	SS	97											
			4	SS	160											
100.1	Bedrock		5	RC BXL	98%											
2.7			6	RC BXL	90%											
			7	RC BXL	100%											
97.0	Queenston Formation Shale															
5.8	Georgian Bay Formation Shale 20% limestone layers (thickness 4-15 cm)															
95.1	End of Borehole															
7.7																

OFFICE REPORT ON SOIL EXPLORATION

³, x⁵: Numbers refer to
Sensitivity 20
15 \pm 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 54

METRIC

Oakville Creek Bridge
 WO 82-26025 LOCATION Co-ords. N 4 812 034.0, E 289 573.0 ORIGINATED BY PD
 DIST 4 HWY GO-ALRT BOREHOLE TYPE Cone Test, S.S. Auger, BXL Core COMPILED BY DD
 DATUM Geodetic DATE 83 11 29 CHECKED BY SO

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
102.8	Ground Surface																
0.0	Silty Clay (CL) occ. shaly layers some/with sand some/with gravel Stiff to Hard		1	SS	79										38 37 20 5		
			2	SS	39												
			3	SS	67												
			4	SS	55												33 33 27 7
99.1	Bedrock		5	SS	101 / 18 cm												
	weathered sound		6	RC BXL	97%												
97.2	Queenston Formation Shale																
5.6	Georgian Bay Formation Shale occ. limestone layers		7	RC BXL	100%												
95.6	End of Borehole																
7.2																	

OFFICE REPORT ON SOIL EXPLORATION

+³, x⁵: Numbers refer to 20
Sensitivity 15-5 (%) STRAIN AT FAILURE
10

Oakville Creek Bridge **RECORD OF BOREHOLE No 55** **METRIC**
 WO 82-26025 LOCATION Co-ords. N 4 812 009.0, E 289 557.0 ORIGINATED BY PD
 DIST 4 HWY GO-ALRT BOREHOLE TYPE Cone Test, S.S. Auger, BXL Core COMPILED BY DD
 DATUM Geodetic DATE 83 11 29 - 30 CHECKED BY SO

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	NUMBER	TYPE	'N' VALUES			20	40	60					
102.7 0.0	Ground Surface													
	Silty Clay (CL) occ. shaly layers some/with sand some/with gravel Firm to Hard	1	SS	32										
		2	SS	99/23										34 34 25 7
		3	SS	56										
99.7 3.0	Bedrock	4	SS	114										
		5	SS	110/20										
	weathered Sound	6	RC BXL	95%										
97.1 5.6	Queenston Formation Shale Georgian Bay Formation Shale occ. limestone layers	7	RC BXL	100%										
95.5 7.2	End of Borehole													

OFFICE REPORT ON SOIL EXPLORATION

+³, x⁵: Numbers refer to Sensitivity 20
 15 $\frac{1}{5}$ (%) STRAIN AT FAILURE 10

RECORD OF BOREHOLE No 56

METRIC

Oakville Creek Bridge
 WO 82-26025 LOCATION Co-ords. N 4 811 973.0, E 289 542.0 ORIGINATED BY PD
 DIST 4 HWY GO-ALRT BOREHOLE TYPE Cone Test, S.S. Auger, BXL Core COMPILED BY DD
 DATUM Geodetic DATE 83 12 02-03 CHECKED BY SO

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	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH						
102.8 0.0	Ground Surface						20 40 60 80 100						
	Silty Clay (CL) occ. shaly layers trace/with sand trace/with gravel Stiff to Hard	1	SS	4									
	Silty Sand	2	SS	16									
100.5 2.3	Bedrock	3	SS	106/23 cm									
	weathered sound	4	RC BXL	92%									
		5	RC BXL	100%									
98.1 4.7	Queenston Formation Shale	6	RC BXL	92%									
	Georgian Bay Formation Shale 15% limestone layers (thickness 2-25 cm)	7	RC BXL	100%									
		8	RC BXL	100%									
		9	RC BXL	100%									
		10	RC BXL	100%									
		11	RC BXL	96%									
		12	RC BXL	95%									
87.6 15.2													

OFFICE REPORT ON SOIL EXPLORATION

Cont

+³, x⁵: Numbers refer to
Sensitivity

20
15
10

5 (% STRAIN AT FAILURE)

Oakville Creek Bridge		RECORD OF BOREHOLE No 56 Cont						METRIC						
WO <u>82-26025</u>		LOCATION <u>Co-ords. N 4 811 973.0, E 289 542.0</u>				ORIGINATED BY <u>PD</u>								
DIST <u>4 HWY GO-ALRT</u>		BOREHOLE TYPE <u>Cone Test, S.S. Auger, BXL Core</u>				COMPILED BY <u>DD</u>								
DATUM <u>Geodetic</u>		DATE <u>83 12 02 - 03</u>				CHECKED BY <u>SO</u>								
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					
87.6														
15.2	Georgian Bay Formation Shale 15% limestone layers (thickness 2-25 cm)	12	RC	95%										
		13	RC BXL	100%										
85.7														
17.1	End of Borehole													

OFFICE REPORT ON SOIL EXPLORATION

+³, x⁵ : Numbers refer to
 Sensitivity

20
 15 \diamond 5 (%) STRAIN AT FAILURE
 10

RECORD OF BOREHOLE No 57 Cont **METRIC**

Oakville Creek Bridge
 WO 82-26025 LOCATION Co-ords. N 4 811 939.0, E 289 514.0 ORIGINATED BY PD
 DIST 4 HWY GO-ALRT BOREHOLE TYPE Cone Test, S.S. Auger, BXL Core COMPILED BY DD
 DATUM Geodetic DATE 83 11 23 - 25 CHECKED BY SO

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					
87.5																
15.2	Georgian Bay Formation Shale 20% limestone layers (thickness 1-25 cm)		12	RC BXL	100%											
			13	RC BXL	100%											
85.5																
17.2	End of Borehole															

OFFICE REPORT ON SOIL EXPLORATION

+³, x⁵: Numbers refer to
 Sensitivity 20
15 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 58

METRIC

Oakville Creek Bridge
 WO 82-26025 LOCATION Co-ords. N 4 811 915.0, E 289 483.0 ORIGINATED BY PD
 DIST 4 HWY GO-ALRT BOREHOLE TYPE Cone Test, S.S. Auger, BXL Core COMPILED BY DD
 DATUM Geodetic DATE 83 11 30 - 83 12 01 CHECKED BY SO

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 PILOT	NUMBER	TYPE			'N' VALUES	20 40 60 80 100						WATER CONTENT (%)
103.3	Ground Surface													
0.0	Silty Clay (CL) occ. shaly layers trace/with sand trace/with gravel Firm to Hard Bedrock ----- weathered sound Queenston Formation Shale ----- Georgian Bay Formation Shale occ. limestone layers	[Hatched]	1	SS	20									
101.8			2	SS	94									
1.5			3	RC BXL	98%									
			4	RC BXL	97%									
97.9			5	RC BXL	97%									
5.4														
96.8	End of Borehole													

OFFICE REPORT ON SOIL EXPLORATION

+³, x⁵: Numbers refer to Sensitivity
 20
 15 + 5 (%) STRAIN AT FAILURE
 10

RECORD OF BOREHOLE No 59

METRIC

Oakville Creek Bridge
 WO 82-26025 LOCATION Co-ords. N 4 811 895.0, E 289 461.0 ORIGINATED BY PD
 DIST 4 HWY GO-ALRT BOREHOLE TYPE Cone Test, S.S. Auger, BXL Core COMPILED BY DD
 DATUM Geodetic DATE 83 12 01 CHECKED BY SO

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	NUMBER	TYPE	'N' VALUES			20	40					
103.6	Ground Surface												
0.0													
102.5	Silty Sand some gravel occ. silty clay pockets <u>Compact to dense</u>	1	SS	37									
1.1	Silty Clay (CL) occ. shaly layers some/with sand some/with gravel Hard	2	SS	40									55 29 12 4
101.2													
2.4	Bedrock	3	SS	93									
		4	RC BXL	100%									
		5	RC BXL	79%									
		6	RC BXL	70%									
	<u>weathered</u> sound												
96.9	Queenston Formation Shale	7	RC BXL	98%									
6.7	* Georgian Bay Formation												
96.5													
7.1	End of Borehole												
	* Shale occ. limestone layers												

OFFICE REPORT ON SOIL EXPLORATION

+3, x⁵: Numbers refer to
Sensitivity

20
15 \diamond 5 (%) STRAIN AT FAILURE
10

RECORD OF TEST PIT NO 1 **METRIC**

Oakville Creek Bridge
 WO 82-26025 LOCATION Co-ords. N 4 812 200.0, E 289 701.0 ORIGINATED BY EM
 DIST 4 HWY GO-ALRT BOREHOLE TYPE Test Pit COMPILED BY DD
 DATUM Geodetic DATE 83 12 07 - 12 CHECKED BY SO *bb*

ELEV DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
			NUMBER	TYPE	'N' VALUES			20	40	60	80	100	W _p	W	W _L		
97.1	Ground Surface																
0.0	Silty Clay (CL) occ. shaly layers trace/some sand trace/some gravel occ. boulders (rock slabs)					**	97										
95.1							96										
94.9	Bedrock*						95										
2.2	End of Test Pit * weathered Georgian Bay Formation Shale occ. limestone layers (thickness up to 10 cm) ** water level not observed																

