

DOCUMENT MICROFILMING IDENTIFICATION

G.I.-30 SEPT. 1976

GEOCRES No. 31L-58

DIST. 13 REGION

W.P. No. 589-92-01

CONT. No. 95-214

W. O. No.

STR. SITE No. 44-40

HWY. No. 522

LOCATION Hwy 11 & McGillivray Creek
Culvert

No of PAGES -

=====

OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:

SHEET
87

2. CLEAR COVER TO REINFORCING STEEL

BOTTOM OF TOP SLAB	50 ± 10
BOTTOM OF BOTTOM SLAB	100 ± 25
REMAINDER	70 ± 20

UNLESS OTHERWISE NOTED

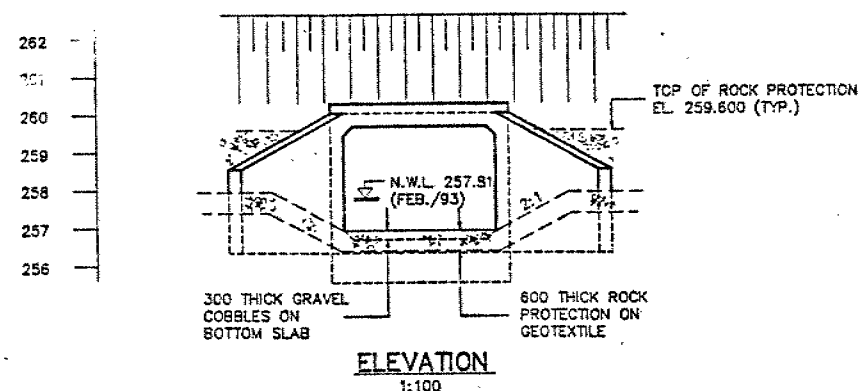
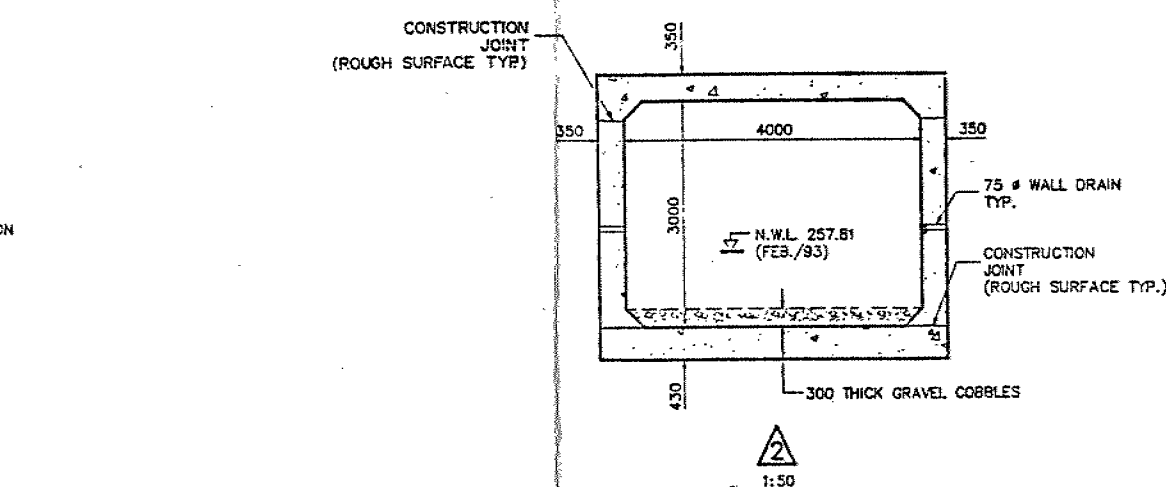
3. REINFORCING STEEL SHALL BE GRADE 400 UNLESS OTHERWISE SPECIFIED. BARS MARKED WITH SUFFIX C DENOTE COATED BARS.
4. MAX. SIZE OF GRAVEL COBBLES TO BE 150 mm

ALT DENOTES ALTERNATE
IF DENOTES INSIDE FACE
OF DENOTES OUTSIDE FACE
EF DENOTES EACH FACE

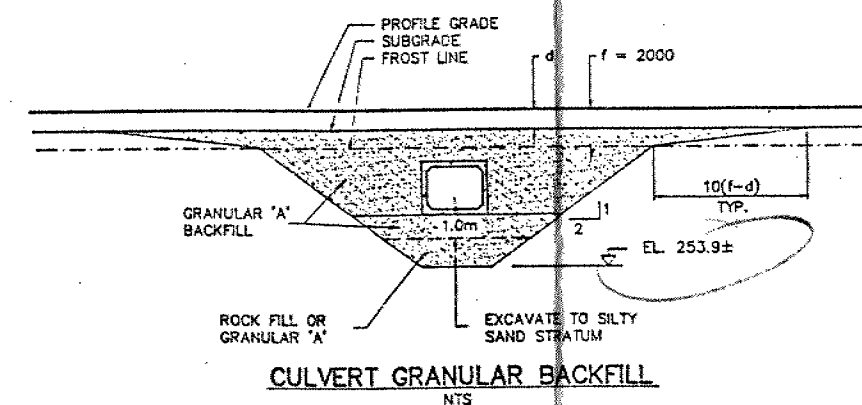
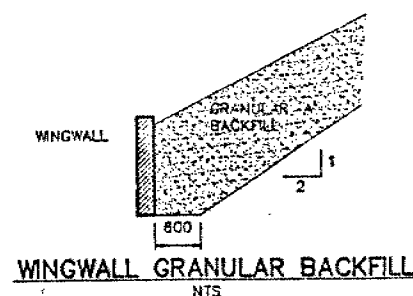
1. NO CONCRETE SHALL BE PLACED UNTIL THE DEPTH OF THE EXCAVATION AND THE CHARACTER OF THE FOUNDATION HAVE BEEN APPROVED BY THE ENGINEER.

