

G.I.-30 SEPT. 1976

GEOCRES No. 4IN-15

DIST. 18 REGION

W.P. No. 907-75-02

CONT. No.

W. O. No.

STR. SITE No.

HWY. No. 17

LOCATION MONTREAL RIVER

No of PAGES -

=====

OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:



Ministry of
Transportation and
Communications

Memorandum

To: B.J. McKenna (2)
Reg. Structural Planning Engineer
Northwestern Region
Thunder Bay

From: Soil Mechanics Section
Geotechnical Office
West Building, Downsview

Attention:

Date: August 20, 1975

Our File Ref.

In Reply to

AUG 22 1975

Subject:

FOUNDATION INVESTIGATION REPORT

For

Montreal River Bridge
Highway 17 Line 'B'
Twp. of Rix, Dist. of Algoma
District #18, Sault Ste. Marie
W.P. 907-75-02

41N-15

GEOCR25 No.

Attached we are forwarding to you our detailed Foundation Investigation Report on the subsoil conditions existing at the above mentioned site.

We believe that the factual data and recommendations contained therein will prove adequate for your requirements. Should additional information be required, please do not hesitate to contact our Office.

M. DEVATA
Supervising Engineer

c.c. E.J. Orr
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B.J. Giroux
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FOUNDATION INVESTIGATION REPORT

For

Montreal River Bridge
Highway 17 Line 'B'
Twp. of Rix, Dist. of Algoma
District #18, Sault Ste. Marie
W.P. 907-75-02

1. INTRODUCTION

The Soil Mechanics Section was requested by Mr. B.J. McKenna, Structural Planning Engineer, Northwestern Region, Thunder Bay, to carry out a foundation investigation at the proposed crossing. An investigation was subsequently carried out by this Section to determine the subsoil, bedrock and groundwater conditions at the above site.

This report contains the factual information obtained from the investigations, together with the recommendations with regard the proposed structure and the approach embankments.

2. DESCRIPTION OF THE SITE AND GEOLOGY

The site is located about 3/4 mile southeast (upstream) of the existing bridge carrying Hwy. 17 over Montreal River. At the present crossing, the Montreal River flows through a steep-walled canyon. The canyon is about 100 ft. deep but very narrow. The canyon resulted from erosion by the river of the diabase dike from between the walls of hard granite. The diabase crystallized from a hot magma and the cooling of the solidified rock resulted in columnar jointing and cracking, whereas the granite is quite massive, consequently the diabase dike eroded more rapidly than the enclosing granite.

The area surrounding the proposed crossing is hilly and heavily wooded. On the south side of Montreal River, Line 'B' passes to the east of a more than 100 ft. high hill, and on the north side of the river it runs between two larger hills. The width of the river at this location is about 240 ft. On the north side the site was reached through a

private dirt track owned by Great Lakes Power Co. On the south side the access was obtained partly through a lumber road and a path which was bulldozed through the woods.

The area generally consists of Precambrian (Algoman) rocks overlain by Pleistocene and recent deposits of sand and gravel. The topography shows the effects of the ice sheet, which advanced from the north. The glaciers rode up the north side of the larger hills, leaving relatively gentle slopes, but formed steep and rugged exposures with numerous rock outcrops on the south sides. Glacial till was deposited throughout the area by the ice sheet. During the recession of the ice, the Lake Superior basin was occupied by a succession of lakes. At one time, in the Lake Algonquin stage, the water reached an elevation of about 400 ft. above the present lake level forming a series of beach terraces at different levels. The glacial till that covered much of the area was removed and redeposited on the lake bottom, in depressions, as stratified clay, sand and gravel.

Most of the area is underlain by granitic intrusive rocks of Algoman System, consisting of granite, granite gneiss and minor syenite, all cut by pegmatite dikes and quartz veins. The granite, which ranges in colour from white and gray to red, is mostly biotitic but grades into hornblende or pyroxene types. The pegmatites occur as ill-defined dikes and irregular masses. The character of these intrusives changes within short distances.

The Montreal River, which is the largest stream in the area developed mainly on glacial deposits; but where it has cut through these deposits to bedrock, its course is, in part, determined by the rock structure. The Great Lakes Power Co. Ltd. operates three dams with hydro-electric plants on the Montreal River. The water level in the river was found to fluctuate up to 5 ft. within 1-2 hours.

3. FIELD AND LABORATORY INVESTIGATION PROCEDURES

A total of 4 boreholes, two on the land (B.H. 1 & 4) and two in the river (B.H. 2 & 3) were carried out during the course of the field work. Dynamic cone penetration tests accompanied each of the holes on the land. Boring was achieved by means of a skid mounted BBS 1 diamond drilling machine using conventional washboring and drilling techniques. For the holes in the river the machine was floated on a 12' X 16' raft consisting of 18 - 40 gallon sealed drums held together by rope and 2 X 8 planking.

Access to borehole on the river banks was gained through the use of a bulldozer to grade the surrounding area. This resulted in a 2 to 4 foot lowering of ground elevations from the original undisturbed elevations.

During the field work, disturbed samples were obtained by means of a standard split-spoon sampler; the energy used in driving it, conformed to the requirements of the Standard Penetration Test (SPT). Driving energy to advance the cone was 350 ft.-lbs. per blow.

The bedrock was proven at all the borehole locations using BX rock coring equipment, the core being logged in the field and identified in the lab.

The borings were surveyed in the field by personnel from the Northwestern Region Engineering Surveys Section. The elevations are referenced to the geodetic datum.

All samples were visually examined and classified at the site as well as in the laboratory. Following this inspection, laboratory tests were carried out on selected samples to determine their grain-size distribution.

The test results are summarized on the Record of Borehole Sheets and Figs. 1 to 3, contained in the Appendix of this report.

4. SUBSOIL CONDITIONS

4.1 General

The subsoil consists of a granular deposit overlying granite bedrock. The granular deposit becomes coarser with depth varying from sandy silt and fine sand in the upper portion to sand and gravel with cobbles and boulders immediately above the bedrock. The thickness of the overburden varies from 0.9 ft. in the river to 33.5 ft. on the east bank. The bedrock slopes in an easterly direction. The maximum depth of water in the river is in the order of 20 ft.

The stratigraphy encountered at the borings put down is plotted on the Record of Borehole Sheets. Stratigraphical profile inferred from this data is plotted on Drawing No. 9057308-A. A detailed description of the subsoil and bedrock encountered from ground surface downward in this area, is presented in the following subsections.

