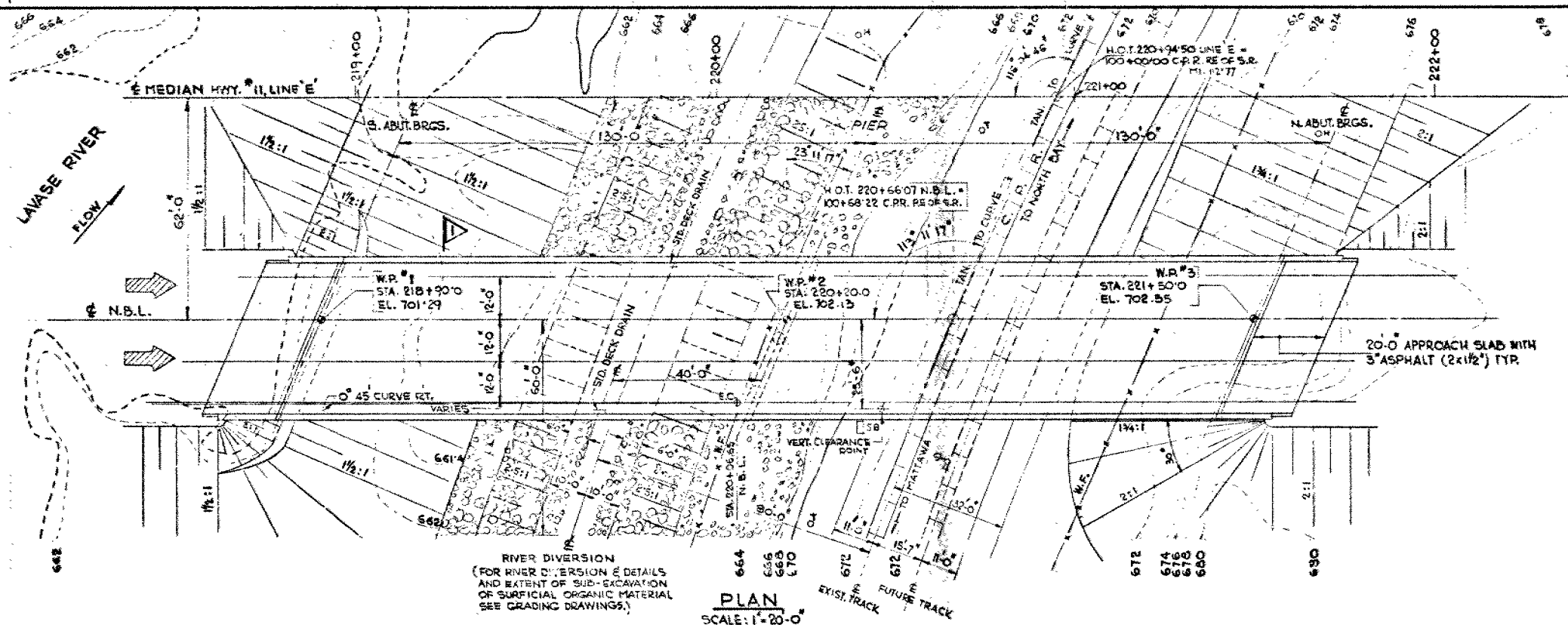


G.I.-30 SEPT. 1976

GEOCRES No. 31L-46DIST. 13 REGION W.P. No. 71-74-05/06CONT. No. 79-53W. O. No. STR. SITE No. 43-200 A & BHWY. No. 11LOCATION Lanark River &  
C.P.R. Overhead SBL & NBCNo of PAGES - =====OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT. REMARKS:



SKW 23° 11' 17"  
SIN: .39375  
COS: .91922  
TAN: .42835

GEODETIC B.M. #2875  
ELEVATION 706.771  
TABLET IN TOP OF RK  
50' LT. 225+52  
QUAD 46079 LINE 271

DIST. 13  
CONT No  
WP No 71-74-06  
LAVASE RIVER E.C.P.R. O'HEAD  
N.B.L. (3.3 MI. SOUTH OF HWY. 17)  
GENERAL LAYOUT

SHEET

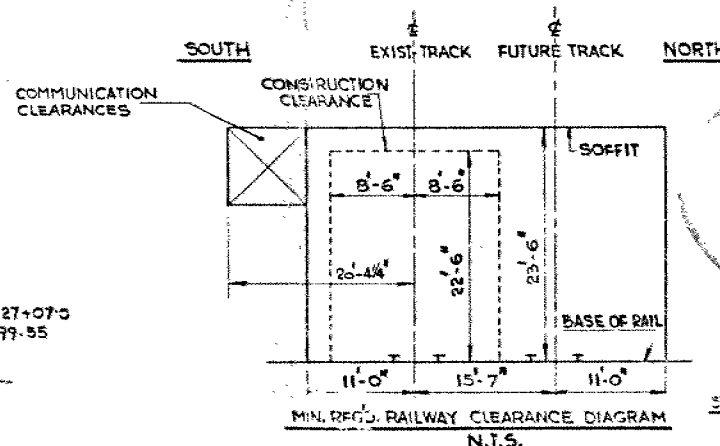
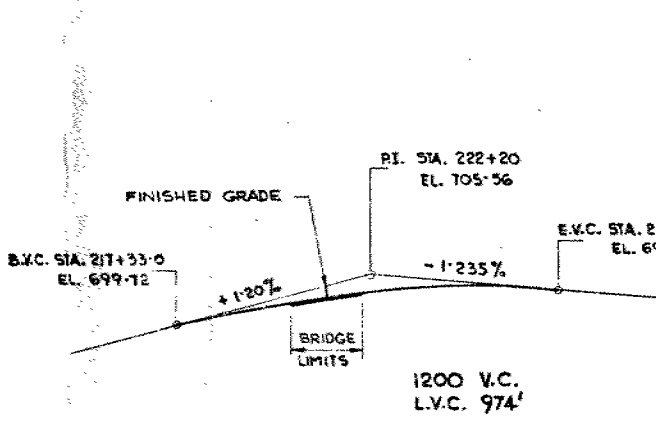
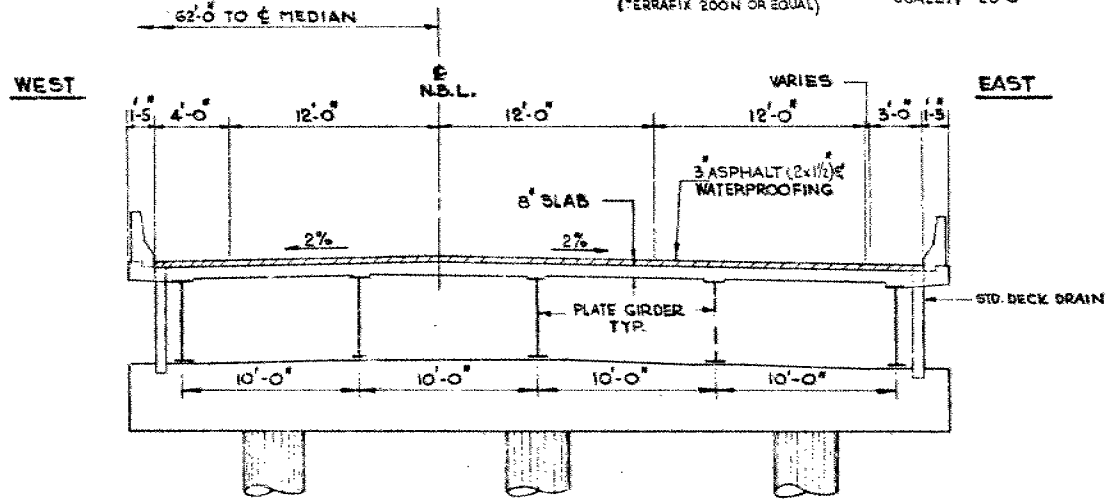
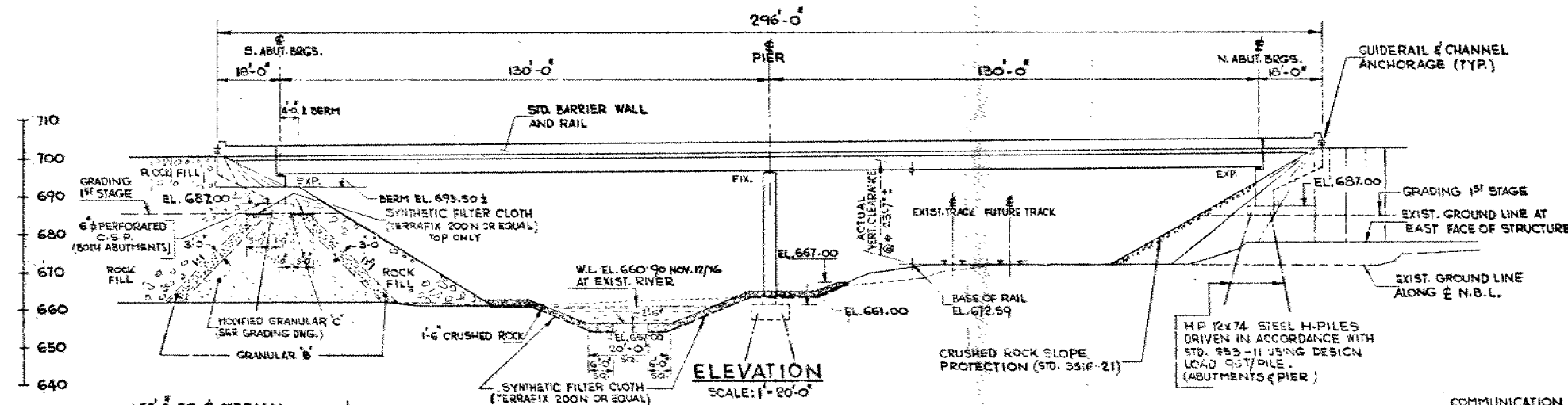
NOTES:  
REINFORCING STEEL  
GRADE 400  
REINFORCING BARS WITH THE DESIGNATION 'C'  
AT THE END OF BAR MARKS SHALL BE COATED BARS.

CLASS OF CONCRETE  
DECK, PIER & BARRIER WALLS - 4000 P.S.I.  
REMAINDER - 3000 P.S.I.  
AND/OR AS NOTED ON DRAWINGS  
CLEAR COVER ON REINFORCING STEEL  
FOOTINGS AND ABUTMENTS - 3"  
PIER - 2"  
DECK: TOP - 2", BOTTOM - 1 1/2"  
AND/OR AS NOTED ON DRAWINGS

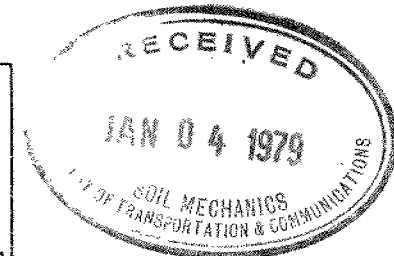
CONSTRUCTION NOTES  
THE CONTRACTOR IS RESPONSIBLE FOR FINISHING  
THE BEARING SEATS DEAD LEVEL TO THE SPECIFIED  
ELEVATIONS WITH A TOLERANCE OF ± 1/8"  
NO CONCRETE SHALL BE PLACED ABOVE THE  
ABUTMENT BEARING SEATS UNTIL CONCRETE  
1: DECK HAS BEEN PLACED.  
TO ACHIEVE THE MINIMUM CLEAR COVER OF 2"  
SPECIFIED, THE TOP LAYER REINFORCEMENT  
SHALL BE PLACED, PRIOR TO CONCRETING,  
WITH A CLEAR COVER OF 2 1/2" ± 1/2" TOLERANCE.  
FORMWORK FOR THE BALLAST WALL (E.G. EXPANDED POLYSTYRENE)  
NEXT TO END OF DIAPHRAGMS SHALL BE REMOVED.

LIST OF DRAWINGS:

- DWG. 43-2008 - 1 GENERAL LAYOUT
- 2 BORE HOLE LOCATIONS & SOIL STRATA
- 3 FOOTING LAYOUT
- 4 SOUTH ABUTMENT
- 5 NORTH ABUTMENT
- 6 PIER
- 7 BEARINGS
- 8 STRUCTURAL STEEL I
- 9 STRUCTURAL STEEL II
- 10 DECK LAYOUT & SCREED ELEVATIONS
- 11 DECK REINFORCEMENT
- 12 BARRIER WALL
- 13 STEEL RAILING (SINGLE TUBE)
- 14 20' APPROACH SLAB
- 15 STANDARD DETAILS I
- 16 STANDARD DETAILS II
- 17 STANDARD DETAILS III
- 18 AS CONSTRUCTED ELEV. & DIM.

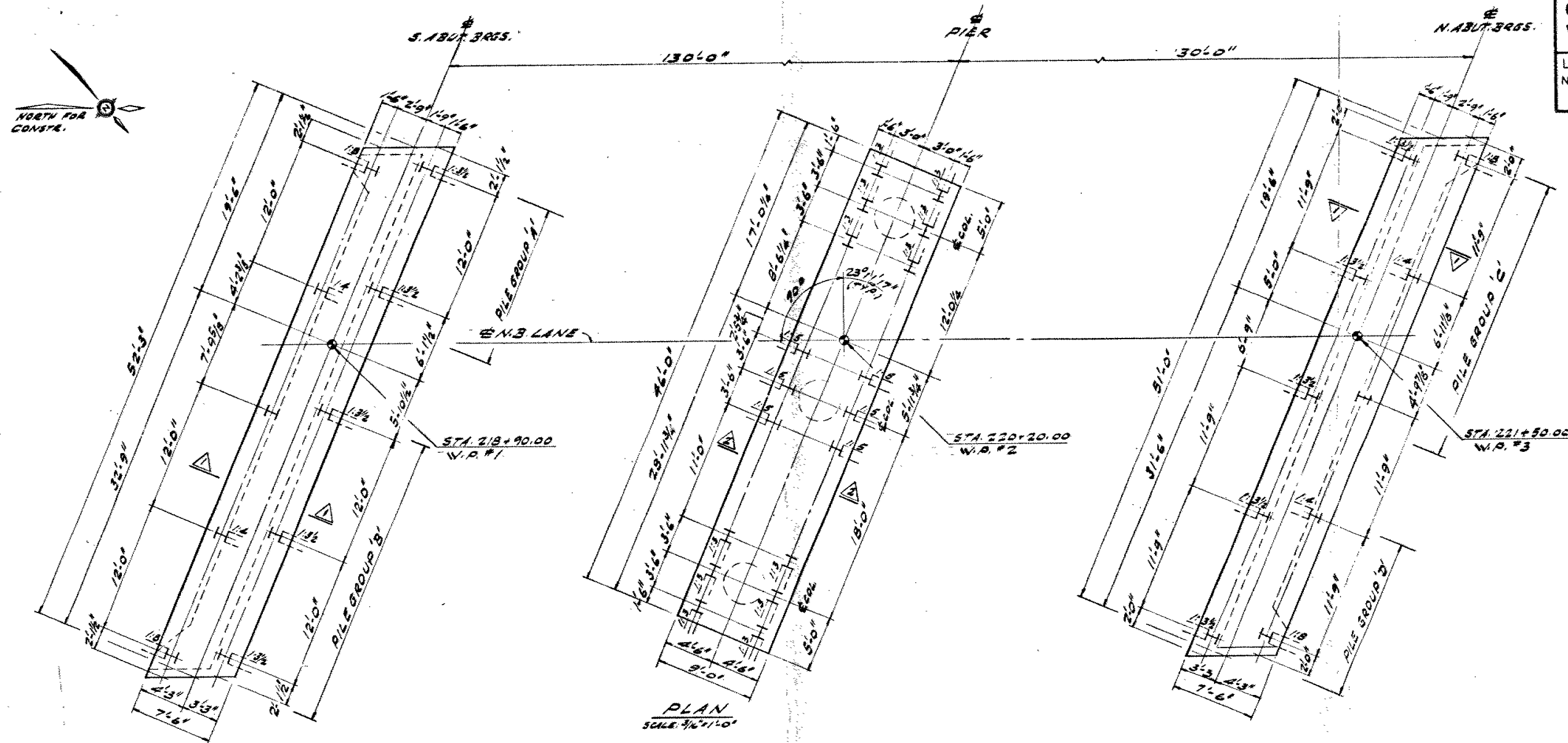


CONCRETE QUANTITIES FOR LUMP SUM TENDER ITEMS  
CONCRETE IN PIER, ABUTMENTS & WALLS 186 CU.YD. 3000 P.S.I.  
TO CU.YD. 4000 P.S.I.  
CONCRETE IN DECK 328 CU.YD.  
CONCRETE IN BARRIER WALLS 80 CU.YD.  
CONCRETE IN APPROACH SLABS 55 CU.YD.