2. BACKFILL SHALL BE PLACED SIMULTANEOUSLY BEHIND BOTH SIDES OF CULVERT KEEPING THE HEIGHT OF THE BACKFILL APPROXIMATELY THE SAME. AT NO TIME SHALL THE DIFFERENCE IN ELEVATION BE GREATER THAN 500mm.

northland
engineering
limited
Consulting Engineers and Planners



1. GENERAL ARRANGEMENT
2. CULVERT DETAILS
3. WINGWALL DETAILS
4. STANDARD DETAILS



B.M. EL. 269.729
TOP OF HCM 67-443
STA. 19+557.7 49.4 RT.

REVISIONS									
	DATE	BY	DESCRIPTION						
DESIGN	S.M.	CHK	S.K.P.	CODE	CHBDC 1991	LOAD	DATE	FEB/91	
DRAWN	D.A.H.	CHK	S.K.P.	SITE	44-40A/STRUCT	SCHEME	DWG T		

METRIC
DIMENSIONS ARE IN METRES
AND / OR MILLIMETRES
UNLESS OTHERWISE SHOWN

CONT No
WP No 589-92-01

MCGILLVAY CREEK CULVERT
PROPOSED HWY 11 S.B.L.
CULVERT DETAILS

SHEET
88

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GENERAL NOTES

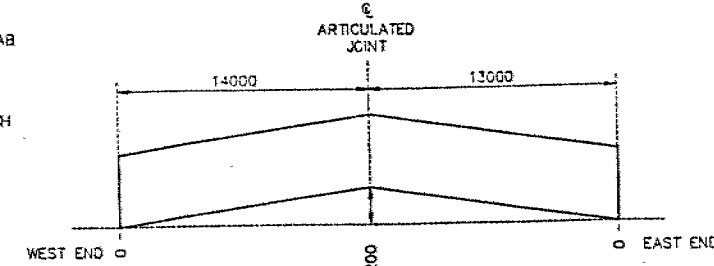
1. CLASS OF CONCRETE TO BE 30MPa.
2. CLEAR COVER TO REINFORCING STEEL
BOTTOM OF TOP SLAB 50 ± 10
BOTTOM OF BOTTOM SLAB 100 ± 25
REMAINDER 70 ± 20 UNLESS OTHERWISE NOTED
3. REINFORCING STEEL SHALL BE GRACE 400 UNLESS
OTHERWISE SPECIFIED. BARS MARKED WITH SUFFIX C
DENOTE COATED BARS.
4. LONGITUDINAL REINFORCING STEEL SHALL BE DISCONTINUED
AT ARTICULATED JOINTS.
5. LEGEND
ALT DENOTES ALTERNATE
IF DENOTES INSIDE FACE
OF DENOTES OUTSIDE FACE
EF DENOTES EACH FACE

CONSTRUCTION NOTES

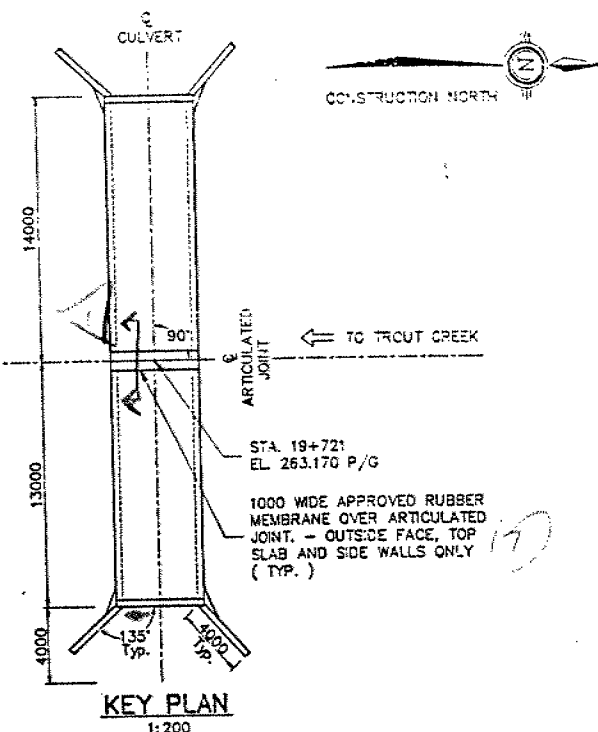
1. BACKFILL SHALL BE PLACED SIMULTANEOUSLY BEHIND
BOTH SIDES OF CULVERT KEEPING THE HEIGHT OF THE
BACKFILL APPROXIMATELY THE SAME. AT NO TIME SHALL
THE DIFFERENCE IN ELEVATION BE GREATER THAN
500mm.
2. NO CONCRETE SHALL BE PLACED UNTIL THE DEPTH OF
THE EXCAVATION AND THE CHARACTER OF THE FOUNDATION
HAVE BEEN APPROVED BY THE ENGINEER.
3. SITE No. AND DATE FIGURES SUPPLIED BY MTO

