

66-F-273 M

SPRING CREEK BRIDGE

LOT 18 , CON. 18/19

WEST WILLIAMS TWP.

B.A. 2465
DOMINION SOIL INVESTIGATION LIMITED

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R. C. DUNN AND ASSOCIATES LTD.
CONSULTING ENGINEER
LONDON ONTARIO

Report on
SOIL INVESTIGATION
for
SPRING CREEK BRIDGE,
LOT 18, CONCESSIONS 18 & 19,
TOWNSHIP OF WEST WILLIAMS.

66-F-272 M

by
DOMINION SOIL INVESTIGATION LIMITED
369 Queens Avenue
LONDON ONTARIO

Reference No. 6-10-L1.
October 21st, 1966.

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SUMMARY

The two boreholes revealed the following general ground succession:- topsoil and clayey fill (1'-0" to 2'-0" thick); firm silty clay (8'-0" to 9'-6" thick); soft organic silty clay (4'-6" to 7'-6" thick); loose organic silt (3'-6" in borehole 1); loose to dense well-graded sand (1'-6" to 4'-6" thick); and stiff to hard silty clay till (13'-0" maximum penetrated).

It is recommended that the structure be supported on deep spread footings within the silty clay till stratum or alternatively a box-type of culvert be employed supported on timber piles which should achieve a suitable set at about El. 135.

I INTRODUCTION

In accordance with a letter of authorization from R. C. Dunn and Associates Limited, dated October 5, 1966, a soil investigation has been carried out in the Township of West Williams where it is proposed to replace an existing road bridge with a new structure.

The existing steel-beam structure is located on Lot 18, Concessions 18 and 19 of the Township where the road crosses Spring Creek.

It is understood that the proposed structure is a concrete culvert with about a 20 foot span. The creek will be re-located and the centre line of the new structure will be moved about 175 feet to the east of the centre line of the existing bridge. The requirements of the project were discussed with Mr. N.M. Wamer, P. Eng., who supplied the foregoing information.

The purpose of this investigation was to reveal the subsurface conditions at the site and to determine the relevant soil properties for the design and construction of the new foundations.

II FIELD WORK

The field work, consisting of 2 boreholes was carried out on October 11 and 12, 1966, at the locations shown on Enclosure 2. The holes were advanced by washboring methods and were lined with Bx casing.

Standard Penetration Tests using a 2 inch outside diameter split-spoon sampler were performed at frequent intervals of depth, using a driving force of a 140 lb. hammer falling freely through 30 inches. The tube is first driven an initial 6 inches to allow for the presence of disturbed material at the bottom of the borehole. The number of standard blows required to drive the sampler a further 12 inches was recorded as the standard penetration resistance (or 'N' value). This test determines the relative density of granular strata and gives an indication of the consistency of cohesive strata. It also enables samples to be obtained for classification purposes.

Insitu vane shear tests using a 4 inch long by 2 inch diameter 4 bladed vane were performed in cohesive strata to determine the undrained shear strength of the soil.

Dynamic cone penetration tests were performed adjacent to each borehole location to obtain an indication of soil density changes with depth.

The results of the field tests are presented on the Geotechnical Data Sheets, Enclosures 3 and 4. Elevations were referred to a site benchmark which was indicated by the client (South corner of east abutment, El. 167.33 feet).

Cont'd over....

III SUBSURFACE CONDITIONS

Detailed descriptions of the strata encountered in each borehole are given on the Geotechnical Data Sheets, comprising Enclosures 3 and 4, and a general picture of the soil stratigraphy is given in the form of a Subsurface Profile on Enclosure 2.