OFFICE REPORT ON SOIL EXPLORATION

+³, x⁵ : Numbers refer to Sensitivity
 20
 15 \diamond 5 (%) STRAIN AT FAILURE
 10

RECORD OF TEST PIT NO 2 **METRIC**

Oakville Creek Bridge

WO 82-26025 LOCATION Co-ords. N 4 812 080.0, E 289 613.0 ORIGINATED BY EM

DIST 4 HWY GO-ALRT BOREHOLE TYPE Test Pit COMPILED BY DD

DATUM Geodetic DATE 83 12 07 - 08 CHECKED BY SO

ELEV DEPTH	DESCRIPTION	STRAT. PLOT	SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
			NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
96.6	Ground Surface																
0.0	Silty Clay (CL) occ. shaly layers trace/some sand trace/some gravel occ. boulders (rock slabs)					**	96										
95.0	Bedrock*						95										
94.9	End of Test Pit																
1.7	* weathered Queenston Formation Shale ** water level not observed																

OFFICE REPORT ON SOIL EXPLORATION

+³, x⁵: Numbers refer to Sensitivity
20
15 \pm 5 (%) STRAIN AT FAILURE
10

RECORD OF TEST PIT NO 3

METRIC

Oakville Creek Bridge
 WO 82-26025 LOCATION Co-ords. N 4 811 981.0, E 289 531.5 ORIGINATED BY EM
 DIST 4 HWY GO-ALRT BOREHOLE TYPE Test Pit COMPILED BY DD
 DATUM Geodetic DATE 83 12 07 - 08 CHECKED BY SO

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					NATURAL MOISTURE CONTENT			UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20	40	60	80	100	W _p	W		
93.0	Ground Surface															
0.0	* Silty Clay (CL)	X				***										
92.6																
92.5	**															
0.5	End of Test Pit * occ. shaly layers trace/some sand trace/some gravel occ. boulders (rock slabs) ** Bedrock Weathered Georgian Bay Formation occ. limestone layers *** water level not observed															

OFFICE REPORT ON SOIL EXPLORATION

*3, x5: Numbers refer to
Sensitivity

20
15-5 (%) STRAIN AT FAILURE
10

TEST PIT LOGS
OAKVILLE CREEK CROSSING, GO-ALRT
W.O. 82-26025R

TEST PIT #1 - OAKVILLE EAST SLOPE

- 0 - 0.40 m Wet, dark brown, silty clay, containing rounded stones (0.5 to 2 cm), slightly organic slopewash containing roots
- 0.40 - 1.20 m Moist becoming dry with depth, reddish to yellowish brown, stiff, silty clay, containing mainly rounded stones (1 to 7.5 cm) with occasional slabs of limestone, probably fill originally till
- 1.20 - 2.00 m Dry, brown to reddish brown, very stiff, silty clay, containing mainly slabs and pieces of disoriented shale and limestone (larger slabs at 1.60 m depth with dimensions 50 x 50 x 10 cm), colluvium i.e. slope creep material, originally till and insitu bedrock
- 2.00 - 2.18 m Bedrock consisting of green-grey, horizontally bedded, alternating limestone and shale (Georgian Bay Formation); upper 10 cm thick limestone layer underlain by moderately weathered green grey shale

TEST PIT #2 - OAKVILLE WEST SLOPE

- 0 - 0.40 m Moist to wet, dark brown, soft, silty clay, containing mainly rounded stones (0.5 to 2 cm), slightly organic slopewash containing roots
- 0.40 - 0.40 m Moist, orange/red brown, stiff silty clay, containing mainly rounded stones (0.5 to 5 cm), with occasional slabs of limestone, till
- 0.40 - 1.00 m Moist, red occasionally green, stiff, containing 0.5 to 1 cm disoriented shale fragments, local shale till
- 1.00 - 1.60 m Dry, red and green layers, very stiff, containing disoriented shale fragments and slabs (up to approx. 10 cm by 10 cm); slumping and creeping, highly weathered (transported) shale; note this is a transported material
- 1.60 - 1.70 m Bedrock, consisting of alternating green and red, moderately weathered, horizontally bedded shale (Queenston Formation)

TEST PIT #3 - OAKVILLE SOUTH SLOPE

- 0 - 0.45 m Moist, red and green, soft, silty clay, containing disoriented slabs and pieces of shale (0.5 to 7.5 cm), colluvium i.e. slope creep material originally till and insitu bedrock
- 0.45 - 0.53 m Bedrock, consisting of green-grey, highly weathered shale (Georgian Bay Formation)

TABLE 1
DESCRIPTION OF ROCK CORE - OAKVILLE CREEK

BOREHOLE NUMBER	CORE RECOVERY		CORE DESCRIPTION	
	DEPTH (m)	%	DEPTH (m)	DESCRIPTION
46	3.0 - 4.5	98	3.0 - 4.5	Shale, green grey (Georgian Bay Fm), highly weathered
	- 6.1	86	4.5 - 6.1	Shale, green grey (Georgian Bay Fm), sound, containing approximately 15% limestone layers
47	5.4 - 7.0	98	5.4 - 5.8	Shale, green grey (Georgian Bay Fm), slightly weathered
	- 8.1	100		
	- 9.7	95	5.8 - 9.7	Shale, green grey (Georgian Bay Fm), sound, containing approximately 15% limestone layers
48	11.6 - 13.1	90	11.6 - 12.0	Shale, green grey and approximately 50% limestone (Georgian Bay Fm), moderately weathered
	- 14.7	92	12.0 - 14.0	Limestone (90%) and green shale (Georgian Bay Fm), sound
			14.0 - 14.7	Shale, green grey (Georgian Bay Fm), sound
50	7.6 - 8.5	75	7.6 - 6.5	Shale, green grey (Georgian Bay Fm), highly weathered
	- 10.1	98		
	- 11.6	100	8.5 - 11.6	Shale, green grey (Georgian Bay Fm), sound, containing approximately 30% limestone layers (25 - 300 mm)
51	5.4 - 6.0	79	5.4 - 5.8	Shale, green grey (Georgian Bay Fm), slightly weathered
	- 6.9	100		
	- 8.4	100	5.8 - 8.4	Shale, green grey (Georgian Bay Fm), sound, containing approximately 25% limestone layers (20 - 200 mm)

TABLE 1
DESCRIPTION OF ROCK CORE - OAKVILLE CREEK - continued

BOREHOLE NUMBER	CORE RECOVERY		CORE DESCRIPTION	
	DEPTH (m)	%	DEPTH (m)	DESCRIPTION
53	3.5 - 4.7	98	3.5 - 4.7	Shale, red (Queenston Fm), moderately weathered
	- 6.2	90		
	- 7.7	100	4.7 - 7.7	Shale, red and green (Queenston/Georgian Bay Fm), sound, containing approximately 20% limestone layers (40 - 150 mm); Queenston/Georgian Bay Fm boundary at approximately 5.8 m
54	4.1 - 5.6	97	4.1 - 4.4	Shale, red (Queenston Fm), moderately weathered
	7.2	100	4.4 - 7.2	Shale, red and green (Queenston/Georgian Bay Fm), sound; Queenston/Georgian Bay Fm boundary at approximately 5.6 m
55	4.1 - 5.6	95	4.1 - 4.7	Shale, red (Queenston Fm), highly weathered
	- 7.2	100	4.7 - 7.2	Shale, red and green (Queenston/Georgian Bay Fm), sound, containing occasional limestone layers; Queenston/Georgian Bay Fm boundary at approximately 5.6 m
56	2.7 - 3.4	92	2.7 - 3.4	Shale, red (Queenston Fm), moderately weathered, containing approximately 5% limestone layers
	- 4.9	100		
	- 6.5	92	3.4 - 4.0	Shale, red (Queenston Fm), slightly weathered
	- 8.0	100	4.0 - 17.0	Shale, green (Queenston/Georgian Bay Fm), sound, containing approximately 15% limestone layers (20 - 250 mm); Queenston/Georgian Bay Fm at approximately 4.7 m
	- 9.6	100		
	- 11.1	100		
	- 12.8	100		
	- 13.9	96		
	- 15.4	95		
	- 17.0	100		

TABLE 1
DESCRIPTION OF ROCK CORE - OAKVILLE CREEK - continued

BOREHOLE NUMBER	CORE RECOVERY		CORE DESCRIPTION	
	DEPTH (m)	%	DEPTH (m)	DESCRIPTION
57	1.9 - 3.3	44	1.9 - 4.0	Shale, red (Queenston Fm), moderately weathered, containing approx-5% limestone layers (10 - 50 mm)
	- 3.7	38		
	- 5.2	62	4.0 - 5.2	Shale, red (Queenston Fm), slightly weathered
	- 6.7	100		
	- 8.3	98	5.2 - 15.4	Shale, red and green grey (Queenston/Georgian Bay Fm), sound, containing approximately 20% limestone layers (10 - 250 mm); Queenston/Georgian Bay Fm boundary at approximately 5.8 m
	- 9.0	100		
	- 11.0	100		
	- 12.6	100		
	- 14.1	100		
	- 15.7	100		
- 17.2	100			
58	1.8 - 3.4	98	1.8 - 2.3	Shale, red (Queenston Fm), moderately weathered
	- 5.0	97		
	- 6.5	97	2.3 - 6.5	Shale, red and green (Queenston/Georgian Bay Fm), sound, containing occasional limestone layers, Queenston/Georgian Bay Fm boundary at approximately 5.4 m
59	2.8 - 3.6	100	2.8 - 3.7	Shale, red (Queenston Fm), moderately weathered
	- 4.2	79		
	- 5.7	70	3.7 - 5.7	Shale, red (Queenston Fm), highly weathered
	- 7.1	98	5.7 - 7.1	Shale, red and green (Queenston/Georgian Bay Fm), sound; Queenston/Georgian Bay Fm boundary at approximately 6.7 m