CULVERT CAMBER DIAGRAM

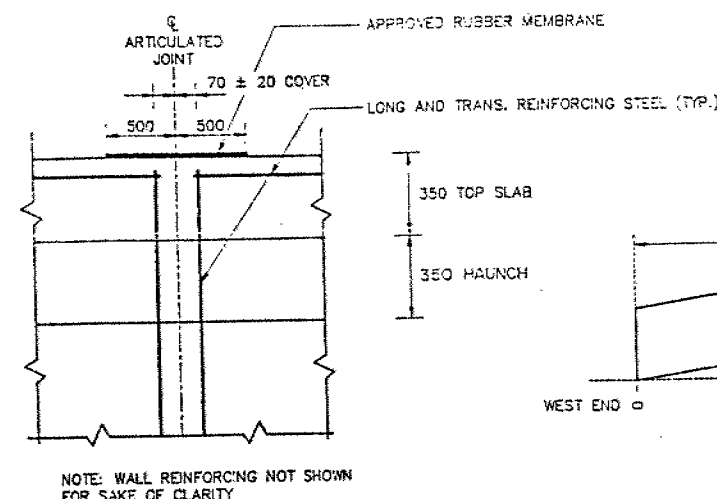
NTS



FOR DESIGN GRADE AND
ELEVATION SEE
GENERAL ARRANGEMENT
DWG. (TYP.)

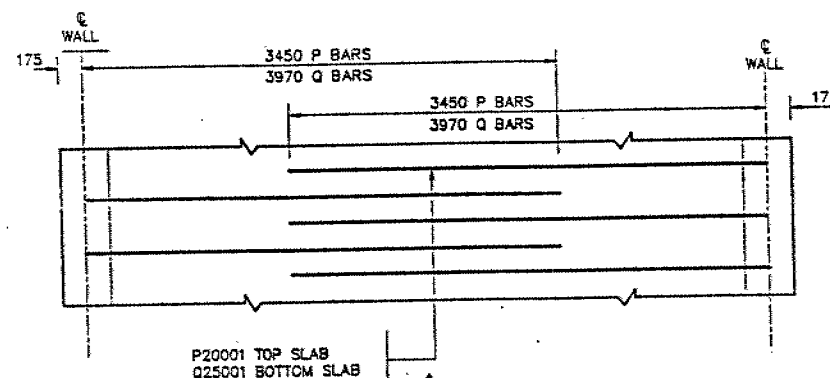


KEY PLAN
1:200

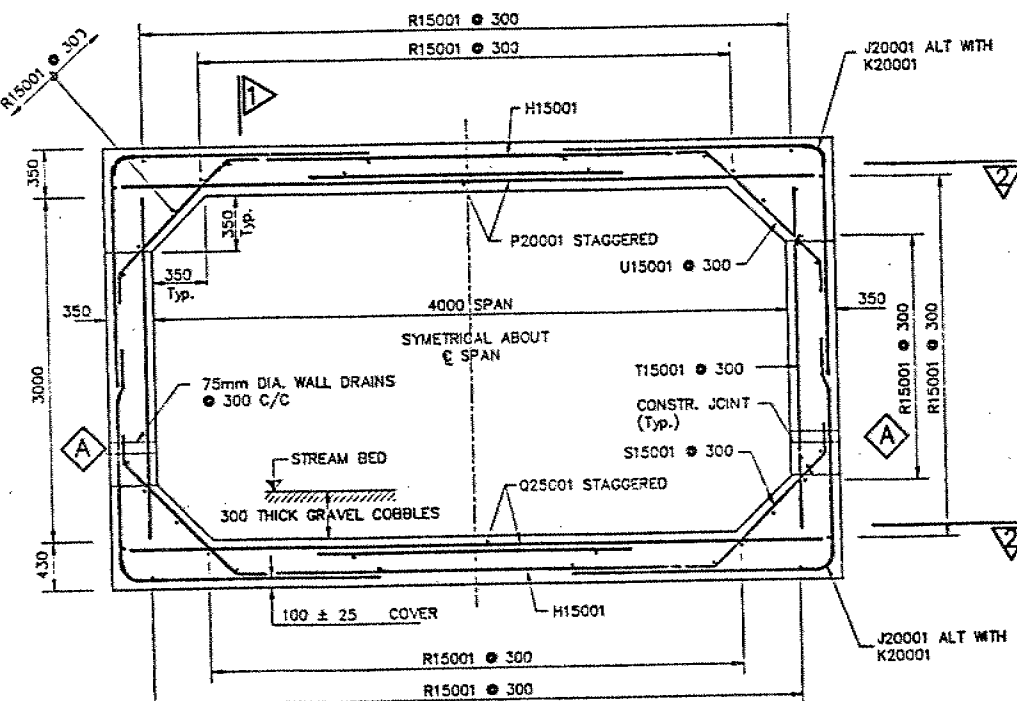
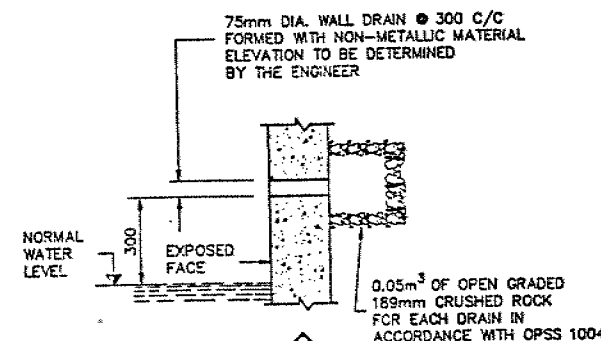
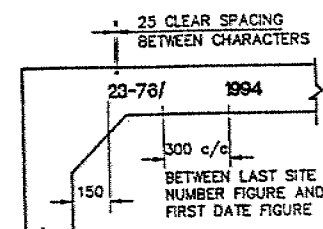


