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FOUNDATION INVESTIGATION REPORT
For
Proposed Structure at the Crossing of
Gravel River No. 2
District 18, Sault Ste. Marie
W.P. 14-74-09 Site 38S-332

GEOCRE # A1J-60

Prepared For;
Ministry of Transportation and Communications

The Trow Group Limited
Toronto, Hamilton, London,
Sudbury, North Bay, Elliot Lake

Project: S-3689
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1. Introduction and Object

The following investigation was carried out on behalf of the Ministry of Transportation and Communications for a proposed bridge over the Gravel River No. 2. The crossing is located on Line M, which is realigned approximately 300 feet northwest of the existing Kings Highway 129.

The proposed single span bridge will have a clear span of approximately 40 feet with a grade set at approximate El. 1134 (creek bed El. ~ 1122 and H.W.L. ~ El. 1126). The deck will be 30 feet wide and will be on a 25 degree skew angle.

The purpose of the investigation was to:

- (a) determine the type, thickness and variability of the subsoil underlying the site;
 - (b) establish groundwater conditions;
 - (c) determine the safe bearing capacities of the various soil strata;
- and (d) comment on foundation design, excavation conditions and earth pressure requirements, etc.



2. Site Description

The proposed bridge will be constructed over the Gravel River No. 2 at station 332 + 00 along the realigned route 'M'.

1 fps The river at this proposed crossing is approximately 35 feet wide with the water level (at the time of the field work) at El. 1123.9. It flows north to south at an average velocity of some 60 feet per minute. It appears, from visual evidence at the site, that the high water level is at approximate elevation 1127 and, during this flooding period, the stream velocity is anticipated to be much greater than the present 60 feet per minute. The maximum creek depth, at the time of the investigation, was approximately 20 inches. 14/77

No bedrock outcrops are visible in the immediate vicinity of the proposed bridge. The present stream bed is strewn with cobbles and the odd boulder. Most of the cobbles are in the order of 10 inch diameter and less, although the odd boulder, up to 2 feet in diameter, is evident.

The proposed line 'M' was cut through the bush last fall and it is located about 250 to 300 feet northwest of the existing Thessalon to Chapleau road (Highway 129). A shallow, abandoned sand and gravel pit is located approximately 300 feet east of the crossing on the proposed centerline of route 'M'.

3. Site Geology

Geologically the site is situated in a deep valley within the Precambrian Shield which in this area comprises mainly granite and other acid intrusive rocks of Archean Age. The bedrock in this area is generally overlain by varying depths of granular glacial



till which, in turn, is overlain by scattered, granular glacial outwash deposits.

4. Field Work

The field work, which was undertaken in the period June 7 to June 14, 1977, consisted of two boreholes to a depth of 41 feet using a conventional diamond drill adapted for soil sampling. Holes were cased with Nx and Bx sized casing and were advanced using washboring techniques. Four accompanying dynamic cone penetration tests to depths of up to 95 feet were also driven.

The elevations of the boreholes were referred to an M.T.C. datum. This geodetic datum, El. 1132.2, was located in a root of a 1.5 foot diameter pine tree at station 330 + 65, 85 feet left of the centerline.

The locations of the boreholes are shown on the accompanying Drawing 147409-A.

5. Subsoil

Details of the soil strata encountered in the borehole logs are included in the Appendix and a soil stratigraphy is plotted on Drawing 147409-A.

This data indicates similar soil strata in both boreholes. Beneath the initial surficial layer of topsoil and roots, the site consists of an upper 10 to 16 foot thick veneer of compact coarse sand, gravel and cobbles with the odd boulder. This gravel stratum is some 10 feet thick in borehole #1, although it increases to approximately 16 feet thick in borehole #2. It is underlain, in turn, by an extensive deposit of compact, mostly fine/medium sand. The sand has some coarse sand and gravel zones, more particularly the upper 6 feet in borehole #1. Indications

10'-16'
is a
veneer?



from the dynamic cone tests infer that the sand deposit extends to depths of at least 76 feet in borehole #1 and 95 feet in borehole #2.