TABLE 2
RESULTS OF UNIAXIAL COMPRESSIVE STRENGTH TESTS
ON SHALES OF THE GEORGIAN BAY FORMATION;
BOREHOLE 56, OAKVILLE CREEK WEST, GO-ALRT WEST

SAMPLE NUMBER	DEPTH IN METRES		DESCRIPTION OF SAMPLE	FAILURE LOAD		UNIAXIAL COMPRESSIVE STRENGTH		STRAIN AT FAILURE %
	FROM	TO		(LBS)	kN	(psi)	(MPa)	
RC-8B	8.89	9.04	Uniform grey shale (problem with comp.equip.)	1471	6.54	(709)	(4.9)	-
RC-8C	9.37	9.55	Uniform grey shale	3150	14.01	1518	10.5	3.25
RC-9A	9.63	9.78	Uniform grey shale (visible cracking before test)	1575	7.01	(759)	(5.2)	-
RC-9B	10.19	10.34	Uniform grey shale	3083	13.71	1486	10.2	2.5
RC-10A	11.81	11.96	Uniform grey shale (problem with comp.equip.)	2452	10.91	1182	8.2	3.75
RC-10C	12.55	12.70	Uniform grey shale	3240	14.41	1561	10.8	1.75
RC-11A	13.00	13.13	Uniform grey shale	3128	13.91	1507	10.4	1.6
RC-11B	13.13	13.28	Uniform grey shale	2610	11.61	1258	8.7	3.0
RC-12A	14.58	14.76	Uniform grey shale	3960	17.61	1908	13.2	2.25
RC-12C	14.96	15.11	Uniform grey shale with a 0.5 cm inclusion 1.0 cm from top	3128	13.91	1507	10.4	2.50
RC-13A	15.65	15.80	Uniform grey shale (visible cracking before test)	1395	6.21	(672)	(4.6)	-
RC-13B	15.95	16.10	Uniform grey shale (visible cracking before test)	1328	5.91	(640)	(4.4)	-

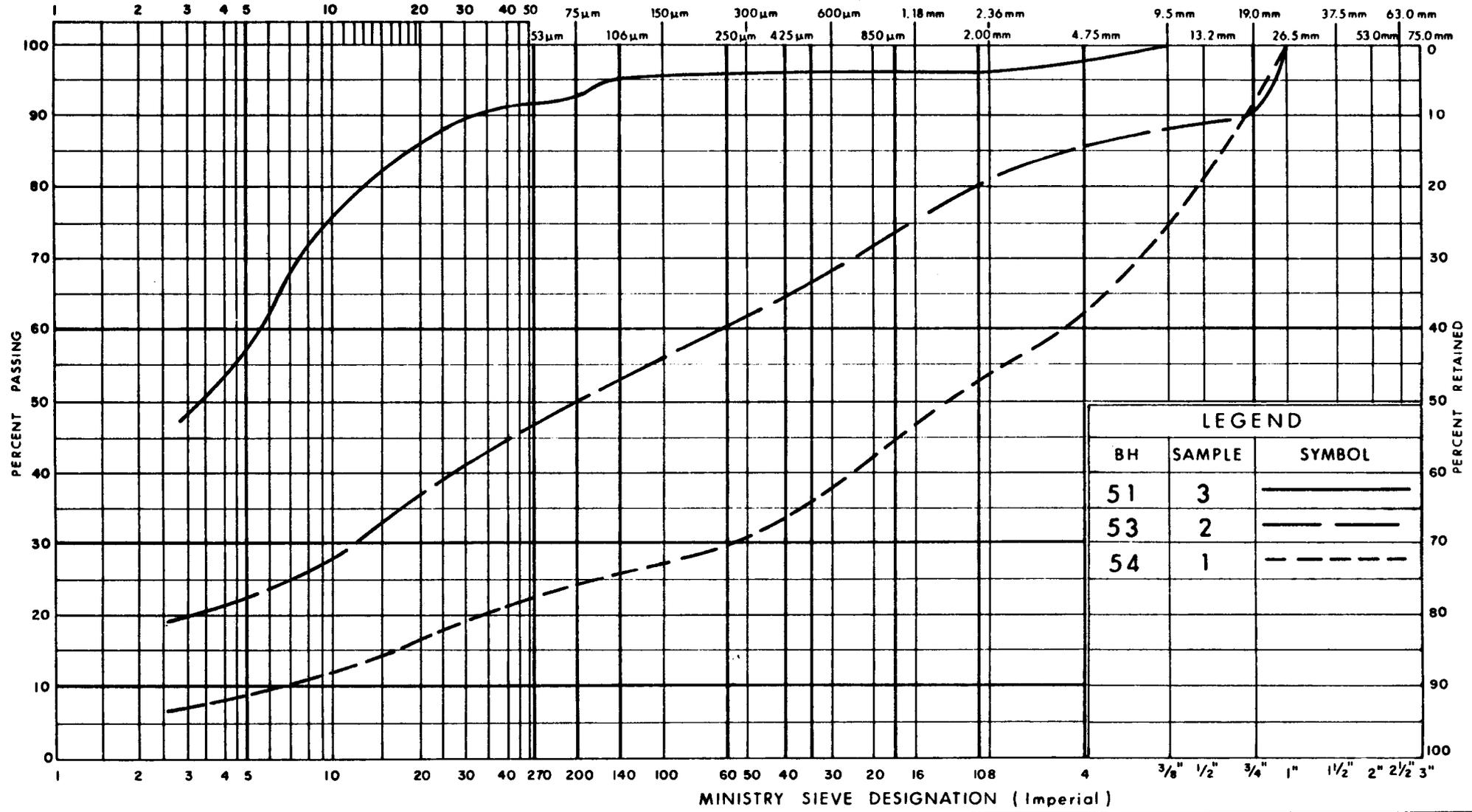
TABLE 3
RESULTS OF UNIAXIAL COMPRESSIVE STRENGTH TESTS
ON SHALES OF THE GEORGIAN BAY FORMATION;
BOREHOLE 57, OAKVILLE CREEK WEST, GO-ALRT WEST

SAMPLE NUMBER	DEPTH IN METRES		DESCRIPTION OF SAMPLE	FAILURE LOAD		UNIAXIAL COMPRESSIVE STRENGTH (psi)	UNIAXIAL COMPRESSIVE STRENGTH (MPa)
	FROM	TO		(LBS)	kN		
RC-8B	8.69	8.84	Green shale with two 2 to 5 cm thick limey layers	3030	13.48	1482.0	10.2
RC-8C	9.07	9.22	2/3 Green shale and 1/3 red shale	1950	8.67	954.0	6.6
RC-8D	9.22	9.35	1/2 Green shale and 1/2 shaley limestone	3320	14.77	1624.3	11.2
RC-10A	11.33	11.46	Uniform green shale	4330	19.26	2118.4	14.6
RC-10B	11.63	11.76	Uniform green shale	3330	14.81	1629.2	11.2
RC-10D	12.14	12.27	Uniform green shale	3450	15.35	1687.9	11.6
RC-12A	14.45	14.60	Green shale with 1 cm shaley limestone	3430	15.26	1678.1	11.6
RC-12B	14.78	14.94	Uniform green shale	3570	15.88	1746.6	12.0
RC-12C	15.00	15.19	Uniform green shale	3670	16.32	1795.5	12.4

UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT	SAND			GRAVEL	
	Fine	Medium	Coarse	Fine	Coarse