NOTE: WALL REINFORCING NOT SHOWN
FOR SAKE OF CLARITY

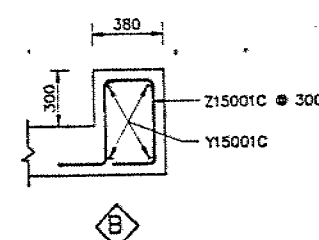
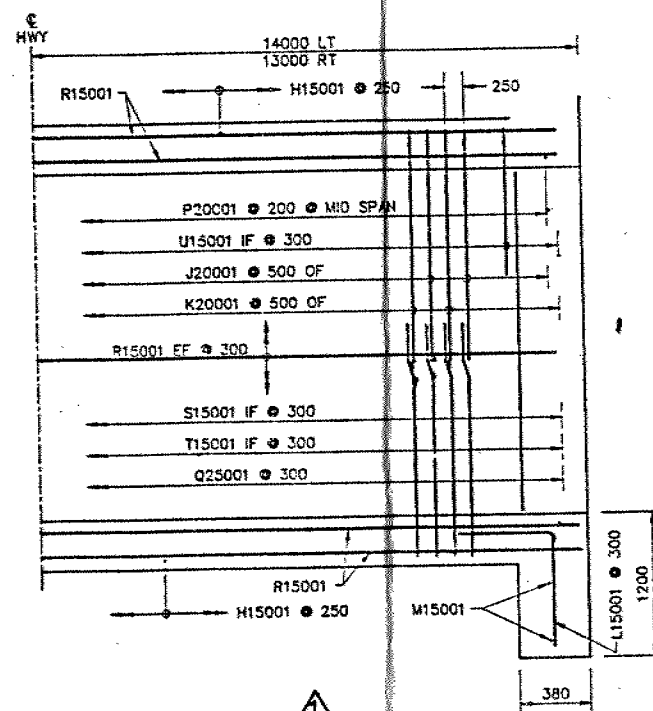
NTS



LOCATION OF SITE NUMBER AND DATE FIGURES



TYPICAL CULVERT SECTION



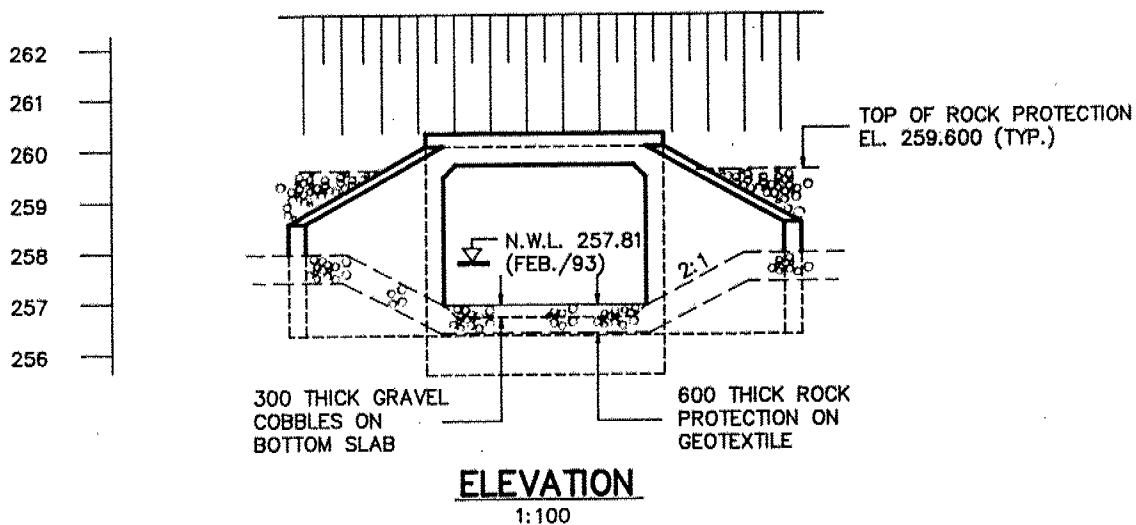
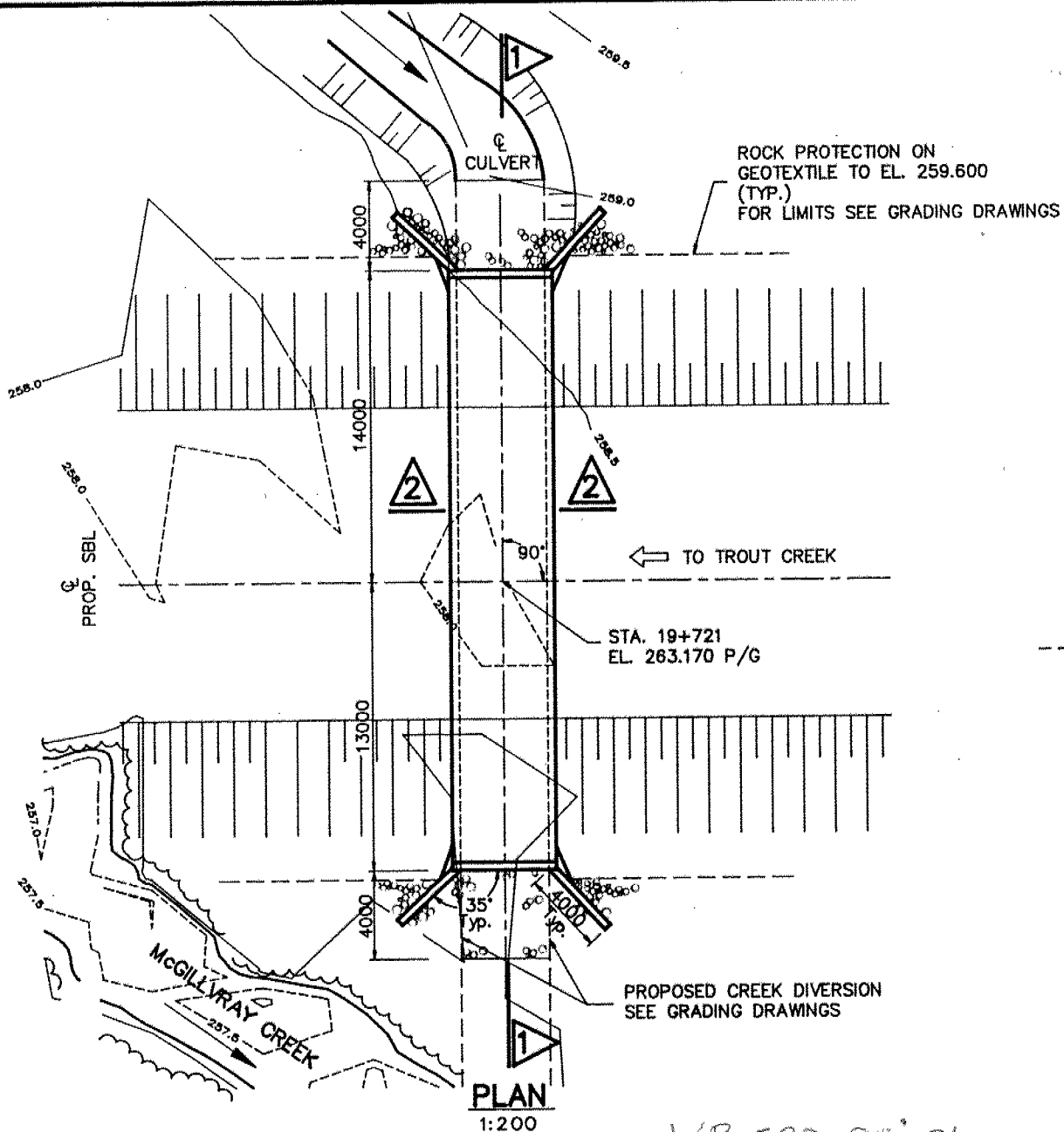
MARK	No. REQ'D	C/C	LENGTH	DETAILS	REMARKS
H15001	216	250	2470	STRAIGHT	TOP OF TOP SLAB BOTTOM OF BOTTOM SLAB
J20001	216	500	3740		J-BARS ALTERNATE WITH K-BARS
K20001	216	500	3430		K-BARS ALTERNATE WITH J-BARS
P20001**	135	200	3450	STRAIGHT	BOTTOM OF TOP SLAB STAGGERED
Q25001**	93	300	3970	STRAIGHT	TOP OF BOTTOM SLAB STAGGERED
R15001	600	300	4650	STRAIGHT 100 SETS @ 6 PER SET	LONGITUDINAL
S15001	186	300	1580		HAUNCH
T15001	186	300	3000	STRAIGHT	INSIDE FACE OF WALLS
U15001	186	300	1470		HAUNCH
L15001	32	300	1495		DOWELS TO APRON WALLS
M15001	4	400	4560	STRAIGHT	APRON WALL
Y15001 C	8	SEE @	4560	STRAIGHT	HEADER WALL
Z15001 C	32	300	1635		HEADER WALL