4.2 Sandy Silt to Fine Sand

This material was found in B.H.'s # 1 and 4 which were put down on the banks of the river. In B.H. #1 on the east bank it is described as sandy silt, while in B.H. #4 on the west bank it is silty sand to fine sand. The thickness of the deposit varies from 7 to 15 ft. The 'N' values range from 1 blow for 18 inches to 4 blows per ft., indicating a very loose relative density.

The grain size analyses on two samples show the following distribution and are plotted on Fig. 1 in the Appendix.

Sand	22 - 83 %
Silt	17 - 78 %

4.3 Fine to Medium Sand

This layer was intersected in all boreholes except B.H. #3. The material consists of fine to medium sand, except in B.H. #4 where it is described as fine to coarse sand. The thickness of the layer varies from 1 to 12 ft. The 'N' values range from 1 blow for 18 inches to 44 blows/ft. indicating a very loose to dense relative density. However, it is estimated that, in general, the relative density is very loose to loose.

Only one grain size analysis was carried out with the following results (see Fig. 2).

Sand	95 %
Silt	5 %

4.4 Sand and Gravel

Underlying the fine to medium sand stratum and overlying the bedrock, this deposit was encountered in all boreholes.

This deposit was composed of an unsorted medium to coarse sand and gravel matrix containing numerous cobbles and boulders varying in size to 1.5' in. diameter, which were cored.

The thickness of this layer ranged from 1.0' at B.H. #3 to 9' at B.H. #1.

The 'N' values obtained were in excess of 100 blows per foot, where refusal to Standard Penetration Test was reached. Based on these values, the relative density is very dense. However, in this type of material 'N' values are unrepresentative because of the large size grains.

4.5 Granite Bedrock

Bedrock was cored in all boreholes, and consists of massive grey granite with quartzite and pegmatite dykes. The bedrock

surface varies erratically in the area and is fractured and jointed. The depth to bedrock, below ground surface or river bottom ranges from 1 to 33.5 ft. Bedrock cores were examined by Mr. B. Glassford, Geologist, MTC, and his report is attached in the Appendix. The upper surface of bedrock in various boreholes is as follows:

B.H.	Bedrock elevation
1	757.6
2	756.8
3	771.3
4	783.5

5. GROUNDWATER CONDITIONS

The water level on the banks are expected to be at the elevation of the water in the river, because of the non-cohesive nature of the overburden. The water level in the river fluctuates upto 5 ft. within 1-2 hours. In Borehole 1, artesian water was encountered in the fine to medium sand stratum at approximate level 776 ft., and continued through to bedrock. Water in the casing rose 3 ft. above ground to elevation 794.5.

6. DISCUSSION AND RECOMMENDATIONS

6.1 General

It is proposed to realign the existing Hwy. 17 in the vicinity of Montreal River Harbour, in order to eliminate sharp and hazardous curves in this area. The new alignment, Line 'B' is about 2 miles long, and crosses the Montreal River about 3/4 mile southeast (upstream) of the existing bridge. The proposed structure is a 3 span (70' - 130' - 70') bridge. The proposed grade is at elevation 807-809 ft. resulting in a maximum height of embankment of 43 ft. above the river bed.

The subsoil consists of a granular overburden overlying granite bedrock. The granular deposit becomes coarser with depth varying from sandy silt and fine sand in the upper portion to sand and gravel with cobbles and boulders immediately above the bedrock. The relative density of the granular deposit is, in general, loose to very loose, in the upper portion and dense to very dense in the lower portion. The bedrock slopes in an easterly direction. The maximum depth of the river is about 20 ft.

6.2 Structure Foundations

6.2.1 Abutments

The abutments may be constructed within the approach fills and supported on end-bearing steel H-piles driven through the fill to bedrock. The maximum allowable load for the particular steel section may be assumed for design purposes. Numerous cobbles and boulders were encountered immediately above the bedrock, therefore, piles should be fitted with reinforced tips.

If steel piles are used to support the abutments, then no bouldery material should be placed within the embankments in zones through which piles have to be driven, and it is recommended that this portion of the fill contain grain sizes not more than 3 inches.

As mentioned earlier, artesian pressure was encountered in the borehole put down on the east bank. If piles are driven to bedrock then, seepage of water along the piles will occur. This may wash the fine sand from underneath the abutment and embankment. Therefore, it is recommended that a minimum 1 ft. thick filter blanket be laid in this area underneath the fill. Gradation curves will be supplied on request.

As an alternative, the abutments may be supported on spread footings placed within well compacted granular fill. A maximum allowable load of 2.5 t.s.f. may be used for design purposes.

At the location of the west abutment, the bedrock was found at a depth of 12 ft. Therefore, it is recommended, that as an alternative, the west abutment may be supported on spread footings placed on bedrock. An allowable bearing pressure of 20 tons per sq. ft. may be used for design. The precise elevation of bedrock in this area will be determined when the footing location is finalized.

6.2.2 Piers

The thickness of overburden in Boreholes 2 (east pier) and 3 (west pier) is 15 and 1 ft. respectively. Therefore, the piers may be founded on spread footing type foundations placed on the bedrock surface. A safe load of 20 tons/sq. ft. may be used for design purposes. The footing should be keyed into bedrock for a distance of at least 1 ft.

As an alternative, the piers may be supported on large diameter caissons founded on bedrock. The caissons should be socketed at least 1 ft. inside the bedrock. For a 36-inch diameter caisson an allowable load of 200 tons per caisson may be used for design purposes. The caissons may be extended to the underside of the deck to act as columns.

As another alternative the piers may be constructed as bents consisting of steel piles (tube or H-piles) keyed into bedrock by dowels or other means. Due to the lack of overburden to provide lateral support for the piles, it will be necessary to temporarily brace these bents in the longitudinal and transverse direction. The tube piles may be filled with tremie concrete. Maximum allowable load for the particular section

chosen may be used for design purposes.

6.3 Embankment

The proposed grade of Hwy. 17 Line 'B' over Montreal River varies from elevation 807 (west) to 809 (east) ft. This would result in embankments which would be 14 ft. above the surrounding ground on the west side and 18 ft. on the east side of the river. The maximum height of approaches above the river bottom would be about 43 ft.

No stability problems are anticipated for the approach fills constructed with 2:1 slopes in the longitudinal and transverse directions because of the non-cohesive nature of the underlying subsoil. The longitudinal slopes should be protected by means of rip rap to guard these from the effects of relatively rapid fluctuations in the water level and the resulting increase in velocity. This aspect should be looked into by the Hydrology Section.

The settlements under the fills will be of elastic nature and will occur instantaneously during construction.