From the ground surface downwards, the different soil strata encountered in the boreholes is described in detail as follows:

5.1) Sand, Gravel, Cobbles and Boulders

A deposit of sand, gravel, cobbles and boulders was encountered beneath surficial cover of topsoil some 6 to 12 inches thick. The thickness of the deposit is 10 feet in borehole #1 increasing to 16 feet in borehole #2. The deposit is essentially coarse sand and gravel with numerous cobble and odd boulder inclusions. It does, however, contain random zones of coarse sand and fine gravel. Because of the presence of cobbles and the odd boulder, the deposit was difficult to sample accurately with a conventional split spoon. In most instances, the spoon 'bounced' on a cobble with little or no penetration. Where a coarse sand and fine gravel seam was intercepted, it was possible to drive the spoon the full depth and recover a soil sample.

A grain size curve for a sand and fine gravel seam from this deposit is shown on Figure 1 in the Appendix. Note that this curve is not representative of the deposit on a whole since sampling of the cobble and boulder sizes was not possible.

— why not?

The moisture content of the deposit is typically in the range of 5.0 to 8.0 per cent. Split spoon tests, where possible in sand and gravel zones, indicated 'N' blows in the range of 12 to 20, confirming that the deposit is essentially compact.



5.2) Sand

Underlying the sand, gravel and cobbles is a stratum of sand which was proved by sampling to extend to a depth of 41 feet below grade and inferred from cone tests to extend to depths of up to 95 feet below grade.

The sand is generally fine/medium (see representative grading curve on Figure 2 in the Appendix), although it contains random zones of coarse sand and gravel. The upper 6 feet of the deposit in borehole #1 is coarse with some fine gravel inclusions.

Moisture contents of the deposit are in the range of 20 to 25 per cent.

The 'N' values vary from 5 to 40 with an average value of 11. It is our opinion, however, that the lower 'N' value could have resulted from disturbance during sampling in the wet sand. The dynamic cone penetration blows are high with reasonably consistent values of between 12 to 16. The deposit is described as compact.

The dynamic cone penetration tests indicate that the sand increases to a dense consistency below approximately 45 feet depth.

6. Groundwater

Groundwater observations are tabulated in the borehole logs and are plotted on the profile Drawing 147409-A. This data indicates that the water table, at the time of the investigation, was at a depth of some 2 to 3 feet below grade (vel. 1123.5). This coincides with the water level in the adjacent river (vel. 1123.9).



Since the soil is granular, we would anticipate that the groundwater table in the immediate vicinity of the river will fluctuate with the rise and fall of the creek level. During high Spring run-off, the level could raise to El. 1227.

7. Discussion and Recommendations

7.1) General

It is proposed to construct a bridge approximately 300 feet northwest of the existing road where the relocated Highway 129 (line 'M') crosses Gravel River (Sharpsand No. 2 crossing). The proposed structure will be a single span (approximately 40 feet) with a width of 30 feet on a 25 degree skew angle. The proposed profile grade of the revised Hwy. 129 will be set at approximate elevation 1134. At this grade, fills in the order of a maximum of 10 feet in height will be required at the approaches.

The subsoil at the site consists of some 10 feet of compact sand, gravel and cobbles with odd boulders overlying compact, fine/medium sand. Bedrock was not encountered in the boreholes.

7.2) Structure Foundations

It should be possible to support the proposed two bridge abutments on normal spread foundations established in the upper compact sand, gravel and cobble deposit using a safe allowable net bearing pressure of up to 3 kips. per square foot. This bearing pressure applicable to spread footings is available below the initial upper softened and weathered zone, i.e., below the initial 3 feet or below elevation 1121 in borehole #1 (east abutment) and below elevation 1123 in borehole #2 (west abutment).



A minimum cover of 6 feet should be provided to the underside of the abutment footing for frost protection purposes.

It should be noted that the prevailing groundwater level will generally coincide with the adjacent river level. At the time of the investigation, this corresponded to an elevation of 1123.5, although it could be at least $3\frac{1}{2}$ feet higher during Spring run-off or after a flash storm. From observations during the field work and examination of the recovered samples, it should be possible to excavate to a depth of approximately 4 feet below the water table, controlling the anticipated groundwater seepages using conventional construction drainage, i.e., pumping from sumps and ditches. It is recommended that the existing narrow river be diverted temporarily from the abutment location during construction to reduce potential groundwater problems.