NOTES: - ALL DIMENSIONS SHOWN TO CENTRE LINE OF BAR
--REPRESENTS VERTICAL DIMENSION
--C/C SPACING GIVEN AT MIDSPAN

QUANTITIES			
ITEM		WALLS & SLABS	WINGWALLS
MASS OF REINFORCING STEEL (tonnes)	uncoated	13.4	2.5
	coated	0.1	0.2
VOLUME OF CONCRETE cubic metres		166.1	24.8
			190.9

STANDARD DRAWING
JUNE 1993
SS114-2
RIGID FRAME BOX CULVERT

REVISIONS	DATE	BY	DESCRIPTION
DESIGN S.H.	CHK	S.K.P.	10000 QHBC 1391
DRAWN D.A.M.	CHK	S.K.P.	SITE 44-40A 1391
			LOAD
			SCHEME
			DWG 2



FILE COPY



Ministry
of
Transportation

Ontario

FOUNDATION DESIGN SECTION

**foundation
investigation and
design report**

ENGINEERING MATERIALS OFFICE
FOUNDATION DESIGN SECTION

CONT. 95-214

WP 589-92-01 DIST 13

HWY 11 STR SITE 44-40

McGillivray Creek, South Crossing
Proposed Southbound Lanes

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FOUNDATION INVESTIGATION REPORT
for
McGillivray Creek, South Crossing
Proposed Southbound Lanes, Highway 11
W.P.589-92-01, Site No. 44-40
District 13, North Bay

INTRODUCTION

This report summarizes the information obtained from the foundation investigation carried out at the above noted site. The investigation was carried out at the request of the Northern Region Structural Section for a new culvert required due to the proposed four laning of Highway 11. The field work, carried out between 93 02 05 and 93 02 12, consisted of three (3) sampled boreholes and three (3) dynamic cone penetration tests along the length of the proposed culvert site.

SITE DESCRIPTION

The site is located on the proposed southbound lanes of Highway 11, approximately 4 km south of the intersection of Highway 534 and 100 m west of the existing Highway 11 embankment in the Township of South Himsworth, District of Parry Sound.

The immediate area is moderately rolling with swampy areas near the creek bed. The site is heavily vegetated with trees. Land use in the adjacent areas includes the highway corridor and livestock pasture. According to the Northern Ontario Engineering Geology Terrain Study published by the Ministry of Natural Resources, the site is located on the edge of a Sandy Glaciolacustrine Plain.