The boreholes revealed the following general ground succession:-

| | <u>Thickness</u> |
|--|-------------------------------|
| (a) Topsoil and clayey fill. | 1'-0" to 2'-0" |
| (b) Brown/bluish grey silty clay. The consistency is described as 'firm' as indicated by standard penetration test results ranging from 4 to 6 blows per foot. | 8'-0" to 9'-6" |
| (c) Grey highly sensitive organic silty clay. This stratum contains an appreciable amount of organic matter and exhibits cohesion. The consistency is described as 'soft' as indicated by standard penetration test results ranging from 2 to 3 blows per foot. The undrained shear strength obtained from the insitu vane shear tests ranges from 480 to 2400 pounds per square foot with a remoulded shear strength of 40 to 240 pounds per square foot. | 4'-6" to 7'-6" |
| (d) Grey organic silt, encountered in borehole 1 only. The relative density of this stratum is described as 'very loose' as indicated by a standard penetration test result of 2 blows per foot. | 3'-6" |
| (e) Grey fine to coarse sand, containing little fine gravel. The relative density of this stratum is described as 'very loose' to 'dense' as estimated from standard penetration test results ranging from 6 to 34 blows per foot. | 1'-6" to 4'-6" |
| (f) Grey silty clay. This is a cohesive plastic material of a glacial origin. Based on visual and tactile examination the shear strength of this stratum increases with depth. The consistency is described as 'stiff' to 'hard' as indicated by standard penetration test results ranging from 16 to 47 blows per foot. | Penetrated 3'-0" to 13'-0" |

Cont'd over....

IV LABORATORY TESTS

Atterberg Limit and moisture content tests were carried out on 2 samples of the silty clay till stratum as a means of classification and as a guide to the probable behaviour of the soil. These gave values of Liquid Limit of 31% and 33%; Plastic Limit of 14% and Plasticity Index of 17 and 19, indicating that the soil is a clay of low plasticity and compressibility. The Liquidity Indices which relate the natural moisture content of the clay to the Atterberg Limits ranged between 0.29 and 0.42 confirming the 'stiff' consistency obtained from the visual and tactile examination.

The results of the Atterberg Limit and moisture content tests are plotted graphically on the Geotechnical Data Sheet for each borehole.

V GROUNDWATER CONDITIONS

The water level in the creek at the time the field work was carried out was at El. 162.9 feet.

Due to the impermeable nature of the subsoil a true groundwater level could not be obtained in the boreholes, however it can be assumed that the groundwater level is closely related to the water level in the creek at any particular time.

VI DISCUSSION

The soil profile consists of loose or soft highly compressible deposits extending down to El. 148[±], therefore the load from the structure must be transferred to the hard silty clay till stratum below.

The type of structure employed may be either an open-type culvert supported on deep spread footings or alternatively a box-type of culvert supported on timber piles which should be driven into the clay till stratum. The two types of culvert will be discussed separately.

Open-type Culvert with deep footings

On the basis of the borehole results the footing grade should be established at El. 147, at which level it will be appropriate to use a maximum allowable soil pressure of 4000 p.s.f. Total settlement of footings mobilizing the above soil pressure is estimated to be less than 1 inch.

The excavations for the footings will require lateral support to prevent "sloughing-in" of the sides of the excavation and also for dewatering purposes the sheeting should be driven into the impervious silty clay till stratum to seal the bottom of the excavation.

Cont'd over....

Box-type Culvert supported on Timber Piles

Timber Piles would be expected to achieve a suitable set at about El. 135. The ultimate bearing capacity of the pile is estimated from the sum of the end-bearing and skin-friction components. For a pile with a 10 inch diameter tip the end-bearing will be 12 tons and the skin-friction component will be 2.3 tons per foot of penetration of the pile into the clay stratum.

As an example, the ultimate bearing capacity of a pile driven 12 feet into the clay stratum will be made up of the 12 tons end-bearing component plus the 27.6 tons attributed to skin-friction, resulting in a 40 ton ultimate capacity.

A factor of safety of 2 is usually applied in the design of piles, therefore the allowable working load for such a pile would be 20 tons.

The foregoing estimates of length and bearing capacity of piles are only theoretical predictions, therefore in practice, the piles should be driven to a satisfactory set in accordance with an accepted pile driving formula such as the Hiley formula.

It is estimated that consolidation settlement of a structure supported on a timber pile foundation will be less than 1/2 inch.

Following excavation for the culvert, it will probably be necessary to place a layer of sand or gravel on the exposed surface to facilitate movement of construction personnel.

In conclusion the use of a timber pile foundation will probably be the least expensive, although choice of design may depend on factors such as availability of material speed of construction etc.

Yours very truly,

DOMINION SOIL INVESTIGATION LIMITED



[Signature]
V. S. Chan, P.Eng.

VSC:jms

Enclosures

LIST OF SYMBOLS, ABBREVIATIONS AND NOMENCLATURE.