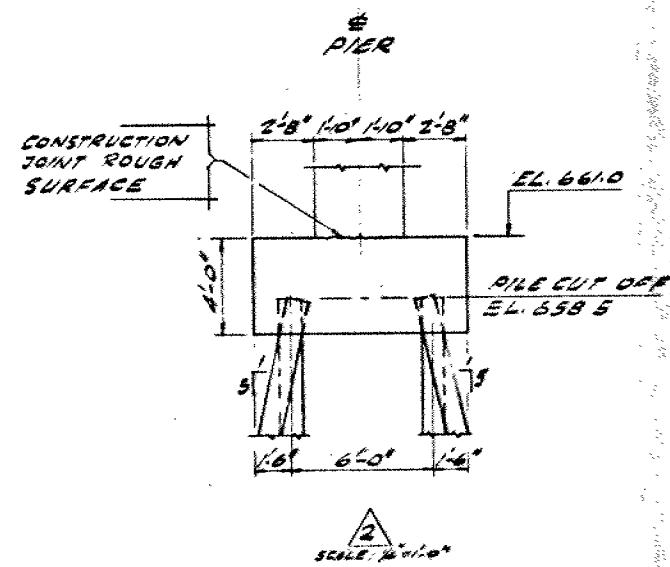
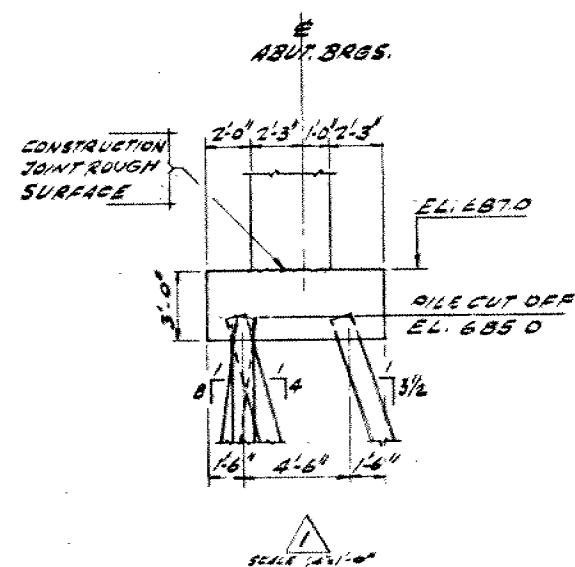


REVISIONS	DATE	BY	DESCRIPTION
DESIGN	CHECK	LOADING	DATE
DRAWING	CHECK	SITE	DWG

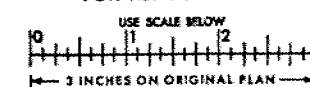
**SHEET**



LOCATION	TYPE	Nº REQ'D	LENGTH	REMARK
SOUTH ABUT.	HP12x74	GROUP 'A' 4 GROUP 'B' 6	49'-0" 52'-0"	WITH DRIVING SWOGS SEE DWG.#1
PIER	HP12x74	18	34'-0"	
NORTH ABUT.	HP12x74	GROUP 'C' 6 GROUP 'D' 4	29'-0" 26'-0"	

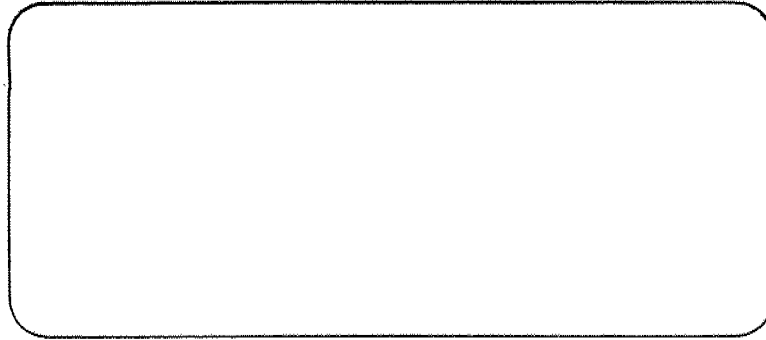


FOR REDUCED PLAN

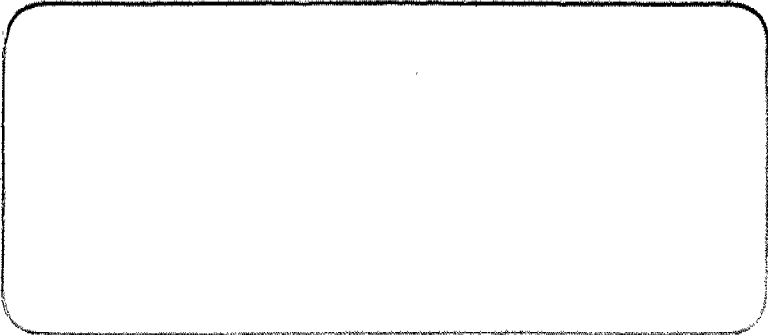


3	REVISIONS					
	DATE BY	DESCRIPTION				
4	DESIGN	CHECK	LOADING	DATE		
	DRAWING	CHECK	SITE No	DWG		

RETAIN THIS COPY  
IN THE OFFICE.



**PETO MacCALLUM LTD.**

- 
- (1) In BH 4 & 5, why B/R is probable? Holes are only 6'±2 ft deep + there is rock out crop near by.
  - (2) They will retain "Near plastic limit" in the log sheet for BH 6
  - (3) In BH 11 & 11A, there is no need to retain the 2<sup>nd</sup> decimal figures.
  - p. 2 (4) Rock is not cored at all ftg locations
  - p. 3 (5) AXT, not AX L & it is not for proving B/R in this case.
  - p. 3 (6) Fig. No. should be Dwg. No. 717405 ~~of~~ 06 - A and - B.
  - p. 5 (7) In BH 20, top soil is 18"
  - p. 6 (8) BH 9 & 10 not BH 8 & 9.
  - (9) No room for  $2\frac{1}{2} : 1$  for the channel.



FOUNDATION INVESTIGATION REPORT  
HIGHWAY #11, DISTRICT #13  
C.P.R. & LaVASE RIVER O'HEADS  
NORTH & SOUTHBOUND LANES  
WP 71-74-05, -06, SITE 43-200 A&B

for

MINISTRY OF TRANSPORTATION AND  
COMMUNICATIONS - ONTARIO

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February 1977

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CONSULTING ENGINEERS

Phone (416) 789-4105

February 28, 1977

Job No. 76 F 277

Ministry of Transportation and  
Communications, Ontario  
West Building  
1201 Wilson Avenue  
Downsview, Ontario  
M3M 1J8

Attention: Mr. M. Devata, P.Eng.  
Geotechnical Office

Dear Sirs:

Re: Foundation Investigation Report  
Highway #11, District #13  
C.P.R. & LaVase River O'Heads  
North & Southbound Lanes

We are pleased to present our report on the foundation investigation carried out for the proposed crossing of Highway #11 re-alignment over C.P.R. tracks and LaVase River.

The attached report provides complete details of the work carried out, the soils, rock and groundwater conditions encountered and specific recommendations for design and construction from geotechnical considerations.

For convenience, for emphasis and for clarity, a synopsis has been included as a preface to the report, outlining the important recommendations.





We trust that this report is complete within our terms of reference. We are available for further consultation as required. We thank you for the opportunity to be of service to the Ontario Ministry of Transportation and Communications.

Yours very truly,

PETO MacCALLUM LTD.,

C.F. Freeman, P.Eng.  
Chief Engineer

GDP/mpj





## SYNOPSIS

The results of an investigation carried out at the site of C.P.R. tracks, LaVase River and proposed Highway #11 overheads in District 13 are reported.

The site is underlain by sands and gravel in a loose to compact state. Biotite Gneiss bedrock is present at relatively shallow depths ranging from outcrops to depths of 39 feet, with an overall average of 25 feet. Boulder concentrations are present in the overburden above the rock.

Groundwater level is controlled by the LaVase River and is at elevation 661± which is at or near the present grade for a greater part of the site.

Recommendations are made for supporting the proposed bridge foundations on steel "H" end bearing piles meeting apparent refusal on rock or dense granulars. Anticipated pile lengths average about 25 feet. Spread footings are recommended for the north-westerly abutments. Both "closed" abutments and "spill through" abutments are discussed.

Anticipated pile capacities are 100 Tons per pile for a heavy steel "H" section. Spread footings on engineered fills are to be designed for a bearing pressure of 5 ksf and on rock for a minimum bearing pressure of 20 ksf.

The anticipated depth of unacceptable material in the swamp averages about 4 feet with the maximum being 8 feet. Full base width excavation as per current M.T.C. practice is recommended. Embankment slopes of 2 horizontal to 1 vertical are recommended.



## II

Dewatering by gravity methods will be required for channel construction for river diversion. Channel slopes of  $2\frac{1}{2}$  horizontal to 1 vertical are recommended.

The need to provide an additional span on the southerly approaches as an alternative to river diversion and embankment construction through the swamp will be governed by economics only.

In summary, the design and construction of the proposed project will be relatively straight forward within the constraints outlined.



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B.

LABORATORY TEST RESULTS

BOREHOLE LOGS

FIELD NOTES ON SWAMP PROBING

SITE PLAN AND STRATIGRAPHIC PROFILES



## 1. INTRODUCTION

Major construction is proposed for King's Highway #11 at a location approximately 5 miles south of North Bay where the proposed 4-lane Highway #11 diversion crosses existing C.P.R. tracks and LaVase River. The project involves two separate bridges for north and south bound lanes and approach embankments. Diversion of the LaVase River is also being considered as part of the project.

A geotechnical investigation was commissioned by the Ontario Ministry of Transportation and Communications to obtain factual data on the subsoil conditions at the project site and provide recommendations for design and construction purposes. Agreement No. 4244-207-76 provided the authority to Peto MacCallum Ltd., to provide services as geotechnical consultants to the project. Co-ordination of the work was carried out with Mr. M. Devata of the Geotechnical Office and Mr. J. McAllister of the North Bay regional office of the Ministry.

## 2. SITE DESCRIPTION AND GEOLOGY

The site is located in concession 14, Electoral District of Nipissing, Lot 32, Geog Twp. West Ferris, in the city of North Bay, Ontario. General location is given on the key plans included with the site plans.



The site is currently vegetated with grass and bush cover. In the area between the railway tracks and LaVase River where the terrain is relatively flat, local swampy areas are present. The south slope of the river valley is pronounced and is dotted with boulders and rock outcrops. Lakeshore Drive is located some 2800 feet from the site.

At the time of the investigation the site was covered with snow. In spite of severe cold weather LaVase River did not freeze over fully, due to warm industrial waste water discharge from nearby industries.

Physiographically, the site is at the northern boundary of the Georgian Bay - Ottawa Valley area. Sub-surface features comprise rounded bedrock knobs having a thin drift cover. The Wisconsin glaciers deposited a sandy and stony till. During their retreat kames and eskers were deposited. Within the flood plain of existing rivers recent alluvium comprising fine sands and silts are deposited.

The region is part of the Precambrian Canadian Shield with bedrock comprised mainly of metasedimentary and metavolcanic origin. Bedrock depths are relatively shallow at the investigated site.

### 3. FIELD AND LABORATORY WORK

A total of thirty-eight boreholes, were put down at the site. Due to the variable nature of the ground conditions several dynamic cone penetration tests and auger holes were carried out to give a better insight into the sub-surface conditions. Diamond drilling was carried out at the bridge pier and abutment locations for the purpose of proving bedrock.



Forty-five hand auger probes on 4 lines were carried out within the river bed and the swampy area as probing by machine was not possible due to the soft ground and flowing river conditions. The field work was carried out using a Mobile B.38 and a C.M.E.55 drill rig equipped with solid/hollow stem continuous flight augers and diamond drilling capabilities.

Samples of the overburden were recovered at required depths, in a 2" O.D. split spoon sampler, which was hammered into the soil in accordance with the Standard Penetration Test. The same method was used to advance the dynamic cone penetration test. Where manual methods were used a lighter hammer was used. However, the recorded "N" values were corrected. Bedrock was proven in the boreholes for the structure by obtaining cores in BXL and AXL sizes.

The presence of large size boulders and severe winter conditions during field work accounted for equipment breakdown and modification of procedures. At several locations the boreholes had to be redrilled before satisfactory results could be obtained.

The groundwater level conditions across the site at the time of the investigation, were determined by recording the water levels in several open boreholes.

The location and elevation of all borings were surveyed by personnel from the North Bay Regional Office. Borehole locations are shown on the appended drawings WP 71-74-05, and 06. -A and -B.

Estimated stratigraphic profiles along the centre lines of the north bound and the south bound lanes are provided with the site plans together with cross sections along the abutment and pier alignments. The stratigraphy between boreholes is interpreted and may therefore vary from that shown on the drawings.



The field work was supervised by Peto MacCallum Ltd. engineering staff. All samples were subjected to a careful visual examination in the field and subsequently in the laboratory. Following this examination, laboratory testing was carried out to determine moisture contents on many samples.

A total of 13 samples were selected for grain-size distribution analysis. Two water samples, one from the groundwater and the other from the river were tested for pH and sulphate content.

Descriptions of the encountered soils, along with the Standard Penetration Test results and laboratory moisture content values are presented on the appended borehole logs. Laboratory grading curves are given on Figure Nos. 1 to 4 appended.

#### 4. SUBSOIL CONDITIONS

##### 4.1 GENERAL

The subsoil is generally non-cohesive, ranging from silty fine sand to gravelly coarse sand with bouldery layers often overlying bedrock. The subsoil is generally in a loose to compact condition. Higher "N" values recorded in the Standard Penetration Tests are probably due to gravel and boulder content.