6.4 Other Considerations

All footings and pile caps should be protected from frost by means of at least 8 ft. earth cover to their undersides.

A positive dewatering scheme will be required to pour concrete in the dry for footings and pile caps placed below the prevailing groundwater level.

7. MISCELLANEOUS

The field work for this project was carried out during the period June 26 to July 11, 1975, under the supervision of Mr. T. Kazmierowski,

Student Technician. The equipment was owned and operated by Dominion Soil Investigation Ltd., Toronto.

This report was prepared by Mr. A. Prakash, Senior Engineer and reviewed by Mr. C. Mirza, Head, Soil Mechanics Section.

A. Prakash

A. PRAKASH

C. Mirza

C. MIRZA



August 1975

REFERENCES:

1. Pye, E.G., Geology and Scenery. North Shore of Lake Superior. Toronto, Ontario Dept. of Mines. 1969
2. Nuffield, E.W., Geology of the Montreal River Area, District of Algoma. Annual Report, Ontario Dept. of Mines. Vol. LXIV, Part 3. 1955
3. Moore, E.S., Batchawana Area, District of Algoma. Annual Report, Ontario Dept. of Mines. Vol. XXXV, Part 2, pp. 53-85. 1926

APPENDIX

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS-ONTARIO
ENGINEERING SERVICES BRANCH-GEOTECHNICAL OFFICE-SOIL MECHANICS SECTION

RECORD OF BOREHOLE NO 1

W.P. 907-75-02 LOCATION Sta. 186 + 70 Line 'B' ORIGINATED BY TK
DIST. 18 HWY. 17 BORING DATE June 26 - July 5, 1975 COMPILED BY OY/NT
DATUM Geodetic BOREHOLE TYPE Washboring, NX & BX Casing, BX Core & Cone CHECKED BY N.Z.

SOIL PROFILE			SAMPLES			GROUND WATER ELEV.	DYNAMIC CONE PENETRATION RESISTANCE PLOT					LIQUID LIMIT — w_L PLASTIC LIMIT — w_p WATER CONTENT — w			UNIT WEIGHT γ	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	N' VALUES		20	40	60	80	100	w_p	w	w_L		
791.5	Ground Level															GR. SA. SI. CL. %
0.0	Silty sand to fine sand, some silt		1	SS	1/18"	790										
	Very Loose		2	SS	2	780										0 83 17 0
776.0																
15.5	Fine to medium sand, trace of gravel.		3	SS	9	770										4 85 11 0
	Loose to Dense															
767.0			4	SS	44											50 43 7 0
24.5	Sand and gravel, numerous cobbles and boulders, trace of silt.		5	SS	70/10"											
	Very Dense		6	RC BX	Rec 53%											
758.0			7	BX	40%	760										
33.5			8	BX	100%											
	Granite Bedrock		9	BX	82%											
			10	BX	100%											
			11	BX	85%											
749.6						750										
41.9	End of Borehole															Sealed hole using bentonite & cement.
						740										

OFFICE REPORT ON SOIL EXPLORATION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS-ONTARIO
ENGINEERING SERVICES BRANCH-GEOTECHNICAL OFFICE-SOIL MECHANICS SECTION

RECORD OF BOREHOLE NO 2

W.P. 907-75-02 LOCATION Sta. 187 + 35 Line 'B' ORIGINATED BY TK
DIST. 18 HWY. 17 BORING DATE July 7, 8, 1975 COMPILED BY OY/NT
DATUM Geodetic BOREHOLE TYPE Washboring, NX Casing, BX Core & Cone CHECKED BY M. J.

SOIL PROFILE			SAMPLES			GROUND WATER ELEV.	DYNAMIC CONE PENETRATION RESISTANCE PLOT					LIQUID LIMIT w_L PLASTIC LIMIT w_p WATER CONTENT w			UNIT WEIGHT γ	REMARKS % GR. SA. SI. CL.
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100	w_p	w	w_L		
787.±	Water Level															
0.0	Water					780										
771.7	River Bottom															
15.3	Fine to Medium Sand		1	SS	1/1.5"	770										0 95 5 0
	Trace of Silt															
	Very Loose		2	SS	4											
759.7						760										
27.3	Sand and gravel with cobbles & boulders.		3	SS	100/3"											
757.0	Very Dense		4	RC BX	Rec. 40%											
30.2	Granite Bedrock															
753.4			5	BX	70%											
33.6	End of Borehole					750										WL not established

W.P. 907-75-02

LOCATION Sta. 188 + 63 5' Lt. of C Line 'B'

ORIGINATED BY TK

DIST. 18 HWY. 17

BORING DATE July 9, 1975

COMPILED BY OY/NT

DATUM Geodetic

BOREHOLE TYPE Washboring, NX Casing, BX Core & Cone

CHECKED BY N. J.

20
15 5 % STRAIN AT FAILURE
10

ENGINEERING SERVICES BRANCH-GEOTECHNICAL OFFICE-SOIL MECHANICS SECTION

RECORD OF BOREHOLE NO 4

W.P. 907-75- 02 LOCATION Sta. 189 + 40 0 Line 'B' ORIGINATED BY TK
 DIST 18 HWY. 17 BORING DATE July 9, 1975 COMPILED BY OY/NT
 DATUM Geodetic BOREHOLE TYPE Washboring, NX & BX Casing, BX Core & Cone CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER ELEV.	DYNAMIC CONE PENETRATION RESISTANCE PLOT					LIQUID LIMIT w_L PLASTIC LIMIT w_p WATER CONTENT w			UNIT WEIGHT γ	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100	w_p	w	w_L		
794.9	Ground Level															
0.0	Sandy Silt															
	Very Loose		1	SS	4	790										0 22 78 0
787.6	Fine to coarse sand															
7.3	Sand & gravel with cobbles & boulders															
8.4																
783.3			2	RC BX	Rec. 52%											2.5' of core dropped in the hole
11.6	Granite Bedrock															
780.9																
14.0	End of Borehole					780										

