926-1-149

MACLEOD GEOTECHNICAL LTD.
soil mechanics and foundation engineering

1451 MARINE DRIVE, WEST VANCOUVER, B.C. V7T 1B8 TELEPHONE 922-0812

SUBSURFACE INVESTIGATION

PROPOSED COMMERCIAL DEVELOPMENT

S.W. CORNER CARNARVON & LORNE STS.

NEW WESTMINSTER, B.C.

FOR E.R. PROBYN LTD.

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APPENDIX

MACLEOD GEOTECHNICAL LTD.
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1.0 INTRODUCTION

As authorized in a letter from Mr. E.V.Ardagh, Special Projects Manager, dated June 29/79, a first stage preliminary subsurface investigation was undertaken for the above project. Following a review of results at a meeting on July 10/79, we were instructed to proceed with a second stage investigation. Preliminary results of this work were given in a letter dated July 25/79. This final report includes the results of all work done to date on the site.

Attached to the report as an appendix is a location plan, cross-sections, borehole logs and laboratory test results.

2.0 SITE DESCRIPTION

The site is presently a paved parking lot located near the foot of the south slope of New Westminster approximately 1 block above the level ground at Columbia Street. The property has dimensions of 153 ft by 131 ft and is bounded on four sides by paved streets. There is an average difference in elevation between Carnarvon Street and Clarkson Street of 23 ft (i.e. an average slope of 15%) and a maximum difference of 32 ft. It was reported that there were previously existing structures

on the property which have since been demolished and filled in.

Location of the site, adjacent major buried services and approximate position of previous structures are shown on Dwg D33-1A.

The south slope in New Westminster is known for artesian groundwater conditions and surface springs. Small amounts of seepage were noted in the inspection of the basements of the adjacent Land Registry Office and of the building at the corner of Clarkson and Begbie Streets.

3.0 FIELD AND LABORATORY WORK

Four holes were drilled and sampled on the site by means of a Mayhew 1000 rotary drill rig using Revert drilling mud to maintain open hole and to control artesian groundwater.

Two air operated piezometers (Petur type P106 canvas pack piezometer) were installed in DH1 and DH2 to measure artesian pressures in the underlying gravel aquifer and were sealed with bentonite pellets as required. Revert drilling mud was used in place of normal bentonite since it "reverts" to a water-like viscosity after 72 hours and minimizes any plugging of the aquifer. A shallow standpipe was installed in the upper sand in DH1 at 12 ft depth for measurement of near surface perched groundwater. Readings were taken on the piezometers 24 hours after installation and on subsequent occasions.

The boreholes were logged in the field and samples taken as required for laboratory identification and classification tests. Blow counts recorded for all Standard Penetration Test drive samples were used to give an approximate correlation with subsoil density.

Spot elevations were taken at the corners of the site and at borehole locations and related to the City of New Westminster brass monument at the corner of Carnarvon and Lorne Streets.

A preliminary check was made of buried services around the site and an inspection was made of basements in adjacent buildings.

4.0 RESULTS

4.1 General: The results of the sampling and laboratory testing are shown on the borehole logs together with piezometer readings taken at the time. A grain size analysis of a reasonably typical sample of the underlying gravel aquifer is shown on Dwg D33-4 and the results of Atterberg Limit tests in the clay-silt deposits are summarized on Dwg D33-5.

4.2 Generalized Subsoil Profile: The subsoil conditions encountered at this site were found to be complex. For engineering purposes in this report they have been generalized into zones as described below and as shown in the typical cross-section of the site Dwg D33-3A. These zones do not everywhere coincide with groundwater conditions.

Zone 1	grey-brown fine SAND, trace silt, together with SAND-GRAVEL-COBBLE material and pieces wood (probably fill) - loose to medium dense (N = 10 to over 30 in cobbles) Overlies most of the site ranging from 12 ft thickness at Carnarvon to almost nothing at Clarkson St.
Zone 2	grey CLAY-SILT with scattered pebbles, tr.shells, occ.sand lenses, ranging from sandy SILT , trace CLAY to silty CLAY; near horizontal bedding; water contents close to liquid limit. Natural water contents range: 22 to 30% Atterberg limits range: L_W = 30.3: P_W = 18.2 to L_W = 26.8: P_W = 18.9 - soft to firm (N = Wt of rods to 24) Ranges from about 3 ft thickness at Carnarvon to 13 ft at Clarkson St.
Zone 3A	grey m.f.SAND, tr.silt, fine silty SAND and sandy SILT; some thin c.m.f. sand and silty clay layers or lenses; thin horizontal bedding. Sandier layers waterbearing under artesian pressure natural water contents in silt: 16 to 21% - medium dense to dense (N = 42 to over 100) Thickness varies from about 22 ft at Carnarvon to about 5 ft in the centre of the site and pinching out at Clarkson St.