SOIL COMPONENTS AND GROUND WATER CONDITIONS.

| | | | | | | | | | | | | |
|--------------------------|--------|--------|------|--------|--------|--------|---------|-------|----------|---------------|--------------------|------------------|
| | | | | | | | | | | | | |
| BOULDER | COBBLE | GRAVEL | | SAND | | | SILT | CLAY | ORGANICS | BEDROCK | GROUND WATER LEVEL | DEPTH OF CAVE-IN |
| | | COARSE | FINE | COARSE | MEDIUM | FINE | | | | | | |
| Ø | > 8" | 3" | ¾" | 4.75mm | 2.0 | 0.42 | 0.074 | 0.002 | > | NO SIZE LIMIT | | |
| U.S. Standard Sieve Size | | | | No. 4 | No. 10 | No. 40 | No. 200 | | | | | |

SAMPLE TYPES.

| | | |
|-----------------------|-----------------------|------------------------------------|
| AS Auger sample | RC Rock core | TP Piston, thin walled tube sample |
| CS Sample from casing | % Recovery | TW Open, thin walled tube sample |
| ChS Chunk sample | SS Split spoon sample | WS Wash sample |

| | | | |
|---------------------|-------------------|--------------------------------|-----------------------|
| SAMPLER ADVANCED BY | static weight : w | OBSERVATIONS MADE WHILE CORING | Steady pressure |
| " | pressure : p | | No pressure |
| " | tapping : t | | Intermittent pressure |

Washwater returns
Washwater lost

PENETRATION RESISTANCES.

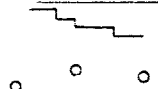
DYNAMIC PENETRATION RESISTANCE : to drive a 2" ϕ , 60° cone attached to the end of the drilling rods into the ground, expressed in blows per foot.

STANDARD PENETRATION RESISTANCE, -N- : to drive a 2" outside dia, split spoon sampler 1 foot into the ground, expressed in blows per foot.

EXTRAPOLATED -N- VALUE

The energy for the penetration resistances is supplied by a 140 lb. hammer falling 30 inches

SYMBOL :



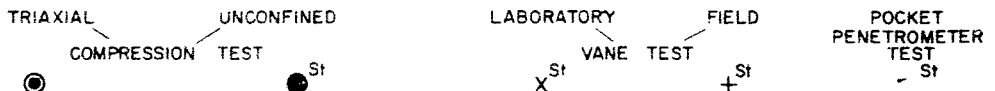
322

SOIL PROPERTIES.

| | | |
|-----------------------|--|---|
| W % Water content | γ^* Natural bulk density (unit weight) | k Coeff of permeability |
| LL % Liquid limit | e Void ratio | C Shear strength in terms of total stress |
| PL % Plastic limit | RD Relative density | ϕ' Angle of int. friction in terms of effective stress |
| PI % Plasticity index | C _v Coeff of consolidation | C Cohesion |
| LI Liquidity index | m _v Coeff of volume compressibility | ϕ' Angle of int. friction |

UNDRAINED SHEAR STRENGTH.