OFFICE REPORT ON SOIL EXPLORATION

GRAIN SIZE DISTRIBUTION

UNIFIED SOIL CLASSIFICATION SYSTEM

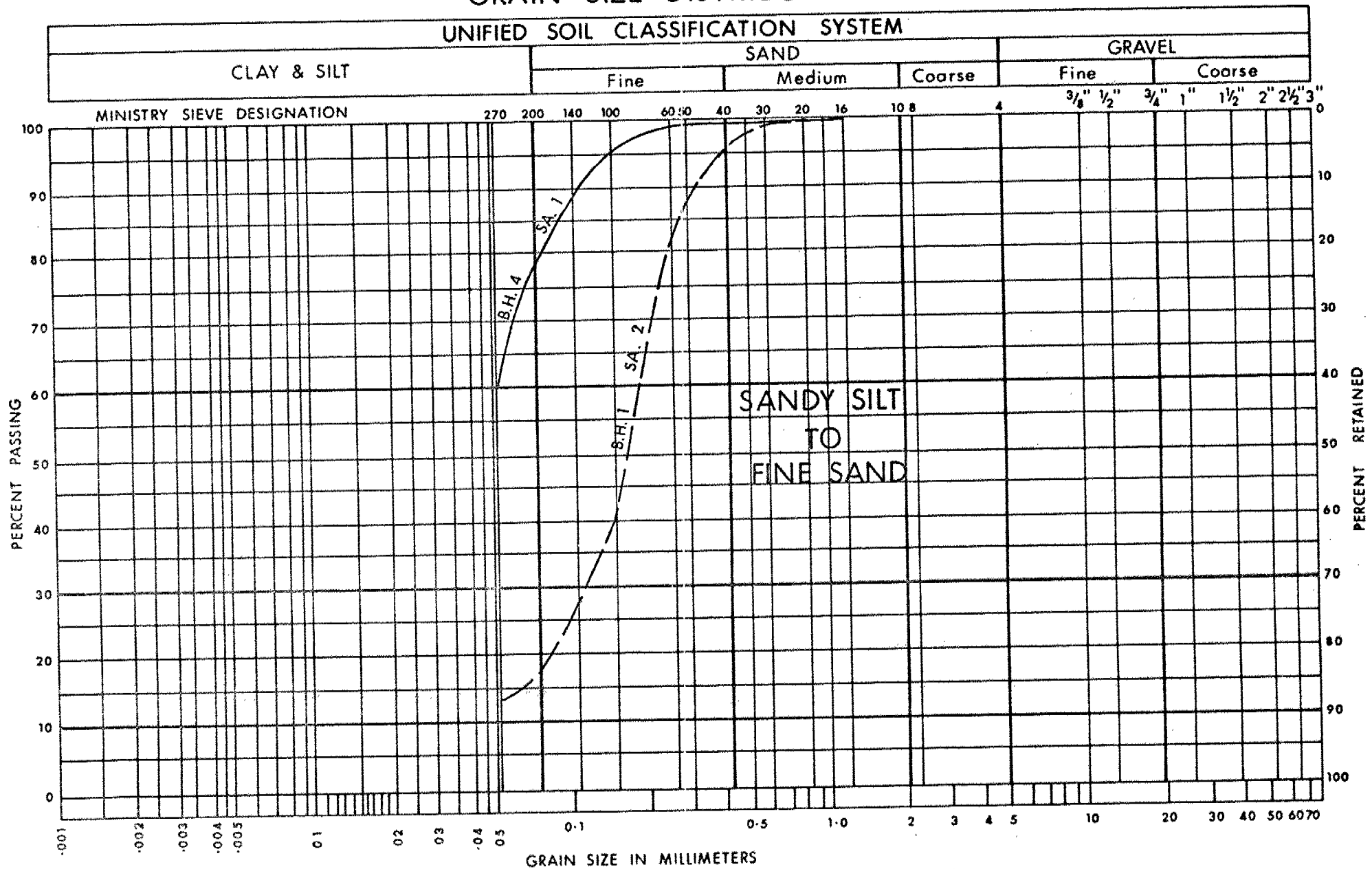


FIG. 1

GRAIN SIZE DISTRIBUTION

UNIFIED SOIL CLASSIFICATION SYSTEM

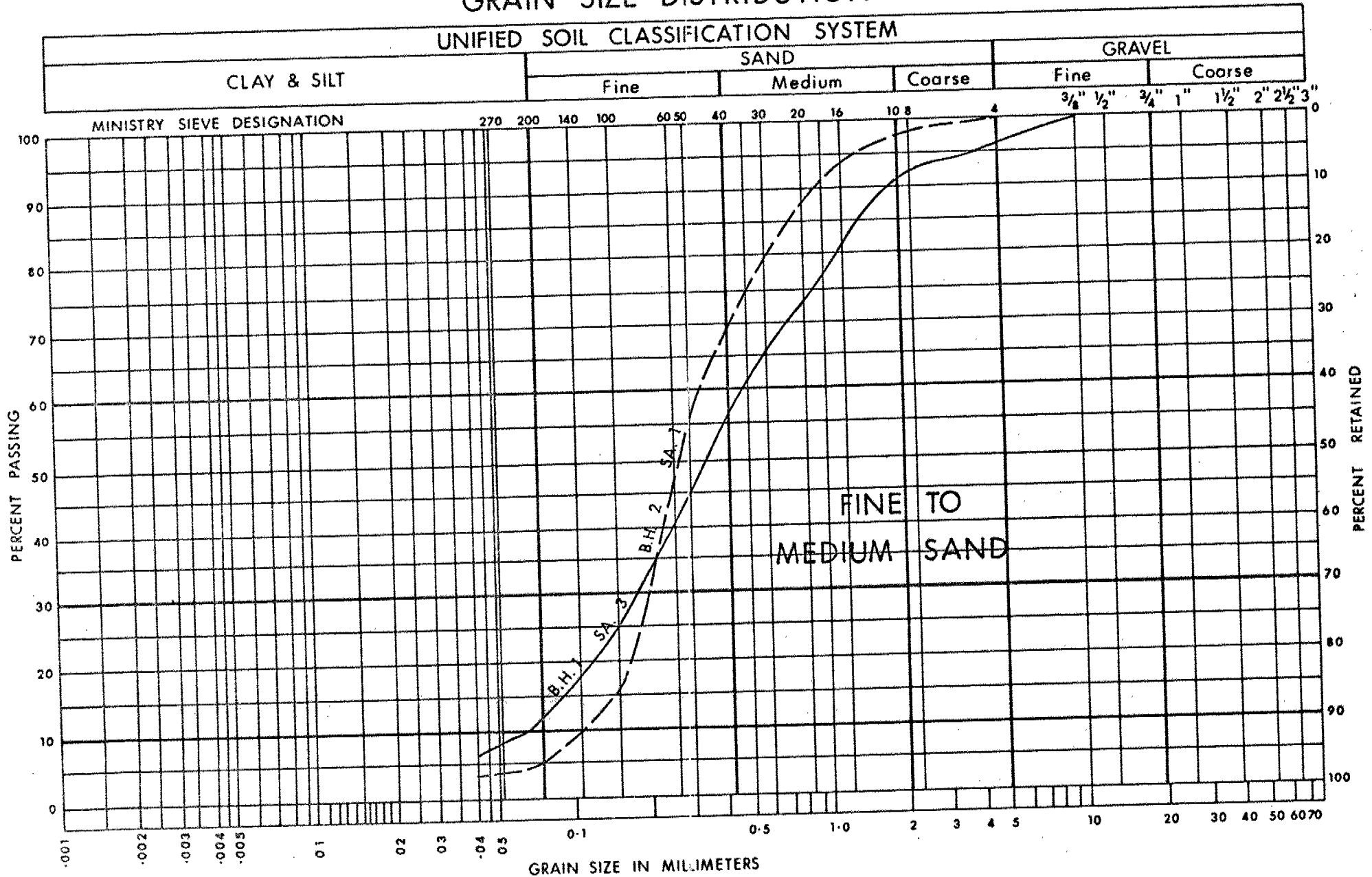


FIG. 2

GRAIN SIZE DISTRIBUTION

UNIFIED SOIL CLASSIFICATION SYSTEM

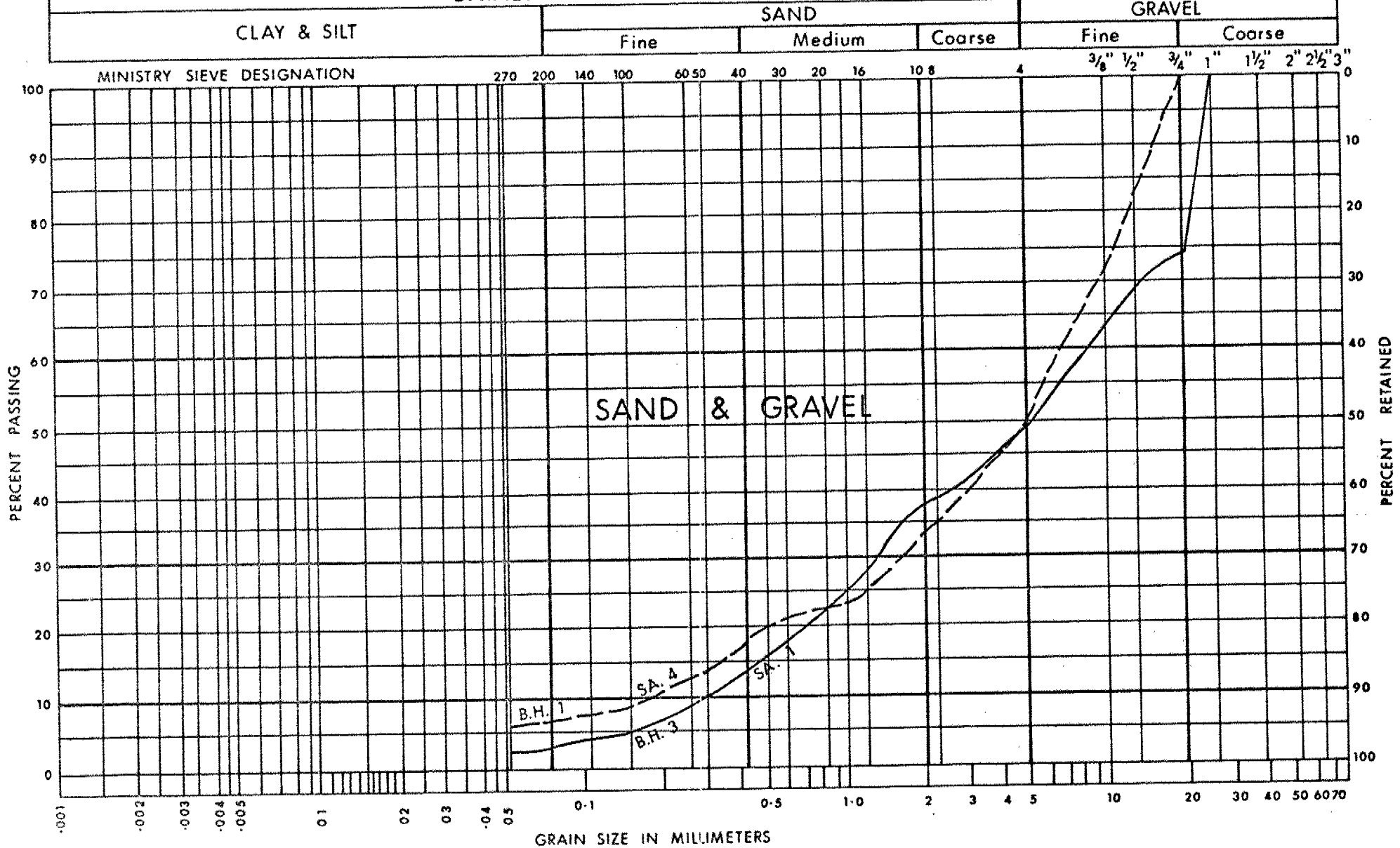


FIG. 3



HOLE NO. 1 SHEET NO. 1

90°

	90
TOTAL FOOTAGE	41.9'

ELEV. COLLAR _____
 DATUM _____
 DATE STARTED _____
 DATE COMPLETED _____
 DRILLED BY _____
 LOGGED BY _____

[illegible]

DATE OF EXAMINATION August 7, 1975

B. K. Glassford



HOLE NO. 2 SHEET NO. 1

DIP

PROPERTY W. P. 907-75-02
LOCATION Montreal River, Hwy. 17 - District 18

LATITUDE _____
DEPARTURE _____
BEARING _____

90°

TOTAL FOOTAGE 34.3'

ELEV. COLLAR

DATUM

DATE STARTED

DATE COMPLETED

DRILLED BY

LOGGED BY

[illegible]

DATE OF EXAMINATION August 7, 1975

B. K. Glassford

DB-MT-113



HOLE NO. 3 SHEET NO. 1

90°

TOTAL FOOTAGE 21.2'

ELEV. COLLAR _____
 DATUM _____
 DATE STARTED _____
 DATE COMPLETED _____
 DRILLED BY _____
 LOGGED BY _____

[illegible]

B. K. Glassford



DIAMOND DRILL RECORD

HOLE NO. 4 SHEET NO. 1

01 P

 90°

PROPERTY W. P. 907-75-02
LOCATION Montreal River - Hwy.17 - District 18

LATITUDE _____
DEPARTURE _____
BEARING _____

TOTAL FOOTAGE 14.0'

ELEV. COLLAR

DATUM

DATE STARTED

DATE COMPLETED

DRILLED BY

LOGGED BY

[illegible]

DATE OF EXAMINATION August 7, 1975

B. K. Glassford

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.