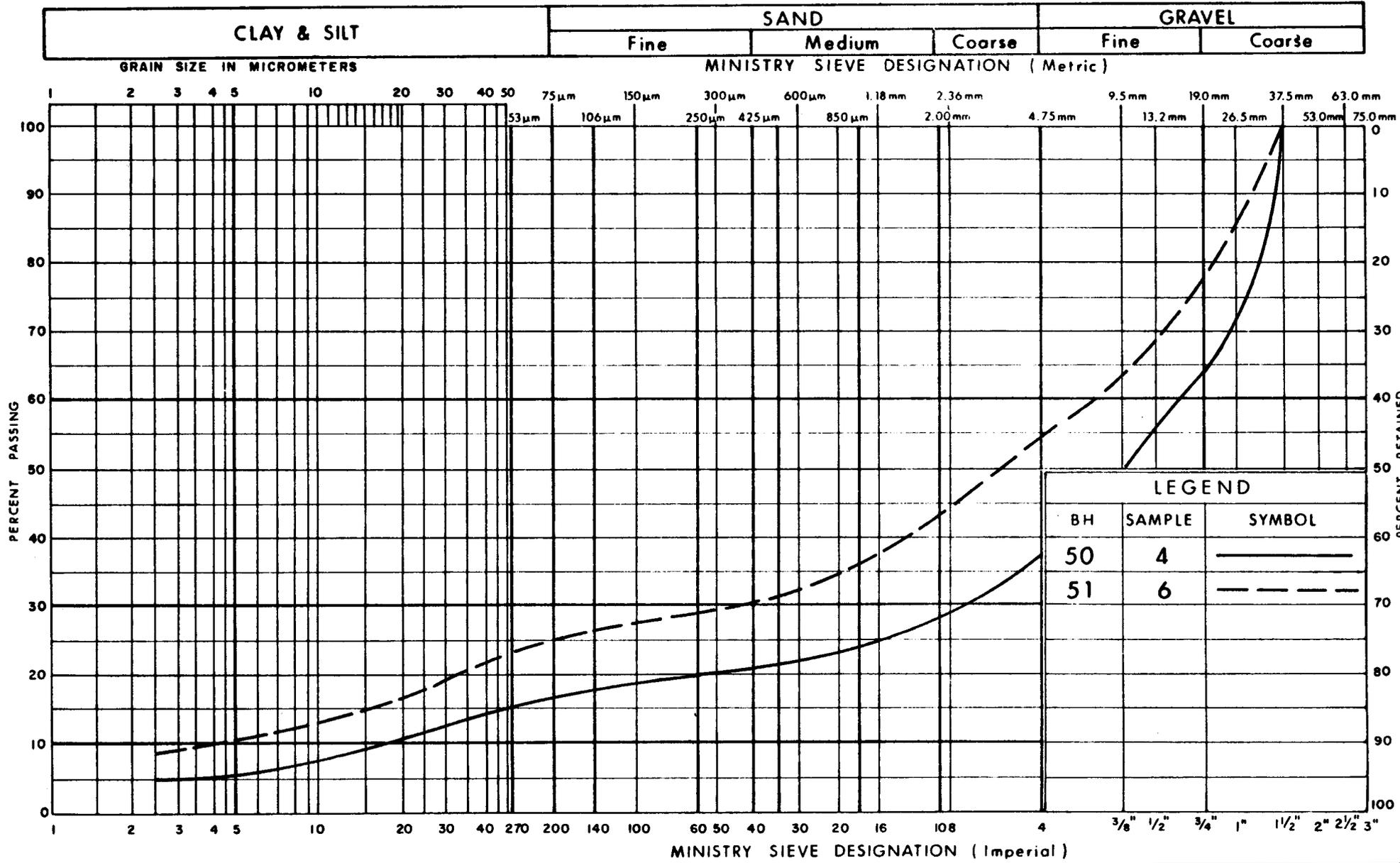
GRAIN SIZE IN MICROMETERS
MINISTRY SIEVE DESIGNATION (Metric)



