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Ministry  
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## FOUNDATION DESIGN SECTION

**foundation  
investigation and  
design report**

**ENGINEERING MATERIALS OFFICE**  
**FOUNDATION DESIGN SECTION**

WP 662-89-00 DIST 6  
HWY 401 to 407 STR SITE -

Feasibility Study of Freeway Link  
From Hwy 401 to Hwy 407  
Pickering/Ajax/Whitby Freeway Link

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GEOCRES 30M15-84

DATE AUG 17 1994

# **FOUNDATION INVESTIGATION REPORT**

For

Feasibility Study of Freeway Link

From Hwy 401 to Hwy 407

Pickering/Ajax/Whitby Freeway Link

W.P. 662-89-00, District 6, Toronto

## **INTRODUCTION**

This report summarizes the results of a foundation investigation for the preliminary design study of the proposed Pickering/Ajax/Whitby Freeway Link from Hwy 401 northerly to Hwy 407 in the Town of Whitby, Region of Durham. The investigation was carried out at the request of Central Region Structural Section.

Several routes were proposed for the study corridor to link the existing Highway 401 and the proposed Hwy 407. All proposed routes were within the Town of Pickering, Ajax and Whitby between Hwy 401 and proposed Hwy 407. However, the technically preferred route, where this foundation investigation took place, was within the Town of Whitby, Region of Durham. The technically preferred freeway link is located on the eastern portion of the study corridor. The proposed Whitby link route is oriented north south at an offset of about 800 m east of Lakeridge Road (west boundary of Town of Whitby). The area investigated extends in a north-south direction from Hwy 401 to the proposed Hwy 407, just east of Lakeridge Road (County Road No. 23). Lakeridge Road defines the boundary between the Town of Ajax and the Town of Whitby, south of Lyndebrook Road, and defines the boundary between the Town of Pickering and the Town of Whitby, north of Lyndebrook Road. The proposed link and proposed structure locations are illustrated in Drawing No. 6628900-A.

This investigation was intended for initial assessment of the feasibility of the proposed alignment from a foundation point of view, with a general coverage of the area by limited number of boreholes.

Before embarking on the Foundation investigation, a Preliminary Geotechnical Conditions report by Geocon Inc. dated July 31, 1992 was reviewed by this office (Geocon Report T11707B, Phase II Route Planning and Environmental Assessment Study).

## **SITE DESCRIPTION**

The site for the proposed Whitby link between Hwy 401 and proposed Hwy 407, is basically farm lands and vacant lands. Four roads (Hwy 2/Dundas St, Rossland Rd/RR 28, Taunton Rd/RR 4, Lyndebrook Rd/5th Concession, Hwy 7/Winchester Rd. West and a CP track) cross this site in a east west direction. Residential properties are primarily located along the major streets which the proposed highway would cross.

The existing ground elevation varies from 82.6m (BH 9) in the south extreme of the proposed Whitby link to 183.0m (BH 8) in the north extreme. Since the proposed link route is about 10 kilometre long (station 1+000 to 11+000). The ground slopes at about 1 per cent towards the south (Lake Ontario). Overall the topography of the terrain is generally flat with some smooth rolling hills. Deep valleys can be found where the wooded ravines and creeks are located.

Physiographically, the area is located in a region referred to as the "South Slope and Iroquois Plain" (Reference: Chapman and Putnam "The Physiography of Southern Ontario; 3rd Edition, 1984). This is the low land bordering Lake Ontario which was inundated in the Pleistocene time by Lake Iroquois. Subsoils in these areas generally are characterized by a mosaic of till plains, drumlins and areas of Glaciolacustrine deposits of silt, sand and clayey silt.

## **INVESTIGATION PROCEDURES**

The field work for the investigation was carried out between 93 12 09 and 93 12 16. The investigation consisted of eight (8) sampled boreholes (BH 1 and 3 through 9). One borehole was put down at each proposed major interchange. Borehole 2 which was intended to be drilled at the proposed interchange of the Whitby Link and Rossland Rd, could not be drilled due to access problem. The boreholes were advanced to depths of 5.8 to 12.3 m.

The boreholes were advanced with a truck mounted machine equipped with continuous flight augers. Conventional hollow stem augers were used. The sampling program consisted of split spoon samples collected in the overburden. Disturbed subsoil samples were retrieved by split spoon sampler in accordance with Standard Penetration Test (ASTM D1586).

Standard Penetration 'N' values were recorded for assessment of the strength of the materials encountered. All subsoil samples were identified in the field and returned to the laboratory for further visual examination and testing. Groundwater levels were measured in each borehole and all boreholes were backfilled upon completion of the field work.

Surveying required to ascertain borehole locations and elevations was carried out by the Central Region Surveys and Plans Section.

### **SUBSURFACE CONDITIONS**

The record of Borehole sheets in the Appendix illustrate the subsurface conditions at the borehole locations. The location and elevation of the boreholes are shown in Drawing No. 6628900-A.

Since the investigation was spread over a large area of 10 kilometre, individual borehole logs should be referred to for information on soil conditions at any structure location. However, the predominant soil strata encountered at the site consisted of glacial till (made up primarily of silty clay to clayey silt) with inclusion of silty sand and silt zones. The surficial deposit at the site was a glacial till. However, in Boreholes 6,7 and 8 the glacial till was overlain by a 1.2m to 1.5m thick deposit of silty sand to sand. Weathered shale fragments were encountered at the bottom of BH 1,3 and 4.

The Standard Penetration test in cohesive glacial till recorded 'N' values from 5 blows to more than 100 blows, but on average 20 to 100 blows. Based on the 'N' values, the cohesive glacial till has a firm to hard consistency, but in general it is very stiff to hard. In non-cohesive glacial till the 'N' value ranged from 21 to more than 100 blows indicating the material to be compact to very dense.

### **GROUNDWATER CONDITIONS**

Individual boreholes should be referred to for groundwater elevation at any proposed structure locations. Groundwater level was recorded in all boreholes during the investigation and is provided in the Record of Borehole sheet for each borehole. The groundwater table stabilized at depths ranging from 0.4m (BH 5) to 5.3m (BH 7) below ground surface. The groundwater elevation ranged from 81.2m (BH 9) to 182.0m (BH 8). Groundwater levels are subject to seasonal fluctuations and may vary from the values provided in this report.

## DISCUSSION AND RECOMMENDATIONS

### General

This report contains recommendations pertaining to the structure foundations, approach embankments, cuts and hydrogeological aspects for various structures for the Whitby Link from the proposed Hwy 407 to the existing Hwy 401 in the Municipality of Whitby, Region of Durham. The recommendations given in the report are tentative based on the limited information available and should definitely be reviewed based on supplementary investigations. The site location is shown on Drawing No 6628900-A.

Total 15 bridge structures are proposed along the Whitby link. This include nine structures for interchanges, five underpasses and one subway.