Zone 3B	grey sandy SILT, trace clay with scattered gravel and cobbles; no bedding - TILL-LIKE texture - dense (N = 73 to over 100) Approx. 2 to 5 ft thickness encountered in boreholes DH2 and DH3
Zone 4	grey, coarse to medium SAND & GRAVEL, occ.cobbles, rounded (little if any binder - hole tended to cave). Waterbearing with artesian pressures - dense (N = over 100) Encountered in all boreholes at levels ranging from 25 to 30 ft elevation. Maximum thickness noted to bottom of borehole DH1 was 13 ft.

4.2 Groundwater: The major aquifer at the site occurs in the underlying SAND & GRAVEL (Zone 4) the upper boundary of which appears to be approximately level across the site at about average elevation 27 ft. Measured water pressure in the sealed air piezometers installed in DH1 at 40 ft depth below existing grade and in DH2 at 18 ft depth were respectively 36 ft head and 17.3 ft head on August 14/79 (approx. 1 month after installation). Reference to the typical section, Dwg D33-3A, indicates that the main confining layers are the CLAY-SILT of Zone 2 and the compact silty TILL-LIKE soil of Zone 3B.

An upper perched aquifer exists in the SAND & FILL material of Zone 1 running on top of the relatively impermeable CLAY-SILT of Zone 2. Groundwater level in this upperaquifer was measured at between 1 and 1.5 ft depth below existing grade in DH1 on July 9/79.

It is important to note that boreholes DH1 and DH4 indicate some variation from the generalized groundwater conditions given above.

In DH1 the relatively impermeable confining layer of silty CLAY (Zone 2) and sandy SILT (Zone 3A) extends down to about 22 ft depth (elevation 41 ft) where the sandy SILT grades into silty SAND (also Zone 3A). This silty SAND overlying the main GRAVEL aquifer (Zone 4) is also under artesian pressure but is considerably less permeable than the GRAVEL.

In DH3 there is a SAND layer (Zone 3A) between 21 and 24 ft depth, lying between the relatively impermeable silty CLAY (Zone 2) and dense till-like SILT (Zone 3B) which can also be expected to have artesian pressure.

5.0 GROUNDWATER CONDITIONS

5.1: The maximum allowable depth of excavation before artesian pressure in the underlying GRAVEL aquifer could cause heave or blow-in of the bottom of the excavation, is indicated to range from 10 ft depth at DH2 to about 17 ft depth at DH1 using piezometer readings at the time of the investigation. Reference to the typical cross-section in Dwg D33-3A indicates the variation in artesian conditions as the existing ground surface drops down closer to the confined GRAVEL aquifer at Clarkson Street.

5.2: Two building schemes have been proposed:

(a) Avoid dewatering of the underlying artesian GRAVEL aquifer and use minimum excavation for basements and major foundations. Based on preliminary results, the maximum indicated depth of excavation ranges from 10' to 17'. However, since major foundations will probably need to be set at depths ranging from 12' to 19', there may be some problems placing foundations at the required depth, especially along Clarkson St, without at least some local dewatering. Some permanent groundwater control and subdrainage of a standard type would still be required.

(b) Dewater the underlying artesian GRAVEL aquifer and make use of excavation for basements and for setting major foundations of whatever suitable depth required.
The GRAVEL aquifer appears to be fairly permeable, relatively shallow and sufficiently thick so that only a few pumped wells would be required for temporary construction drainage.
Permanent drainage of the GRAVEL aquifer could make use of gravel filters and/or drainage trenches into the GRAVEL aquifer below

the basement floor slab instead of permanent relief wells, depending on relative costs. Drainage would be by gravity into the City storm drain system.

6.0 FOUNDATION DESIGN

6.1: For purposes of preliminary foundation design, we have estimated the minimum depths to competent bearing strata as indicated by the results of each borehole for the types of structures noted.

	DH1	DH4	DH3	DH2
Depth to firm bearing for light structures	9'to 12'	6'±	10'±	10'±
Depth to firm bearing for heavy structures	15'	12'	19'	13'

The intent is to place major foundations below the CLAY layers of varying density and thickness encountered in the boreholes in order to minimize possible differential settlement problems for a proposed highrise structure.

6.2: For major foundations bearing on compact undisturbed SAND-SILT soil (Zone 3A & 3B), at depths noted in item 6.1 above, an allowable bearing pressure = 6 KIPS/SF (D.L.+L.L.) can be used. Footings should have a minimum width of 2 ft. and be set at least 2 ft. below final adjacent grade.

Minor foundations supported on undisturbed natural ground including CLAY-SILT (Zone 2) as noted in 6.1 above can use an allowable bearing pressure = 3 KIPS/SF (D.L.+L.L.)

Care should be taken to prevent water ponding in footing excavations and all fill material should be removed from under foundation areas.

It is anticipated that differential settlement will be less than 3/4 inches using the above foundation recommendations.

6.3: For basement wall design an equivalent fluid lateral load of 35 psf/lf can be used providing a granular drainage layer is backfilled between the wall and the excavation cut to prevent water pressure loading.