— DERIVED FROM —



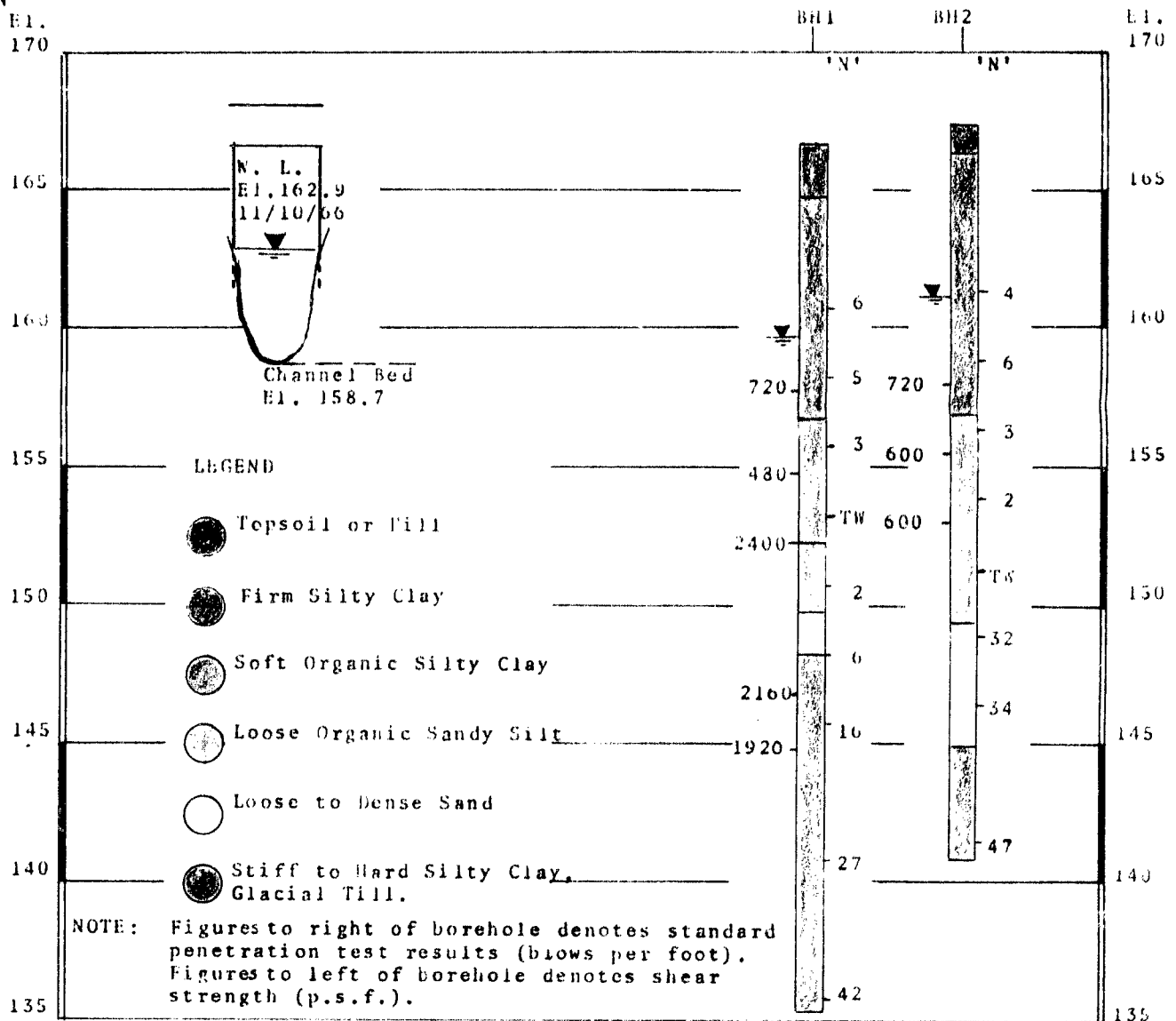