GRAIN SIZE DISTRIBUTION
SILTY CLAY
 OCC SHALY LAYERS, TRACE / WITH SAND & GRAVEL

FIG No 1
 GO - ALRT
 OAKVILLE CREEK BRIDGE

UNIFIED SOIL CLASSIFICATION SYSTEM



LEGEND		
BH	SAMPLE	SYMBOL
50	4	—————
51	6	- - - - -



GRAIN SIZE DISTRIBUTION
HETEROGENEOUS MIXTURE OF BOULDERS, COBBLES, GRAVEL,
SAND, SILT AND CLAY

FIG No 2
 GO - ALRT
 OAKVILLE CREEK BRIDGE

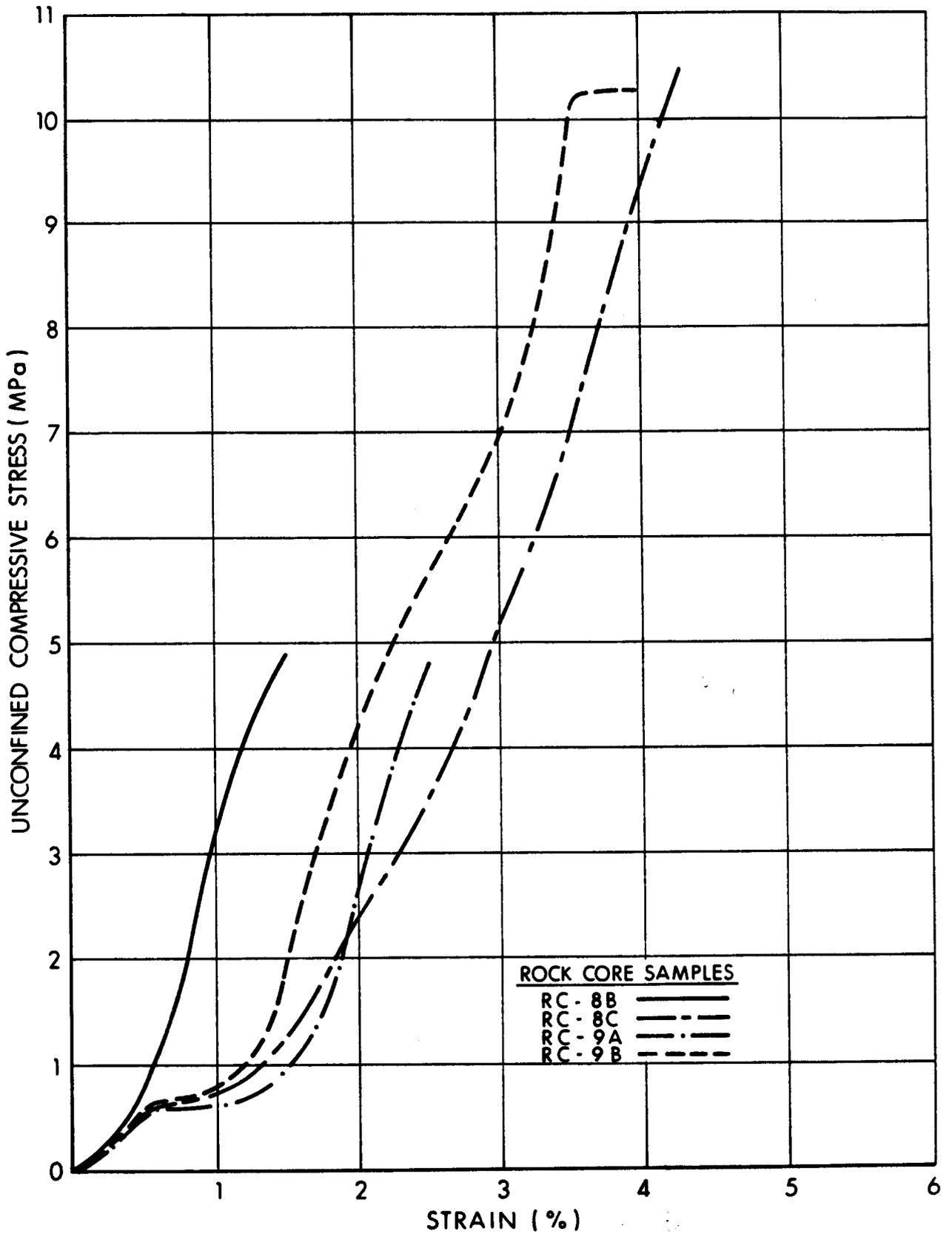


FIG 3 - STRESS - STRAIN CURVES BORE HOLE 56
 OAKVILLE CREEK WEST BRIDGE - GO-ALRT

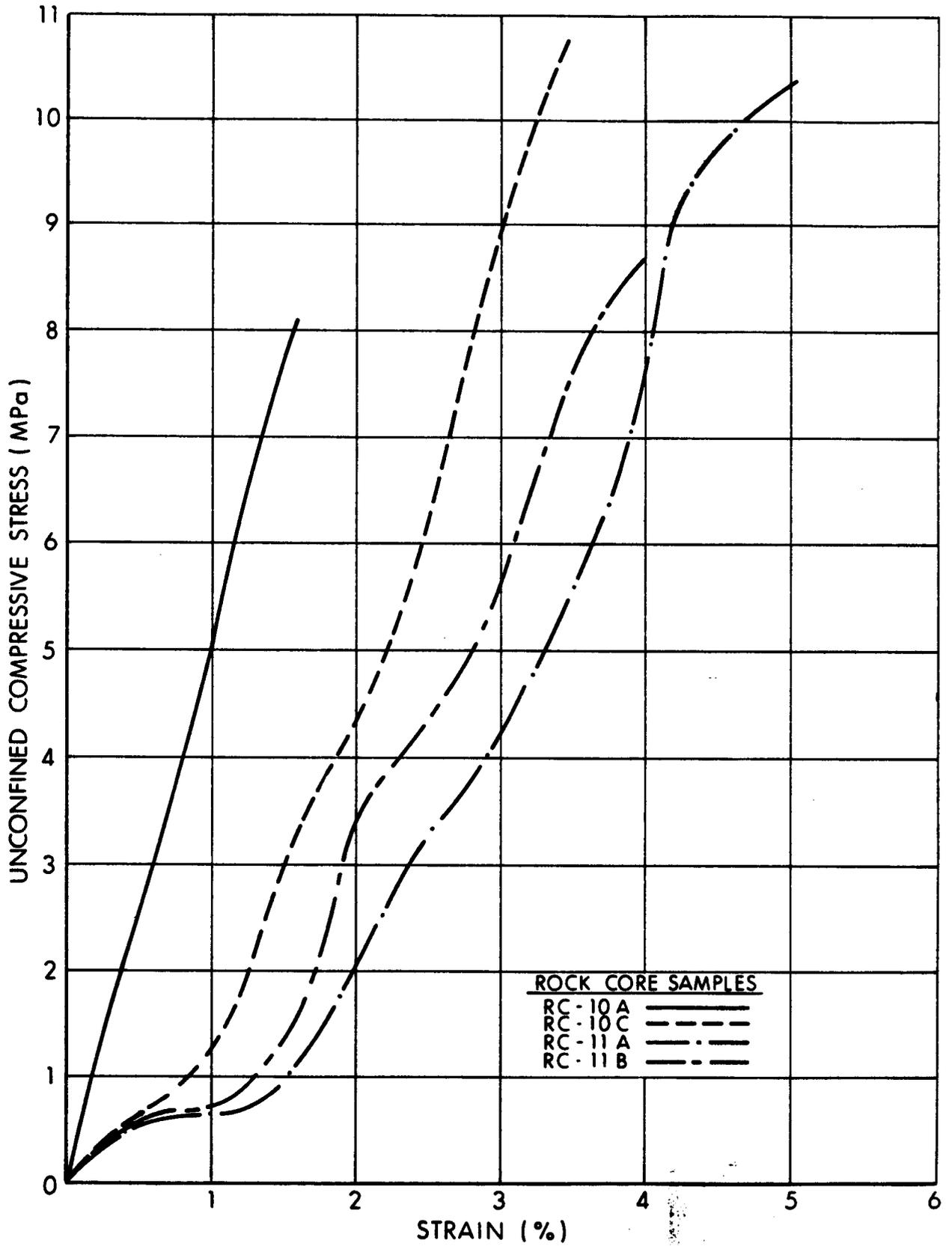
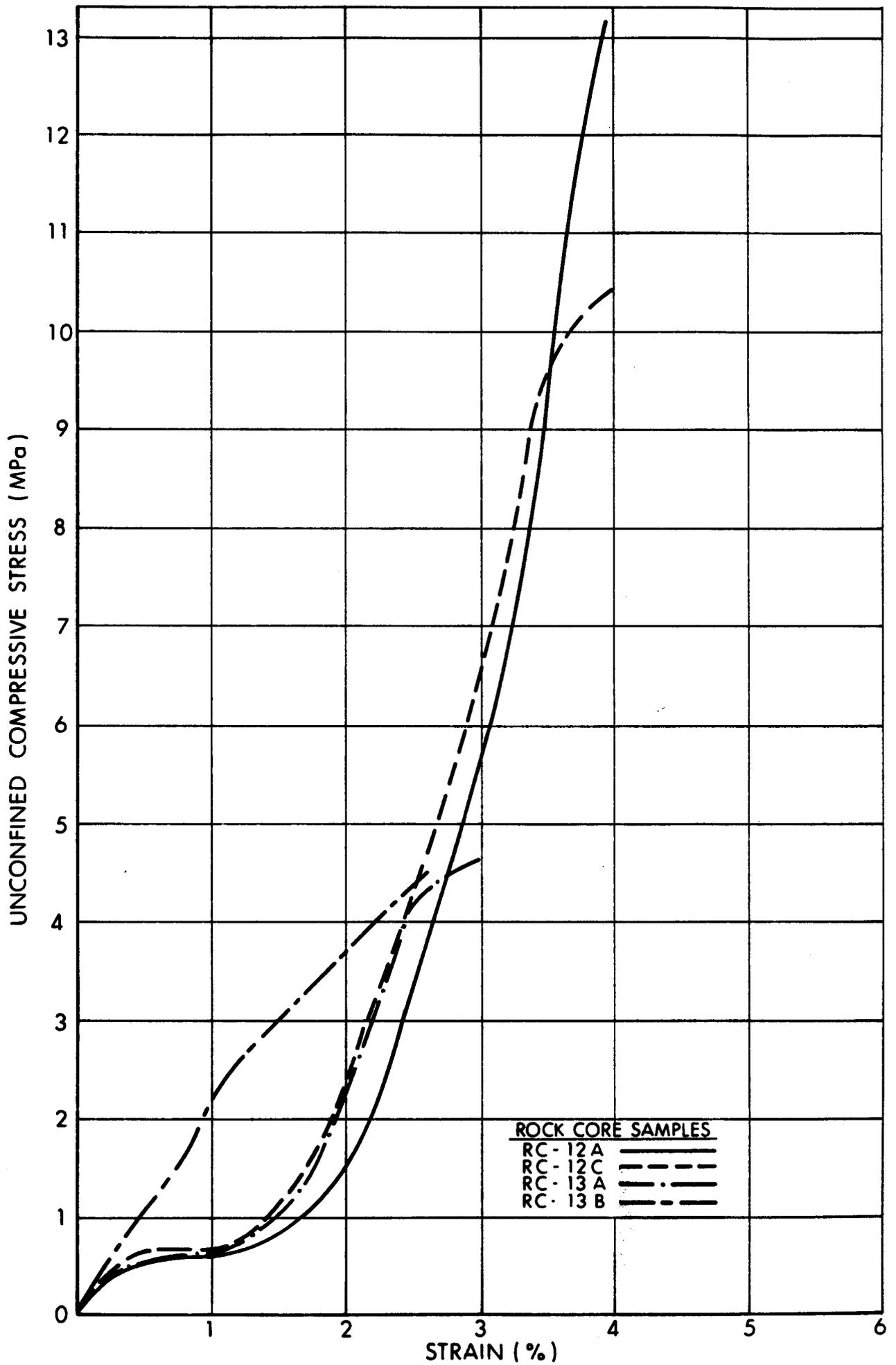