The various soil types encountered are as follows:



#### 4.2 TOPSOIL

On the high ground surficially sandy topsoil was encountered varying from nominal thickness to about 6 inches.

#### 4.3 ALLUVIAL DEPOSITS

Within the channel of the LaVase River, and in the swampy area (Figure 5), surficially clayey silt, interlayered with fine sand and minor organics, was noted. Generally this deposit is soft. A shear strength value of 870 psf recorded in borehole 11 by a field vane test is probably due to the sand content and is not considered representative. These deposits are recognized along the centre line of the south abutment of the north bound lanes.

Similarly, organic sandy silt was located in borehole 22 and probe 22A near the southern approach to the south bound lanes.

Extensive probing was carried out within the river using hand auger equipment. From the field work it is inferred that the depth of this stratum varies from 2 feet to a maximum of 8 feet. The maximum depths are generally along the centre line of the present river course. An average value of 4 feet is considered realistic. Field notes on swamp probing are appended with the borehole logs.

#### 4.4 GRAVELLY SAND AND FINE SAND

The overburden is comprised of gravelly sand and fine sand. The compositions of these granular deposits are variable. Representative grading curves are appended. (Figure Nos. 1 to 3).



No distinctive layering is recognized. Often bouldery layers are present within this deposit which could not be penetrated by power auger equipment. Relative density can be rated as loose to compact; with depth the density appears to increase.

A thin veneer of silty sand till 2 to 4 feet thick is recognized over bedrock at some locations, (boreholes 3 and 8). A typical grading curve is given on Figure 4.

#### 4.5 BEDROCK

Bedrock surface is very uneven across the site. There are several rock outcrops on the high ground along the northerly approaches and on the valley rim to the east and west of the proposed right-of-way.

Generally, bedrock occurs at relatively shallow depth. It is very close to the surface at boreholes 4 and 5 near the centre line of the north abutment of the south bound lane. It dips to depths ranging from 36 to 39 feet at boreholes 8 and 9 at the centre pier of the same lane. <sup>(9 & 10)</sup> On the average, depths to bedrock vary from 15 to 25 feet across the site. Bedrock was proven in boreholes 2, 8, 9, 10, 11, 12, 17, and 22 by core drilling. At other locations bedrock was assumed where augers met refusal to further penetration and driller's judgement precluded boulders.

The bedrock underlying the site is a fine to medium grained meta-sediment derived largely from siliceous sandstone and siltstone. The predominant lithology is a biotite gneiss which is generally migmatitic, i.e., it contains veins and lenses of granitic material.

Rock Quality Designator based on BX core varies from fair to excellent, indicating a generally good quality rock.



## 5. GROUNDWATER CONDITIONS

Groundwater level observations have been carried out, during the period of the investigation, in several boreholes. The observations are recorded on the borehole log sheets and summarized on the appended drawings. Some water levels are inferred because the boreholes caved.

The recorded observations indicate that the groundwater level in the overburden varies from approximate elevation 661 near the river to about 679 in borehole 6 at the northern approach to the south bound lane. Water level in the LaVase River at the time of the investigation was recorded at elevation 660.8. Water samples from the river and borehole 11 gave pH values 7.2 and 6.8 and sulphate contents 20 and 30 ppm respectively. These do not indicate conditions leading to aggressive sulphate attack on concrete.



## 6. DISCUSSION AND RECOMMENDATIONS

### 6.1 GENERAL

The proposed Highway #11 re-alignment will have four lanes, two in each direction. The proposed construction will comprise two separate parallel bridges. Anticipated clear spans are in the order of 80 to 100 feet.

Anticipated maximum height of the approach embankments will be about 48 feet on the south side through the swamp. (Approximate chainage 220+50). Anticipated roadway elevation at the bridge is about 701.0.

The proposed stream diversion channel will be about 8 feet deep and 30 feet wide. The water level is about 661.

In making the following recommendations reference is made to the appended borehole logs and stratigraphic profiles.

### 6.2 FOUNDATION SELECTION AND DESIGN

The overburden across the site comprises soft clayey silts and loose sandy silts to depths ranging from 3 to 8 feet within the flood plain of the LaVase River. Elsewhere loose to compact sands and gravel with variable boulder concentrations are present.

Bedrock outcrops on the north-west side of the site. Elsewhere at the proposed bridge pier and abutment locations depths to bedrock vary from 11 feet at borehole 2 to 39 feet at borehole 10.



It has been reported that the existing bridge north of the site is supported on spread footings on the northerly approaches and on steel piles to rock on the southerly approaches and piers. The present investigation has revealed conditions favouring a similar design.

#### 6.2.1 Spread Footings

Spread footings are feasible for the northerly abutments. Bedrock is available at nominal depth at the northerly abutment of the south bound lanes. The spread footings can be designed using an allowable bearing pressure of not less than 20 ksf subject to minimum footing size requirements. Higher bearing pressures of up to 100 ksf may be permitted on sound bedrock subject to inspection.

Prior to pouring the footings, the exposed bedrock should be examined, any loose and shattered zone sub-excavated and a levelling course of concrete poured. From the available information the variation in assumed rock elevation across the north abutment of the south bound lanes (boreholes 4 and 5) is minimal. However, in the area of boreholes 1A and 2 the depth to rock from existing grade varies from 10 feet to 20 feet across the north abutment of the north bound lanes.

If spread footings are chosen as an alternative to pile foundations for the north abutment of the north bound lane as well, we recommend that the surficial loose to compact sands be excavated and the exposed subgrade compacted with heavy vibratory rollers. Filling can be carried out using M.T.C. standard procedures, with the fill comprised of non-frost susceptible granular "A" or equivalent material compacted to minimum 98 percent modified Proctor density. In such a case, spread footings can be designed using an allowable bearing pressure of 5 ksf on the engineered fill.



Anticipated frost penetration in the North Bay district is in the order of 6 feet. An all-round frost cover of 6 feet as per M.T.C. standards will be applicable.

In summary, spread footings are recommended on rock at elevation 675± for the northerly abutment for the south bound lanes. For the north bound lanes spread footings on rock can be designed between elevation 660 and 665 or on compacted granular "A" above elevation 670 using procedures outlined earlier in this section.

For footings placed on compacted fill anticipated settlements will be less than one inch, and due to the granular nature of the subsoils will occur during construction. Long term settlements are not anticipated.

#### 6.2.2. Pile Foundations

For the centre piers and south abutments for both the north bound and south bound lanes pile foundations merit consideration and are recommended. Along the centre piers bedrock is available between elevations 620 and 630 (boreholes 10, 9, 7 and 8). Along the south abutment anticipated rock elevation is between 655 and 640 (boreholes 22, 17, 12 and 11). Depths to rock from existing grade are generally in excess of 20 feet, with the exception of borehole 17 where rock is available at 8 feet below grade..

Overburden comprises sands and gravel with a bouldery zone above rock. In several instances it was impossible to penetrate this zone without resorting to diamond drilling methods.

Based on the available information we are of the opinion that driven piles will refuse between depths of 20 and 30 feet generally. Shallower depths are possible in the area of borehole 17 and deeper penetration in the area of borehole 9. For estimating purposes an average elevation of 635 is perhaps applicable.



A heavy steel "H" section is the most appropriate pile type due to its relative capability to penetrate bouldery layers. Besides this section is also easily adaptable to the anticipated variation in refusal depths and pile lengths. The pile sections should be designed as end bearing piles. The anticipated capacity for a 14 BP 90 lbs or similar size is in the order of 100 Tons, attaining practical refusal on rock or refusing in the sand and gravel stratum after penetrating a minimum 25 feet. For lower penetration depths the pile capacity anticipated can be derived by assuming a sustaining value of about 800 psf. Practical refusal is defined as a penetration of less than 0.08 inch per blow with a hammer delivering a minimum of 15,000 foot pounds energy per blow for the context of this report.

In view of the variable penetration depths at the site for driven steel piles, we recommend restricting the allowable unit stress in steel to 9 ksi for the purposes of estimating the maximum pile capacity. We recommend reinforcing the pile tips with welded steel plates or rock points to minimize damage during driving and penetration of bouldery layers.

We recommend a pile load test to prove the design capacity, anticipated penetration depths and sustaining unit perimeter stress. Two tests are recommended, one in the area of the south abutment and the other in the area of the centre piers. The tests should be carried out to at least twice the design load. Pile capacities during installation may be controlled using the Hiley formula as per current M.T.C. practice.

It is noted that the piles will be below the groundwater table generally. It is unlikely that apparent refusal to driven piles by pore pressure buildup will be attained at a higher elevation than anticipated based on the dynamic cone penetration tests.



The piles will be located in relatively free draining granular materials. Any requirements for redriving should be based on the performance of the test piles.

Recommended minimum spacing between piles is 3.5 feet in the short direction. We do not anticipate any group settlement problems as the piles will be terminating either on rock or in very dense granular materials. Anticipated maximum settlements will be less than one inch.

#### 6.2.3 Bored Caissons or Piers

Though bored caissons or piers taken into the dense strata or on to bedrock are feasible designed for friction and end bearing, we do not favour their use due to the groundwater conditions requiring liners and pumping.

Quicking in the sands may be anticipated and bellling is not possible. Hence the design of caissons is not looked into further.

### 6.3 APPROACHES AND ABUTMENTS

#### 6.3.1 Embankments

To meet the grade of the proposed structure fills will be required to be placed on either side. Anticipated maximum height is in the order of 48 feet along the south approach.

Within the flood plain of the LaVase River surficial soft organic clays and silts are anticipated. Extensive probing has indicated that the thickness of this stratum varies from 2 feet to a maximum of 8 feet. An average value of 4 feet is considered realistic for estimating purposes. The actual depths to be excavated are subject to inspection during construction.





For swamp treatment, current M.T.C. procedures are recommended. We recommend swamp excavation to be carried out for the full embankment base width along the southerly approaches, between centre line chainages 218+00 to 220+50 approximately as shown on Figure 5.

As the river level reflects the groundwater table, dewatering will be expensive for swamp excavation. We recommend drag line methods and encroachment with granular fills, below the water table. The granulars should be free draining as it will be difficult to attain a good degree of compaction.

Foundation soils under the embankments after swamp treatment will be mainly granular. Assuming that M.T.C. approved granular soils will be used for embankment construction we do not anticipate any base or slope stability problems, using embankment slopes of 2 horizontal to 1 vertical. A safety factor greater than 1.3 is available.

Along the northerly approaches prior to placing the fill we recommend excavating the topsoil layer for later reuse as a base for the sod for the embankment. We recommend inspecting the exposed subgrade and removing or compacting any soft spots as required.

As the foundation soils are compact to dense granulars we do not anticipate long term settlement problems. Settlements will be predominantly due to compressions within the fills and will occur during construction. Anticipated long term settlements will be less than one inch.



### 6.3.2 Abutments

Both "closed" and "spill through" abutments are feasible at the site as there are no severe space limitations. On the south side "spill through" abutments are practical due to the anticipated approach embankment heights in the order of 48 feet. For the northerly approaches, the choice is marginal due to the limitations of the C.P.R. right-of-way.

#### 6.3.2.1 Closed Abutment

The closed abutments will be designed as gravity type retaining structures. They can be supported on spread footings either on rock or on compacted engineered fill as discussed in section 6.2.1 for the northerly approaches. For the southerly approaches and the north abutment of the north bound lanes pile foundations can be used as discussed in section 6.2.2.

If the structure is designed as a continuous/rigid frame, a co-efficient of earth pressure at rest ( $K_0$ ) of 0.5 is recommended for granular fill behind the wall. However, if some movement of the top of the wall is permitted, then a co-efficient of active earth pressure ( $K_a$ ) of 0.33 can be assumed. Recommended bulk density for compact granular material is 135 pcf.

Recommended angle of internal friction is 30 degrees for wall design between the fill and wall. For computation of passive resistance a co-efficient ( $K_p$ ) of 3.0 is recommended. For computing resistance against sliding a co-efficient of friction of 0.5 is suggested between rock and concrete and 0.3 between compact granular soils and concrete. Safety factors as per standard practice are applicable.



#### 6.3.2.2 Spill Through Abutment

Spill through abutment is practical for the south approaches. If this solution is to be adopted for the northerly approaches, it may be necessary to move the north abutment locations some 50 feet or so to the north in order to accommodate the clear space required in the longitudinal direction without encroaching on to the C.P.R. right-of-way.

The abutments may be "perched" within the approach fills. They can be supported on end-bearing piles driven to practical refusal. Pre-augering should be allowed for if piles are to be driven through compacted granular fill. No bouldery or rock fill should be used in areas in which piles are to be driven. If spread footings are to be perched within the approach fills, then the procedures outlined in section 6.2.1 should be followed.

We recommend adopting longitudinal and transverse slopes of 2 horizontal to 1 vertical for the approach fills.

#### 6.3.2.3 Drainage

No flowing water conditions will be encountered along the approaches. We recommend the provision of erosion protection measures such as seeding/sodding, toe drains and rip-rap as per M.T.C. standards for the approaches and abutments.

In order to relieve the buildup of hydrostatic pressure behind the retaining structures, suitable drainage measures should be provided. If the embankments are not constructed of a relatively free-draining type of granular material, the following measures are recommended.



An 8-foot wide vertical strip of free-draining granular material should be provided behind the wall. The remainder of the backfill could consist of locally available material similar to that used for embankment construction. In addition to the 8-foot wide gravel strip behind the wall, a horizontal layer of granular 4 feet thick should be built into the backfill at half the height of the wall, and should extend for a distance equal to one-half the height of the wall. Suitable weepholes and other positive drainage measures should be provided at the base of the wall as per M.T.C. standards.

#### 6.4 CONSTRUCTION

The following comments are pertinent to the construction of the bridges, approaches and river diversion.

##### 6.4.1 Abutments and Piers

Construction of the abutments and piers as required will not present any unusual problems either using spread footings or piles. The footings or pile caps will be located above the water table anticipated at 661. Any localized lowering of the water table can be handled by sump pumps.

The excavation will be relatively shallow and will be in granular materials. Construction slopes of  $1\frac{1}{2}$  horizontal to 1 vertical may be anticipated.

In the swampy area we recommend swamp treatment and placement of fills to at least the pile cap level prior to driving the piles as this will provide access to equipment. In its present state the swamp is impassable to heavy equipment.



As the subsoils are free-draining granulars we do not anticipate any performance problems for the C.P.R. tracks due to driving relatively low displacement steel 'H' piles. Problems associated with embankment stability due to pile cap excavations are not present as there is sufficient distance between the toe of the embankment and the anticipated pile cap location for the centre piers. If this assumption is not valid then temporary shoring should be provided. This can comprise either timber or steel sheet piling designed as cantilever sections, which can be withdrawn after completion of work.

#### 6.4.2 River Diversion

It is proposed that the LaVase River be diverted to flow under the proposed bridge, parallel to the existing C.P.R. tracks and south of them as shown on the appended drawings. The proposed stream channel width is about 30 feet at the base and will have a depth of about 8 feet. The water level in the stream will be about 660± on the average and will be subject to seasonal fluctuations. Both lined and unlined channel sections are being considered.