Since excavation will be below the water table, the Contractor should expect the founding subsoil (sand, gravel and cobbles), to be wet and therefore, the foot traffic of workmen in the footing areas should be restricted to avoid potential disturbance in the subsoil. If necessary, the workmen should work off large pieces of plywood or alternatively a thin, 6 inch lift of 2 inch crusher run could be tamped into the footing areas to 'firm-up' the base and prevent potential disturbance. Sides of excavations should remain stable if sloped back at 45 degrees above the water table, although below this level, the sides will tend to 'slough' back to flatter slopes in the order of 2H:1V.

Below a depth of approximately 4 feet below the water table (~El. 1119.5), excavation conditions will become increasingly more problematic because of increased water seepages. (This elevation will vary depending on the river level at the time of construction.) In this regard, if deeper excavations are required, then positive methods of groundwater control are recommended such as a system of vacuum well-points or excavation



within the confines of sheeting. Both these alternatives will present problems because of cobble and boulder obstructions which extend to a depth of some 10 feet below grade.

Other foundation alternatives include either piles driven into the underlying sand or possibly a large C.S.P. or concrete culvert. Since difficulties would be experienced driving piles through the upper bouldery zone (they would also have to be driven to depths in excess of 50 feet to develop acceptable capacities), it would appear doubtful therefore if piles would be a viable alternative. A culvert, on the other hand, would be feasible provided it could accommodate the flow in the river. Additional detailed comments could be provided if a culvert is to be seriously considered.

7.3) Settlement Considerations

Provided the recommended bearing pressure of 3 kips. per square foot is not exceeded, and the foundation concrete is placed on clean undisturbed soil, then settlement will be very small and much less than 1 inch.

7.4) Related Considerations

7.4.1) Design Considerations

For the design of the abutments, the following design values may be used:

Coefficient of earth pressure at rest (K_0) = 0.5 (rigid wall);

Coefficient of active earth pressure (K_a) = 0.33 (some movement at the top of wall permitted);

Coefficient of passive earth pressure (K_p) = 3.0 (in front of the abutment);

Sliding resistance between abutment and subsoil $\tan \phi = 0.6$.



7.4.2) Stability of Approach Fills

As mentioned previously, the maximum height of approach fills will be in the order of 10 feet. Approaches of this height will be inherently stable against a deep-seated rotational type of failure, provided standard 2:1 slopes are adopted.

Settlement of the subsoil beneath the surcharge loading will be essentially 'elastic' in nature and negligible in magnitude.

7.4.3) Scour Protection

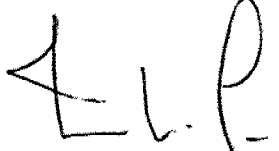
As mentioned previously, the river bed is strewn with gravel and cobbles and as such we would anticipate only a nominal scouring effect during normal flooding. The abutment foundations set at 6 feet below creek level should be sufficient to protect against scour damage. It is recommended, however, that the larger cobbles and boulders excavated during construction be placed around the abutments and approach fills to act as rip-rap and provide additional protection.

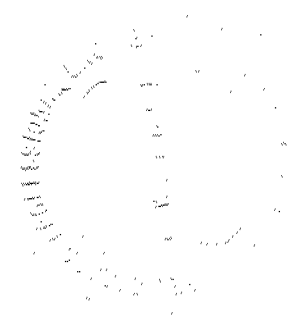
8. Miscellaneous

The investigation was carried out under the general supervision of Mr. I. W. Gore, P. Eng., of The Trow Group Limited, Sudbury Branch. Mr. I. W. Gore also prepared the report.

The field equipment used was provided and operated by Canadian Longyear Limited, operating from Sudbury.

THE TROW GROUP LIMITED


I. W. Gore, P. Eng.



IWG:gmw
Encl.

Dist: Ministry of Transportation & Communications (14)
Attention: Mr. M. Devata, P. Eng.