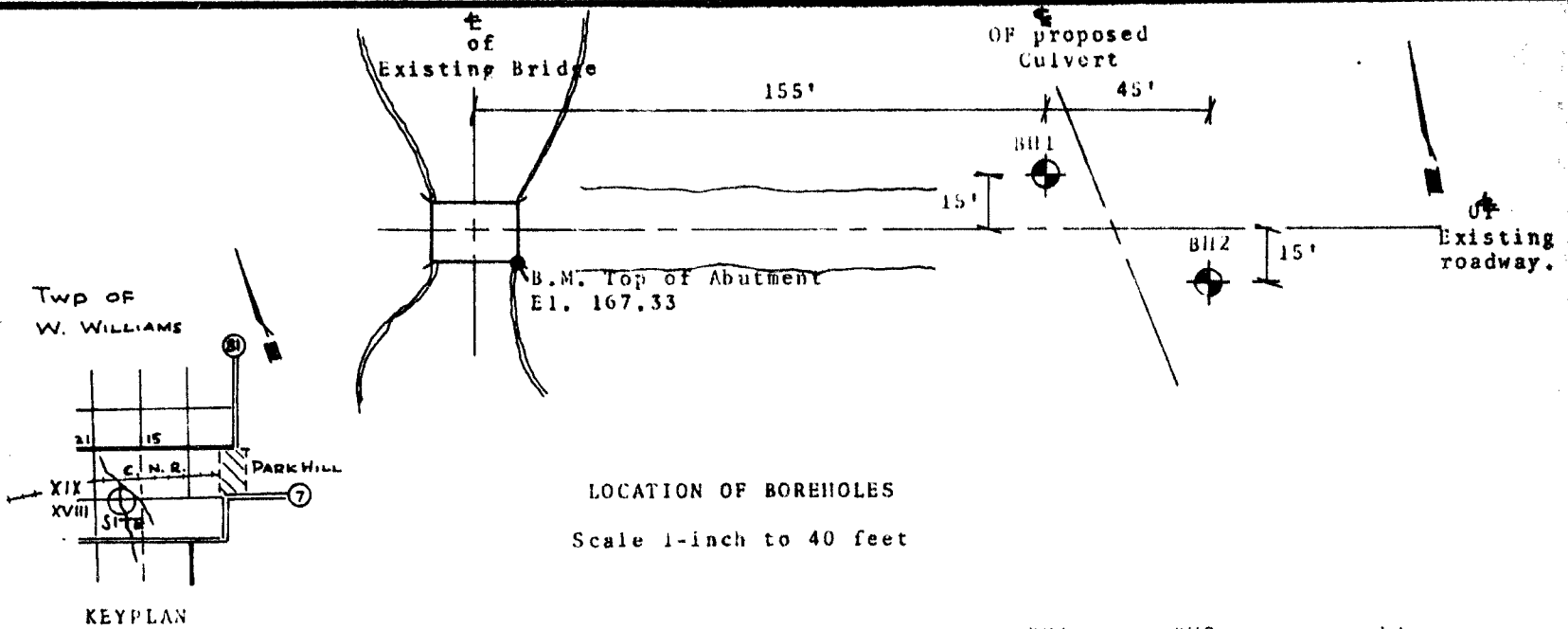
Strain at failure is represented by direction of stem