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

γ	UNIT WEIGHT OF SOIL (BULK DENSITY)
γ_s	UNIT WEIGHT OF SOLID PARTICLES
γ_w	UNIT WEIGHT OF WATER
γ_d	UNIT DRY WEIGHT OF SOIL (DRY DENSITY)
γ'	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
τ_f	SHEAR STRENGTH
c'	EFFECTIVE COHESION INTERCEPT
ϕ'	EFFECTIVE ANGLE OF SHEARING RESISTANCE, OR FRICTION
c_u	APPARENT COHESION
ϕ_u	APPARENT ANGLE OF SHEARING RESISTANCE, OR FRICTION
μ	COEFFICIENT OF FRICTION
S_t	SENSITIVITY

GENERAL

π	= 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
σ	NORMAL STRESS
σ'	NORMAL EFFECTIVE STRESS ($\bar{\sigma}$ IS ALSO USED)
τ	SHEAR STRESS
ϵ	LINEAR STRAIN
γ	SHEAR STRAIN
ν	POISSON'S RATIO (μ IS ALSO USED)
E	MODULUS OF LINEAR DEFORMATION (YOUNG'S MODULUS)
G	MODULUS OF SHEAR DEFORMATION
K	MODULUS OF COMPRESSIBILITY
η	COEFFICIENT OF VISCOSITY

EARTH PRESSURE

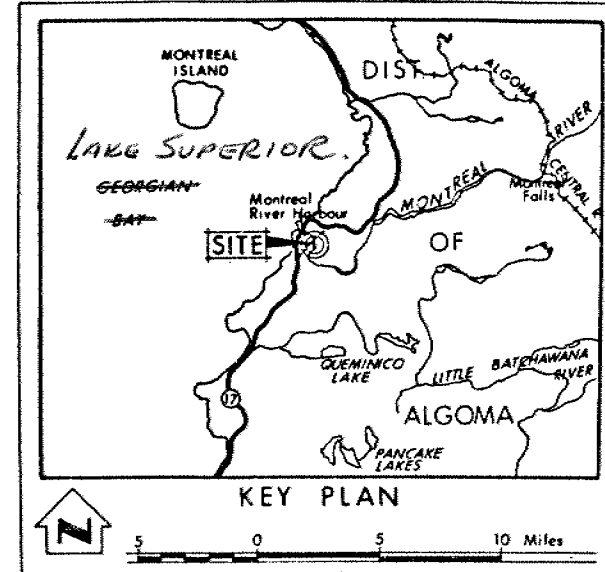
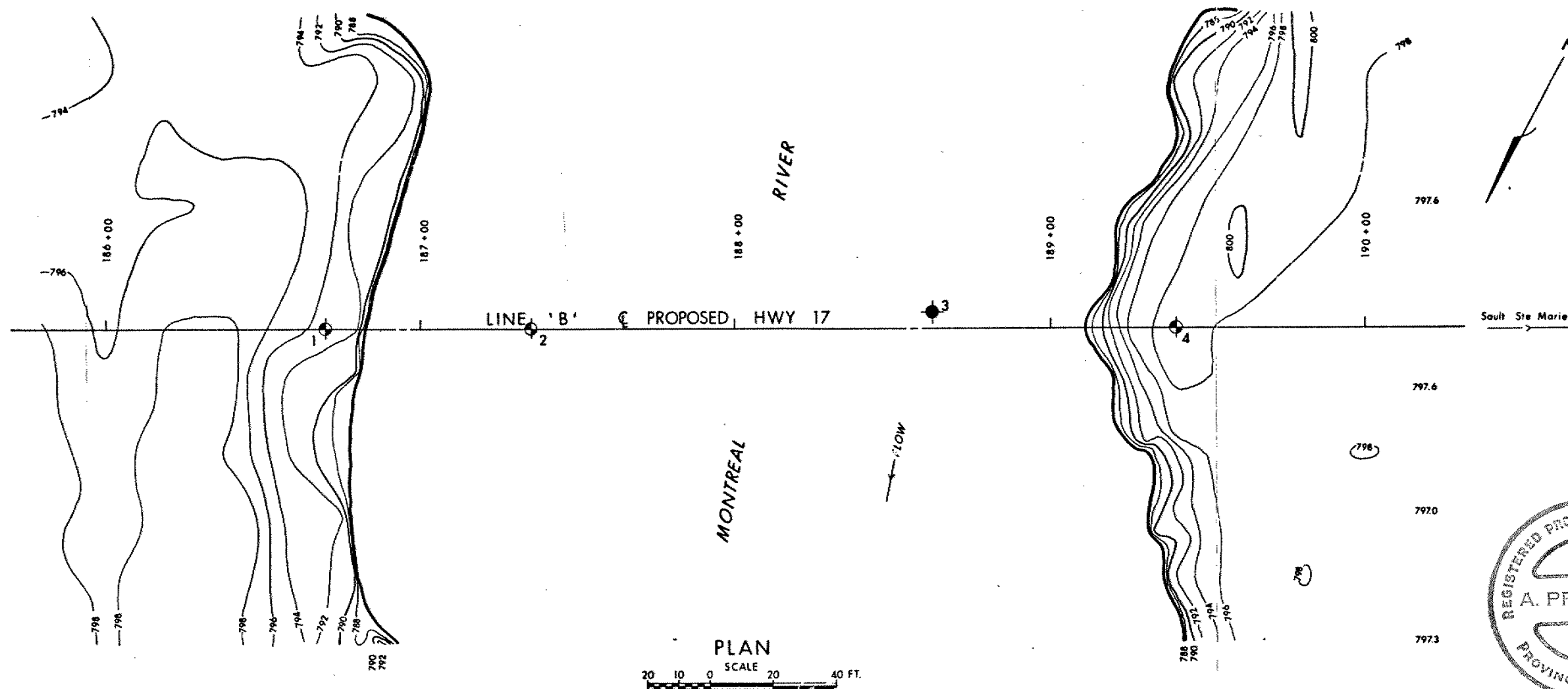
d	DISTANCE FROM TOP OF WALL TO POINT OF APPLICATION OF PRESSURE
δ	ANGLE OF WALL FRICTION
K	DIMENSIONLESS COEFFICIENT TO BE USED WITH VARIOUS SUFFIXES IN EXPRESSIONS REFERRING TO NORMAL STRESS ON WALLS
K_0	COEFFICIENT OF EARTH PRESSURE AT REST