FIG 4 - STRESS-STRAIN CURVES BORE HOLE 56
OAKVILLE CREEK WEST BRIDGE - GO-ALRT



**FIG 5 - STRESS-STRAIN CURVES BORE HOLE 56
OAKVILLE CREEK WEST BRIDGE - GO-ALRT**

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

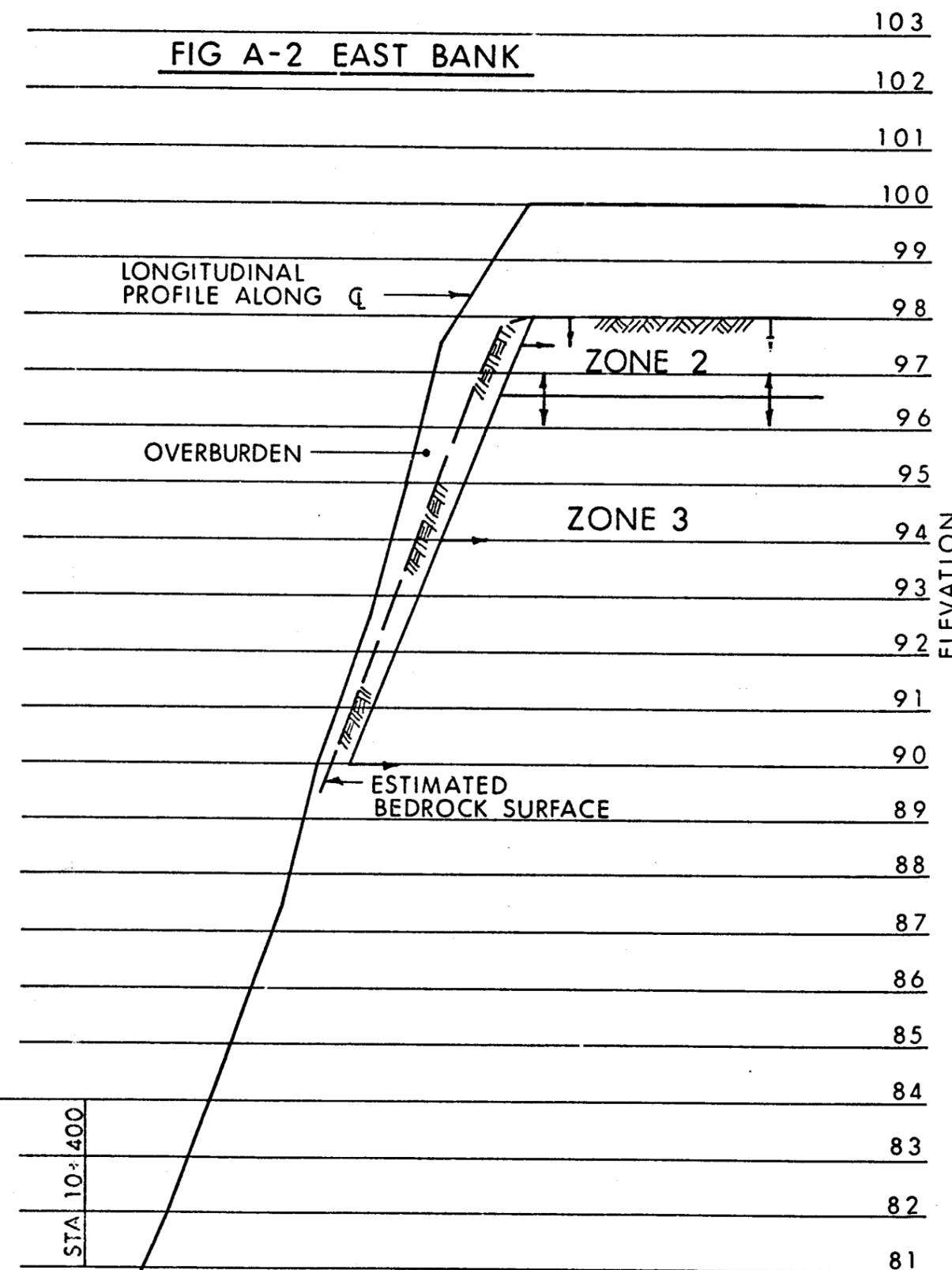
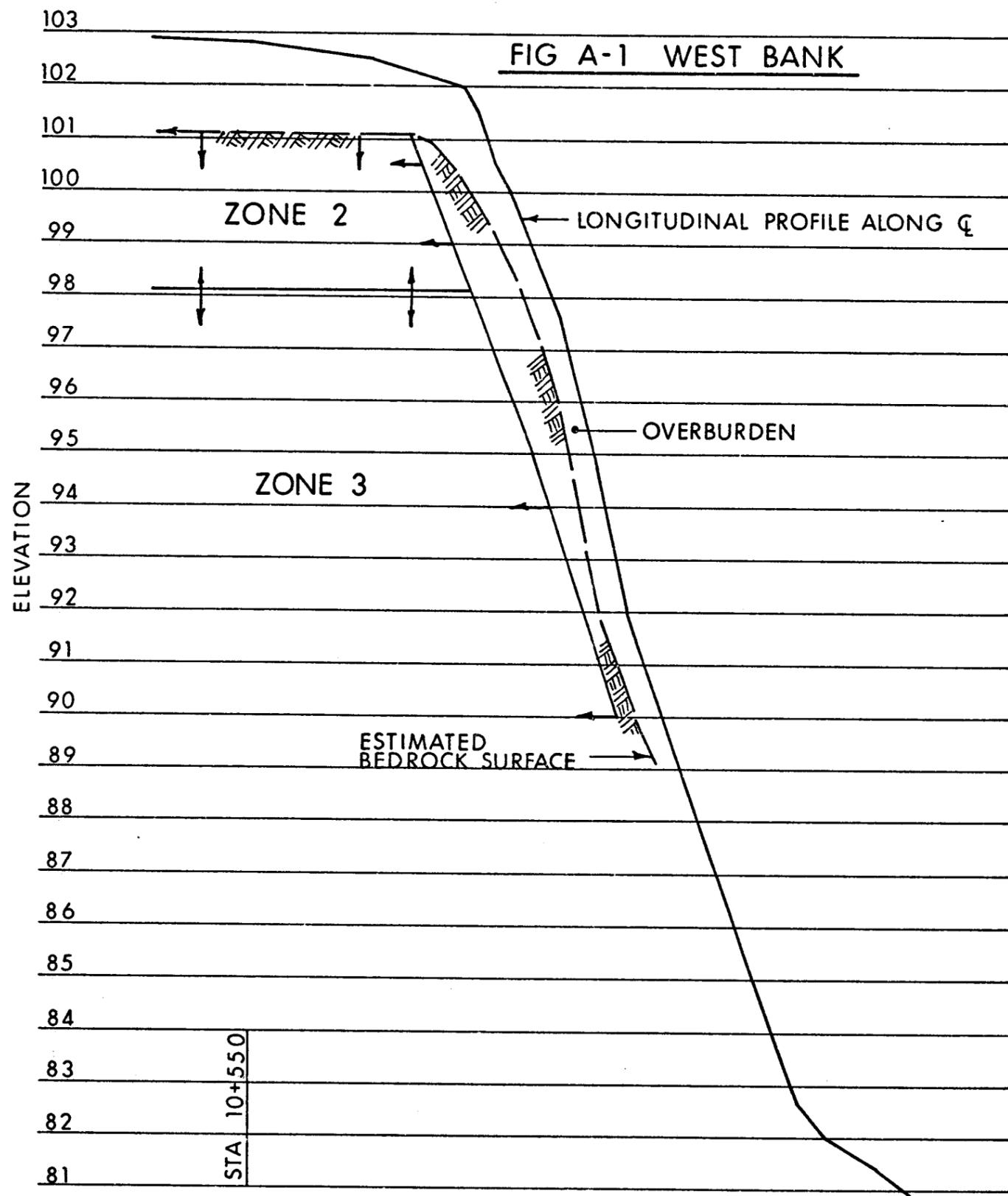
m_v	kPa^{-1}	COEFFICIENT OF VOLUME CHANGE
C_c	1	COMPRESSION INDEX
C_s	1	SWELLING INDEX
C_α	1	RATE OF SECONDARY CONSOLIDATION
c_v	m^2/s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
T_v	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
σ'_{v0}	kPa	EFFECTIVE OVERBURDEN PRESSURE
σ'_p	kPa	PRECONSOLIDATION PRESSURE
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	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						

FIG A - FOOTING ZONES & SUBSURFACE CONDITIONS
 GO-ALRT WEST EXTENSION OAKVILLE PROJECT - OAKVILLE CREEK

CONSTRUCTION EAST →

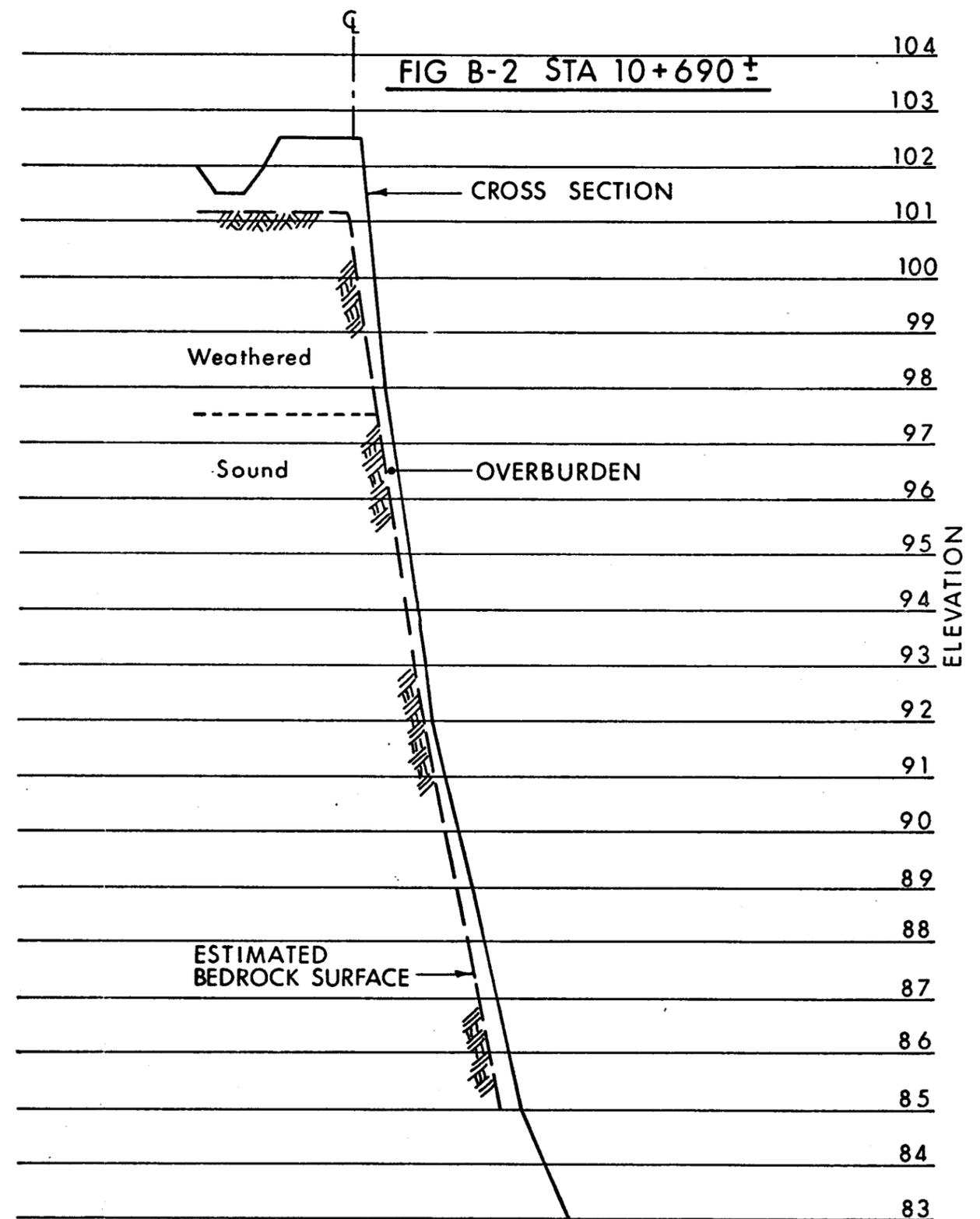
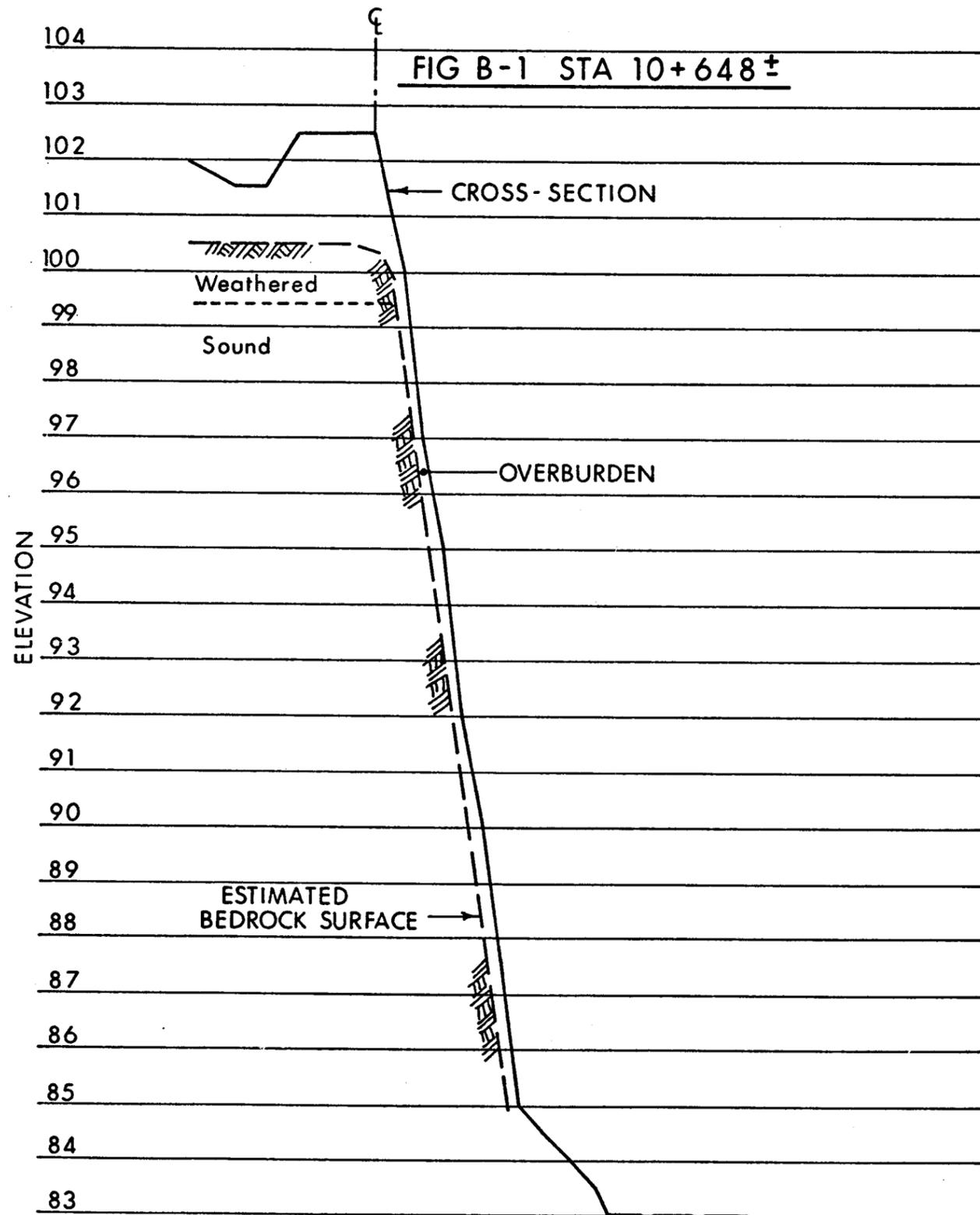