In general, the geotechnical conditions within the proposed route corridors are favourable. There are no foundation concerns that would require realignment of the proposed Whitby Link. Subsurface conditions over the site are uniform and competent for structure foundation and embankment loadings. The glacial till is expected to provide adequate bearing for most structures and may be able to sustain low to medium loads on shallow spread footings. However, deep foundations such as caissons and piles may be required to transfer heavier loads to greater depths and to more competent bearing material. Our comments from the feasibility, design and construction of the various structures are given on the Foundation Data Sheets included in the Appendix. Eight data sheets (Area 1, and 3 to 9) are provided for the 15 structures; the area locations are also shown on Drawing No. 6628900-A. An explanation of information provided on the data sheet is outlined below:

1. The structure number given (i.e. 1,2,3 etc is a numbering system developed for the purpose of the feasibility study. The area is the location of boreholes drilled for this study (1, 2, 3, etc) The actual location is shown on Drawing No. 6628900-A.
2. The original ground elevation is based on the survey results of the borehole locations along the proposed Whitby Link alignment.
3. The grades of roadway given is based on the proposed grades of Whitby Link at the respective sites, obtained from a profile of the Technically Preferred Route supplied to us (no reference no).

4. Subsurface conditions are described very briefly and are based on generally one borehole per area.

5. Structure Foundations

The recommendations are for pier and abutment foundations. The options for structure foundations are given in preferential order based on geotechnical/economical considerations. Further elaboration of structure recommendations made on the data sheets are given below:

Compacted Granular 'A' Core (Engineered Fill) - This option is generally for abutments where subsurface conditions are competent. The minimum requirements of a compacted granular 'A' core are shown on Figure No. 1 (attached). Furthermore, the footing for this scheme could be designed using the following parameters:

Factored Bearing Capacity at U.L.S. = 900 kPa  
Bearing Capacity at S.L.S. Type II = 350 kPa

Spread Footings: This option is given for abutments and piers where subsurface conditions are competent. The highest elevation and corresponding maximum design load is given. It is to be noted the spread footing should be provided with a minimum of 1.2m of earth cover for frost protection purposes. In addition, where the spread footing is to be founded on a cohesive deposit, subject to softening upon exposure to construction or weather conditions, it would be necessary to protect the base of the footing excavation from softening by placing a working slab of lean concrete immediately upon completion of the footing excavation. Also, where the footing is located in a non cohesive deposit and the water table is at or above the footing founding level, it will be necessary to prevent the base of the footing from "boiling" due to an unbalanced excess hydrostatic head. In this case a dewatering scheme would be required.

**End-Bearing Piles:** This founding scheme is recommended for the abutments and piers where appropriate. The recommendation gives the estimated pile tip elevation. Generally, the end-bearing piles can be designed for the factored axial capacity at U.L.S. and the axial capacity at S.L.S. Type II which is dependent on the pile section chosen. The following design parameters are recommended for the pile foundation:

<u>Pile Type</u>	<u>Factored Axial Capacity at U.L.S. (kN)</u>	<u>Axial Capacity at S.L.S. Type II (kN)</u>
310X79	1150	900
310X110	1600	1150

It is generally assumed steel 'H' piles will be used. Pile driving would be field controlled by the Hiley Formula unless it is being driven to the bedrock surface or in clayey subsoil.

## 6. Approaches

The recommendation for fill slopes, cut slopes and berm requirements, are based on the proposed preliminary grades assuming fills are constructed of acceptable earth borrow according to current MTO Specifications. Any changes in profile grade would require a reassessment of these recommendations. Also, discussed under this heading is special treatment, i.e. benching, slope protection, etc., that is anticipated at this location. No excessive settlements of embankments at the proposed fill heights are anticipated at this stage.

## 7. Other Considerations

The granular 'A' or 'B' backfill should be in accordance with Special Provision. The following properties will be used for the calculation of lateral pressure:

Granular 'A'	$\gamma = 22.8 \text{ kN/m}^3$ , $\phi = 35^\circ$ , $K_o = 0.43$ , $K_a = 0.27$
Granular 'B'	$\gamma = 21.2 \text{ kN/m}^3$ , $\phi = 30^\circ$ , $K_o = 0.50$ , $K_a = 0.33$
Native Soil	$\gamma = 20.0 \text{ kN/m}^3$ , $\phi = 26^\circ$ , $K_o = 0.56$ , $K_a = 0.39$

If the structure is to be designed as a rigid frame then the coefficient of earth pressure at rest ( $K_0$ ) will be used.

All foundation elements should have a minimum of 1.2m earth cover for frost protection. The concrete for the footings should be formed 'in the dry'. Consequently a dewatering scheme will be required if the concrete is poured below the prevailing water level

#### 8. Remarks

In this column comments are made about any construction difficulties, dewatering and hydrogeological concerns at any given site.

#### MISCELLANEOUS

The tentative foundation recommendations outlined in this report are for feasibility study or preliminary planning purposes only as they are based on very limited subsurface information. It will be necessary to carry out a detailed foundation investigation at each of the structure sites when the design details and geometries are finalized and approved. In some areas, groundwater studies and special in-situ field testing may be warranted.

The field work for this investigation was carried out under the supervision of K. Ahmad, Project Foundation Engineer, and L.R. Lake, Engineer in Training. The equipment was owned and operated by Dominion Soil Ltd.

The project was carried out by K. Ahmad under the supervision of D. Dundas, Acting Chief Foundation Engineer. The report was prepared by K. Ahmad and L.R. Lake, and reviewed and approved by D. Dundas, Acting Chief Foundation Engineer.



A handwritten signature in cursive script, reading "K.S.Q. Ahmad".

K.S.Q. Ahmad, P. Eng.  
Project Foundation Engineer

A handwritten signature in cursive script, reading "D. Dundas".

D.H. Dundas, P. Eng.  
Chief Foundation Engineer (Acting)

## **APPENDIX**

## **FOUNDATION DATA SHEETS**

## FOUNDATION DATA SHEET

W.P. 662 - 89 - 00 AREA 1 BRIDGE REF. Nos. 3, 5 LOCATION HWY 401 IC: Ramp W-N over Ramp N - E, Hwy 2 Underpass  
 ORIGINAL GROUND ELEV. 85.0 PROPOSED Whitby Link GRADE ELEV. 84.0, 85.0

Reference:

SUBSURFACE CONDITIONS	RECOMMENDATIONS		REMARKS
	STRUCTURE	APPROACHES	
<u>REFERENCE BOREHOLE</u>  <u>BH. 1</u>  0.0 - 2.1 m Clayey Silt Fill V. Stiff to Hard  2.1 - 9.4 m Silty Clay to Clayey Silt Firm to Hard (Glacial Till)   <u>Groundwater Elevation</u>  82.8 m	1.) For piers spread footings placed within very stiff glacial till below Elev. 80.0 m and below a frost depth of 1.2 m may be designed for:  - Factored Bearing Capacity at U.L.S = 500 kPa - Bearing Capacity at S.L.S. Type II = 300 kPa  2.) For Abutments at higher elevations, spread footings can be placed on a well compacted granular 'A' pad designed for:  - Factored Bearing Capacity at U.L.S. = 900 kPa - Bearing Capacity at S.L.S. Type II = 350 kPa  3.) Higher Bearing Capacities can be utilized at elevations below 76.0 m  4.) For higher bearing capacity, piles and caissons are also feasible, but should be selected on a cost comparison basis.	Cut up to 6 m deep will be stable at 2 H : 1 V side slope.  Fill up to 8 m will be stable at 2 H : 1 V side slopes.	1.) No serious foundation problems are anticipated.  2.) No major dewatering problems are anticipated.  3.) Not a suitable site for an infiltration pond.