Boreholes 20, 21, 8, 7, 9 and 10 located along the route represent the anticipated subsoil conditions. Basically the invert soils comprise fine sand in a loose to compact state with zones of silt and gravel. Cobble sizes are also not uncommon within these granulars. The significant feature is the high water table at or near the present grade, requiring dewatering for construction, and channel slope protection in the long term.



#### 6.4.2.1 Dewatering

Based on the gradation curves of the in situ soils gravity drainage methods will be successful in lowering the water table for construction purposes to about 2 feet below the anticipated invert depth of the channel or about 12 feet from present grade.

A system of pumped wells taken down to about 25 feet depth and spaced about 60 feet apart staggered on either side of the excavation are likely to be adequate using 10 inch diameter wells. The wells can be installed by wash methods with minimal driving. We recommend that filter material be used inside the wells as backfill. Pumping will be required to be maintained until channel construction is completed.

Due to the width of the channel and large quantities of water anticipated we do not consider that well pointing will be satisfactory. The spacing required also will be close.

#### 6.4.2.2 Channel Stability

The regional water table will be unaffected in the long term by the construction. Consequently not much advantage will be derived by using a concrete lined channel as opposed to other flexible forms.

Most of the time the channel will be in a submerged state. During very dry weather a steady state seepage condition is anticipated. The recommended channel slope is  $2\frac{1}{2}$  horizontal to 1 vertical through the compact sand and gravel.



The major factor governing the design is to permit seepage through the slopes and flow from the base without creating loss of ground. We recommend inspection of the base and side slopes after excavation. Any loose and soft spots should be made good by compact granular materials. We recommend the provision of granular filter bedding layer of 12 inches thick minimum prior to placing the channel lining. As an alternative, it is advantageous to use synthetic filter mats such as "Terrafix", which have been successfully used in Ontario. These are relatively easy to lay and weld in the field.

We do not favour a rigid lining as this will have to resist uplift forces and frost action. If precast concrete slabs are used the joints should be flexible and allow for free flow of water either through the joints or through weep holes protected from plugging by filter material. The same recommendation will apply if cast-in-place concrete is used.

As an alternative, graded rip-rap, armour stone or gabions are recommended for slope protection. We recommend that the channel be flooded by diverting the discharge from the wells and turning off alternate wells before switching off the entire system. This will enable restoration of the water table without creating loss of ground due to surging water.

Based on the available data we do not foresee the need to build a retaining structure alongside the C.P.R. embankment for protection against river action. However, this has to be re-evaluated at the time of final design, as it may have a bearing on construction if the berm is narrow and the channel section is close to the railway embankment.



### 6.4.3 Alternatives

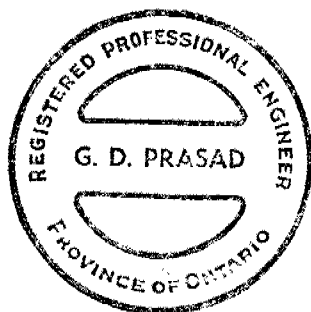
As an alternative to river diversion and placement of fills on the southerly approaches through the swamp and the river flood plain, an additional bridge span may be included. Based on the available information (boreholes 24 and 25) pile foundations can be used for the relocated southerly abutments. The spans may require to be adjusted so that the middle piers can be located on stable ground without much swamp excavation and replacement, mainly for the purpose of access to construction equipment.

The final choice is to be decided on economic considerations only as the alternatives discussed are technically feasible.

## 7. MISCELLANEOUS

The field work was performed during the period December 8, 1976 and January 21, 1977 under the immediate supervision of Mr. J.B. Simpson, Project Foundation Engineer. The equipment was owned and operated by Atcost Soils Drilling Inc., Toronto.

Assistance in the preparation of this report was provided by Mrs. M. Bechai, Office Foundation Engineer. All the laboratory, drafting and secretarial work was carried out at Peto MacCallum Ltd., Toronto offices.



PETO MacCALLUM LTD.

*G. Prasad*

G.D. Prasad, Ph.D., P.Eng.  
Consulting Engineer



LABORATORY TESTS RESULTS



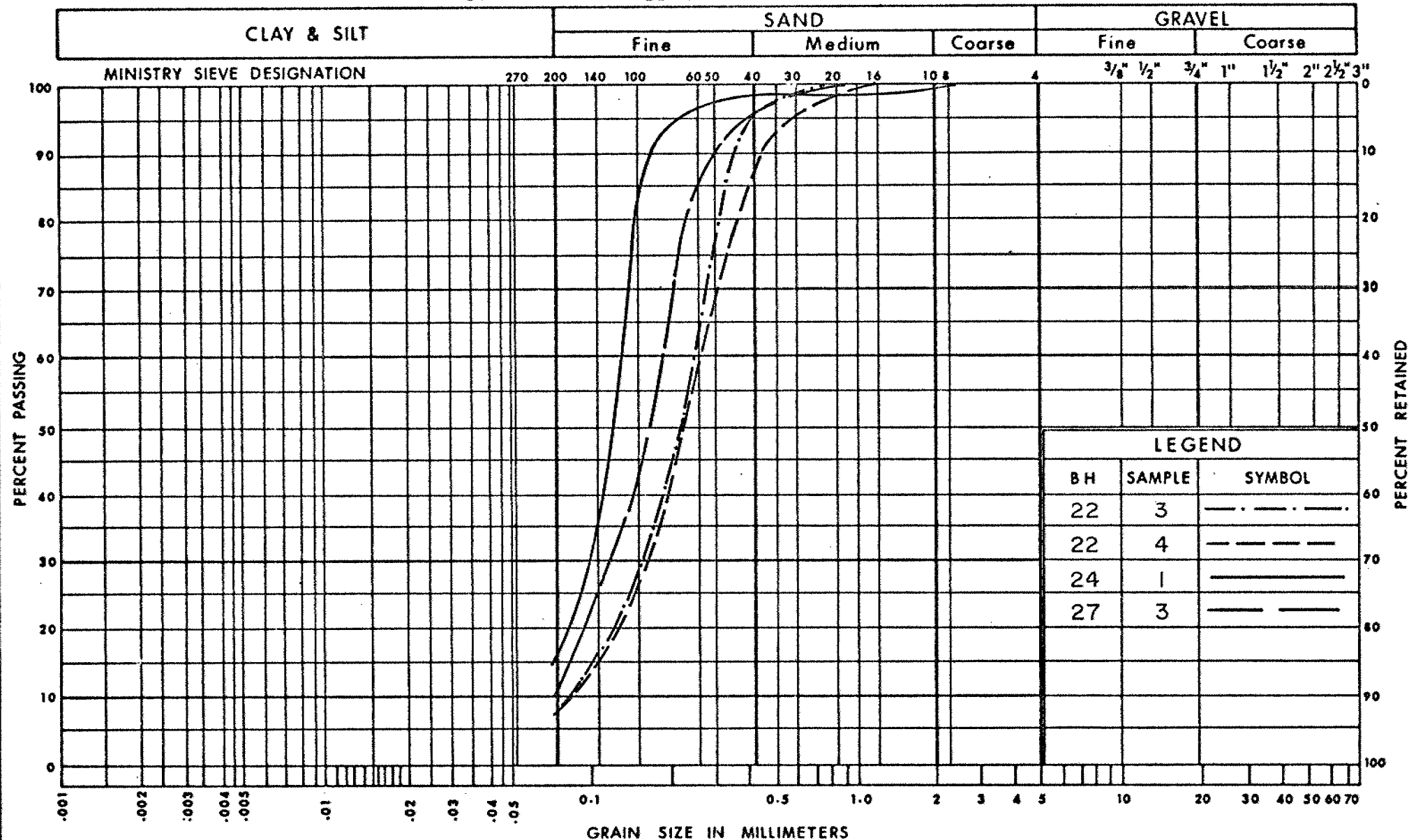
Job No. 76 F 277

January 31, 1977

pH VALUE AND SULPHATE CONTENTS OF WATER SAMPLES

<u>Borehole No.</u>	<u>Depth</u>	<u>pH Value</u>	<u>Sulphate Content ppm as SO<sub>4</sub></u>	<u>Relative Degree Sulphate Attack on Concrete</u>
River	Water	7.2	20	Negligible
11	Water	6.8	30	Negligible

## UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of  
Transportation and  
Communications

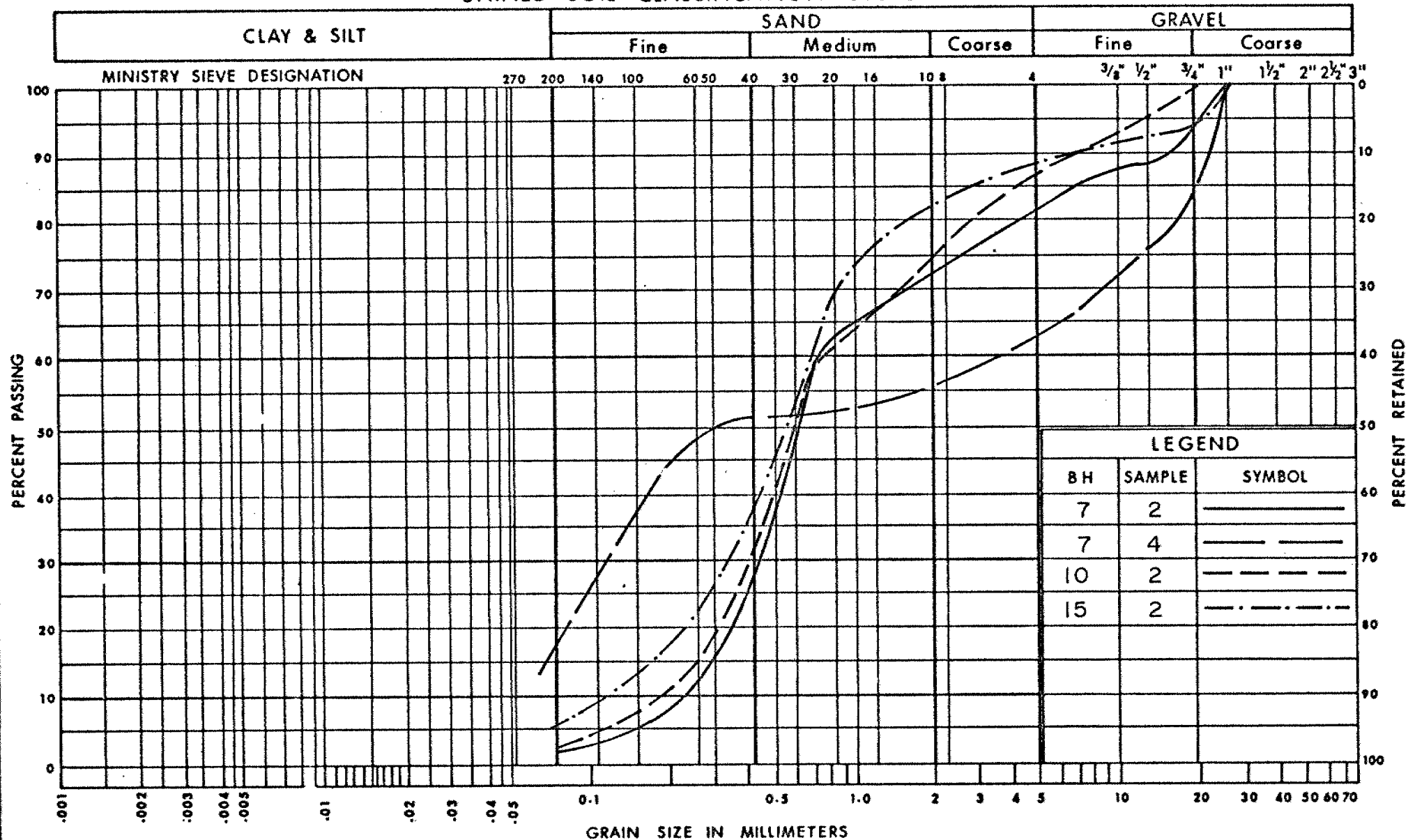
Ontario  
ENGINEERING SERVICES BRANCH

GRAIN SIZE DISTRIBUTION  
SAND  
FINE

FIG No 1

W P 71-74-05 & 06

## UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of  
Transportation and  
Communications

ENGINEERING SERVICES BRANCH

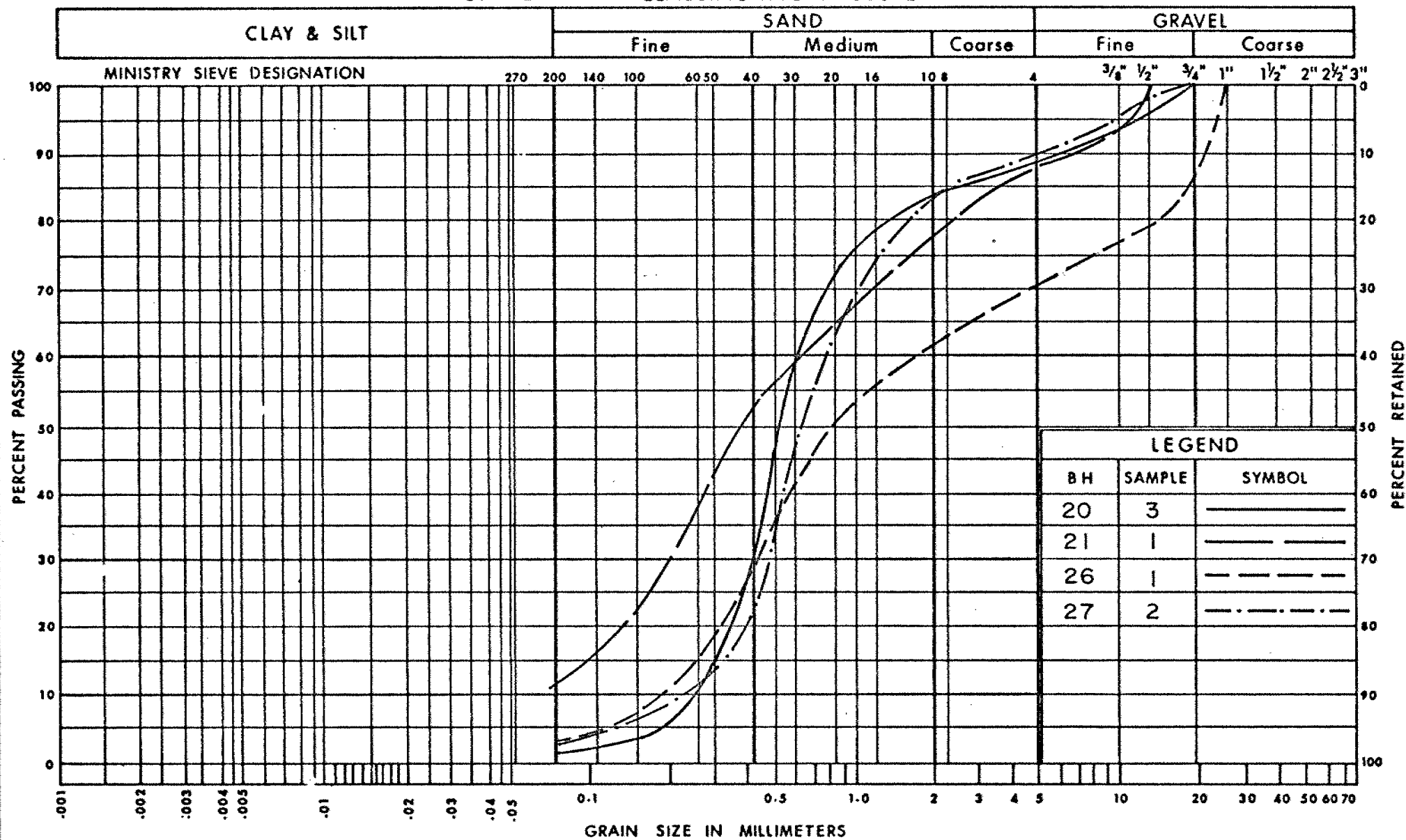
# GRAIN SIZE DISTRIBUTION GRAVELLY SAND

FIG No 2

W P 71-74-05 & 06



## UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of  
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Communications  
Ontario  
ENGINEERING SERVICES BRANCH