SCALE HOR 1:500
 VERT 1:100

FIG B - SUBSURFACE CONDITIONS

GO-ALRT WEST EXTENSION OAKVILLE PROJECT - OAKVILLE CREEK

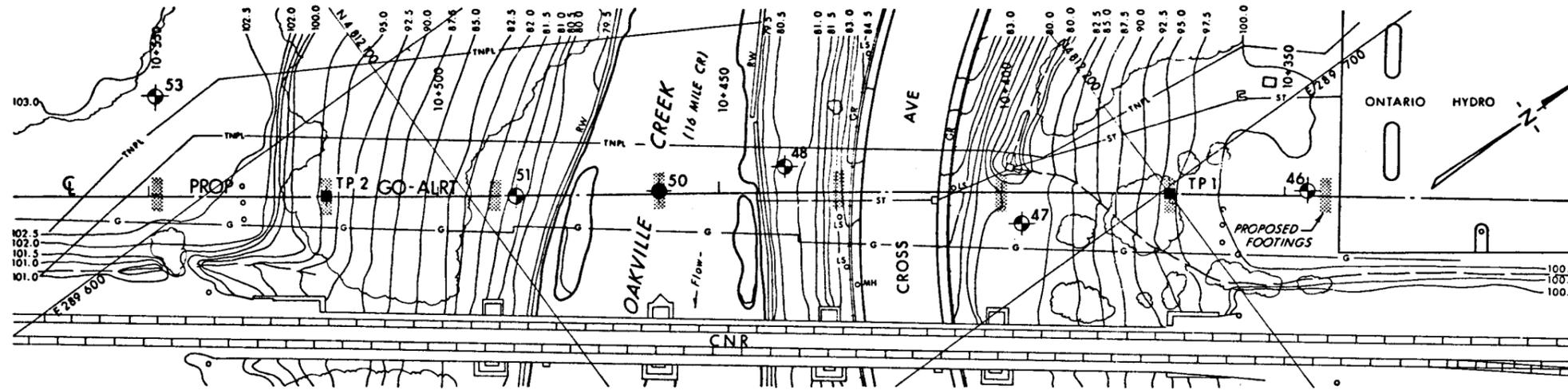
CONSTRUCTION NORTH →



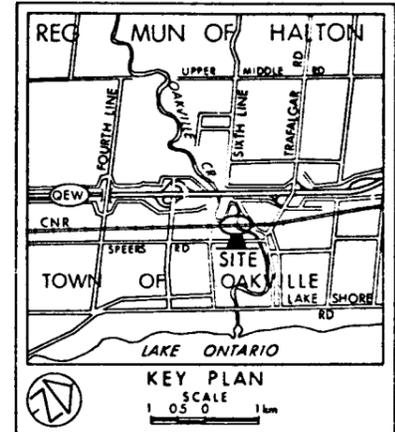
SCALE HOR 1:500
VERT 1:100

METRIC

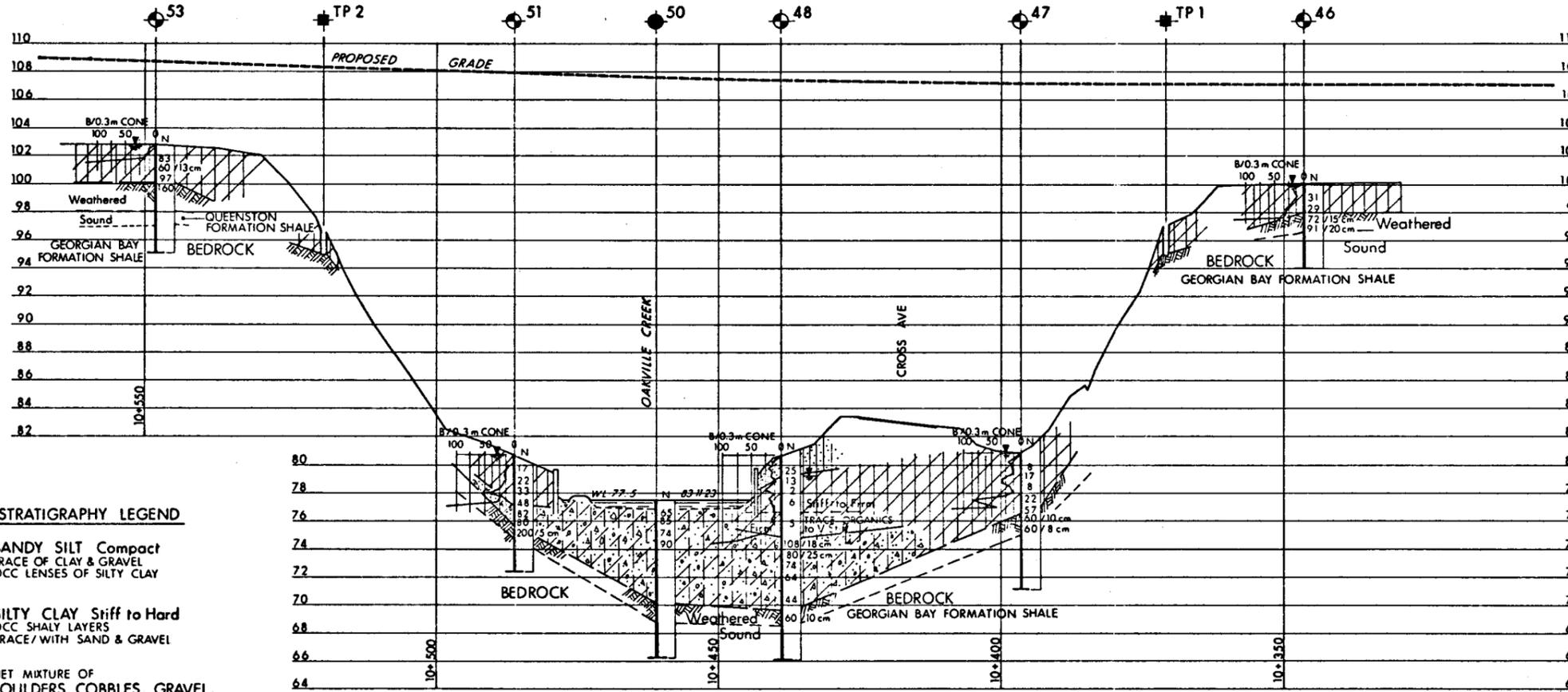
ALL DIMENSIONS SHOWN ARE IN METRES AND/OR MILLI-METRES UNLESS OTHERWISE NOTED.