A P P E N D I X

RECORD OF BOREHOLE NO 1

WP 14-74-09 LOCATION Sta. 332 + 20 G' Rt. centerline Hwy 129 Line ORIGINATED BY A.C.
 DIST 18 HWY 129 BORING DATE June 7, 8, 1977 COMPILED BY I.G.
 DATUM Geodetic BOREHOLE TYPE Washboring NW & BW Casing & Cone Test CHECKED BY I.G.

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		
1125.2	Ground Surface															
0.0	TOPSOIL & ROOTS ~12" overlying SAND, GRAVEL COBBLES & BOULDERS - mostly coarse sand with cobbles, brown, organic stained in upper few feet, wet below 3' depth (compact)		1	SS	60	1123										42 56 (2)
1115.0			2	SS	21	1120										
10.0			3	SS	14											
1108.0	SAND - mostly coarse brown sand with gravel incl, wet (compact)		4	SS	11											4 89 (7)
17.0			5	SS	40	1110										
	SAND - mostly fine/medium sand with some coarse sand & gravel layers, brown with grey/brown zones, wet (compact)		6	SS	10											0 88 (12)
			7	SS	14	1100										
			8	SS	7											
			9	SS	12	1090										
1083.7			10	SS	10											
41.5	END OF SAMPLED BOREHOLE															
	Notes (1) Borehole advanced by conventional, cased wash boring techniques in period June 7 to June 8, 1977. (2) Dynamic cone penetration test (a) driven from bottom of hole at 41.5' depth to refusal at 75' depth. Second adjacent hole cleaned out to 10' depth & cone (b) driven from 11' depth & cone driven from 11' depth to refusal at 63' depth.															
1050.2																
75.0	END OF CONE TEST															

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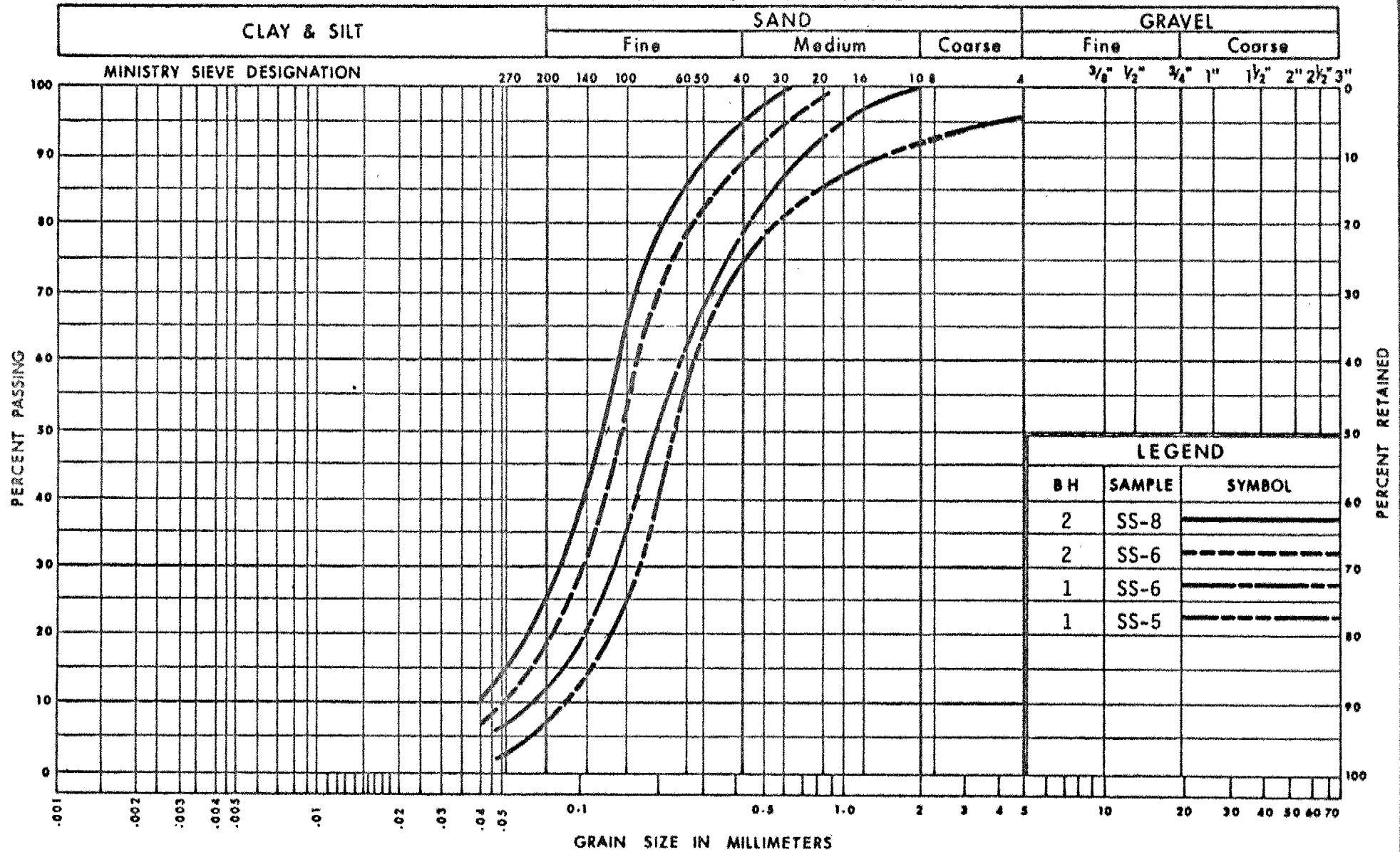
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SAND & FINE GRAVEL SEAM