6.4: If tieback anchors are proposed for shoring of the excavation, the anchor design and construction should take into account the layers of coarse granular material indicated in the borehole logs as well as artesian groundwater conditions.

7.0 CONCLUSIONS & RECOMMENDATIONS

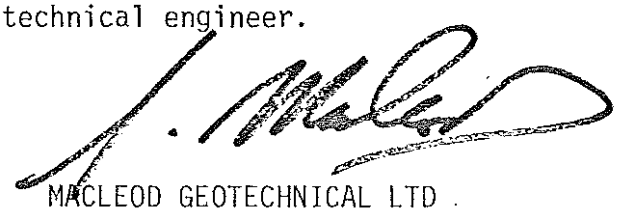
1. A generalized subsoil profile based on the borehole logs is shown on Dwg. D33-3A. Although the detailed stratigraphy is somewhat complex, the following observations can be made:

   (a) The underlying GRAVEL aquifer was encountered in all boreholes at elevations ranging from elevation 25 to 30 ft., i.e. roughly level across the site. Both piezometers recorded artesian pressures in the GRAVEL close to existing ground level at the time of the investigation.

   (b) The near surface deposits are primarily SAND except in borehole DH2 which consists of soft to firm silty CLAY with some silt and sand interbedding. There was some indication that part of the upper sand is backfill, possibly in old building basement areas.

2. Recommendations on artesian groundwater control and foundation design are given in section 5.0 and 6.0 of the report.

3. It is recommended that the proposed foundation design and groundwater control system be reviewed by the geotechnical engineer.



MACLEOD GEOTECHNICAL LTD.
G. Macleod, P. Eng.
Aug.31/79

BORING No. DH1

LOCATION SEE PLAN
[MIDPT. OF SITE AT CARNARVON ST.]

GROUND SURFACE ELEV.
63.1 ft. GEODETIC DATUM

GROUND WATER ELEV.
(at time of boring) SEE PZ. RDGS.

METHOD OF SAMPLING: MAYHEW 1000 ROTARY DRILL
Casing ..... o.d., Hamr. ..... lbs., Drop ..... inch
Drive sample 1 3/8" i.d., Hammer 140 lbs., Drop 30 inch
(Blows per 6" penetration unless otherwise noted)
Thinwall Shelby, ... o.d. and ..... o.d.
Piston sample
X Lost sample 72 HR REVERT DRILLING MUD USED
W.S. Wash sample

WTN 1080056

Depth, ft.	Elev., ft.	Blows on Sampler	Symbol	Description	Sample No.	Natural Water Content %	
0				ASPHALT			ROUGH DRILLING to 4' BENTONITE
				SAND-GRAVEL-COBBLES – FILL (?) –			
5		9,9,10		gy-gr. & br. f. SAND sm. silt, tr. b'kn. shells, smell: organic & oil – MEDIUM DENSE	1		1" ϕ PERFORATED STANDPIPE STANDPIPE RDGS W.L. JULY 9/79 : 1' DEPTH
10		21,26,19		[SAND in wash return]	2		DENSER DRILLING @ 9' (PUSHING STONE (?))
		9,8,2		gy-gr. silty f. SAND with layers silty CLAY, pebbles, wht. flakes – FIRM	2A		EASY DRILLING
15		10/3" bouncing			3	27.8	BENTONITE $L_w = 28.2$ $P_w = 19.1$
				gy. sandy SILT w/ some interbedded silty CLAY w/ scatt. pebbles – DENSE			AIR PIEZOMETER RDGS JULY 6/79 : 37' HEAD 9/79 : 37' AUG 14/79 : 36'
20		13,18, 24			4		
25		24,32, 39			5		
				gy. f. silty SAND, thin horizontal bedding, occ. loose silty clay – DENSE			DRILLING INDICATED WATER PRESSURE IN SAND @ 30' (±)
30		35,47, 60			6		
50				BTM. OF HOLE @ 52'			OVERNIGHT @ 40'

PEA GRAVEL
BACKFILL: PEA GRAVEL & CUTTINGS
PE

E.R. PRODYN LTD	MACLEOD GEOTECHNICAL LTD. 1451 MARINE DRIVE WEST VANCOUVER, B.C.		
PROPOSED DEVT. S.W. CR. CARNARVON AT LORNE NEW WESTMINSTER	BOREHOLE LOG DH1	By:	Date: JULY 3, 79
		Job: D33	Dwg: D33-2A

BORING No. DH2

LOCATION SEE PLAN

GROUND SURFACE ELEV. 43.0 ft. ± GEODETIC

GROUND WATER ELEV.

(at time of boring) SEE PZ. RDGS

METHOD OF SAMPLING: MAYHEW 1000 ROTARY

Casing ..... o.d., Hammer 140 lbs., Drop 30 inch

Drive sample 1 3/8 i.d., Hammer ..... lbs., Drop ..... inch

(Blows per 6" penetration unless otherwise noted)

Thinwall Shelby, ... o.d. and ..... o.d.