The existing Highway 11 embankment is approximately 4 m high at this location with the watercourse accommodated by a rigid frame concrete bridge.

INVESTIGATION PROCEDURES

Soil data and inherent properties were obtained by in-situ and laboratory testing. The procedures employed are discussed below.

Field

The field work for the investigation was carried out between 93 02 05 and 93 02 12 and

consisted of three (3) sampled boreholes and three (3) dynamic cone penetration tests. BH 2 and BH 3 were advanced to refusal at depths of 15.0 m and 12.2 m respectively. Borehole No.1 was advanced to a depth of 8.1 m and terminated in the Silty Sand stratum common to all the boreholes.

The boreholes were advanced using conventional hollow stem augering techniques with two track mounted continuous flight auger machines. The sampling program consisted of split spoon and shelly tube samples collected in the overburden. Disturbed subsoil samples were retrieved by split spoon sampler in accordance with Standard Penetration Test (ASTM D1586). Standard Penetration ('N') values were recorded for assessment of the denseness of the materials encountered. Relatively undisturbed samples were randomly retrieved in the cohesive stratum using thin walled shelly tube samplers in accordance with Standard Practice (ASTM D1587). All subsoil samples were identified in the field and returned to the laboratory for further examination and appropriate testing.

Dynamic Cone Penetration tests were carried out at the location of each borehole. In situ vane shear tests were also carried out in the cohesive strata to determine the undisturbed and remoulded undrained shear strengths of these soils. The test was conducted employing the standard MTO 'N' vane.

Groundwater levels were measured in each borehole and in the watercourse. All boreholes were backfilled upon completion of the field work.

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

Laboratory

The laboratory testing on selected soil samples consisted of the following:

- Atterberg Limit Test
- Grain Size Distribution
- Natural Moisture Content Determination
- Unit Weight Determination
- Consolidation Test
- Unconfined Compressive Test

Laboratory results are given in the following section of this report and are illustrated on Record of Borehole sheets included in the Appendix.

SUBSURFACE CONDITIONS

General

The Record of Borehole sheets in the Appendix illustrate the subsurface conditions at the borehole locations. The locations of the boreholes are shown in Dwg. No. 5899201-A.

The predominant soil strata encountered in the boreholes consisted of Organic Silty clay, Organic Clayey Silt and Silty Sand. A minor layer of Silt was contacted in BH 1. Non-cohesive glacial till was encountered in BH 2. A subsurface profile is shown in Dwg. No. 5899201-B.

Following are the specific descriptions of the materials encountered in the investigation:

Organic Silty Clay/Organic Clayey Silt

This material was encountered at the surface to a depth of 2.7 m in BH 1, 4.4 m in BH 2 and 5.2 m in BH 3. The Standard Penetration Resistance 'N' values recorded in BH 2 were 1 to 5 blows/0.3 m.

Four field vane shear tests were conducted in this material resulting in an undrained shear strengths of 34 to 48 kPa with sensitivities of 3 to 7. The results of the two unconfined compressive tests carried out indicate undrained shear strengths of 19.8 kPa and 26.9 kPa. These values are much lower than the field vane tests values probably due to sample disturbance.

Typical properties of the material, as determined by laboratory tests on representative samples may be summarized as follows:

<u>Property</u>	<u>Range</u>	<u>No. of Test</u>
Natural Moisture Content (w%)	31.5-68.5	7
Unit Weight (kN/m ³)	14.5-15.8	2
Liquid Limit (w _L %)	40-64	4
Plastic Limit (w _p %)	29-43	4
Grain Size Distribution(%)		5
-Gravel	0	
-Sand	1-44	
-Silt	50-81	
-Clay	6-18	

The consolidation test carried out indicates compression index of 0.18 and initial void ratio of 0.91. The preconsolidation pressure obtained is 120 kPa which is higher than the overburden pressure.

Silty Sand, Trace Gravel & Clay

This non-cohesive material was found in all three boreholes at a depth of 2.7 to 5.2 m below the organic layers. Standard Penetration Resistance 'N' values ranged from 7 to 28 blows/0.3 m indicating loose to compact state, but typically compact. One very low 'N' value of 1 blow/0.3 m was recorded in BH 1. This low blowcount is due to unbalanced hydrostatic head and does not represent the denseness of the material.

Typical properties of this material, as determined by laboratory tests may be summarized as follows:

<u>Property</u>	<u>Range</u>	<u>No. of Test</u>
Natural Moisture Content (w%)	19.5-39.0	3
Grain Size Distribution (%)		3
-Gravel	0-9	
-Sand	8-75	
-Silt	9-77	
-Clay	6-15	

Heterogeneous Mixture of Silt, Sand, and Gravel (Glacial Till)

This non-cohesive deposit is only contacted in BH 2 just above bedrock. The remaining boreholes were generally terminated in the silty sand stratum. The material is described as a heterogeneous mixture of silt, sand and gravel, occasional boulders and cobbles. Standard Penetration Resistance 'N' value ranges from 16 blows/0.3 m to 82 blows/0.15 m, indicating compact to very dense state of denseness.

Groundwater

The groundwater level measured in the boreholes was typically close to the ground surface at El. 257 to 258.1 m. During the time of the investigation, the water level in the creek was at El. 257.2 m.

Groundwater levels are subject to seasonal fluctuations and hence may vary from the elevations given in this report.

DISCUSSION AND RECOMMENDATIONS

General

The proposed culvert is a 6 m X 3 m or 7 m X 3 m open footing rigid frame culvert. The culvert is required to carry water from McGillvray Creek through the proposed SBL of Highway 11. The proposed grade will result in a fill height of about 4 m over the new structure and approach fill of up to 6.5 m high.