W P 14-74-09

UNIFIED SOIL CLASSIFICATION SYSTEM



GRAIN SIZE DISTRIBUTION

FINE TO MEDIUM SAND

FIG No 2

W P 14-74-09



Ontario

 Ministry of
Transportation and
Communications

ABBREVIATIONS USED IN THIS REPORT

PENETRATION RESISTANCE

STANDARD PENETRATION RESISTANCE 'N' - 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>'N' BLOWS/FT.</u>	<u>c LB./ SQ. FT.</u>	<u>DENSENESS</u>	<u>'N' BLOWS/ FT.</u>
VERY SOFT	0 - 2	0 - 250	VERY LOOSE	0 - 4
SOFT	2 - 4	250 - 500	LOOSE	4 - 10
FIRM	4 - 8	500 - 1000	COMPACT	10 - 30
STIFF	8 - 15	1000 - 2000	DENSE	30 - 50
VERY STIFF	15 - 30	2000 - 4000	VERY DENSE	> 50
HARD	> 30	> 4000		

TYPE OF SAMPLE

S.S.	SPLIT SPOON	T.W.	THINWALL OPEN
W.S.	WASHED SAMPLE	T.P.	THINWALL PISTON
S.B.	SCRAPER BUCKET SAMPLE	O.S.	OESTERBERG SAMPLE
A.S.	AUGER SAMPLE	F.S.	FOIL SAMPLE
C.S.	CHUNK SAMPLE	R.C.	ROCK CORE
S.T.	SLOTTED TUBE SAMPLE		
	P.H. SAMPLE ADVANCED HYDRAULICALLY		
	P.M. SAMPLE ADVANCED MANUALLY		

SOIL TESTS

Qu	UNCONFINED COMPRESSION	L.V.	LABORATORY VANE
Q	UNDRAINED TRIAXIAL	F.V.	FIELD VANE
Qcu	CONSOLIDATED UNDRAINED TRIAXIAL	C	CONSOLIDATION
Od	DRAINED TRIAXIAL	S	SENSITIVITY

ABBREVIATIONS 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
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_i	SENSITIVITY

GENERAL

T	= 3-1416
e	BASE OF NATURAL LOGARITHMS 2.7183
$\log_e \sigma$ OR $\ln \sigma$	NATURAL LOGARITHM OF σ
$\log_{10} \sigma$ OR $\log \sigma$	LOGARITHM OF σ 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