Piston sample

Lost sample

W.S. Wash sample

DRILLED W/ 72 hr. REVERT DRILLING MUD

LOTN 108057

Depth, ft.	Elev., ft.	Blows on Sampler	Symbol	Description	Sample No.	Natural Water Content %
				ASPHALT		
5		-wt. of rods 12" then 6/6"		gy. silty CLAY w/ pebbles interbedded with minor sandy silt & silty sand - FIRM	1	31.2 L_w=29.4 ; P_w=17.6
10		4,4,4			2	30.7 L_w=29.8 ; P_w=21.1
15		30,53 33/4"		gy. Sandy SILT w/ trace clay, scattered pebbles and gravel - COMPACT / TILL-LIKE	3	14.3
20	25		W.S. W.S.	gy. c.m. SAND & GRAVEL, rounded - DENSE	4 5	
25				BTM. OF HOLE		

BENTONITE SEAL

EASY DRILLING

BACKFILL: CUTTINGS

PEA GRAVEL

BENTONITE SEAL

BENTONITE SEAL

PNEUMATIC PIEZOMETER AT 18' DEPTH

ROUGH DENSE DRILLING

PEA GRAVEL

SAND & GRAVEL

AIR PIEZOMETER READINGS:

JULY 20 : 17.3' head
JULY 23 : 17.2' head
AUG 14 : 17.3' head

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MACLEOD GEOTECHNICAL LTD. 1451 MARINE DRIVE WEST VANCOUVER, B C

PROPOSED DEVT. CARNARVON AT LORNE NEW WESTMINSTER B.C.

BOREHOLE LOG DH2

By: DG

Date: JULY 19/79

Job: D33

Dwg: D33-2B

BORING No. DH3 /

LOCATION SEE PLAN

GROUND SURFACE ELEV. 56.5 ft ± GEODETIC

GROUND WATER ELEV.

(at time of boring)

METHOD OF SAMPLING: AYHEW 1000 ROTARY

Casing ..... o.d., Hammer ..... lbs., Drop ..... inch

Drive sample 1 3/8 i.d., Hammer 140 lbs., Drop 30 inch

(Blows per 6" penetration unless otherwise noted)

Thinwall Shelby, ... o.d. and ..... o.d.

Piston sample

X Lost sample

W.S. Wash sample

WTN 108058

Depth, ft.	Elev., ft.	Blows on Sampler	Symbol	Description	Sample No.	Natural Water Content %	
0				ASPHALT			QUICK and SMOOTH DRILLING to 14 ft.
5		7,10, 10		gy-br & br. m.f. SAND, tr. silt – FILL? – – MEDIUM DENSE	1	24.4	
10		8,9,9		(gy.)	2	22.3	
				gravel layer or lense			ROUGH DRILLING
15		2,7,17		gy, silty CLAY w/ pebbles, interbedded with sand lenses – FIRM	3	34.0 32.2	– L_w = 30.3 ; P_w = 18.2 QUICK DRILLING w/ occ. ROUGH SECTIONS
20		23,28, 31		gy, m. f. SAND w/ tr. silt, horizontal bedding, some small 1/8" silty CLAY lenses – MED. DENSE to DENSE	4	20.9	BECOMING MORE DENSE @ 19'
25		22,51		gy. sandy SILT w/ pebbles and gravel – COMPACT / TILL-LIKE	5		DENSE DRILLING
	29.5		W.S.	gy. c.m. SAND & GRAVEL, rounded – DENSE	6		VERY ROUGH, DENSE DRILLING
30				BTM OF HOLE @ 30.5'	7		

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MACLEOD GEOTECHNICAL LTD. 1451 MARINE DRIVE WEST VANCOUVER, B.C

PROPOSED DEVT. CARNARVON AT LORNE NEW WESTMINSTER

BOREHOLE LOG DH3

By: DG

Date: JULY 23/79

Job: D33

Dwg: D33-2C

BORING No. DH 4

LOCATION SEE PLAN

GROUND SURFACE ELEV. 49.0 ft.± GEODETIC

GROUND WATER ELEV.

(at time of boring)

METHOD OF SAMPLING: AYHEW 1000 ROTARY

Casing ..... o.d., Hammer ..... lbs., Drop ..... inch

Drive sample 1 3/8" i.d., Hammer 140 lbs., Drop 30 inch

(Blows per 6" penetration unless otherwise noted)

Thinwall Shelby, ... o.d. and ..... o.d.