# FOUNDATION DATA SHEET

W.P. 662 - 89 - 00 AREA 3 BRIDGE REF. Nos. 6 LOCATION Rossland Road Underpass  
 ORIGINAL GROUND ELEV. 102.0 PROPOSED Whitby Link GRADE ELEV. 97.0  
 Reference:

SUBSURFACE CONDITIONS	RECOMMENDATIONS		REMARKS
	STRUCTURE	APPROACHES	
<u>REFERENCE BOREHOLE</u>  <u>BH. 3</u>  0.0 - 4.4 m Clayey Silt V. Stiff to Hard (Glacial Till)  4.4 - 5.9 m Silty Clay Stiff to V. Stiff  5.9 - 10.4 m Clayey Silt V. Stiff (Glacial Till)  10.4 - 11.4 m Silty Sand V. Dense  11.4 - 12.3 m Weathered Shale   <u>Groundwater Elevation</u>  96.9 m	1.) For piers and abutments, spread footings placed below elevation 96.0 m within a very stiff glacial till and below a frost depth of 1.2 m may be designed for:  - Factored Bearing Capacity at U.L.S. = 300 kPa - Bearing Capacity at S.L.S. Type II = 200 kPa  2.) Alternatively, spread footings can be placed on a well compacted granular 'A' pad designed for:  - Factored Bearing Capacity at U.L.S. = 900 kPa - Bearing Capacity at S.L.S. Type II = 350 kPa  3.) For higher bearing capacity, piles and caissons are also feasible, but should be selected on a cost comparison basis.	Cut up to 6 m deep will be stable at 2 H : 1 V side slope.	1.) No serious foundation problems are anticipated.  2.) No major dewatering problems are anticipated.  3.) Not a suitable site for an infiltration pond.

# FOUNDATION DATA SHEET

W.P. 662 - 89 - 00 AREA 4 BRIDGE REF. Nos. 7 LOCATION CP Belleville Subway  
 ORIGINAL GROUND ELEV. 102.3 PROPOSED Whitby Link GRADE ELEV. 98.5  
 Reference:

SUBSURFACE CONDITIONS	RECOMMENDATIONS		REMARKS
	STRUCTURE	APPROACHES	
<u>REFERENCE BOREHOLE</u> <u>BH. 4</u> 0.0 - 2.9 m Clayey Silt V. Stiff to Hard (Glacial Till) 2.9 - 5.3 m Sandy Silt to Silt Compact to Dense 5.3 - 10.2 m Clayey Silt to Silt V. Stiff to Hard (Glacial Till) 10.2 - 11.1 m Shale  <u>Groundwater Elevation</u> 101.6 m	1.) For piers and abutments, spread footings below elevation 97.0 m within very stiff glacial till and below a frost depth of 1.2 m may be designed for:  - Factored Bearing Capacity at U.L.S. = 500 kPa - Bearing Capacity at S.L.S. Type II = 300 kPa  2.) Foundations on piles and caissons supported on shale are also feasible, but should be selected on a cost comparison basis.	Cut up to 6 m deep will be stable at 2 H : 1 V side slope.	1.) No serious foundation problems are anticipated.  2.) Dewatering will be required for excavation below water table within non cohesive material.  3.) Infiltration ponds are not feasible due to high water level.

## FOUNDATION DATA SHEET

W.P. 662 - 89 - 00 AREA 5 BRIDGE REF. Nos. 8 LOCATION Taunton Road Underpass

ORIGINAL GROUND ELEV. 111.6 PROPOSED Whitby Link GRADE ELEV. 112.0  
Reference:

SUBSURFACE CONDITIONS	RECOMMENDATIONS		REMARKS
	STRUCTURE	APPROACHES	
<u>REFERENCE BOREHOLE</u>  <u>BH. 5</u>  0.0 - 8.4 m Clayey Silt to Silt Hard (Glacial Till)  8.4 - 9.4 m Silt V. Dense (Glacial Till)   <u>Groundwater Elevation</u>  111.3 m	1.) For piers and abutments spread footings placed within hard glacial till below Elev. 111.0 m and below a frost depth of 1.2 m may be designed for:  - Factored Bearing Capacity at U.L.S. = 600 kPa - Bearing Capacity at S.L.S. Type II = 400 kPa  2.) For higher bearing capacity, piles and caissons are also feasible, but should be selected on a cost comparison basis.	Fill up to 8 m high can be constructed at 2 H : 1 V side slopes.	1.) No serious foundation problems are anticipated.  2.) No major dewatering problems are anticipated.  3.) This is not a suitable site for an infiltration pond. The soil is of low permeability. Groundwater table will be high after construction.

## FOUNDATION DATA SHEET

W.P. 662 - 89 - 00 AREA 6 BRIDGE REF. Nos. 9 LOCATION Lyndbrook Road Underpass  
 ORIGINAL GROUND ELEV. 131.4 PROPOSED Whitby Link GRADE ELEV. 133.0  
 Reference:

SUBSURFACE CONDITIONS	RECOMMENDATIONS		REMARKS
	STRUCTURE	APPROACHES	
<u>REFERENCE BOREHOLE</u>  <u>BH. 6</u>  0.0 - 1.3 m Sand Loose  1.3 - 6.2 m Clayey Silt Hard (Glacial Till)  <u>Groundwater Elevation</u>  130.1 m	1.) For piers, spread footings placed within hard glacial till below Elevation 128.5 m and below a frost depth of 1.2 m may be designed for:  - Factored Bearing Capacity at U.L.S = 1000 kPa - Bearing Capacity at S.L.S. Type II = Not Governed  2.) For Abutments, spread footings placed within hard glacial till below Elevation 130.0 m and below a frost depth of 1.2 m, may be designed for:  - Factored Bearing Capacity at U.L.S. = 500 kPa - Bearing Capacity at S.L.S. Type II = 300 kPa  3.) Alternatively, at higher elevations, spread footings can be placed on a well compacted Granular 'A' pad designed for:  - Factored Bearing Capacity at U.L.S. = 900 kPa - Bearing Capacity at S.L.S. Type II = 350 kPa  4.) For higher Bearing Capacity, piles and caissons are also feasible, but should be selected on a cost comparison basis.	Fill up to 8 m high will be stable at a 2 H : 1 V side slope.  Cut up to 6 m deep will be stable at a 2 H : 1 V side slope.	1.) No serious foundation problems are anticipated.  2.) No major dewatering problems are anticipated.  3.) This is not a suitable site for an infiltration pond. The soil is of low permeability. Groundwater table will be high after construction.