FOUNDATIONS

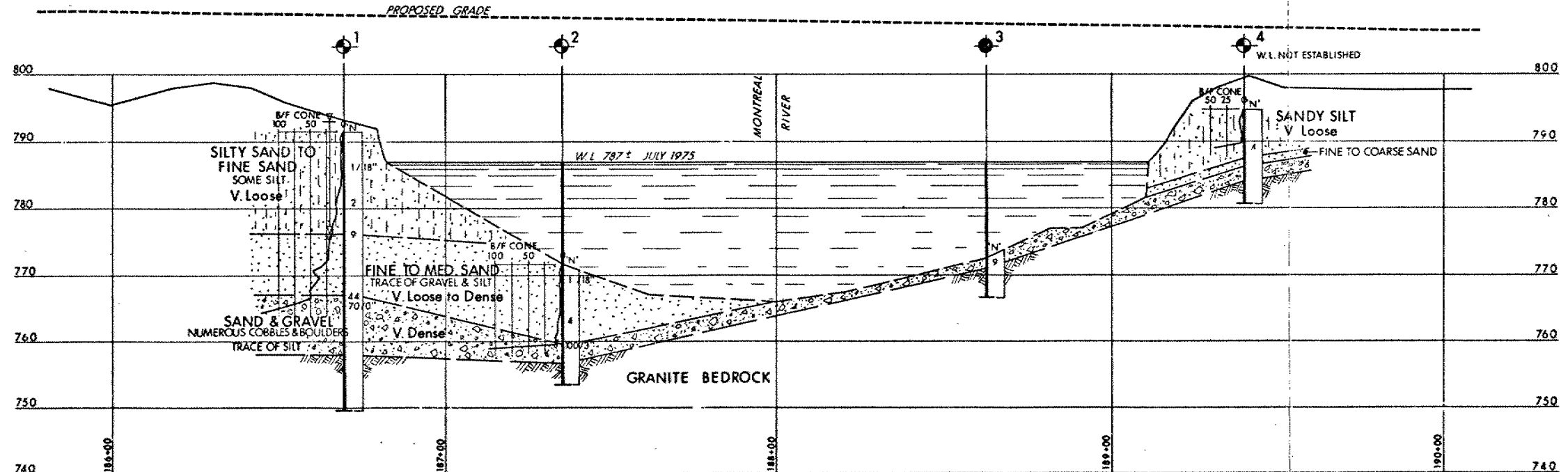
B	BREADTH OF FOUNDATION
L	LENGTH OF FOUNDATION
D	DEPTH OF FOUNDATION BENEATH GROUND
N	DIMENSIONLESS COEFFICIENT USED WITH A SUFFIX APPLYING TO SPECIFIC GRAVITY, DEPTH AND COHESION ETC. IN THE FORMULA FOR BEARING CAPACITY
k_s	MODULUS OF SUBGRADE REACTION

SLOPES

H	VERTICAL HEIGHT OF SLOPE
D	DEPTH BELOW TOE OF SLOPE TO HARD STRATUM
β	ANGLE OF SLOPE TO HORIZONTAL



LEGEND			
	Bore Hole		
	Dynamic Cone Penetration Resistance Test		
	Bore Hole & Cone Test		
	Water Levels established at time of field investigation, JULY 1975		
	Head		
	Encountered		
		ARTESIAN CONDITION	
NO.	ELEVATION	STATION	OFFSET
1	791.5	186+70	€
2	787.2	187+35	€
3	787.1	188+63	5' LT.
4	794.9	189+40	€



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 FOR CONTRACT DOCUMENT
The complete foundation investigation report for this structure may be examined at the Structural Office and Foundations Office, Downsview, and at the SAULT STE MARIE District Office.

REVISION	DATE	BY	DESCRIPTION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS—ONTARIO
ENGINEERING SERVICES BRANCH—GEOTECHNICAL OFFICE—SOIL MECHANICS SECTION