Piston sample

X Lost sample

W.S. Wash sample

WIN 109059

Depth, ft.	Elev., ft.	Blows on Sampler	Symbol	Description	Sample No.	Natural Water Content %	
0				ASPHALT			
				br. SAND, GRAVEL w/ COBBLES and decomposed wood – FILL(?) –			ROUGH DRILLING to 6'
5		16, 20, 22			1		
		7, 3, 2		gy. silty CLAY with pebbles interbedded with sandy SILT – FIRM	2		QUICK EASY DRILLING to 11.5'
			W.S.		3		
10		push			4	36.6 – CLAY 27.7 – CLAY – L_W = 26.8 : P_W = 18.9 22.0 – SILT	
		23, 30, 25			5		
15		22, 39, 43		gy. f. sandy SILT, tr clay interbedded w/ minor c.m.f. sand lenses – DENSE	6	16.1 – SILT	SMOOTH DENSE DRILLING.
20		21, 59			7	19.5 – SILT	
	28		W.S.		8		VERY ROUGH DRILLING, LITTLE BINDER, HOLE CAVING AFTER 25', SOME MUD LOSS
25				gy. c.m. SAND & GRAVEL, rounded – MED. DENSE to DENSE			
			W.S.		9		
			W.S.		10		
30				BTM. OF HOLE			

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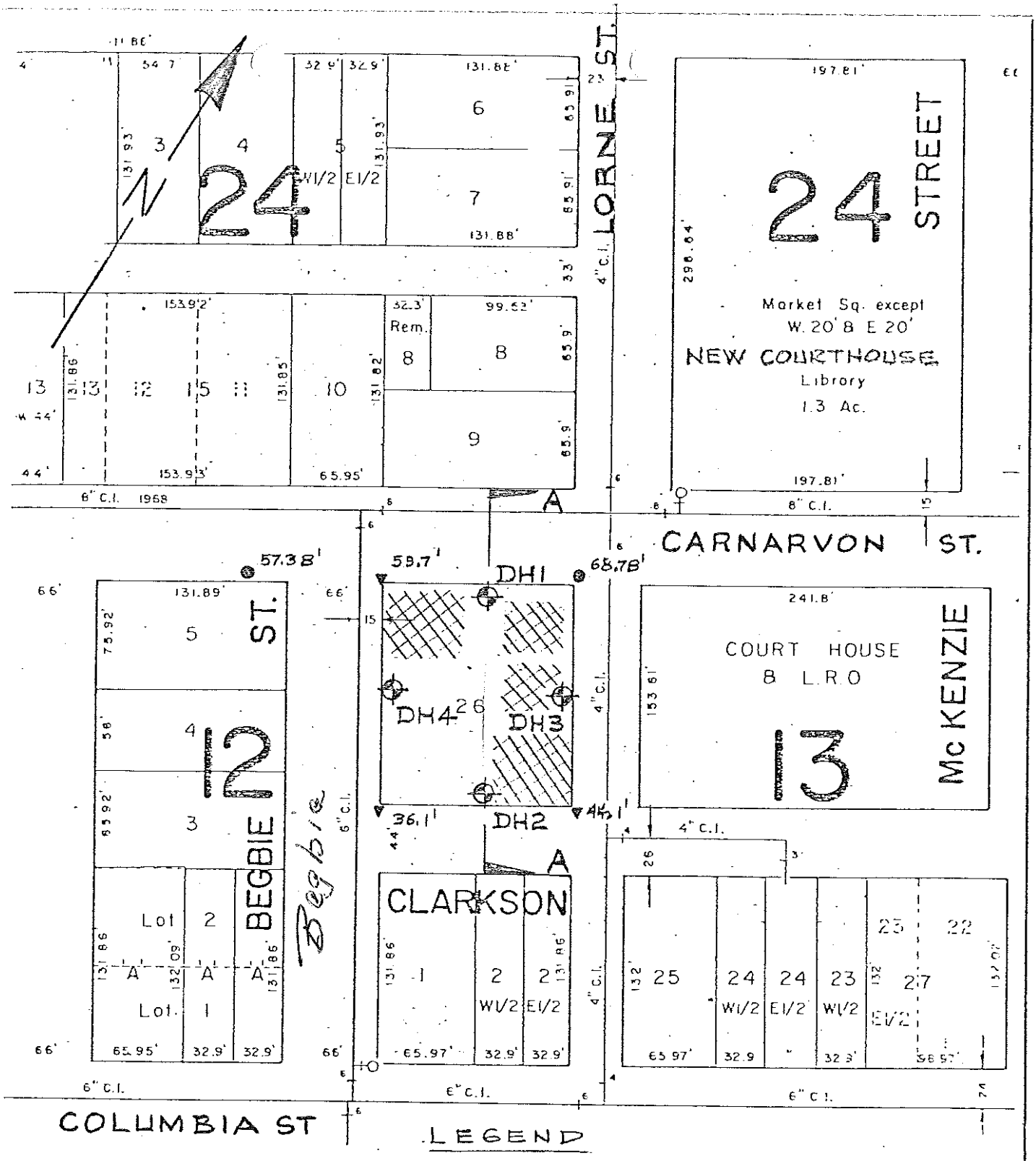
MACLEOD GEOTECHNICAL LTD. 1451 MARINE DRIVE WEST VANCOUVER, B.C.