Foundation

The proposed top of footing elevation is El. 257.2 m. Assuming a footing thickness of about 0.4 m, the founding elevation is at about El. 256.8 \pm m. Based on the investigation results, the subsoils at or below the proposed footing founding elevation typically comprises organic silty clay/organic clayey silt over loose to compact silty sand. It is considered the subsoil is not suitable for shallow foundations. Deep foundation construction is considered to be a more cost-effective solution.

The structure can be supported by steel H-piles driven to bedrock. The foundation soils will undergo settlements due to the weight of fill and this will result in a downward frictional force on the pile supported structure. To account for this force, the following effective pile capacities shall be used in the design in accordance with the O.H.B.D.C.

	<u>HP 310 X 79</u>	<u>HP 310 X 110</u>
Factored Axial Capacity at U.L.S.	950 kN	1320 kN
Axial Capacity at S.L.S. Type II	890 kN	1150 kN

For preliminary estimating purpose, the pile tip elevation can be assumed to be at El. 243 to 245 m. Due to the existence of boulders and cobbles in the glacial till stratum, the piles should be equipped with standard MTO tip reinforcement to minimize damage.

Alternatively, pressure treated timber piles may be used. Size 36 timber piles driven to bedrock may be designed for a capacity of 250 kN.

Wingwalls may also be supported by piles. Alternatively, considerations may be given to designing them as flexible reinforced earth type wall construction. If this option is

chosen, our office should be contacted for details.

Alternatively, if a box type of culvert is used instead of open footing culverts, the organic layers have to be removed down to the silty sand stratum and the excavation be backfilled with engineered fill, consisting of rock fill and granular 'A' material. The factored bearing capacity at U.L.S. recommended as per the O.H.B.D.C. is 375 kPa. From serviceability considerations, a design capacity of 150 kPa may be used. At this pressure, a settlement of up to 200 mm will occur, which is expected due to the difficulties in site control regarding underwater excavation and placement of fill. The design of the structure should include a camber of 200 mm at the centre of the culvert and articulated joints to accommodate possible differential settlements of up to 200 mm along the length of the culvert.

Depth of excavation required will be up to $5.2 \pm$ m. Excavation may be carried out underwater at a gradient as steep as possible. Backfill to the culvert should consist of rock fill or granular material to about 1 m below the underside of the box culvert. Granular 'A' material should be used for backfilling the remainder of the excavation. During backfilling with rock fill, it is recommended a surcharge be applied by placing an additional rock fill thickness of 2 m above final grade as a rolling surcharge that would be advanced as the concurrent subexcavation/backfilling operation progresses. This would enhance the compactness of the rock fill.

Dewatering will be required during placement of the culvert so that the operation can be carried out in the 'dry'. Dewatering may be in the form of pilot trenches with sump pumping to draw the water level down to at least 0.5 m below the founding elevation of the culvert.

Frost Protection

The minimum earth cover required for frost protection is 2.0 m or equivalent insulation, unless the culvert is structurally designed to withstand frost pressures.

Earth Pressure

Backfill to culvert walls should consist of granular material in accordance with MTO Standard Special Provision No. 109F03.

Computation of earth pressures should be in accordance with Section 6.7 of the

O.H.B.D.C. The at-rest condition will govern earth pressure design for unyielding condition. For design purposes, the following properties for backfill are recommended:

<u>Material</u>	<u>ϕ</u>	<u>γ</u>	<u>K_0</u>
Granular A	35°	22.8 kN/m ³	0.43
Granular B	30°	21.2 kN/m ³	0.50

Embankment Slopes

Approach embankment slopes may be safely constructed at a gradient of 2H:1V or flatter up to a maximum height of 7.0 m. Surficial organic material should be removed prior to filling at the approaches adjacent to the structure to avoid differential settlements. Only relatively free draining granular material should be used below the water level.

Construction Considerations

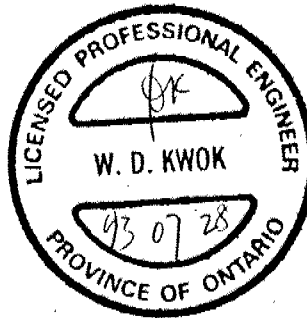
For pile cap construction, temporary excavation up to 3 ± m is required. Cut slopes should be formed to 2H:1V gradient or flatter. Provision for creek diversion and dewatering in the excavation will be required to allow construction be carried out in the dry. An oversized excavation is recommended which can allow sump pumping from perimeter ditches to maintain the ground water below the bottom of the footings.

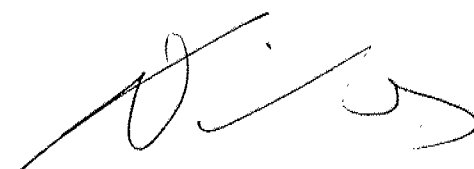
Culvert inlet and outlet treatments should comply with MTO Standards.

MISCELLANEOUS

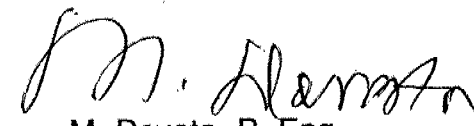
The fieldwork for this investigation was carried out under the supervision of D. Kwok, Project Foundation Engineer, B. Liegler, Engineering Trainee and L. Sheppard, Pavement Design and Evaluation Officer, using the equipment owned and operated by Dominion Soil Investigation Inc.

The project was carried out by D. Kwok under the general supervision of B. Iyer, Senior Foundation Engineer. The report was written by D. Kwok, reviewed by B. Iyer, and approved by M. Devata, Chief Foundation Engineer.