## FOUNDATION DATA SHEET

W.P. 662 - 89 - 00 AREA 7 BRIDGE REF. Nos. 10 LOCATION Highway 7 Underpass  
 ORIGINAL GROUND ELEV. 156.4 PROPOSED Whitby Link GRADE ELEV. 169.0  
 Reference:

SUBSURFACE CONDITIONS	RECOMMENDATIONS		REMARKS
	STRUCTURE	APPROACHES	
<u>REFERENCE BOREHOLE</u> <u>BH. 7</u> 0.0 - 1.5 m Organic Silt V. Stiff 1.5 - 2.1 m Silty Sand Loose 2.1 - 6.4 m Clayey Silt V. Stiff to Hard (Glacial Till)  <u>Groundwater Elevation</u> 151.1 m	1.) For piers and abutments, spread footings can be placed on a well compacted Granular 'A' pad constructed on V. Stiff to Hard glacial till at Elevation 154.3 m and designed for: - Factored Bearing Capacity at U.L.S = 980 kPa - Bearing Capacity at S.L.S. Type II = 350 kPa  2.) Higher Bearing Capacities can be utilized at lower elevations below 153.0 m  3.) For higher bearing capacity, piles and caissons are also feasible, but should be selected on a cost comparison basis.	Fill up to 8 m high can be constructed at 2 H : 1 V side slopes.	1.) No serious foundation problems are anticipated.  2.) No major dewatering problems are anticipated.  3.) Not an ideal site for an infiltration pond due to the thin deposit of sand.

## FOUNDATION DATA SHEET

W.P. 662-89-00 AREA 8 BRIDGE REF. Nos. 11, 12, 13, 14, 15 LOCATION HWY 407 IC Ramps: S-W over E-S, S-W, S-W over E-N/S, E-S & NS-E over W-S

ORIGINAL GROUND ELEV. 183.4 PROPOSED Whitby Link GRADE ELEV. 184.0  
Reference:

SUBSURFACE CONDITIONS	RECOMMENDATIONS		REMARKS
	STRUCTURE	APPROACHES	
<p><u>REFERENCE BOREHOLE</u></p> <p><u>BH.8</u></p> <p>0.0 - 1.4 m Silty Sand V. Dense</p> <p>1.4 - 5.8 m Silty Clay to Clayey Silt Hard (Glacial Till)</p> <p><u>Groundwater Elevation</u></p> <p>182.0 m</p>	<p>1.) For piers and abutments, spread footings placed within hard glacial till below Elev. 182.0 m and below a frost depth of 1.2 m may be designed for:</p> <ul style="list-style-type: none"> <li>- Factored Bearing Capacity at U.L.S = 1000 kPa</li> <li>- Bearing Capacity at S.L.S. Type II = Not Governed</li> </ul> <p>2.) For higher bearing capacity, piles and caissons are also feasible, but should be selected on a cost comparison basis.</p>	<p>Fill up to 8 m high can be constructed at 2 H : 1 V side slopes.</p> <p>Cut up to 6 m deep will be stable at 2 H : 1 V side slope.</p>	<p>1.) No serious foundation problems are anticipated.</p> <p>2.) No major dewatering problems are anticipated.</p> <p>3.) Not a potential site for an infiltration pond.</p>

## FOUNDATION DATA SHEET

W.P. 662 - 89 - 00 AREA 9 BRIDGE REF. Nos. 1, 2, 4 LOCATION HWY 401 IC: Ramp E-N/S, Ramp W-N, and Ramp N-E  
 ORIGINAL GROUND ELEV. 82.6 PROPOSED Whitby Link GRADE ELEV. 83.0  
 Reference:

SUBSURFACE CONDITIONS	RECOMMENDATIONS		REMARKS
	STRUCTURE	APPROACHES	
<u>REFERENCE BOREHOLE</u>  <u>BH. 9</u>  0.0 - 6.5 m Clayey Silt Stiff to Hard (Glacial Till)          <u>Groundwater Elevation</u>  81.3 m	1.) For piers spread footings placed within very stiff glacial till below Elev. 80.0 m and below a frost depth of 1.2 m may be designed for:  - Factored Bearing Capacity at U.L.S = 500 kPa - Bearing Capacity at S.L.S. Type II = 300 kPa  2.) For Abutments spread footings at higher elevations above 80.0 m can be placed on a well compacted granular 'A' pad designed for:  - Factored Bearing Capacity at U.L.S. = 900 kPa - Bearing Capacity at S.L.S. Type II = 350 kPa  3.) Higher Bearing Capacities can be utilized at elevations below 78.0 m  4.) For higher bearing capacity, piles and caissons are also feasible, but should be selected on a cost comparison basis.	Fill up to 8 m high can be constructed at 2 H : 1 V side slopes.          Cut up to 6 m deep will be stable at 2 H : 1 V side slope.	1.) No serious foundation problems are anticipated.          2.) No major dewatering problems are anticipated.          3.) This is not a suitable site for an infiltration pond. The soil is of low permeability. Groundwater table will be high after construction.

## EXPLANATION OF TERMS USED IN REPORT

**N VALUE:** THE STANDARD PENETRATION TEST (SPT) N VALUE IS THE NUMBER OF BLOWS REQUIRED TO CAUSE A STANDARD 51mm O D SPLIT BARREL SAMPLER TO PENETRATE 0.3m INTO UNDISTURBED GROUND IN A BOREHOLE WHEN DRIVEN BY A HAMMER WITH A MASS OF 63.5kg, FALLING FREELY A DISTANCE OF 0.76m. FOR PENETRATIONS OF LESS THAN 0.3m N VALUES ARE INDICATED AS THE NUMBER OF BLOWS FOR THE PENETRATION ACHIEVED. AVERAGE N VALUE IS DENOTED THUS  $\bar{N}$ .

**DYNAMIC CONE PENETRATION TEST:** CONTINUOUS PENETRATION OF A CONICAL STEEL POINT (51mm O D 60° CONE ANGLE) DRIVEN BY 475 J IMPACT ENERGY ON 'A' SIZE DRILL RODS. THE RESISTANCE TO CONE PENETRATION IS MEASURED AS THE NUMBER OF BLOWS FOR EACH 0.3m ADVANCE OF THE CONICAL POINT INTO THE UNDISTURBED GROUND.