## GRAIN SIZE DISTRIBUTION GRAVELLY SAND

FIG No 3

W P 71-74-05 &amp; 06

## UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY &amp; SILT

SAND

GRAVEL

Fine

Medium

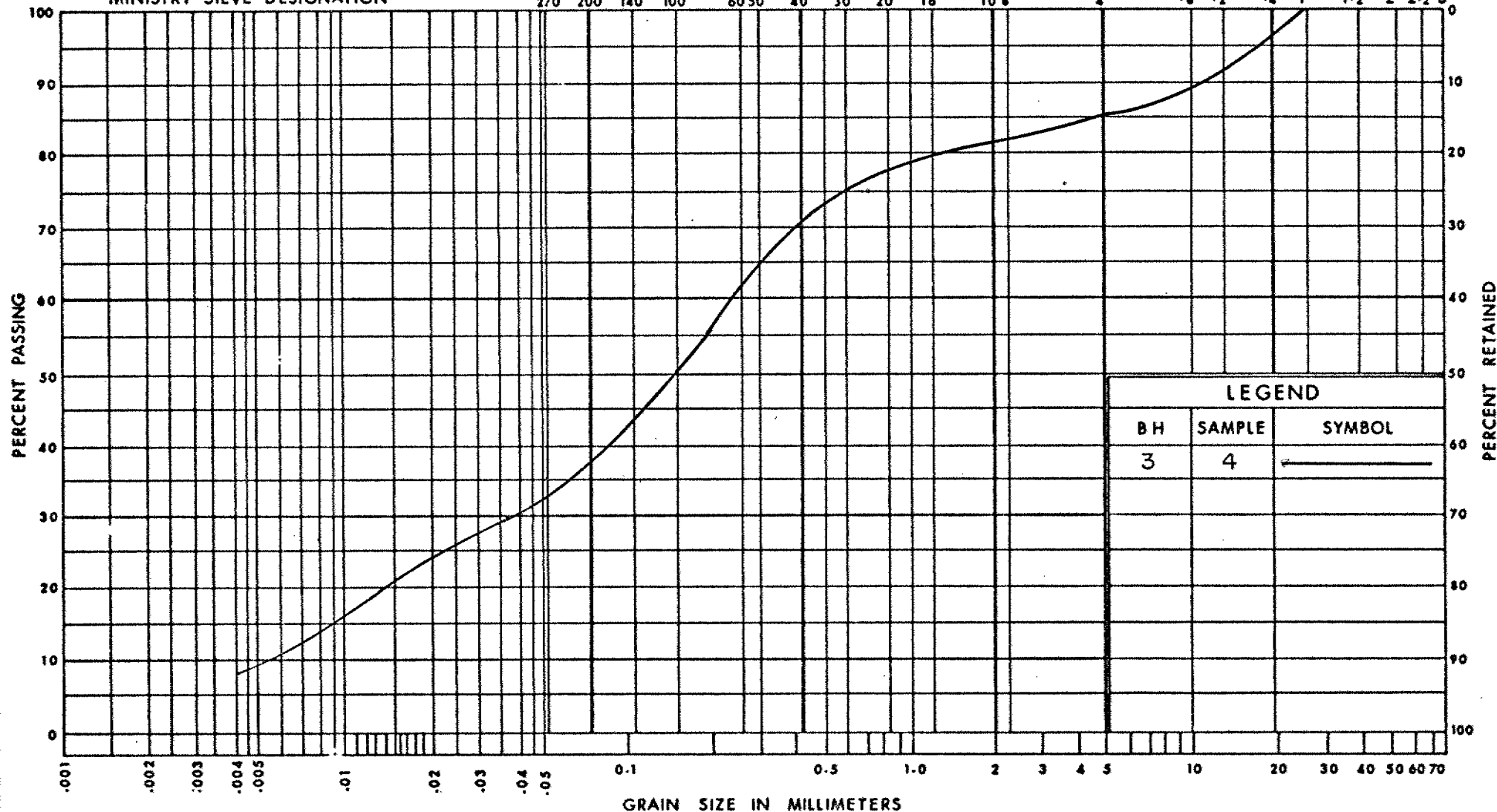
Coarse

Fine

Coarse

MINISTRY SIEVE DESIGNATION

270 200 140 100 60 50 40 30 20 16 10 8 4 3/8" 1/2" 3/4" 1" 1 1/2" 2" 2 1/2" 3"



Ontario

 Ministry of  
Transportation and  
Communications

ENGINEERING SERVICES BRANCH

 GRAIN SIZE DISTRIBUTION  
SILTY SAND TILL

FIG No 4

W P 71-74-05 &amp; 06

## ABBREVIATIONS & SYMBOLS USED IN THIS REPORT

### PENETRATION RESISTANCE

'N'-STANDARD PENETRATION RESISTANCE : - THE NUMBER OF BLOWS REQUIRED TO ADVANCE A STANDARD SPLIT SPOON SAMPLER 12 INCHES INTO THE SUBSOIL, DRIVEN BY MEANS OF A 140 POUND HAMMER FALLING FREELY A DISTANCE OF 30 INCHES.

DYNAMIC PENETRATION RESISTANCE : - THE NUMBER OF BLOWS REQUIRED TO ADVANCE A 2 INCH, 60 DEGREE CONE, FITTED TO THE END OF DRILL RODS, 12 INCHES INTO THE SUBSOIL, THE DRIVING ENERGY BEING 350 FOOT POUNDS PER BLOW.

RQD = Rock Quality Designator : Length of core in pieces 4 inches and longer/  
length of run expressed as percentage.

### DESCRIPTION OF SOIL

THE CONSISTENCY OF COHESIVE SOILS AND THE RELATIVE DENSITY OR DENSENESS OF COHESIONLESS SOILS ARE DESCRIBED IN THE FOLLOWING TERMS :-

<u>CONSISTENCY</u>	<u>c LB/SQ. FT.</u>	<u>DENSENESS</u>	<u>'N' BLOWS / FT.</u>
VERY SOFT	0 - 250	VERY LOOSE	0 - 4
SOFT	250 - 500	LOOSE	4 - 10
FIRM	500 - 1000	COMPACT	10 - 30
STIFF	1000 - 2000	DENSE	30 - 50
VERY STIFF	2000 - 4000	VERY DENSE	> 50
HARD	> 4000		

TERMS TO BE USED IN DESCRIBING SOILS:-

TRACE < 10% , SOME 10-25% , WITH 25-40% , > 40% SILTY, SANDY, GRAVELLY, CLAYEY ETC.

### TYPE OF SAMPLE

S.S	SPLIT SPOON	T.W	THINWALL OPEN
W.S	WASHED SAMPLE	T.P	THINWALL PISTON
S.T	SLOTTED TUBE SAMPLE	O.S	OESTERBERG SAMPLE
A.S	AUGER SAMPLE	F.S	FOIL SAMPLE
C.S	CHUNK SAMPLE	R.C	ROCK CORE

P.H. SAMPLE ADVANCED HYDRAULICALLY

P.M. SAMPLE ADVANCED MANUALLY

### SOIL TESTS

U	UNCONFINED COMPRESSION	L.V	LABORATORY VANE
UU	UNCONSOLIDATED UNDRAINED TRIAXIAL	F.V	FIELD VANE
CIU	CONSOLIDATED ISOTROPIC UNDRAINED TRIAXIAL	C	CONSOLIDATION
CID	" " DRAINED "	S	SENSITIVITY
CAU	" ANISOTROPIC UNDRAINED "		
CAD	" " DRAINED "		

# ABBREVIATIONS & SYMBOLS USED IN THIS REPORT

## SOIL PROPERTIES

$\gamma$	UNIT WEIGHT OF SOIL (BULK DENSITY)
$\gamma_s$	UNIT WEIGHT OF SOLID PARTICLES
$\gamma_w$	UNIT WEIGHT OF WATER
$\gamma_d$	UNIT DRY WEIGHT OF SOIL (DRY DENSITY)
$\gamma'$	UNIT WEIGHT OF SUBMERGED SOIL
G	SPECIFIC GRAVITY OF SOLID PARTICLES $G = \frac{\gamma_s}{\gamma_w}$
e	VOID RATIO
n	POROSITY
w	WATER CONTENT
$S_r$	DEGREE OF SATURATION
$w_L$	LIQUID LIMIT
$w_p$	PLASTIC LIMIT
$I_p$	PLASTICITY INDEX
$w_s$	SHRINKAGE LIMIT
$I_L$	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$
$I_c$	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$
$e_{max}$	VOID RATIO IN LOOSEST STATE
$e_{min}$	VOID RATIO IN DENSEST STATE
$I_D$	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
	RELATIVE DENSITY $D_r$ IS ALSO USED
h	HYDRAULIC HEAD OR POTENTIAL
q	RATE OF DISCHARGE
v	VELOCITY OF FLOW
i	HYDRAULIC GRADIENT
k	COEFFICIENT OF PERMEABILITY
j	SEEPAGE FORCE PER UNIT VOLUME
$m_v$	COEFFICIENT OF VOLUME CHANGE = $\frac{-\Delta e}{(1+e)\Delta\sigma}$
$c_v$	COEFFICIENT OF CONSOLIDATION
$C_c$	COMPRESSION INDEX = $\frac{\Delta e}{\Delta \log_{10} \sigma}$
$T_v$	TIME FACTOR = $\frac{c_v t}{d^2}$ (d, DRAINAGE PATH)
U	DEGREE OF CONSOLIDATION
$\tau_f$	SHEAR STRENGTH
$c'$	EFFECTIVE COHESION INTERCEPT
$\phi'$	EFFECTIVE ANGLE OF SHEARING RESISTANCE, OR FRICTION
$c_u$	APPARENT COHESION
$\phi_u$	APPARENT ANGLE OF SHEARING RESISTANCE, OR FRICTION
$\mu$	COEFFICIENT OF FRICTION
$S_t$	SENSITIVITY

## GENERAL

$\pi$	= 3.1416
e	BASE OF NATURAL LOGARITHMS 2.7183
$\log_e a$ OR $\ln a$	NATURAL LOGARITHM OF a
$\log_{10} a$ OR $\log a$	LOGARITHM OF a TO BASE 10
t	TIME
g	ACCELERATION DUE TO GRAVITY
V	VOLUME
W	WEIGHT
M	MOMENT
F	FACTOR OF SAFETY

## STRESS AND STRAIN

u	PORE PRESSURE
$\sigma$	NORMAL STRESS
$\bar{\sigma}$	NORMAL EFFECTIVE STRESS ( $\bar{\sigma}$ IS ALSO USED)
$\tau$	SHEAR STRESS
$\epsilon$	LINEAR STRAIN
$\gamma$	SHEAR STRAIN
$\nu$	POISSON'S RATIO ( $\mu$ IS ALSO USED)
E	MODULUS OF LINEAR DEFORMATION (YOUNG'S MODULUS)
G	MODULUS OF SHEAR DEFORMATION
K	MODULUS OF COMPRESSIBILITY
$\eta$	COEFFICIENT OF VISCOSITY

## EARTH PRESSURE

d	DISTANCE FROM TOP OF WALL TO POINT OF APPLICATION OF PRESSURE
$\delta$	ANGLE OF WALL FRICTION
K	DIMENSIONLESS COEFFICIENT TO BE USED WITH VARIOUS SUFFIXES IN EXPRESSIONS REFERRING TO NORMAL STRESS ON WALLS
$K_0$	COEFFICIENT OF EARTH PRESSURE AT REST

## FOUNDATIONS

B	BREADTH OF FOUNDATION
L	LENGTH OF FOUNDATION
D	DEPTH OF FOUNDATION BENEATH GROUND
N	DIMENSIONLESS COEFFICIENT USED WITH A SUFFIX APPLYING TO SPECIFIC GRAVITY, DEPTH AND COHESION ETC. IN THE FORMULA FOR BEARING CAPACITY
$k_s$	MODULUS OF SUBGRADE REACTION

## SLOPES

H	VERTICAL HEIGHT OF SLOPE
D	DEPTH BELOW TOE OF SLOPE TO HARD STRATUM
$\beta$	ANGLE OF SLOPE TO HORIZONTAL



## BOREHOLE LOGS

## HIGHWAY ENGINEERING DIVISION - ENGINEERING MATERIALS OFFICE - SOIL MECHANICS SECTION

## RECORD OF BOREHOLE No 1,1A

WP 71-74-05 &amp; 06

LOCATION

Co-ords. 16,814,727 N; 1,026,275 E.

ORIGINATED BY JBS

DIST 13 HWY 11

BORING DATE

December 8, 1976

COMPILED BY GDP

DATUM Geodetic

BOREHOLE TYPE

Solid Stem Auger

CHECKED BY MB

SOIL PROFILE			SAMPLES			GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT					LIQUID LIMIT — $w_L$ PLASTIC LIMIT — $w_p$ WATER CONTENT — $w$			UNIT WEIGHT $\gamma$	REMARKS
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100	$w_p$	$w$	$w_L$		
679.6	Ground Level															GR SA SI CL
679.3	Topsoil															
0.3	Gravelly sand, odd cobbles. Becoming fine sand trace silt. Trace gravel. Light brown fine sand layers. Very dense. Brown		1	SS	50	675						o				Very hard augering
			2	SS	65							o				
672.6	End of Borehole. Refusal to augering, probable boulder. Note: Borehole dry on completion.															
7.0																
	Borehole No. 1A Co-ords. 16,814,729 N; 1,026,272 E.															
679.6	Ground Level															
	Topsoil															
0.3	Soil conditions similar to borehole 1 no samples taken to 9.6					675										
	Gravelly sand, odd cobble sizes.		1	SS	38	670						o				Very hard augering
	Dense. Brown					665										
663.6																
16.0	End of Borehole. Refusal to augering, probable bedrock. Note: Borehole dry on completion.															

## HIGHWAY ENGINEERING DIVISION - ENGINEERING MATERIALS OFFICE - SOIL MECHANICS SECTION

## RECORD OF BOREHOLE No 2,2A

WP 71-74-05 &amp; 06

LOCATION

Co-ords. 16,814,684 N; 1,026,247 E.