20%
15% — 5%
10%

St : sensitivity = $\frac{\text{shear strength in undisturbed state}}{\text{shear strength in remoulded state}}$

SOIL DESCRIPTION.

| COHESIONLESS SOILS : | RD : | COHESIVE SOILS : | C lbs/sq ft |
|----------------------|------------|------------------|---------------|
| Very loose | 0 - 15 % | Very soft | less than 250 |
| Loose | 15 - 35 % | Soft | 250 - 500 |
| Compact | 35 - 65 % | Firm | 500 - 1000 |
| Dense | 65 - 85 % | Stiff | 1000 - 2000 |
| Very dense | 85 - 100 % | Very stiff | 2000 - 4000 |
| | | Hard | over 4000 |



GEOTECHNICAL DATA SHEET FOR BOREHOLE . 1

OUR REFERENCE NO 6-10-L1

CLIENT R.C. Dunn & Associates Ltd.,

PROJECT Spring Creek Bridge No. 2

LOCATION Lot 18, Concs. 18 & 19, Twp. of W. Williams DATE October 11, & 12, 1966

DATUM ELEVATION

METHOD OF BORING Washboring

DIAMETER OF BOREHOLE Bx (3-inch)

ENCLOSURE NO 5

| ELEVATION ft | DEPTH ft | STRATIFICATION DESCRIPTION | SYMBOL | SAMPLES | | | PENETRATION RESISTANCE blows per foot | | | | | CONSISTENCY water content % | | | | REMARKS |
|-----------------|-------------|-------------------------------|--------|---------|------|--------------------------------------|--|------|------|------|-----|--------------------------------|----|----|----|---------|
| | | | | NUMBER | TYPE | N or Advancement of Sampler | 20 | 40 | 60 | 80 | 100 | PL | W | LI | | |
| | | | | | | | 1000 | 2000 | 3000 | 4000 | | 10 | 20 | 30 | 40 | |
| 166.7 | 0.0 | Ground Surface | | | | | | | | | | | | | | |
| 165 | 2.0 | Clayey Fill | | | | | | | | | | | | | | |
| | | Firm | | | | | | | | | | | | | | |
| | | silty | | | | | | | | | | | | | | |
| 160 | | clay | | 1 | SS | 6 | | | | | | | | | | |
| | | brown | | | | | | | | | | | | | | |
| | | bluish | | 2 | SS | 5 | | | | | | | | | | |
| | | grey | | | | | | | | | | | | | | |
| 10.0 | | | | | | | | | | | | | | | | |
| 155 | | Soft grey | | 3 | SS | 3 | | | | | | | | | | |
| | | organic | | | | | | | | | | | | | | |
| | | silty clay | | 4 | TW | | | | | | | | | | | |
| 14.5 | | | | | | | | | | | | | | | | |
| | | Very loose grey | | | | | | | | | | | | | | |
| | | organic sandy | | 5 | SS | 2 | | | | | | | | | | |
| 150 | | silt. | | | | | | | | | | | | | | |
| 17.0 | | | | | | | | | | | | | | | | |
| | | Very loose grey | | | | | | | | | | | | | | |
| 18.5 | | fine to coarse | | 6 | SS | 6 | | | | | | | | | | |
| | | sand. | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | |
| 148 | | Stiff | | 7 | SS | 16 | | | | | | | | | | |
| | | to | | | | | | | | | | | | | | |
| | | hard | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | |
| 140 | | grey | | 8 | SS | 27 | | | | | | | | | | |
| | | silty | | | | | | | | | | | | | | |
| | | clay. | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | |
| 135 | 31.5 | (Glacial Till) | | 9 | SS | 42 | | | | | | | | | | |
| | | End of Borehole | | | | | | | | | | | | | | |

W. L.
El. 159.7
12/10/66

VERTICAL SCALE: 1 IN. TO FT.

DOMINION SOIL INVESTIGATION LIMITED

MADE.

CH'D.

GEOTECHNICAL DATA SHEET FOR BOREHOLE . 2

OUR REFERENCE NO. 6-10-L1

CLIENT: R.C. Dunn & Associates Ltd

PROJECT: Spring Creek Bridge No. 2

LOCATION: Lot 18, Concs. 18 & 19, Twp. of Williams DATE: October 12, 1966

DATUM ELEVATION:

METHOD OF BORING: Washboring

DIAMETER OF BOREHOLE 8x (3-inch)

ENCLOSURE NO. 4

| ELEVATION ft. | DEPTH ft. | STRATIFICATION DESCRIPTION | STRATIFICATION SYMBOL | SAMPLES | | | PENETRATION RESISTANCE blows per foot | | | | | CONSISTENCY water content % | | | | REMARKS |
|------------------|--------------|-------------------------------|--------------------------|---------|------|--------------------------------------|--|------|------|------|------|--------------------------------|----|----|----|---------|
| | | | | NUMBER | TYPE | N or Advancement of Sampler | 20 | 40 | 60 | 80 | 100 | PL | W | LI | | |
| | | | | | | | 1000 | 2000 | 3000 | 4000 | 5000 | 10 | 20 | 30 | 40 | |
| 167.4 | 0.0 | Ground Surface | | | | | | | | | | | | | | |
| | 1.0 | Topsoil | | | | | | | | | | | | | | |
| 165 | | Firm | | | | | | | | | | | | | | |
| | | silty brown | | 1 | SS | 4 | | | | | | | | | | |
| | | bluish | | | | | | | | | | | | | | |
| 160 | | clay. grey | | 2 | SS | 6 | | | | | | | | | | |
| | 10.5 | | | 3 | SS | 3 | | | | | | | | | | |
| | | Soft grey | | | | | | | | | | | | | | |
| 155 | | organic | | 4 | SS | 2 | | | | | | | | | | |
| | | silty | | | | | | | | | | | | | | |
| | | clay | | 5 | TW | | | | | | | | | | | |
| 150 | 18.0 | wood | | | | | | | | | | | | | | |
| | | Dense gravelly | | 6 | SS | 32 | | | | | | | | | | |
| | | grey fine | | | | | | | | | | | | | | |
| | | to coarse | | 7 | SS | 34 | | | | | | | | | | |
| 145 | 22.5 | | | | | | | | | | | | | | | |
| | | Hard grey | | | | | | | | | | | | | | |
| | | silty clay | | | | | | | | | | | | | | |
| | | (Glacial Till) | | 8 | SS | 47 | | | | | | | | | | |
| 140 | 26.5 | End of Borehole | | | | | | | | | | | | | | |

W. L.

E1. 161.1

12/10/66

W. L.
El. 161.1
12/10/66