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

**CONSISTENCY:** COHESIVE SOILS ARE DESCRIBED ON THE BASIS OF THEIR UNDRAINED SHEAR STRENGTH ( $c_u$ ) AS FOLLOWS:

$c_u$ (kPa)	0 - 12	12 - 25	25 - 50	50 - 100	100 - 200	> 200
	VERY SOFT	SOFT	FIRM	STIFF	VERY STIFF	HARD

**DENSENESS:** COHESIONLESS SOILS ARE DESCRIBED ON THE BASIS OF DENSENESS AS INDICATED BY SPT N VALUES AS FOLLOWS:

N (BLOWS/0.3m)	0 - 5	5 - 10	10 - 30	30 - 50	> 50
	VERY LOOSE	LOOSE	COMPACT	DENSE	VERY DENSE

ROCKS ARE DESCRIBED BY THEIR COMPOSITION AND STRUCTURAL FEATURES AND/OR STRENGTH.

**RECOVERY:** SUM OF ALL RECOVERED ROCK CORE PIECES FROM A CORING RUN EXPRESSED AS A PERCENT OF THE TOTAL LENGTH OF THE CORING RUN.

**MODIFIED RECOVERY:** SUM OF THOSE INTACT CORE PIECES, 100mm+ IN LENGTH EXPRESSED AS A PERCENT OF THE LENGTH OF THE CORING RUN. THE ROCK QUALITY DESIGNATION (RQD), FOR MODIFIED RECOVERY, IS:

RQD (%)	0 - 25	25 - 50	50 - 75	75 - 90	90 - 100
	VERY POOR	POOR	FAIR	GOOD	EXCELLENT

**JOINTING AND BEDDING:**

SPACING	50mm	50 - 300mm	0.3m - 1m	1m - 3m	> 3m
JOINTING	VERY CLOSE	CLOSE	MOD. CLOSE	WIDE	VERY WIDE
BEDDING	VERY THIN	THIN	MEDIUM	THICK	VERY THICK

## ABBREVIATIONS AND SYMBOLS

### FIELD SAMPLING

S S	SPLIT SPOON	T P	THINWALL PISTON
W S	WASH SAMPLE	O S	OSTERBERG SAMPLE
S T	SLOTTED TUBE SAMPLE	R C	ROCK CORE
B S	BLOCK SAMPLE	P H	T W ADVANCED HYDRAULICALLY
C S	CHUNK SAMPLE	P M	T W ADVANCED MANUALLY
T W	THINWALL OPEN	F S	FOIL SAMPLE

### STRESS AND STRAIN

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

### MECHANICAL PROPERTIES OF SOIL

$m_v$	kPa <sup>-1</sup>	COEFFICIENT OF VOLUME CHANGE
$C_c$	1	COMPRESSION INDEX
$C_s$	1	SWELLING INDEX
$C_\alpha$	1	RATE OF SECONDARY CONSOLIDATION
$c_v$	m <sup>2</sup> /s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
$T_v$	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
$\sigma'_{vo}$	kPa	EFFECTIVE OVERBURDEN PRESSURE
$\sigma'_p$	kPa	PRECONSOLIDATION PRESSURE
$\tau_f$	kPa	SHEAR STRENGTH
$c'$	kPa	EFFECTIVE COHESION INTERCEPT
$\phi'$	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
$c_u$	kPa	APPARENT COHESION INTERCEPT
$\phi_u$	-°	APPARENT ANGLE OF INTERNAL FRICTION
$\tau_R$	kPa	RESIDUAL SHEAR STRENGTH
$\tau_r$	kPa	REMOULDED SHEAR STRENGTH
$S_t$	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

### PHYSICAL PROPERTIES OF SOIL



$\rho_s$	kg/m <sup>3</sup>	DENSITY OF SOLID PARTICLES	e	1, %	VOID RATIO	$e_{min}$	1, %	VOID RATIO IN DENSEST STATE
$\gamma_s$	kN/m <sup>3</sup>	UNIT WEIGHT OF SOLID PARTICLES	n	1, %	POROSITY	$I_D$	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
$\rho_w$	kg/m <sup>3</sup>	DENSITY OF WATER	w	1, %	WATER CONTENT	D	mm	GRAIN DIAMETER
$\gamma_w$	kN/m <sup>3</sup>	UNIT WEIGHT OF WATER	$S_r$	%	DEGREE OF SATURATION	$D_n$	mm	n PERCENT - DIAMETER
$\rho$	kg/m <sup>3</sup>	DENSITY OF SOIL	$w_L$	%	LIQUID LIMIT	$C_u$	1	UNIFORMITY COEFFICIENT
$\gamma$	kN/m <sup>3</sup>	UNIT WEIGHT OF SOIL	$w_p$	%	PLASTIC LIMIT	h	m	HYDRAULIC HEAD OR POTENTIAL
$\rho_d$	kg/m <sup>3</sup>	DENSITY OF DRY SOIL	$w_s$	%	SHRINKAGE LIMIT	q	m <sup>3</sup> /s	RATE OF DISCHARGE
$\gamma_d$	kN/m <sup>3</sup>	UNIT WEIGHT OF DRY SOIL	$I_p$	%	PLASTICITY INDEX = $w_L - w_p$	v	m/s	DISCHARGE VELOCITY
$\rho_{sat}$	kg/m <sup>3</sup>	DENSITY OF SATURATED SOIL	$I_L$	1	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$	i	1	HYDRAULIC GRADIENT
$\gamma_{sat}$	kN/m <sup>3</sup>	UNIT WEIGHT OF SATURATED SOIL	$I_C$	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$	k	m/s	HYDRAULIC CONDUCTIVITY
$\rho'$	kg/m <sup>3</sup>	DENSITY OF SUBMERGED SOIL	$e_{max}$	1, %	VOID RATIO IN LOOSEST STATE	j	kN/m <sup>3</sup>	SEEPAGE FORCE
$\gamma'$	kN/m <sup>3</sup>	UNIT WEIGHT OF SUBMERGED SOIL						

# RECORD OF BOREHOLE No 1

1 OF 1

METRIC

W.P. 662-89-00 LOCATION Co-ords: N 4 859 072.2:E 346 970.9 ORIGINATED BY LRL  
 DIST 6 HWY 401/407 Link BOREHOLE TYPE Hollow Stem Auger COMPILED BY LRL  
 DATUM Geodetic DATE 1993 12 09 CHECKED BY KA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W <sub>P</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa								WATER CONTENT (%)		
								20 40 60 80 100										
85.0	Ground Surface																	
0.0	Clayey Silt with Some Sand V. Stiff to Hard  (Fill)		1	SS	15													
82.9			2	SS	35													
2.1	Silty Clay to Clayey Silt With Traces of Sand and Gravel Firm to Hard  (Glacial Till)		3	SS	16													
			4	SS	15													
			5	SS	10													
			6	SS	5													
			7	SS	39													
			8	SS	23													
			9	SS	100													
75.6																		
9.4	End of Borehole																	