ORIGINATED BY WJ

DIST 13 HWY 11

BORING DATE

December 9, 1976 &amp; January 21, 1977

COMPILED BY MB

DATUM Geodetic

BOREHOLE TYPE

Hollow Stem Auger, BXL Rock Core &amp; Cone Test

CHECKED BY MB

SOIL PROFILE			SAMPLES			GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT					LIQUID LIMIT —WL PLASTIC LIMIT —WP WATER CONTENT —W			UNIT WEIGHT γ	REMARKS
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100	Wp	Wo	WL		
670.5	Ground Level															
0.2	Topsoil					670										
	Sand, fine		1	SS	13											
	Compact.															
	Some gravel below 6.5 feet.		2	SS	19	665										
659.5	Compact. Brown		3	SS	13	660										
11.0	Bedrock. Biotite Gneiss. Sound rock.															
	RQD = 96%		4	RC BXL	100% REC											
	RQD = 86%		5	BXL	100% REC	655										
	RQD = 83%		6	RC BXL	100% REC	650										
	RQD = 91%		7	RC BXL	100% REC	645										
643.9																
26.6	End of Borehole Note: On completion hole caved at 664.5															
	Borehole No. 2A Co-ords. 16,814,688 N; 1,026,243 E.															
670.5	Ground Level															
0.2	Topsoil					670										
	Hole augered without sampling to check ref sal.															
	Soil conditions as in borehole 2.					665										
658.5	Compact. Brown					660										
12.0	End of Borehole. Refusal to augering, probable bedrock. Note: On completion hole caved at 660.8. Water level not established.															

 BX casing  
reamed  
from 11.0  
to 11.5.  
Sampling  
with BXL  
core  
barrel  
from 11.0.



## HIGHWAY ENGINEERING DIVISION - ENGINEERING MATERIALS OFFICE - SOIL MECHANICS SECTION

## RECORD OF BOREHOLE NO 3, 3A

WP 71-74-05 &amp; 06

LOCATION

Co-ords. 16,814,822 N; 1,026,107 E.

ORIGINATED BY JBS

DIST 13 HWY 11

BORING DATE

December 10, 1976

COMPILED BY MB

DATUM Geodetic

BOREHOLE TYPE

Solid Stem Auger

CHECKED BY MB

SOIL PROFILE			SAMPLES			GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT					LIQUID LIMIT — $w_L$ PLASTIC LIMIT — $w_p$ WATER CONTENT — $w$			UNIT WEIGHT $\gamma$	REMARKS
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100	$w_p$	$w$	$w_L$		
682.7	Ground Level															
0.2	Topsoil															
	Gravelly sand, some silt.		1	SS	46	680										
	Occasional cobble sizes.		2	SS	36											
	Compact to dense.					675										
570.7	Brown		3	SS	23											
12.0	Silty sand till.					670										
667.7	Very dense. Brown		4	SS	50											14 49 33 4
15.0	End of Borehole. Refusal to augering, probable bedrock. Note: On completion hole caved at 673.2															
	Borehole No. 3A Co-ords. 16,814,832 N; 1,026,107 E.															
682.7	Ground Level															
0.0	Borehole augered without sampling to check refusal.					680										
	Soil conditions as in borehole 3.															
	Gravelly sand, compact to dense.					675										
	Brown					670										
668.7	End of Borehole. Refusal to augering, probable bedrock. Note: Water level not established.															

## HIGHWAY ENGINEERING DIVISION - ENGINEERING MATERIALS OFFICE - SOIL MECHANICS SECTION

## RECORD OF BOREHOLE No 4,5,6

WP 71-74-05 &amp; 06

LOCATION

Co-ords. 16,814,653 N; 1,026,139 E.

Co-ords. 16,814,614 N; 1,026,103 E.

Co-ords. 16,814,761 N; 1,025,990 E.

ORIGINATED BY JBS

DIST 13 HWY 11

BORING DATE December 12, 1976

COMPILED BY MB

DATUM Geodetic

BOREHOLE TYPE Solid Stem Auger

CHECKED BY MB

SOIL PROFILE			SAMPLES			GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT					LIQUID LIMIT — $w_L$ PLASTIC LIMIT — $w_p$ WATER CONTENT — $w$			UNIT WEIGHT $\gamma$	REMARKS			
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100	SHEAR STRENGTH							
												○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE					$w_p$ — $w$ — $w_L$		
												WATER CONTENT % 10 20 30							
677.4	Ground Level																		
676.9	Topsoil																		
0.5	End of Borehole. Refusal to augering, probable bedrock. Rock outcrops nearby. Note: Borehole dry on completion.					675													
	Borehole No. 5 Co-ords. 16,814,614 N; 1,026,103 E.																		
679.6	Ground Level																		
	Topsoil																		
0.5	Gravelly sand.																		
677.6	Cobbles.																		
2.0	End of Borehole. Refusal to augering, probable bedrock. Rock outcrops nearby. Note: Borehole dry on completion.					675													
	Borehole No. 6 Co-ords. 16,814,761 N; 1,025,990 E.																		
690.2	Ground Level																		
	Minimal topsoil. Gravelly sand. Layers of fine sand or silt. Rust Brown		1	SS	15														
686.2	4.0 Silty clay, Near plastic limit.		2	SS	23	685													
683.2	Firm to stiff. Brown																		
7.0	Sandy silt, trace of clay																		
680.2	Dense. Brown					680													
10.0	Sand, fine.		3	SS	38														
678.7	Dense. Brown																		
11.5	End of Borehole. Refusal to augering, probable bedrock. Note: Three attempts to further probing failed to penetrate surficial cobble layer.																		

## HIGHWAY ENGINEERING DIVISION - ENGINEERING MATERIALS OFFICE - SOIL MECHANICS SECTION

## RECORD OF BOREHOLE NO 7

WP 71-74-05 & 06 LOCATION Co-ords. 16,814,595 N; 1,026,317 E. ORIGINATED BY JBS  
 DIST 13 HWY 11 BORING DATE December 15, 1976 COMPILED BY MB  
 DATUM Geodetic BOREHOLE TYPE Solid Stem Auger and Cone Test CHECKED BY MB

SOIL PROFILE			SAMPLES			GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT					LIQUID LIMIT $w_L$ PLASTIC LIMIT $w_p$ WATER CONTENT $w$			UNIT WEIGHT $\gamma$	REMARKS
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100	WATER CONTENT % $w_p$ $w$ $w_L$				
666.8	Ground Level															
0.0	Nominal topsoil.															
	Gravelly sand, coarse, with some silt layers.		1	SS	11											
	Compact															
	Brown changing to grey		2	SS	17											
	Becoming gravelly fine sand with some silt. Cobbles below 21.0		3	SS	10											
	Compact		4	SS	19											
641.8																
25.0	End of Borehole. Refusal to augering, probable boulder.															
638.8																
28.0	End of Cone Test.															

## HIGHWAY ENGINEERING DIVISION - ENGINEERING MATERIALS OFFICE - SOIL MECHANICS SECTION

## RECORD OF BOREHOLE NO 8

WP 71-74-05 & 06 LOCATION Co-ords. 16,814,622 N; 1,026,374 E. ORIGINATED BY JBS  
 DIST 13 HWY 11 BORING DATE December 15, 1976 & January 17 & 19, 1977 COMPILED BY MB  
 DATUM Geodetic BOREHOLE TYPE Hollow Stem Auger, BXL Rock Core & Cone Test CHECKED BY MB

SOIL PROFILE			SAMPLES			GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT					LIQUID LIMIT $W_L$ PLASTIC LIMIT $W_P$ WATER CONTENT $W$			UNIT WEIGHT $\gamma$	REMARKS
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	N' VALUES		20	40	60	80	100	$W_P$	$W$	$W_L$		
662.5	Ground Level															
0.4	Topsoil															
	Gravelly sand, coarse		1	SS	15	660										
	Cobbles below 7.6					655										
	Very bouldery below 9.0		2	SS	65	650										
	Compact to very dense.															
	Refusal on augers at 15.0 - boulder.															
647.5			3	BXL	44% RC											
15.0	Boulders		4	BXL	49% RC	645										
643.5			5	BXL												
19.0	Gravelly sand		6	SS	123											
	Very dense		7	SS	128	640										
635.5	Brown					635										
27.0	Grey															
	Silty sand, fine, some gravel.					630										
630.5																
32.0	Silty sand till.															
628.5	Very dense. Grey															
34.0	Bedrock. Biotite Gneiss. Fractured		8	BXL	100% RC	625										
	RQD = 35%															
	RQD = 37%		9	BXL	100% RC											
	RQD = 17%		10	BXL	100% RC	620										
	RQD = 56%		11	BXL	100% RC	615										
612.8																
49.7	End of Borehole															

WP 71-74-05 & 06 LOCATION Co-ords. 16,814,628 N; 1,026,378 E. ORIGINATED BY JBS  
DIST 13 HWY 11 BORING DATE December 15, 1976 COMPILED BY MB  
DATUM Geodetic BOREHOLE TYPE Solid Stem Auger CHECKED BY MB

15  $\frac{20}{10}$  5 % STRAIN AT FAILURE



## HIGHWAY ENGINEERING DIVISION - ENGINEERING MATERIALS OFFICE - SOIL MECHANICS SECTION

## RECORD OF BOREHOLE NO 9

WP 71-74-05 &amp; 06

LOCATION Co-Ords. 16,814,564 N; 1,026,228 E.

ORIGINATED BY JBS

DIST 13 HWY 11

BORING DATE December 15, 1976 &amp; January 6 &amp; 7, 1977

COMPILED BY MB

DATUM Geodetic

BOREHOLE TYPE Hollow Stem Auger, BX Rock Core &amp; Cone Test

CHECKED BY MB

SOIL PROFILE			SAMPLES			GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT					LIQUID LIMIT $w_L$ PLASTIC LIMIT $w_p$ WATER CONTENT $w$			UNIT WEIGHT $\gamma$	REMARKS
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100	$w_p$	$w$	$w_L$		
661.6	Ground Level															
0.5	Topsoil Sand, fine															
	Loose	Brown	1	SS	5	660										
653.6						655										
8.0	Gravelly sand, coarse, with occasional layers of medium sand.		2	SS	25	650										
	Compact		3	SS	18	645										
			4	SS	10	640										
636.6		Brown														
25.0	Very dense.	Grey	5	SS	100/6"	635										
	Boulders					630										
625.6						625										
36.0	Bedrock. Biotite Gneiss. Sound rock.		6	RC BXL	100% REC.	620										
	RQD = 54%															
			7	RC BXL	100% REC.	615										
	RQD = 41%															
			8	RC BXL	100% REC.	610										
	RQD = 90%															
611.1																
50.5	End of Borehole					610										

 BX casing  
reamed to  
36.5.  
Diamond  
drilling in  
BXL core  
started  
from 36.0.

## RECORD OF BOREHOLE NO 10

WP 71-74-05 & 06 LOCATION Co-ords. 16,814,546 N; 1,026,179 E. ORIGINATED BY JBS  
 DIST 13 HWY 11 BORING DATE December 16, 1976 & January 20, 1977 COMPILED BY MB  
 DATUM Geodetic BOREHOLE TYPE Hollow Stem Auger, BXL Rock Core & Cone Test CHECKED BY MB

SOIL PROFILE			SAMPLES			GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT					LIQUID LIMIT $W_L$ PLASTIC LIMIT $W_P$ WATER CONTENT $W$			UNIT WEIGHT $\gamma$	REMARKS
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100	$W_P$	$W$	$W_L$		
661.3	Ground Level															GR SA SI CL
0.0	Nominal topsoil.					660										
	Gravelly sand, coarse, with occasional silt layers and odd cobbles.		1	SS	20	655										
	Compact.		2	SS	8	650										13 85 2 0
		Brown	3	SS	20	645										
	More gravel below 23.0		4	SS	11	640										
637.3			5	RC												
24.0	Boulders		6	BXL	100%	635										
	Refusal on augers. BX casing reamed to 24.5. Sand washing up.		7	RC BXL	35% REC	630										
	AX casing reamed to 28.3.			RC AXT	37% REC											
	After sample 3, sand washing up.					625										
622.3																
39.0	Bedrock. Biotite Gneiss. Fractured.		8	RC BXL	100% REC	620										BX casing driven to 37.0 and diamond drilling in BXL
	RQD = 76%															
617.3																
44.0	End of Borehole					615										casing started at 39.0.

## RECORD OF BOREHOLE NO 11

WP 71-74-05 &amp; 06

LOCATION Co-ords. 16,814,564 N; 1,026,451 E.

ORIGINATED BY WJ

DIST 13 HWY 11

BORING DATE December 16, 1976 &amp; January 11, 1977

COMPILED BY MB

DATUM Geodetic

BOREHOLE TYPE Hollow Stem Auger, BXL Rock Core &amp; Cone Test

CHECKED BY MB

SOIL PROFILE			SAMPLES			GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT					LIQUID LIMIT $w_L$ PLASTIC LIMIT $w_p$ WATER CONTENT $w$			UNIT WEIGHT $\gamma$	REMARKS
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100	$w_p$	$w$	$w_L$		
661.8	Ground Level															
0.0	Clayey silt with silty clay and fine sand layers.															
	Some organics and hair roots.		1	TW	PM											
654.95	Very soft, Dark Grey		2	SS	1											
6.85	Sand, fine. Some silt.															
	Cobbles below $\pm 10.0$		3	SS	8											
	Loose to compact															
	Grey															
	Very bouldery from 15.0 to 20.0		4	SS	29											
	Sandy from 20.0 to 23.0															
	Bouldery again below 23.0															
636.2	Very dense. Grey															
25.6	Bedrock. Biotite Gneiss. RQD = 38% weathered sound		5	RC	BXL100% REC.											
	RQD = 80%		6	RC	BXL100% REC.											
	RQD = 96%		7	RC	BXL100% REC.											
	RQD = 94%		8	RC	BXL100% REC.											
621.3																
40.5	End of Borehole															

73.8

BX casing reamed to 25.8. Diamond drilling in BXL core barrel from 25.5.

## HIGHWAY ENGINEERING DIVISION - ENGINEERING MATERIALS OFFICE - SOIL MECHANICS SECTION

## RECORD OF BOREHOLE NO 11A

WP 71-74-05 & 06 LOCATION Co-ords. 16,814,560 N; 1,026,447 E. ORIGINATED BY JBS  
 DIST 13 HWY 11 BORING DATE December 17, 1976 COMPILED BY MB  
 DATUM Geodetic BOREHOLE TYPE Solid Stem Auger CHECKED BY MB

SOIL PROFILE			SAMPLES			GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT					LIQUID LIMIT $W_L$ PLASTIC LIMIT $W_P$ WATER CONTENT $W$			UNIT WEIGHT $\gamma$	REMARKS
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100	$W_p$	$W$	$W_L$		
661.8	Ground Level															GR SA SI CL
0.0	Hole augered without sampling to check refusal. Clayey silt with silty clay and fine sand layers.					660										
654.95						655										
6.85	Sand, fine					650										
	Bouldery					645										
640.3						640										
21.5	End of Borehole. Refusal to augering, probable boulder. Note: Water level not established.															

## RECORD OF BOREHOLE NO 12

WP 71-74-05 &amp; 06

LOCATION Co-ords. 16,814,521 N; 1,026,417 E.