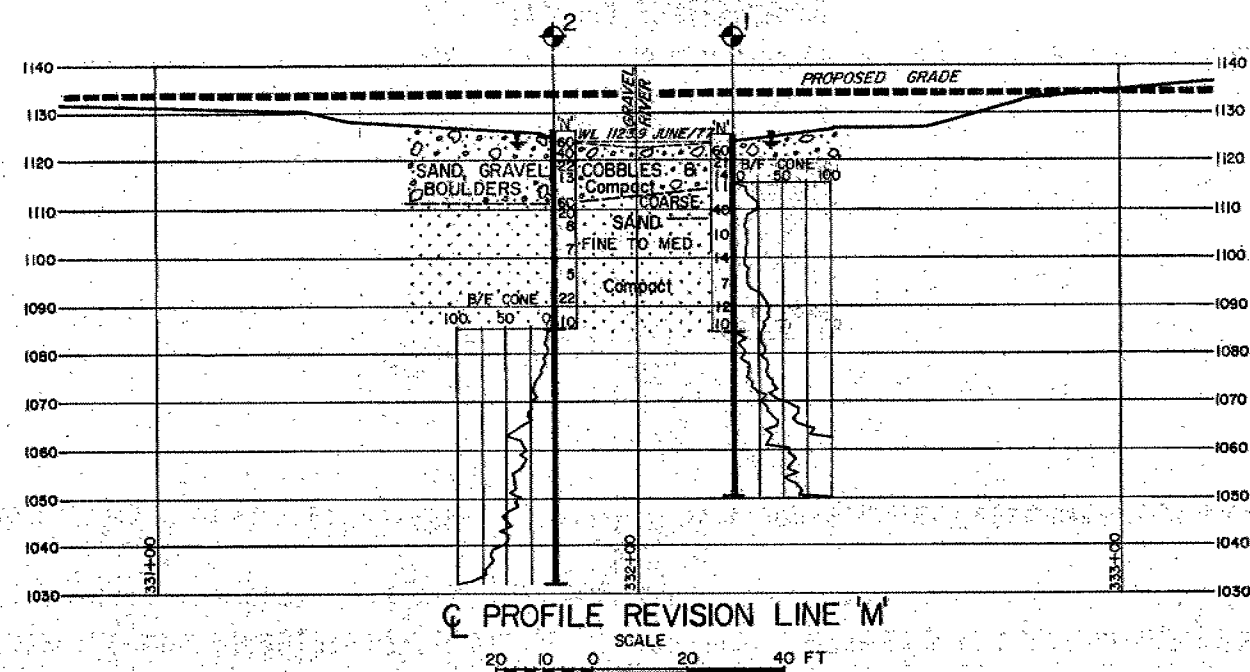
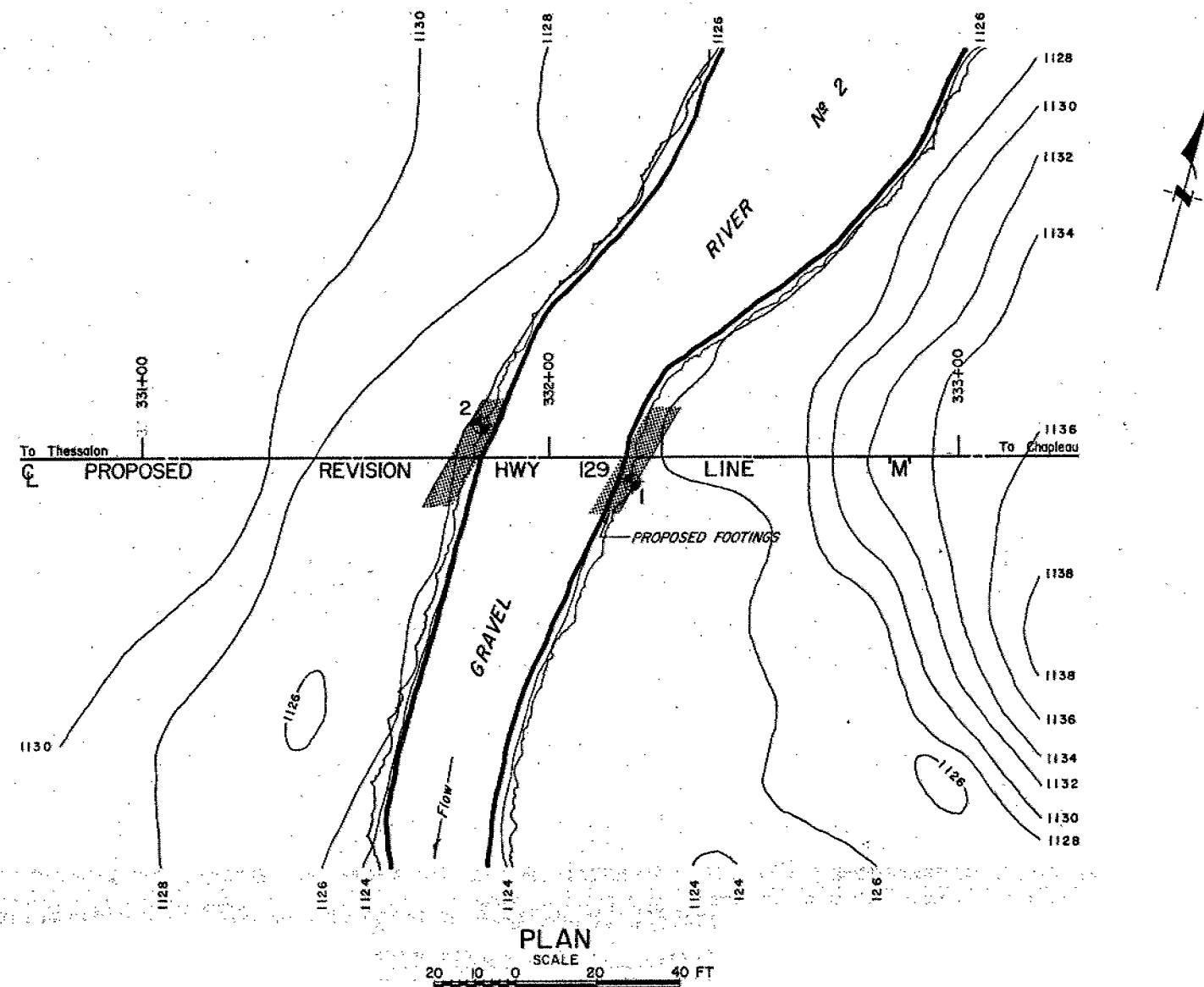
d	DISTANCE FROM TOP OF WALL TO POINT OF APPLICATION OF PRESSURE
δ	ANGLE OF WALL FRICTION
K	DIMENSIONLESS COEFFICIENT TO BE USED WITH VARIOUS SUFFIXES IN EXPRESSIONS REFERRING TO NORMAL STRESS ON WALLS
K_0	COEFFICIENT OF EARTH PRESSURE AT REST