# RECORD OF BOREHOLE No 3

1 OF 1

METRIC

WP 662-89-00 LOCATION Co-ords: N 4 860 951.7; E 346 081.7 ORIGINATED BY LRL

DIST 6 HWY 401/407 Link BOREHOLE TYPE Hollow Stem Auger COMPILED BY LRL

DATUM Geodetic DATE 1993 12 13 CHECKED BY KA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
102.0	Ground Surface													
0.0														
	Clayey Silt with Some Sand and Gravel V. Stiff to Hard (Glacial Till)		1	SS	31		101							
			2	SS	22		100							
			3	SS	32		99							
			4	SS	24		98							
97.6			5	SS	17		97							
4.4	Silty Clay with Occ. Layers of Sand & Silt Stiff to V. Stiff		6	SS	21		96							
			7	SS	12		95							
96.1			8	SS	20		94							
5.9	Clayey Silt with Traces of Sand and Gravel Occ. Sand Layers V. Stiff (Glacial Till)		9	SS	21		93							
			10	SS	28		92							
91.6			11	SS	71		91							
10.4	Silty Sand with Traces of Shale Fragments Very Dense						90							
90.6														
11.4	Weathered Shale Bedrock													
89.7			12	SS	100	/8cm								
12.3	End of Borehole													

+3, x5: Numbers refer to  
Sensitivity

20  
15-5 (%) STRAIN AT FAILURE  
10

# RECORD OF BOREHOLE No 4

1 OF 1

METRIC

W.P. 662-89-00 LOCATION Co-ords: N 4 861 476.9; E 345 899.7 ORIGINATED BY LRL  
 DIST 6 HWY 401/407 Link BOREHOLE TYPE Hollow Stem Auger COMPILED BY LRL  
 DATUM Geodetic DATE 1993 12 13 CHECKED BY KA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>P</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
102.3	Ground Surface																
0.0	Clayey Silt with Traces of Sand and Gravel V. Stiff to Hard (Glacial Till)		1	SS	34		102										
			2	SS	35		101										
			3	SS	25		100										
99.4	Sandy Silt to Silt Compact to Dense		4	SS	37		99										
2.9			5	SS	21		98										
			6	SS	27		97										
97.0	Clayey Silt to Silt with Some Sand and Gravel V. Stiff to Hard (Glacial Till)		7	SS	51		96										
5.3			8	SS	30		95										
			9	SS	28		94										
92.1	Shale		10	SS	100		93										
10.2							92										
91.2																	
11.1	End of Borehole																

## 1 OF 1

METRIC

DATUM Geodetic DATE 1993 12 15 CHECKED BY KA

+3, x5: Numbers refer to Sensitivity

# RECORD OF BOREHOLE No 6

1 OF 1

METRIC

WP 662-89-00 LOCATION Co-ords: N 4 864 852.9; E 344 766.1 ORIGINATED BY LRL  
 DIST 6 HWY 401/407 Link BOREHOLE TYPE Hollow Stem Auger COMPILED BY LRL  
 DATUM Geodetic DATE 1993 12 15 CHECKED BY KA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
131.4	Ground Surface																
0.0	Sand with Traces of Organics Loose		1	SS	4		131										
130.1			2	SS	32		130										
1.3	Silty Sand With Some Gravel V. Dense		3	SS	95		129										
	Clayey Silt With Traces of Sand and Gravel Hard (Glacial Till)		4	SS	100	/10cm	128										
			5	SS	100	/5cm	127										
			6	SS	100	/10cm	126										
125.3			7	SS	100	/5cm											
6.1	End of Borehole																

# RECORD OF BOREHOLE No 7

1 OF 1

METRIC

W.P. 662-89-00 LOCATION Co-ords: N 4 866 898.8; E 344 510.2 ORIGINATED BY LRL

DIST 6 HWY 401/407 Link BOREHOLE TYPE Hollow Stem Auger COMPILED BY LRL

DATUM Geodetic DATE 1993 12 16 CHECKED BY KA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>P</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100							WATER CONTENT (%) 10 20 30			
								SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100										
156.4	Ground Surface																	
0.0	Organic Silt With Traces of Sand and Gravel V. Stiff					/10cm 	156											
154.9			1	SS	26		155											
1.5	Silty Sand With Traces of Organics Loose		2	SS	8		154											
154.3																		
2.1	Clayey Silt With Some Sand and Gravel V. Stiff to Hard (Glacial Till)		3	SS	10													
			4	SS	28		153											
			5	SS	78	152												
			6	SS	100	151												
150.0																		
6.4	End of Borehole																	

# RECORD OF BOREHOLE No 8

1 OF 1

METRIC

W.P. 662-89-00 LOCATION Co-ords: N 4 867 704.8; E 343 854.2 ORIGINATED BY LRL

DIST 6 HWY 401/407 Link BOREHOLE TYPE Hollow Stem Auger COMPILED BY LRL

DATUM Geodetic DATE 1993 12 16 CHECKED BY KA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
183.4	Ground Surface													
0.0	Silty Sand With Some Gravel and Packets of Organic Silt V. Dense		1	SS	63		183							
182.0			2	SS	179		182							
1.4			3	SS	100	/13cm	181							
			4	SS	100	/8cm	180							
	Silty Clay to Clayey Silt With Some Sand and Gravel Hard (Glacial Till)		5	SS	100	/8cm	179							
			6	SS	100	/3cm	178							
177.6			7	SS	100	/5cm	178							
5.8	End of Borehole													