PROPOSED DEVT. CARNARVON AT LORNE NEW WESTMINSTER

BOREHOLE LOG DH4

By: D. G. | Date: JULY 20/73

Job: D 33 | Dwg: D33-2D



LEGEND

DH1 DRILL HOLE LOCATION

ELEVATIONS - GEODETIC DATUM

▼ MEASURED

● N.W. MONUMENT

SCALE: 1" = 100 ft.

PREVIOUS STRUCTURES. (APPROX. LOCATION)

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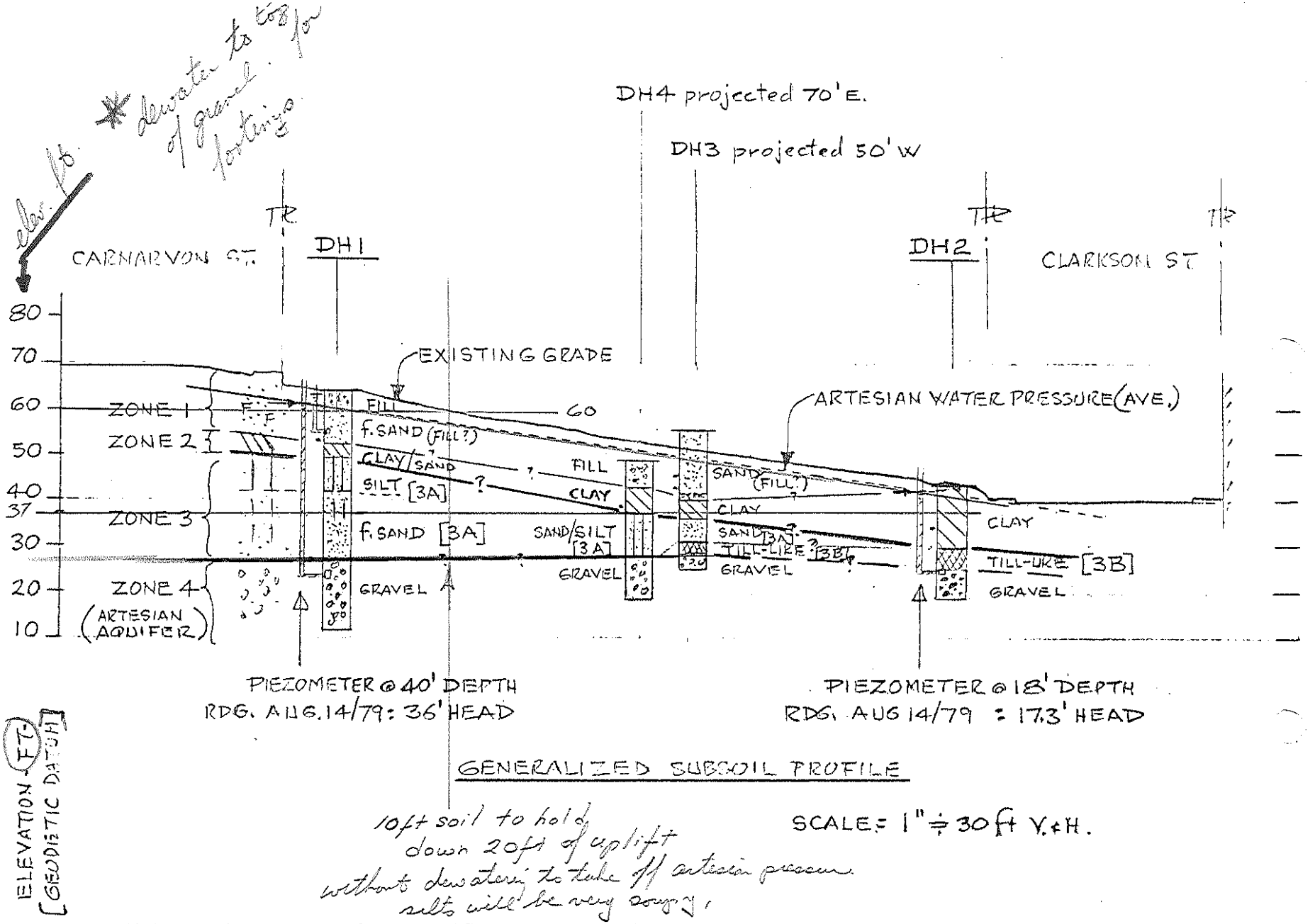
PROPOSED DEVELOPMENT CARNARVON AT LORNE NEW WESTMINSTER	LOCATION PLAN	By: DG	Date: AUG/79
		Job: D33	Dwg: D33-1A



GENERALIZED SUBSOIL PROFILE

SCALE: 1" = 30 ft V. & H.

10ft soil to hold down 20ft of uplift without dewatering to take off artesian pressure silts will be very soupy.