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



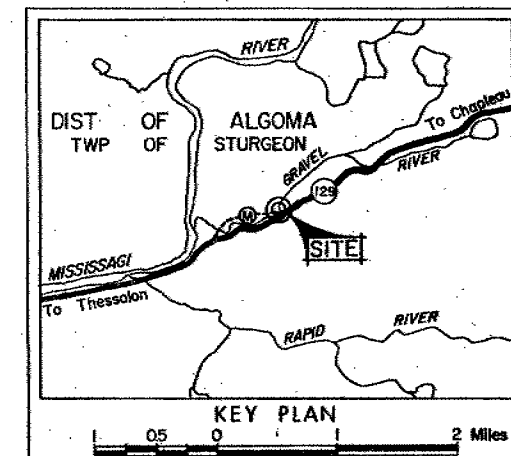
CONT No
WP No 14-74-09



GRAVEL RIVER No 2 BRIDGE
BORE HOLE LOCATIONS & SOIL STRATA

SHEET

THE TROW GROUP LIMITED



LEGEND

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

No	ELEVATION	STATION	OFFSET
1	1125.2	332+20	6' RT
2	1126.6	331+83	8' LT

-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 129 LINE 'M' REVISION	DIST 18
SUBWD	CHECKED
DATE JUNE 30, 1977	SITE 388-332
DRAWN	CHECKED
APPROVED	DWG 147409-A

REF No E-5181-1; November 1975