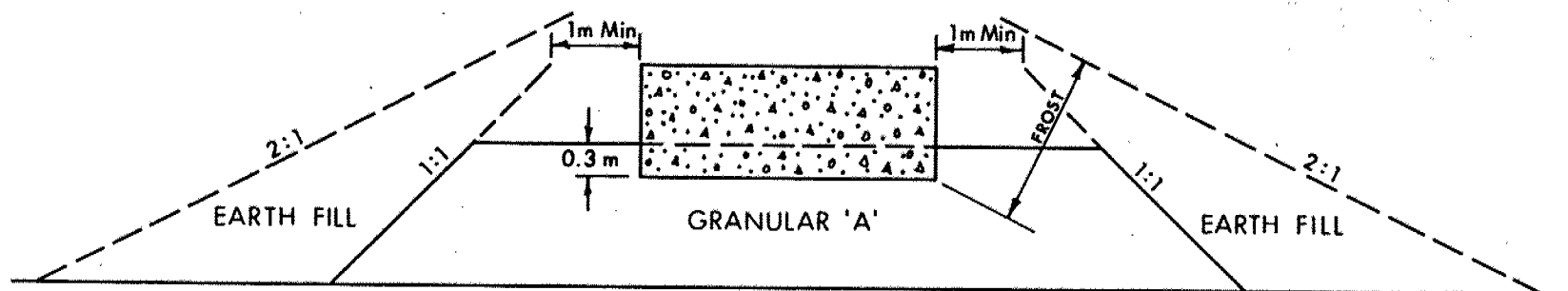
# RECORD OF BOREHOLE No 9

1 OF 1

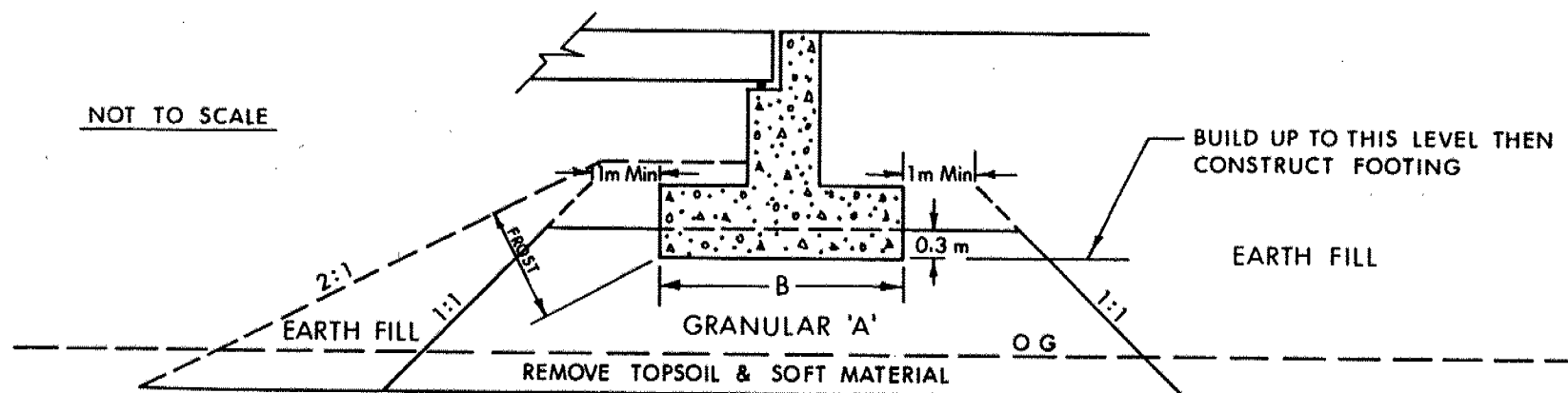
METRIC

W.P. 662-89-00 LOCATION Co-ords: N 4 858 247.0; E 347 406.1 ORIGINATED BY LRL  
 DIST 6 HWY 401/407 Link BOREHOLE TYPE Hollow Stem Auger COMPILED BY LRL  
 DATUM Geodetic DATE 1993 12 09 CHECKED BY KA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40						60	80	100
82.6	Ground Surface																
0.0	Clayey Silt With Traces of Sand and Gravel Stiff to Hard (Glacial Till)		1	SS	12												
			2	SS	23												
			3	SS	9												
			4	SS	23												
			5	SS	60												
			6	SS	124												
			7	SS	74	/15cm											
76.1			8	SS	140	/20cm											
6.5	End of Borehole																



X SECTION



LONGITUDINAL SECTION

NOTES:

- 1 - REMOVE TOPSOIL &/OR SOFT SUBSOIL UNDER AREA OF COMPACTED GRANULAR 'A' & EARTH FILL.
- 2 - PLACE GRANULAR 'A' & EARTH FILL TO BOTTOM OF FOOTING LEVEL, COMPACTED ACCORDING TO CURRENT M T O STANDARDS.
- 3 - CONSTRUCT CONCRETE FOOTING.
- 4 - PLACE REMAINDER OF GRANULAR 'A' & EARTH FILL AS REQUIRED.