NOTE: GROUND STRATIFICATION IS ESTIMATED ONLY BY INTERPOLATED LINES BETWEEN BOREHOLES — SIMILARLY FOR LINE SHOWING ARTESIAN WATER PRESSURE.

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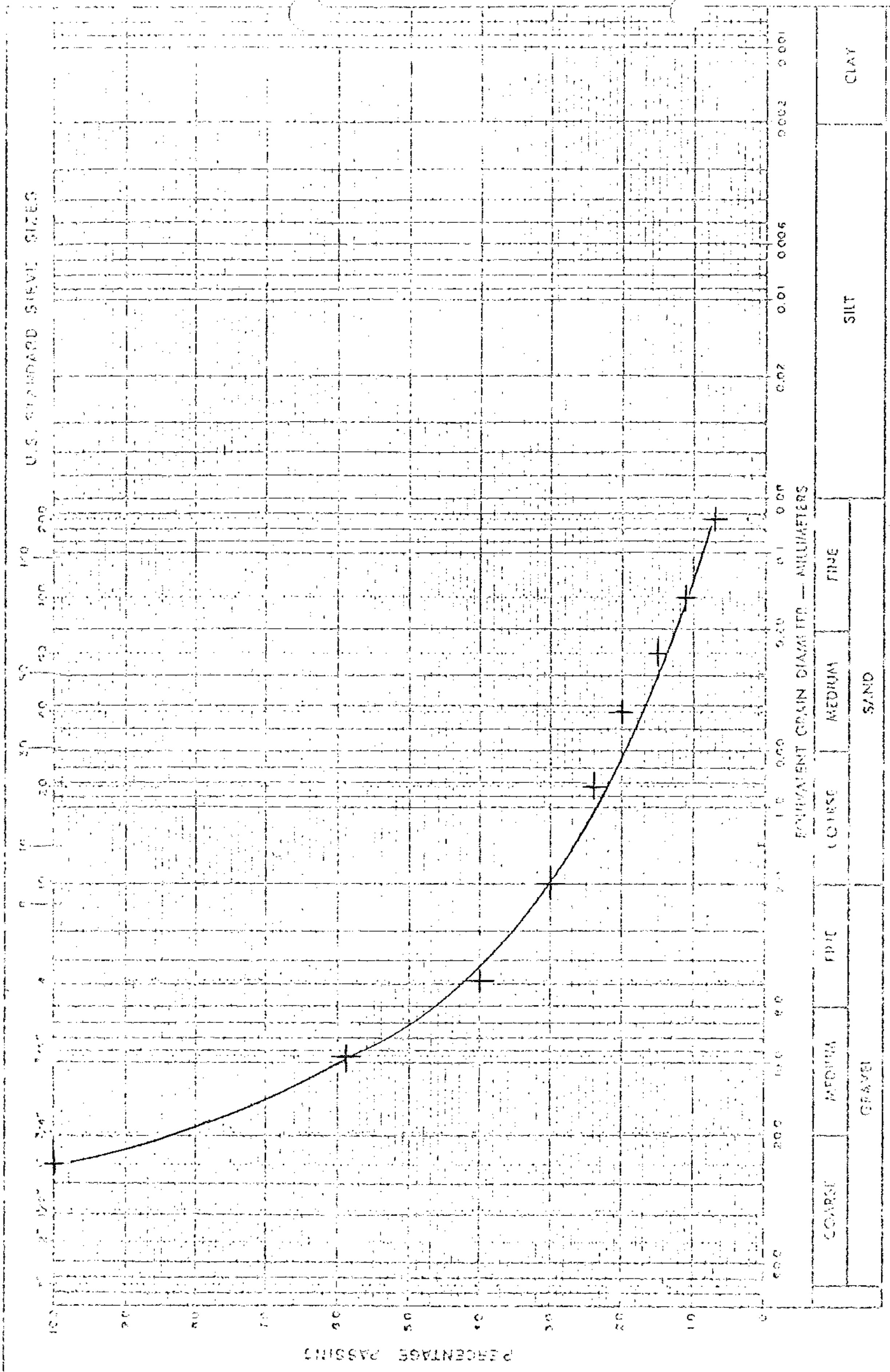
PROPOSED DEVELOPMENT
CARNARVON AT LORNE
NEW WESTMINSTER

CROSS-SECTION A-A

MACLEOD GEOTECHNICAL LTD.
1451 MARINE DRIVE
WEST VANCOUVER, B.C.