PLAN
SCALE
10m 5 0 10m



KEY PLAN
SCALE
1 0.5 0 1km



SOIL STRATIGRAPHY LEGEND

- SANDY SILT Compact
TRACE OF CLAY & GRAVEL
OCC LENSES OF SILTY CLAY
- SILTY CLAY Stiff to Hard
OCC SHALY LAYERS
TRACE WITH SAND & GRAVEL
- HET MIXTURE OF
BOULDERS, COBBLES, GRAVEL,
SAND, SILT & CLAY Very Dense
OCC SHALY LAYERS

PROFILE PROP GO-ALRT
SCALE
10m 5 0 10m Hor
4m 2 0 4m Vert

LEGEND

- Bore Hole
- Dynamic Cone Penetration Test (Cone)
- Bore Hole & Cone
- N Blows/0.3m (Std Pen Test, 475 J/blow)
- CONE Blows/0.3m (60° Cone, 475 J/blow)
- W L at time of investigation 8311 & 12
- Test Pit

No	ELEVATION	CO-ORDINATES	
		NORTH	EAST
46	100.1	4 812 220.0	289 715.0
47	80.9	4 812 176.0	289 690.0
48	80.7	4 812 148.0	289 657.0
50	77.5	4 812 128.0	289 647.0
51	80.7	4 812 107.0	289 633.0
53	102.8	4 812 066.0	289 580.0
TP 1	97.1	4 812 200.0	289 701.0
TP 2	96.6	4 812 080.0	289 613.0

Geocres No 30M5-140

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.

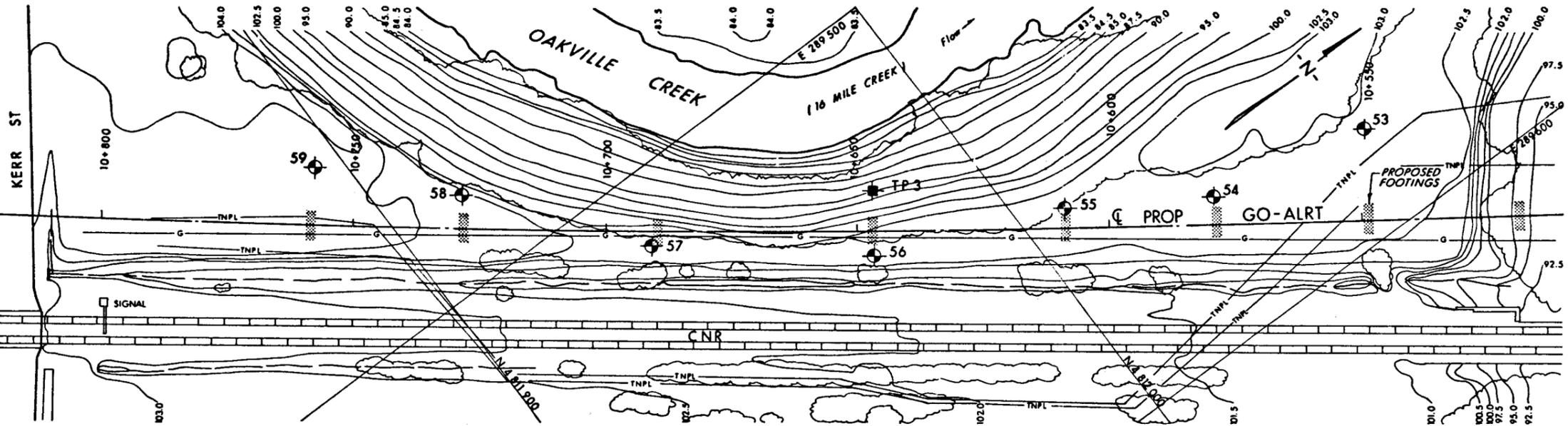


GO-ALRT REF PD2-300-

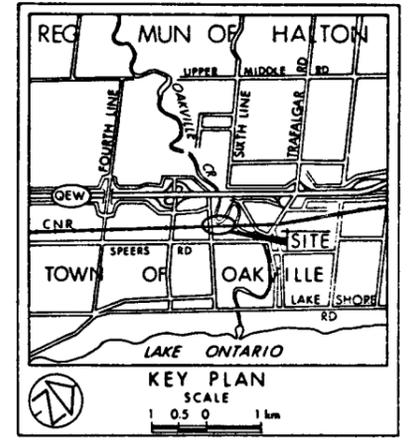
REFERENCE DRAWINGS	REVISIONS	DRAWN BY: SO 1984 01 17 CHK'D BY:	DESIGNED BY: APPROVED BY:	ENGINEERING MATERIALS OFFICE FOUNDATION DESIGN SECTION	 Ministry of Transportation and Communications OAKVILLE PROJECT - WEST EXTENSION	HALTON REGION OAKVILLE CREEK BRIDGE BORE HOLE LOCATIONS & SOIL STRATA STA 10+460	CONTRACT NO	DWG NO	REV	SHEET
		SCALE: FULL SIZE ONLY AS SHOWN					PROJECT MANAGER			

METRIC

ALL DIMENSIONS SHOWN ARE IN METRES AND/OR MILLI-METRES UNLESS OTHERWISE NOTED.



PLAN
SCALE
10m 5 0 10m



LEGEND

- ◆ Bore Hole
- ⊕ Dynamic Cone Penetration Test (Cone)
- ⊕ Bore Hole & Cone
- N Blows/0.3m (Srd Pen Test, 475 J/blow)
- CONE Blows/0.3m (60° Cone, 475 J/blow)
- ⬇ W.L. at time of investigation 8311 & 12
- ⊛ Test Pit

No	ELEVATION	CO-ORDINATES NORTH	EAST
53	102.8	4812 066.0	289 580.0
54	102.8	4812 034.0	289 573.0
55	102.7	4812 009.0	289 557.0
56	102.8	4811 973.0	289 542.0
57	102.7	4811 939.0	289 514.0
58	103.3	4811 915.0	289 483.0
59	103.6	4811 895.0	289 461.0
TP 3	93.0	4811 981.0	289 531.5

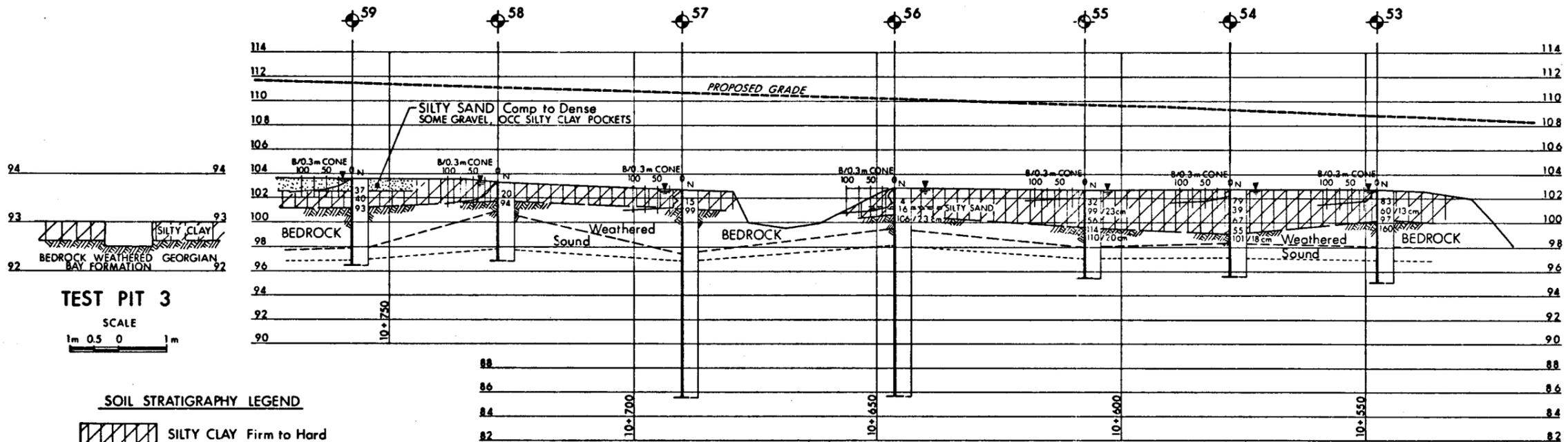
Geocres No 30M5-140

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GO-ALRT REF PD2-300-



PROFILE PROP GO-ALRT

SCALE
10m 5 0 10m Hor
4m 2 0 4m Vert

SOIL STRATIGRAPHY LEGEND

- SILTY CLAY Firm to Hard OCC SHALY LAYERS, SOME/WITH SAND & GRAVEL
- BEDROCK
- QUEENSTON FORMATION SHALE
- GEORGIAN BAY FORMATION SHALE
- OCC LIMESTONE LAYERS



REFERENCE DRAWINGS

REVISIONS

DRAWN BY: SO
DESIGNED BY: LXD
1984 01 12
CHK'D BY: [Signature]
APPROVED BY: K.L.S.
SCALE: FULL SIZE ONLY
AS SHOWN

ENGINEERING MATERIALS OFFICE
FOUNDATION DESIGN SECTION



HALTON REGION
OAKVILLE CREEK WEST BRIDGE
BORE HOLE LOCATIONS & SOIL STRATA
STA 10+647.500

CONTRACT NO	DWG NO	REV	SHEET
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PROJECT MANAGER