ORIGINATED BY WJ

DIST 13 HWY 11

BORING DATE December 17, 1976, January 8 &amp; 10, 1977

COMPILED BY MB

DATUM Geodetic

BOREHOLE TYPE Hollow Stem Auger, BXL Rock Core &amp; Cone Test

CHECKED BY MB

SOIL PROFILE			SAMPLES			GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT					LIQUID LIMIT $w_L$ PLASTIC LIMIT $w_p$ WATER CONTENT $w$			UNIT WEIGHT $\gamma$	REMARKS
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100	$w_p$	$w$	$w_L$		
661.9	Ground Level															
0.0	Clayey silt, some hair roots.		1	AS		660										
655.9	Very soft to firm. Brown		2	SS	5	655										
6.0	Sand, fine															
	Trace of gravel.		3	SS	23	650										
			4	SS	16	645										
	Compact to dense.															
640.4	Grey		5	SS	40	640										
21.5	Bedrock. Biotite Gneiss. RQD = 56%		6	RC BXL	100% REC.											
	RQD = 63%		7	RC BXL	100% REC.	635										
	weathered sound		8	RC BXL	100% REC.	630										
	RQD = 48%		9	RC BXL	100% REC.	625										
625.4	RQD = 92%															
36.5	End of Borehole. Note: On completion hole caved at 656.9															

 BX casing  
reamed to  
21.7.  
Diamond  
drilling  
in BXL core  
barrel  
started  
from 21.5.

20  
15  $\phi$  5 % STRAIN AT FAILURE  
10

## HIGHWAY ENGINEERING DIVISION - ENGINEERING MATERIALS OFFICE - SOIL MECHANICS SECTION

## RECORD OF BOREHOLE NO 15,16

WP 71-74-05 & 06 LOCATION Co-ords. 16,814,510 N; 1,026,510 E. ORIGINATED BY JBS  
 DIST 13 HWY 11 BORING DATE December 18, 1976 COMPILED BY MB  
 DATUM Geodetic BOREHOLE TYPE Solid Stem Auger & Cone Test CHECKED BY MB

SOIL PROFILE			SAMPLES			GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT					LIQUID LIMIT $w_L$ PLASTIC LIMIT $w_p$ WATER CONTENT $w$			UNIT WEIGHT $\gamma$	REMARKS
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100	SHEAR STRENGTH ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE				
662.2	Ground Level															
0.0	Clayey silt with sand layers.		1	TW	PM	660										
658.2	Firm. Dark Grey		2	SS	9											
4.0	Gravelly sand, coarse, saturated.					655										
	Some layers of fine sand.		3	SS	6											
	Loose Grey					650										
	Occasional cobble and boulder below 17.0					645										
641.2	End of Borehole. Refusal to augering, probable bedrock. Note: Water level not established.					640										
21.0	Borehole No. 16 Co-ords. 16,814,575 N; 1,026,542 E.															
662.2	Ground Level															
0.0						665										
						660										
						655										
						650										
644.2	End of Cone Test.															
18.0																

## HIGHWAY ENGINEERING DIVISION - ENGINEERING MATERIALS OFFICE - SOIL MECHANICS SECTION

## RECORD OF BOREHOLE No 17, 17A

WP 71-74-05 &amp; 06

LOCATION

Co-ords. 16,814,507 N; 1,026,284 E.

ORIGINATED BY WJ

DIST 13 HWY 11

BORING DATE

December 18, 1976 &amp; January 8, 1977

COMPILED BY MB

DATUM Geodetic

BOREHOLE TYPE

Hollow Stem Auger, BXL Rock Core &amp; Cone Test

CHECKED BY MB

SOIL PROFILE			SAMPLES			GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT					LIQUID LIMIT — $w_L$ PLASTIC LIMIT — $w_p$ WATER CONTENT — $w$			UNIT WEIGHT $\gamma$	REMARKS
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100	$w_p$	$w$	$w_L$		
663.1	Ground Level															
0.0	Sand, fine															
	Loose.		1	SS	6											
655.1	Brown															
8.0	Bedrock. Biotite Gneiss. Sound rock.		2	RC BXL	100% REC.											
	RQD = 92%															
			3	RC BXL	100% REC.											
	RQD = 100%															
			4	RC BXL	100% REC.											
	RQD = 63%															
639.6																
23.5	End of Borehole															
	Borehole No. 17A															
	Co-ords. 16,814,512 N; 1,026,282 E.															
663.1	Ground Level															
0.0	Borehole augered without sampling to check refusal.															
	Soil conditions similar to borehole 17.															
	Sand, fine															
	Loose.															
	Brown															
652.6																
10.5	End of Borehole. Refusal to augering, probable bedrock. Note: Water level not established.															



## HIGHWAY ENGINEERING DIVISION - ENGINEERING MATERIALS OFFICE - SOIL MECHANICS SECTION

## RECORD OF BOREHOLE NO 18

WP 71-74-05 & 06 LOCATION Co-Ords. 16,814,545 N; 1,026,315 E. ORIGINATED BY JBS  
 DIST 13 HWY 11 BORING DATE December 20, 1976 COMPILED BY MB  
 DATUM Geodetic BOREHOLE TYPE Solid Stem Auger CHECKED BY MB

SOIL PROFILE			SAMPLES			GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT					LIQUID LIMIT $W_L$ PLASTIC LIMIT $W_P$ WATER CONTENT $W$			UNIT WEIGHT $\gamma$	REMARKS	
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100	SHEAR STRENGTH ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE					WATER CONTENT %
667.5	Ground Level																
0.0	Sand, fine  Rust brown brown  Sand, fine, with trace of gravel and occasional cobbles.          Gravelly at 19.5																
665																	
660																	
655																	
650																	
647.0																	
20.5	End of Borehole. Refusal to augering probable bedrock. Note: Water level not established.																

20  
15  $\phi$  5 % STRAIN AT FAILURE  
10

## HIGHWAY ENGINEERING DIVISION - ENGINEERING MATERIALS OFFICE - SOIL MECHANICS SECTION

## RECORD OF BOREHOLE NO 20

WP 71-74-05 &amp; 06

LOCATION Co-ords. 16,814,699 N; 1,026,568 E.

ORIGINATED BY JBS

DIST 13 HWY 11

BORING DATE December 21, 1976

COMPILED BY MB

DATUM Geodetic

BOREHOLE TYPE Solid Stem Auger

CHECKED BY MB

SOIL PROFILE			SAMPLES			GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT					LIQUID LIMIT — $w_L$ PLASTIC LIMIT — $w_p$ WATER CONTENT — $w$			UNIT WEIGHT $\gamma$	REMARKS
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100	$w_p$	$w$	$w_L$		
663.5	Ground Level															
0.0	Topsoil															
662.0																
1.5	Sand, fine															
660.5	trace silt.		1	SS	13	660										
3.0	Gravelly sand, coarse,		2	SS	6											
						655										
			3	SS	8											
	After sample 3, hole augered without sampling to check refusal.					650										
						645										
						640										
						635										
632.5																
31.0	End of Borehole. Refusal to augering, probable bedrock.															

## HIGHWAY ENGINEERING DIVISION - ENGINEERING MATERIALS OFFICE - SOIL MECHANICS SECTION

## RECORD OF BOREHOLE No 21, 21A

WP 71-74-05 &amp; 06

LOCATION

Co-ords. 16,814,643 N; 1,026,462 E.

ORIGINATED BY JBS

DIST 13 HWY 11

BORING DATE

December 21, 1976

COMPILED BY MB

DATUM Geodetic

BOREHOLE TYPE

Solid Stem Auger

CHECKED BY MB

SOIL PROFILE			SAMPLES			GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT					LIQUID LIMIT — $w_L$ PLASTIC LIMIT — $w_p$ WATER CONTENT — $w$			UNIT WEIGHT $\gamma$	REMARKS
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100	$w_p$	$w$	$w_L$		
665.4	Ground Level															
0.0	Borehole augered without sampling to check refusal. Sand, fine.					665										
661.4	Brown															
4.0	Gravelly sand, coarse, some cobbles and boulders.		1	AS		660										13 75 12 0
	Brown					655										
652.4																
13.0	End of Borehole. Refusal to augering, probable boulder. Note: Water level not established.															
	Borehole No. 21A Co-ords. 16,814,647 N; 1,026,457 E.															
665.4	Ground Level					665										
0.0	Borehole augered without sampling to check refusal. Sand, fine.															
661.4																
4.0	Gravelly sand with cobbles and boulders.					660										
	Brown					655										
650.4																
15.0	End of Borehole. Refusal to augering, probable boulder. Note: Water level not established.					650										

## HIGHWAY ENGINEERING DIVISION - ENGINEERING MATERIALS OFFICE - SOIL MECHANICS SECTION

## RECORD OF BOREHOLE NO 22

WP 71-74-05 & 06 LOCATION Co-ords. 16,814,445 N; 1,026,270 E. ORIGINATED BY WJ  
 DIST 13 HWY 11 BORING DATE December 22, 1976 COMPILED BY MB  
 DATUM Geodetic BOREHOLE TYPE Hollow Stem Auger, BXL Rock Core & Cone Test CHECKED BY MB

SOIL PROFILE			SAMPLES			GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT					LIQUID LIMIT $W_L$ PLASTIC LIMIT $W_P$ WATER CONTENT $W$			UNIT WEIGHT $\gamma$	REMARKS
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100	$W_p$	$W$	$W_L$		
661.4	Ground Level															
0.4	Clayey silt.					660										
	Very soft. Brown		1	SS	1											
657.4																
4.0	Organic silt with medium to coarse sand.		2	SS	1	655										
653.4	Very loose. Dark Brown															
8.0	Sand, fine		3	SS	4	650										
	Loose to compact.															
	Brown		4	SS	3	645										
642.5			5	SS	11	640										
21.5	Boulders															
637.9																
23.5	Bedrock. Biotite Gneiss. Sound rock. RQD = 57% (on first run)		6	RC BXL	100% REC.	635										
633.4			7	RC BXL	58% REC.											
28.0	End of Borehole.															

## HIGHWAY ENGINEERING DIVISION - ENGINEERING MATERIALS OFFICE - SOIL MECHANICS SECTION

## RECORD OF BOREHOLE NO 22A,B,C,D

WP 71-74-05 & 06 LOCATION Co-ords. 16,814,440 N; 1,026,259 E. & 16,814,435 N; 1,026,250 E. ORIGINATED BY WJ  
 DIST 13 HWY 11 BORING DATE January 17, 1977 1,026,280 E. & 16,814,434 N; 1,026,273 E. COMPILED BY MB  
 DATUM Geodetic BOREHOLE TYPE Solid Stem Auger CHECKED BY MB

SOIL PROFILE			SAMPLES			GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT					LIQUID LIMIT — $w_L$ PLASTIC LIMIT — $w_p$ WATER CONTENT — $w$			UNIT WEIGHT $\gamma$	REMARKS
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES		20 40 60 80 100					$w_p$ — $w$ — $w_L$				
							SHEAR STRENGTH ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE					WATER CONTENT %				
661.6	Ground Level															
0.0	Sandy silt, trace of clay & gravel.		1	AS		660									Borehole augered without sampling to check organic.	
659.6	Brown															
2.0	Organic silt with some sand.		2	AS												
656.6	Dark Brown															
5.0	Sand, fine,		3	AS		655										
654.6	Light Grey															
7.0	End of Borehole Note: Water level not established.															
	Borehole No. 22B Co-ords. 16,814,435 N; 1,026,250 E.															
662.0	Ground Level															
0.0	Sand, fine, slight silt content.		1	AS		660									Borehole augered without sampling to check organic.	
	Brown															
657.0	Light Grey		2	AS												
5.0	End of Borehole Note: Water level not established.															
	Borehole No. 22C Co-ords. 16,814,442 N; 1,026,280 E.															
661.4	Ground Level															
0.0	Sand, fine.					660									Borehole augered without sampling to check organic.	
	Brown		1	AS												
656.4																
5.0	End of Borehole Note: Water level not established.															
	Borehole No. 22D Co-ords. 16,814,434 N; 1,026,273 E.															
662.0	Ground Level															
0.0	Sand, fine.					660									Borehole augered without sampling to check organic.	
	Brown															
657.0																
5.0	End of Borehole Note: Water level not established.															

## HIGHWAY ENGINEERING DIVISION - ENGINEERING MATERIALS OFFICE - SOIL MECHANICS SECTION

## RECORD OF BOREHOLE NO 23

WP 71-74-05 & 06 LOCATION Co-ords. 16,814,428 N; 1,026,343 E. ORIGINATED BY WJ  
 DIST 13 HWY 11 BORING DATE December 23, 1976 & January 14, 1977 COMPILED BY MB  
 DATUM Geodetic BOREHOLE TYPE Solid Stem Auger & Cone Test CHECKED BY MB

SOIL PROFILE			SAMPLES			GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT					LIQUID LIMIT $W_L$ PLASTIC LIMIT $W_p$ WATER CONTENT $W$			UNIT WEIGHT $\gamma$	REMARKS
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100	$W_p$	$W$	$W_L$		
663.0	Ground Level															
0.3	Topsoil															
661.0	Sand, fine with some gravel. Loose. Brown															
2.0	Gravelly sand, medium to coarse.															
	Loose Brown		1	SS	7											
654.0																
9.0	Sand, fine, some gravel.															
	Very loose. Grey		2	SS	2											
			3	SS	2											
645.5																
17.5	End of Borehole. Refusal to augering, probable bedrock. Note: On completion hole caved at 660.0.															

HIGHWAY ENGINEERING DIVISION - ENGINEERING MATERIALS OFFICE - SOIL MECHANICS SECTION

RECORD OF BOREHOLE No 24

WP 71-74-05 & 06 LOCATION Co-Ords. 16,814,385 N; 1,026,397 E. ORIGINATED BY WJ  
 DIST 13 HWY 11 BORING DATE December 23, 1976 COMPILED BY MB  
 DATUM Geodetic BOREHOLE TYPE Solid Stem Auger & Cone Test CHECKED BY MB

SOIL PROFILE			SAMPLES			GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT					LIQUID LIMIT $w_L$ PLASTIC LIMIT $w_p$ WATER CONTENT $w$			UNIT WEIGHT $\gamma$	REMARKS
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100	SHEAR STRENGTH ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE				
665.5	Ground Level															
0.3	Topsoil Sand, fine					665										
	Loose.		1	SS	9	660										0 84 16 0
	Brown Grey		2	SS	6	655										
651.5																
14.0	Gravelly sand, coarse, some cobbles and boulders. Dense		3	SS	35	650										
	Grey															
645.5																
20.0	End of Borehole. Refusal to augering, probable bedrock.					645										



## RECORD OF BOREHOLE NO 25

WP 71-74-05 & 06 LOCATION Co-Ords. 16,814,376 N; 1,026,516 E. ORIGINATED BY WJ  
 DIST 13 HWY 11 BORING DATE January 4 and 14, 1977 COMPILED BY MB  
 DATUM Geodetic BOREHOLE TYPE Solid Stem Auger & Cone Test CHECKED BY MB

SOIL PROFILE			SAMPLES			GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT					LIQUID LIMIT $w_L$ PLASTIC LIMIT $w_p$ WATER CONTENT $w$			UNIT WEIGHT $\gamma$	REMARKS
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100	$w_p$	$w$	$w_L$		
671.2	Ground Level															
0.25	Topsoil Silty sand, fine, odd gravel, Yellow Brown Pale Brown Compact		1	SS	16	670										
661.7						665										
9.5	Gravelly sand, fine to coarse Very loose. Brown Grey		2	SS	5	660										
			3	SS	3	655										
650.2			4	SS	17	650										
21.0	Sand, fine, some gravel, odd cobble, Compact to dense. Boulders from 27.0 Grey		5	SS	30	645										
641.7																
29.5	End of Borehole. Refusal to augering, probable bedrock. Note: On completion wet cave in at 662.2 water level inferred.															