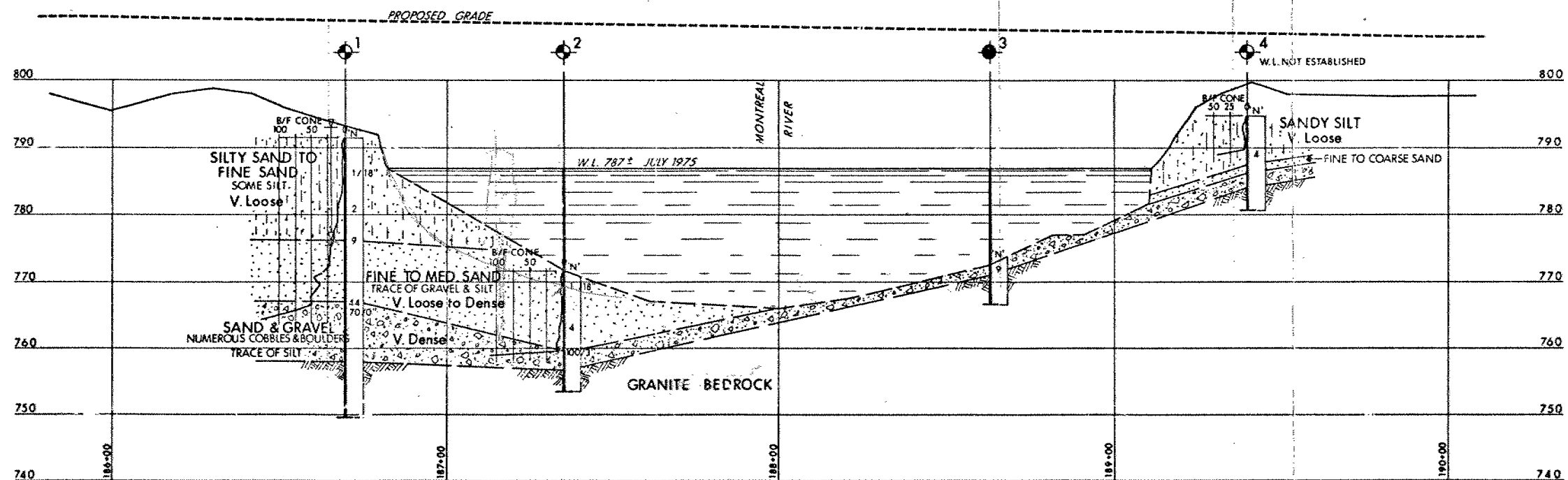
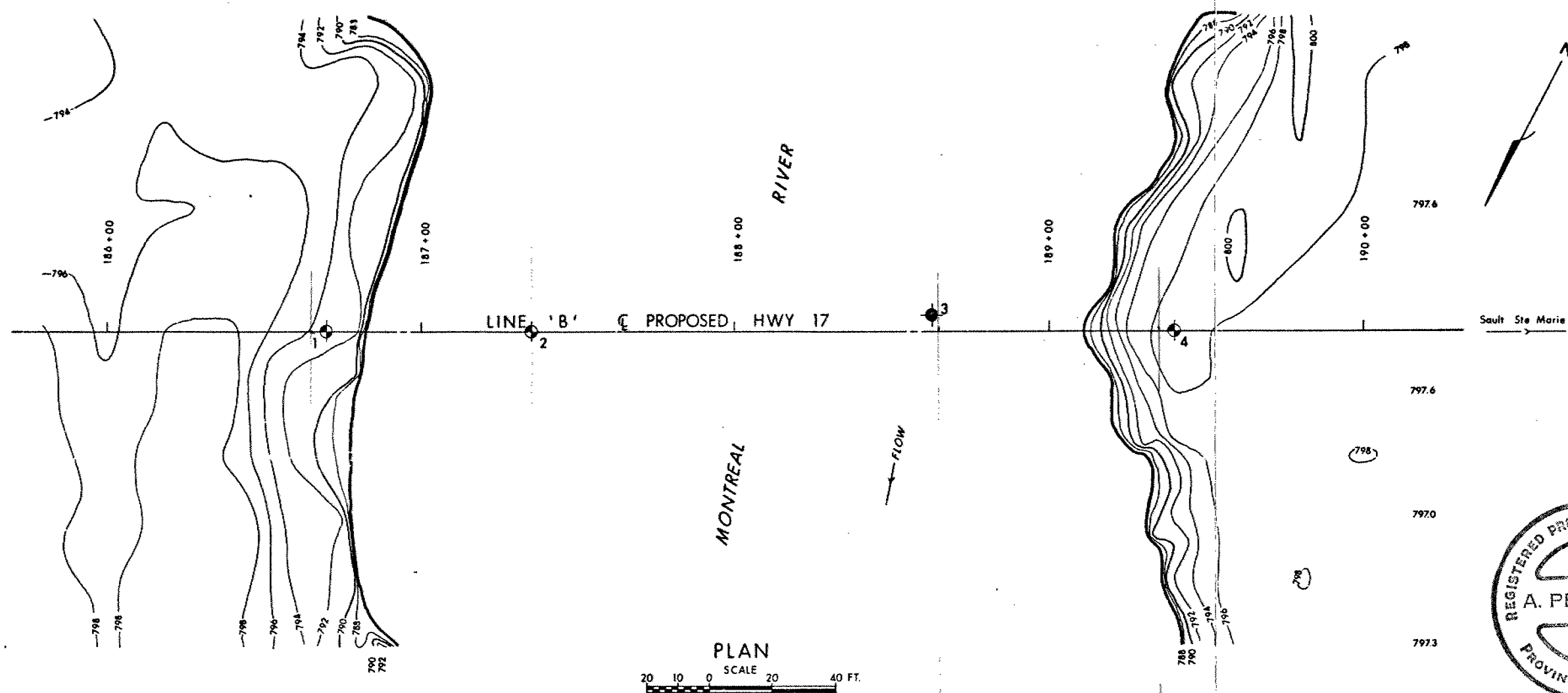
MONTREAL RIVER

HIGHWAY NO. 17 LINE 'B' DIST. NO. 18
DIST. OF ALGOMA
TWP. RIX LOT CON

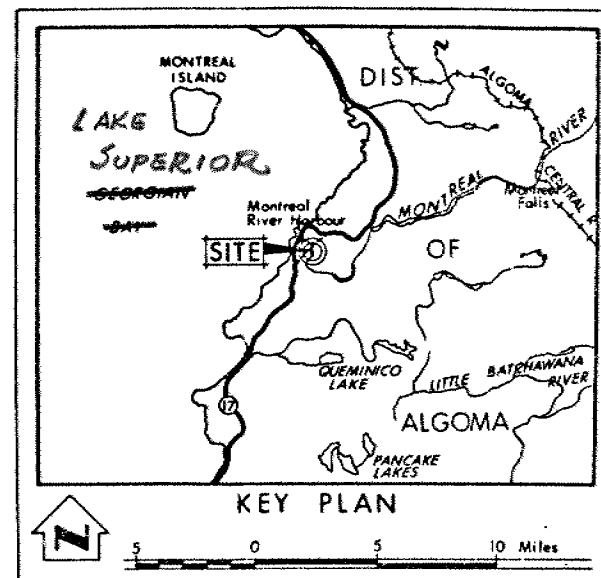
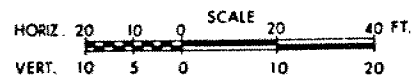
BORE HOLE LOCATIONS & SOIL STRATA

SUBMIT A.P. CHECKED	W.P. NO. 907-75-02	DRAWING NO.
DRAWN O.Y. CHECKED	W.O. NO.	9077502-A
DATE 8 AUG 1975	SITE NO.	BRIDGE DRAWING NO.
APPROVED	CONT. NO.	

REF NO. E-5174-1 MAY 1975



PROFILE - LINE 'B'



LEGEND

- Bore Hole
- ⊕ Dynamic Cone Penetration Resistance Test
B/P CONE - Blows/Ft. Cone Test (350 ft. lbs. energy/blow)
- ⊕ Bore Hole & Cone Test
- ⊕ Water Levels established at time of field investigation, JULY 1975
- ⊕ Head
- ⊕ Encountered

NO.	ELEVATION	STATION	OFFSET
1	791.5	186+70	℄
2	787.±	187+35	℄
3	787.±	188+63	5' LT.
4	794.9	189+40	℄

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REVISIONS	DATE	BY	DESCRIPTION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS—ONTARIO
ENGINEERING SERVICES BRANCH—GEOTECHNICAL OFFICE—SOIL MECHANICS SECTION

MONTREAL RIVER

HIGHWAY NO. 17 LINE 'B' DIST. NO. 18
DIST. OF ALGOMA
TWP. RIX LOT. CON.

BORE HOLE LOCATIONS & SOIL STRATA

SUBMIT A.P. CHECKED	W.P. NO. 907-75-02	DRAWING NO.
DRAWN O.Y. CHECKED	W.D. NO.	9077502-A
DATE 8 AUG 1975	SITE NO.	BRIDGE DRAWING NO.
APPROVED	CONF. NO.	

REF NO. E-5174-1 MAY 1975