By: DG
Date: AUG/79
Job: D23
Dwg: D33-3A

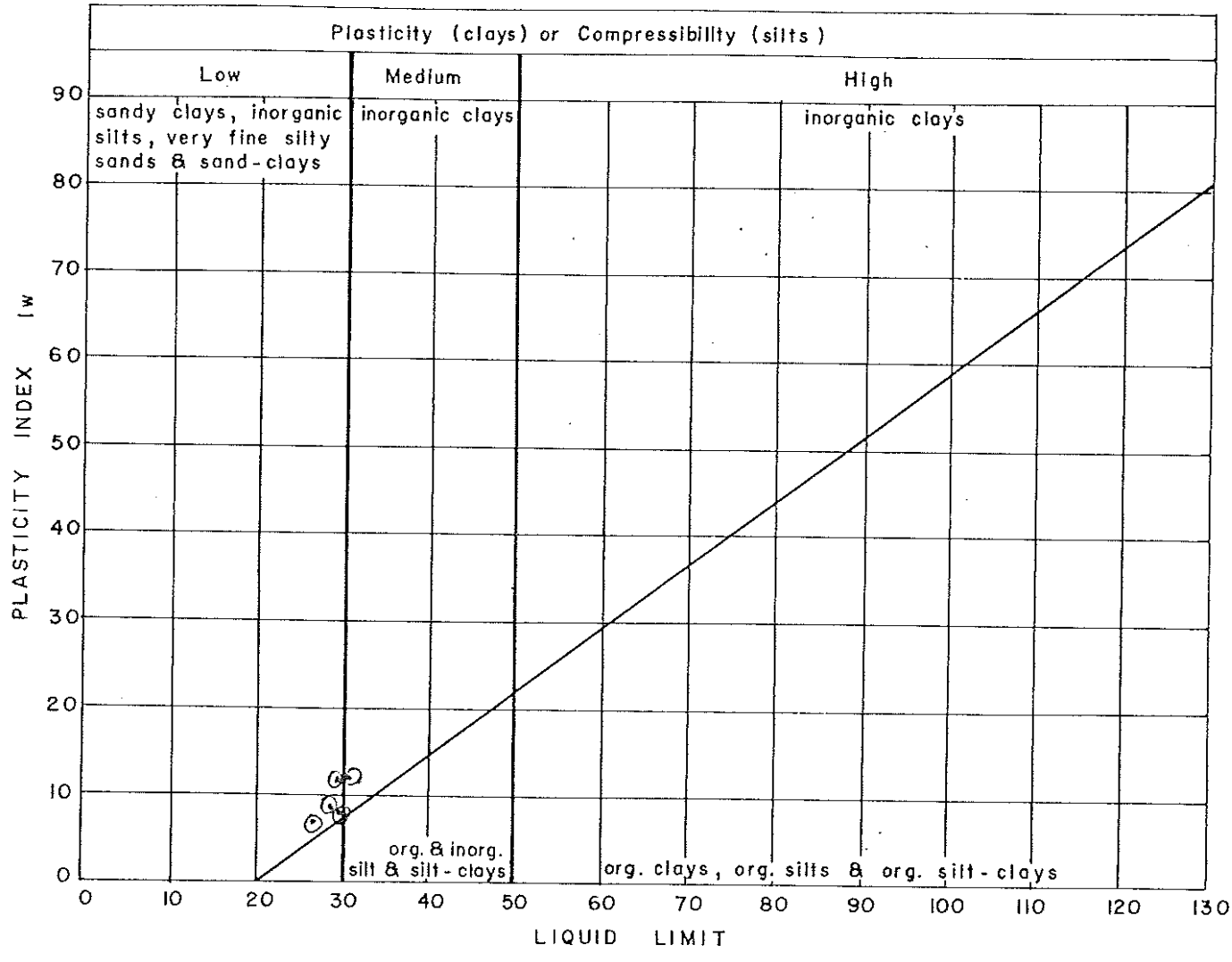


REMARKS

Split spoon sample at 40' - Zone 4" SAND + GRAVEL - rounded [from artesian aquifer]

E. R. PROBYN LTD.	MACLEOD GEOTECHNICAL LTD.		
PROPOSED DEVELOPMENT S.W. CR. CARNARVON AT LORNE NEW WESTMINSTER.	GRAIN SIZE ANALYSIS DH1 — SAMPLE 10	By D.G.	Date JULY 10/79
		Job D33	Dwg D33-4

Hole No.	Sample No.	Depth	..C. %	Lw %	Pw %	Iw %	Description & Remarks
DH1	3	15	27.8	28.2	19.1	9.1	(SPLIT SPOON SAMPLE)
DH2	1	6	31.2	29.4	17.6	11.8	
	2	11	30.7	29.3	21.1	8.7	"ZONE 2"
DH3	3	16	32.2	30.3	18.2	12.1	
			(34.0)				
DH4	4	11	(36.6	clay)			
			27.7	26.8	18.9	7.9	
			(22.0	silt)			



PLASTICITY CHART FOR SOIL CLASSIFICATION

E.R. PROBYN LTD	MACLEOD GEOTECHNICAL LTD. West Vancouver, B.C.		
PROPOSED DEVT. CARNARVON @ LORNE NEW WESTMINSTER	PLASTICITY CHART	by	date JULY/79
		job D77	dwg D33-5