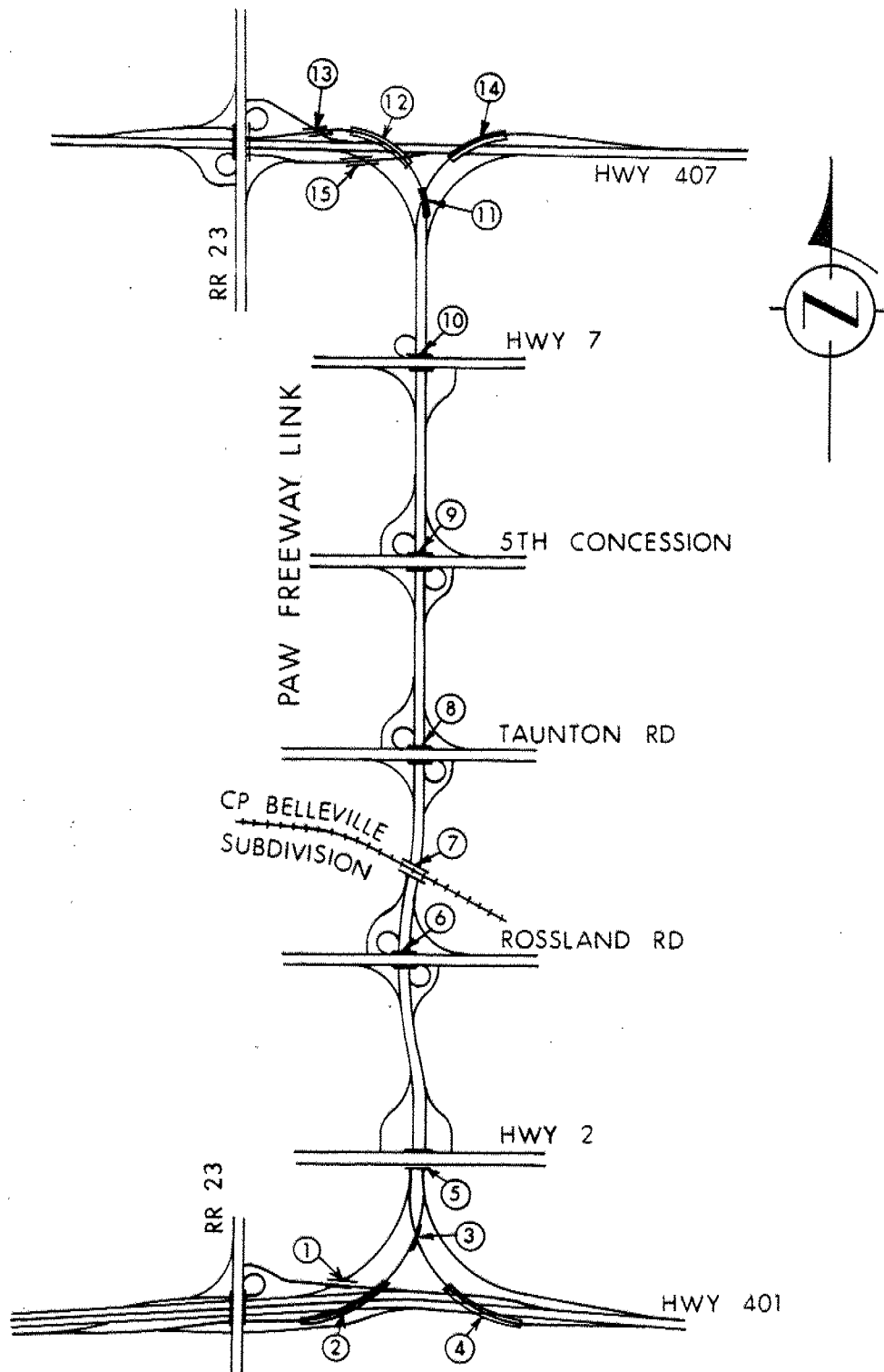
Ontario

Ministry of  
Transportation

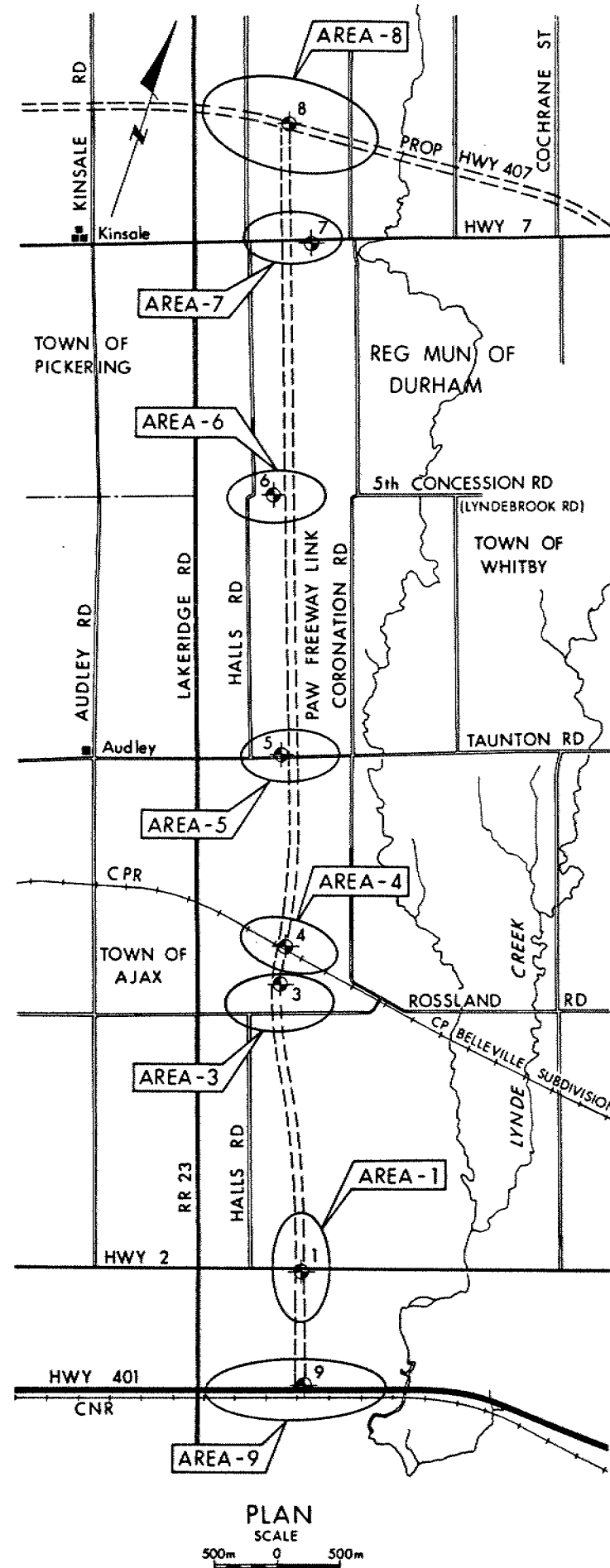
# ABUTMENT ON COMPACTED FILL SHOWING GRANULAR 'A' CORE

FIG No 1

W P 662 - 89 - 00



STRUCTURAL REFERENCE PLAN



AREA & BOREHOLE No BRIDGE REFERENCE No

1	{	3	Ramp W-N over Ramp N-E at PAW Link / Hwy 401 interchange
		5	Hwy 2 (Kingston Rd) Underpass
		6	Rossland Rd Underpass
3		7	CP Belleville Subdivision over PAW Link
4		8	Regional Rd 4 (Taunton Rd) Underpass
5		9	5th Concession Rd (Lyndebrook Rd) Underpass
6		10	Hwy 7 (Winchester Rd) Underpass
7		11	Ramp S-W over Ramp E-S at PAW Link / Hwy 407 interchange
8	{	12	Ramp S-W over Hwy 407 at PAW Link / Hwy 407 interchange
		13	Ramp S-W at PAW Link / Hwy 407 interchange over Ramp E-N/S at RR23
		14	Ramp E-S over Hwy 407 at PAW Link / Hwy 407 interchange
		15	Ramp N/S-E at RR 23 over Ramp W-S at PAW Link / Hwy 407 interchange
9	{	1	Ramp E-N/S at RR23 over Ramp N-W at PAW Link / Hwy 401 interchange
		2	Ramp W-N over Hwy 401 at PAW Link / Hwy 401 interchange
		3	Ramp N-E over Hwy 401 at PAW Link / Hwy 401 interchange
		4	

DESCRIPTION

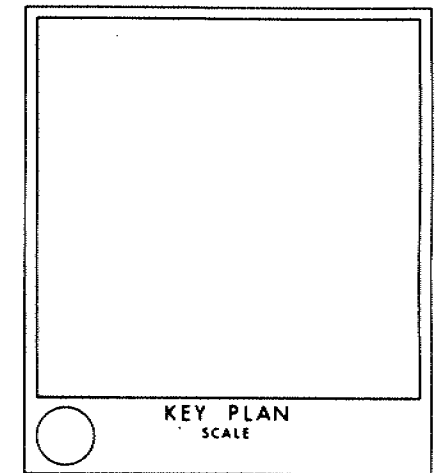
**METRIC**  
DIMENSIONS ARE IN METRES  
AND / OR MILLIMETRES UNLESS  
OTHERWISE SHOWN. STATIONS  
IN KILOMETRES + METRES.

CONT No  
WP No 662-89-00

PAW FREEWAY LINK  
HWY 401 TO PROP HWY 407  
BORE HOLE LOCATIONS & SOIL STRATA



SHEET



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 93 12

No	ELEVATION	CO-ORDINATES NORTH	EAST
1	85.0	4 859 072.2	346 970.9
3	102.0	4 860 951.7	346 061.7
4	102.3	4 861 476.9	345 899.7
5	111.6	4 862 924.7	345 581.2
6	131.4	4 864 852.9	344 766.1
7	156.4	4 866 898.8	344 510.2
8	183.4	4 867 704.8	343 854.2
9	82.6	4 858 247.0	347 406.1

NOTE

For Soil details refer to  
Record of Borehole Sheets

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 GC 2.01 of OPS Gen Cond.



REV.	DATE	BY	DESCRIPTION
1			

Geocres No 30M15-84

HWY No 401/407 PAW FREEWAY LINK	DIST 6
SUBM'D K.A. CHECKED DATE 1994 06 23	SITE
DRAWN DT. CHECKED 85	APPROVED

OWG 6628900-A