## HIGHWAY ENGINEERING DIVISION - ENGINEERING MATERIALS OFFICE - SOIL MECHANICS SECTION

## RECORD OF BOREHOLE No 26, 27

WP 71-74-05 & 06 LOCATION Co-ords. 16,814,478 N; 1,026,302 E. ORIGINATED BY WJ  
 DIST 13 HWY 11 BORING DATE January 21, 1977 COMPILED BY MB  
 DATUM Geodetic BOREHOLE TYPE Hand Auger\* CHECKED BY MB

SOIL PROFILE			SAMPLES			GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT					LIQUID LIMIT $W_L$ PLASTIC LIMIT $W_P$ WATER CONTENT $W$			UNIT WEIGHT $\gamma$	REMARKS  % GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	N' VALUES		20	40	60	80	100	$W_P$	$W$	$W_L$		
660.8	Water Level															
0.0	Water					660										
656.55	River Bottom															
4.25	Gravelly sand, coarse		1	SS	15	655										30 66 4 0
	Loose to compact.		2	SS	9											
652.6	Grey Brown		3	SS	100/5"											
8.2	End of Borehole. Refusal to augering, probable bedrock.					650										
	Borehole No. 27 Co-ords. 16,814,464N; 1,026,266 E.															
660.8	Water Level															
0.0	Water					660										
	River Bottom															
2.75	Sand															
3.25	Organic silt with some sand seams.		1	SS	5	655										
654.3	Loose. Dark Brown		2	SS	15											10 87 3 0
6.5	Gravelly sand, fine to coarse. Some sand seams.		3	SS	25	650										
	Compact. Grey Brown															
645.8			4	SS	30	645										0 89 11 0
15.0	Sand, fine		5	SS	45	640										
	Odd gravel.															
636.0	Dense. Grey		6	SS	100/3"											
24.8	End of Borehole. Refusal to augering, probable bedrock.					630										
	*Note: 41 lb. Hammer used. N-values shown on logs are corrected values corresponding to standard weight hammer and standard drop.															

FIELD NOTES ON SWAMP PROBING





Job No. 76 F 277

FIELD NOTES ON SWAMP PROBING

HAND AUGER PROBES

<u>Distance from Shore</u> <u>(North to South)</u>	<u>Depth of Water</u>	<u>Depth of Loose</u> <u>and Soft Material</u> <u>below River Bed Level</u>
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River Crossing - Line No. 1

5'	3'5"	1'11"
10'	5'0"	0'7"
20'	3'4"	2'8"
30'	3'6"	1'4"
40'	2'5"	4'11"
50'	1'6"	4'0"
60'	1'4"	2'1"

River Crossing - Line No. 2

5'	1'1"	2'5"
15'	1'2"	2'8"
25'	1'4"	2'5"
35'	1'6"	2'6"
45'	1'2"	3'4"
55'	1'1"	3'2"
65'	2'1"	2'4"
70'	3'0"	1'0"
85'	3'4"	1'0"
95'	3'0"	0'5"
105'	2'0"	1'4"

River Crossing - Line No. 3

5'	2'0"	3'6"
10'	3'0"	3'0"
15'	3'2"	5'2"
20'	3'2"	5'2"
30'	3'6"	4'6"
40'	3'2"	4'4"
50'	4'0"	3'0"
60'	5'8"	2'8"
70'	6'0"	2'0"
80'	5'6"	1'6"
90'	3'0"	3'6"
100'	2'8"	4'0"



Distance from Shore  
(North to South)

Depth of Water

Depth of Loose  
and Soft Material  
below River Bed Level

River Crossing - Line No. 4

10'	3'5"	1'1"
20'	3'9"	0'8"
30'	4'8"	0'6"
40'	4'0"	0'4"
50'	4'0"	0'4"
60'	3'6"	0'4"
70'	3'0"	0'6"
80'	3'0"	0'5"
90'	4'10"	2'2"
100'	5'10"	2'2"
110'	4'6"	2'4"
120'	3'6"	2'0"
130'	3'6"	4'0"
140'	3'6"	2'11"
150'	4'10"	3'2"



SITE PLAN & STRATIGRAPHIC PROFILES



REF No. E-5070-1; JAN/77



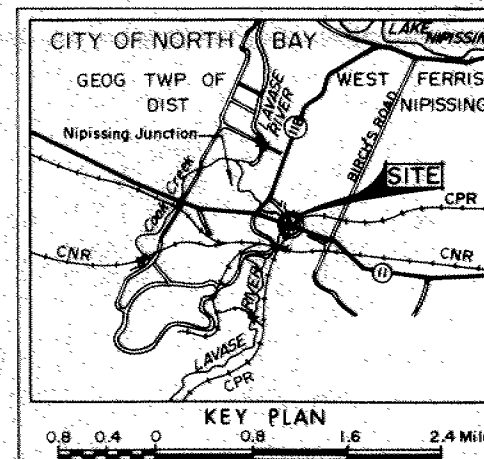
CONT No  
WP No 71-74-05 & 06



CPR & LAVASE RIVER  
BORE HOLE LOCATIONS & SOIL STRATA

SHEET

PETO MacCALLUM LTD.



### LEGEND

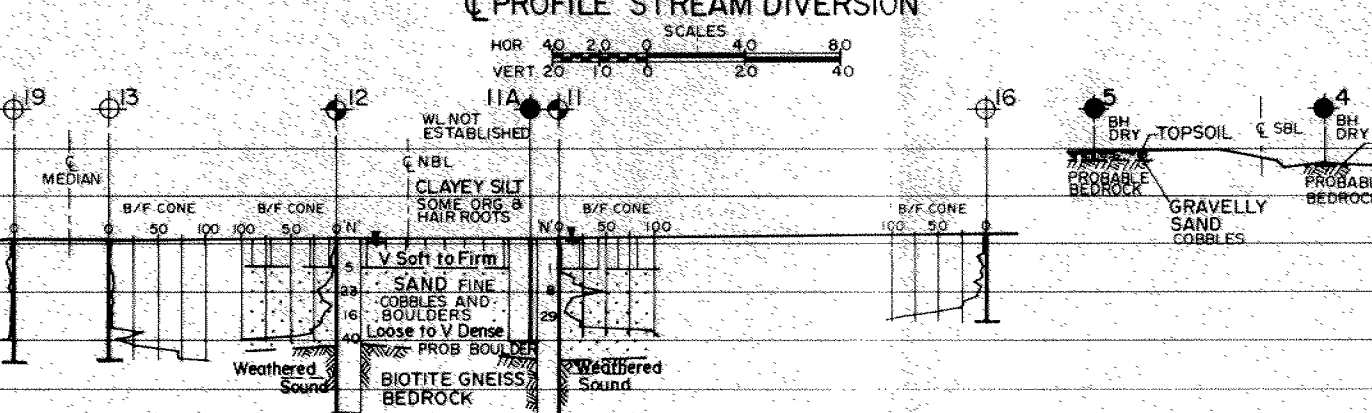
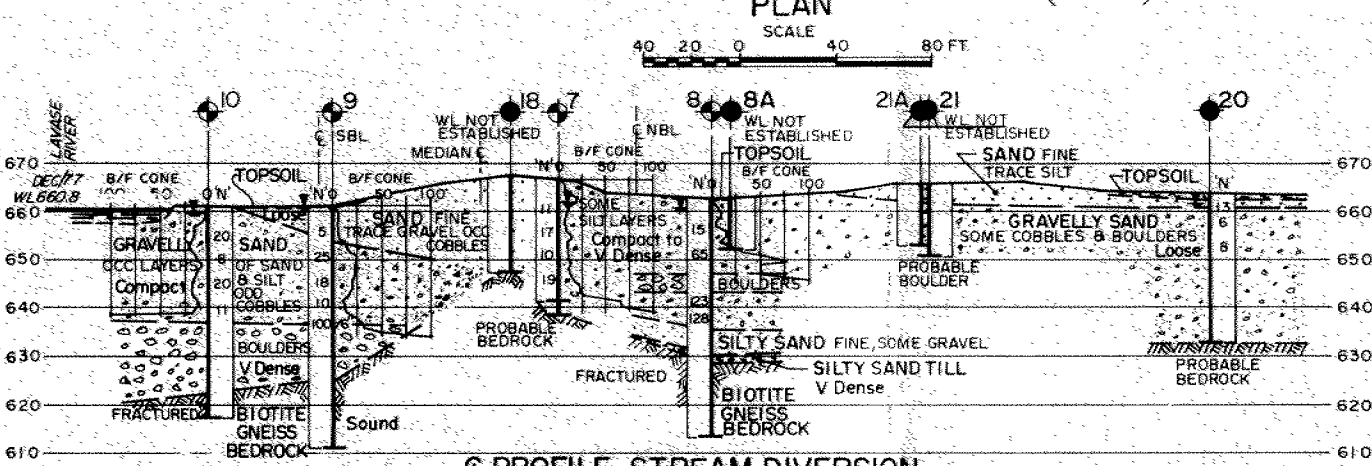
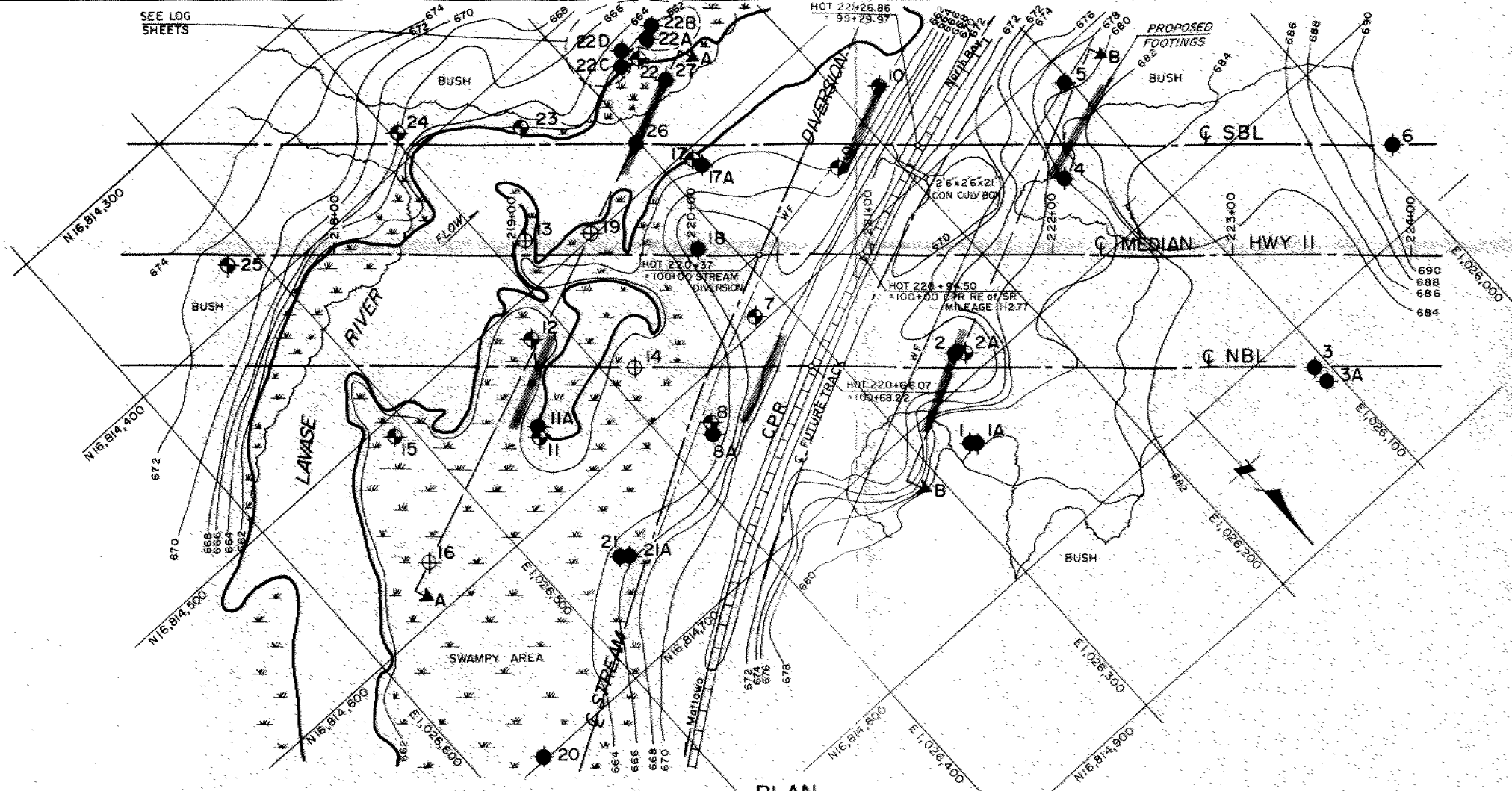
- Bore Hole
- ⊕ Dynamic Cone Penetration Test (Cone)
- ⊙ Bore Hole & Cone
- N' Blows/ft (Std Pen Test 350 ft lbs energy)
- CONE Blows/ft (60° Cone, 350 ft lbs energy)
- ↓ WL at time of investigation Dec. 1976  
Jan. 1977

No	ELEVATION	CO-ORDINATES	
		NORTH	EAST
1A	679.6	16,814,727	1,026,275
2	673.6	16,814,729	1,026,272
2A	670.5	16,814,684	1,026,247
3	670.5	16,814,688	1,026,243
3A	662.7	16,814,822	1,026,107
4	677.4	16,814,833	1,026,107
5	679.6	16,814,639	1,026,139
6	690.2	16,814,714	1,026,103
7	666.8	16,814,595	1,026,317
8	662.5	16,814,622	1,026,374
8A	662.5	16,814,628	1,026,378
9	661.6	16,814,564	1,026,228
10	661.3	16,814,546	1,026,179
11	661.3	16,814,564	1,026,251
12	661.3	16,814,564	1,026,247
13	661.5	16,814,521	1,026,417
14	661.5	16,814,477	1,026,383
15	661.5	16,814,477	1,026,383
16	661.5	16,814,477	1,026,383
17	661.5	16,814,477	1,026,383
18	661.5	16,814,477	1,026,383
19	661.5	16,814,477	1,026,383
20	661.5	16,814,477	1,026,383
21	661.5	16,814,477	1,026,383
22	661.5	16,814,477	1,026,383
23	661.5	16,814,477	1,026,383
24	661.5	16,814,477	1,026,383
25	661.5	16,814,477	1,026,383
26	661.5	16,814,477	1,026,383
27	661.5	16,814,477	1,026,383

-NOTE-  
The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence.

REVISIONS	DATE	BY	DESCRIPTION

HWY No 11  
SUBMD J S  
DRAWN K K  
CHECKED MB  
DATE Feb. 15, 1977  
SITE 43-200 A&B  
DWG 717405B06-B



B-B

REF No E-5070-1, JAN/77