D. Kwok, P. Eng.
Project Foundation Engineer




M. Devata, P. Eng.
Chief Foundation Engineer

APPENDIX

EXPLANATION OF TERMS USED IN REPORT

N VALUE: THE STANDARD PENETRATION TEST (SPT) N VALUE IS THE NUMBER OF BLOWS REQUIRED TO CAUSE A STANDARD 51mm O.D SPLIT BARREL SAMPLER TO PENETRATE 0.3m INTO UNDISTURBED GROUND IN A BOREHOLE WHEN DRIVEN BY A HAMMER WITH A MASS OF 63 kg, FALLING FREELY A DISTANCE OF 0.76m. FOR PENETRATIONS OF LESS THAN 0.3m N VALUES ARE INDICATED AS THE NUMBER OF BLOWS FOR THE PENETRATION ACHIEVED. AVERAGE N VALUE IS DENOTED THUS \bar{N} .

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

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

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

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

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

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

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

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

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

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

JOINTING AND BEDDING:

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

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

SS SPLIT SPOON	TP THINWALL PISTON
WS WASH SAMPLE	OS OSTERBERG SAMPLE
ST SLOTTED TUBE SAMPLE	RC ROCK CORE
BS BLOCK SAMPLE	PH TW ADVANCED HYDRAULICALLY
CS CHUNK SAMPLE	PM TW ADVANCED MANUALLY
TW THINWALL OPEN	FS FOIL SAMPLE

STRESS AND STRAIN

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

MECHANICAL PROPERTIES OF SOIL

m_v	kPa ⁻¹	COEFFICIENT OF VOLUME CHANGE
C_c	1	COMPRESSION INDEX
C_s	1	SWELLING INDEX
C_α	1	RATE OF SECONDARY CONSOLIDATION
c_v	m ² /s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
T_v	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
σ'_{vo}	kPa	EFFECTIVE OVERBURDEN PRESSURE
σ'_p	kPa	PRECONSOLIDATION PRESSURE
τ_f	kPa	SHEAR STRENGTH
c'	kPa	EFFECTIVE COHESION INTERCEPT
ϕ'	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
c_u	kPa	APPARENT COHESION INTERCEPT
ϕ_u	-°	APPARENT ANGLE OF INTERNAL FRICTION
τ_R	kPa	RESIDUAL SHEAR STRENGTH
τ_r	kPa	REMOULDED SHEAR STRENGTH
S_i	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

PHYSICAL PROPERTIES OF SOIL

ρ_s	kg/m ³	DENSITY OF SOLID PARTICLES	e	1, %	VOID RATIO	e_{min}	1, %	VOID RATIO IN DENSEST STATE
γ_s	kN/m ³	UNIT WEIGHT OF SOLID PARTICLES	n	1, %	POROSITY	I_D	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
ρ_w	kg/m ³	DENSITY OF WATER	w	1, %	WATER CONTENT	D	mm	GRAIN DIAMETER
γ_w	kN/m ³	UNIT WEIGHT OF WATER	S_r	%	DEGREE OF SATURATION	D_n	mm	n PERCENT - DIAMETER
ρ	kg/m ³	DENSITY OF SOIL	w_L	%	LIQUID LIMIT	C_u	1	UNIFORMITY COEFFICIENT
γ	kN/m ³	UNIT WEIGHT OF SOIL	w_p	%	PLASTIC LIMIT	h	m	HYDRAULIC HEAD OR POTENTIAL
ρ_d	kg/m ³	DENSITY OF DRY SOIL	w_s	%	SHRINKAGE LIMIT	q	m ³ /s	RATE OF DISCHARGE
γ_d	kN/m ³	UNIT WEIGHT OF DRY SOIL	I_p	%	PLASTICITY INDEX = $w_L - w_p$	v	m/s	DISCHARGE VELOCITY
ρ_{sat}	kg/m ³	DENSITY OF SATURATED SOIL	I_L	1	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$	i	1	HYDRAULIC GRADIENT
γ_{sat}	kN/m ³	UNIT WEIGHT OF SATURATED SOIL	I_C	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$	k	m/s	HYDRAULIC CONDUCTIVITY
ρ'	kg/m ³	DENSITY OF SUBMERGED SOIL	e_{max}	1, %	VOID RATIO IN LOOSEST STATE	j	kn/m ³	SEEPAGE FORCE
γ'	kN/m ³	UNIT WEIGHT OF SUBMERGED SOIL						

RECORD OF BOREHOLE No 1

1 OF 1

METRIC

W.P. 589-92-01 LOCATION Co-ords : N 5 100 634.1 E 316 888.4 ORIGINATED BY DK/LS
 DIST 13 HWY 11 BOREHOLE TYPE H.S. Auger, Cone Test COMPILED BY DK
 DATUM Geodetic DATE 93 02 11 CHECKED BY BI

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT	PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES								
258.1	Ground Surface												
0.0	Organic Silty Clay With Wood Fibres	Brown Grey	1	AS	-							14.5	
255.4			2	TW	PH								
2.7	Silt layers		3	SS	16								0 8 77 15
	Silty Sand Trace Clay and Gravel Brown, Compact		4	SS	** 1								6 75 13 6
	becoming more Gravelly		5	SS	11								
250.0			6	SS	28								
8.1	End of Borehole												
	Probable Silty Sand Some Gravel												
245.3													
12.8	End of Cone Test												
	* Unstabilized Water Level recorded at completion of drilling												
	** Low blowcount due to unbalanced hydrostatic head												

RECORD OF BOREHOLE No 2

1 OF 1

METRIC

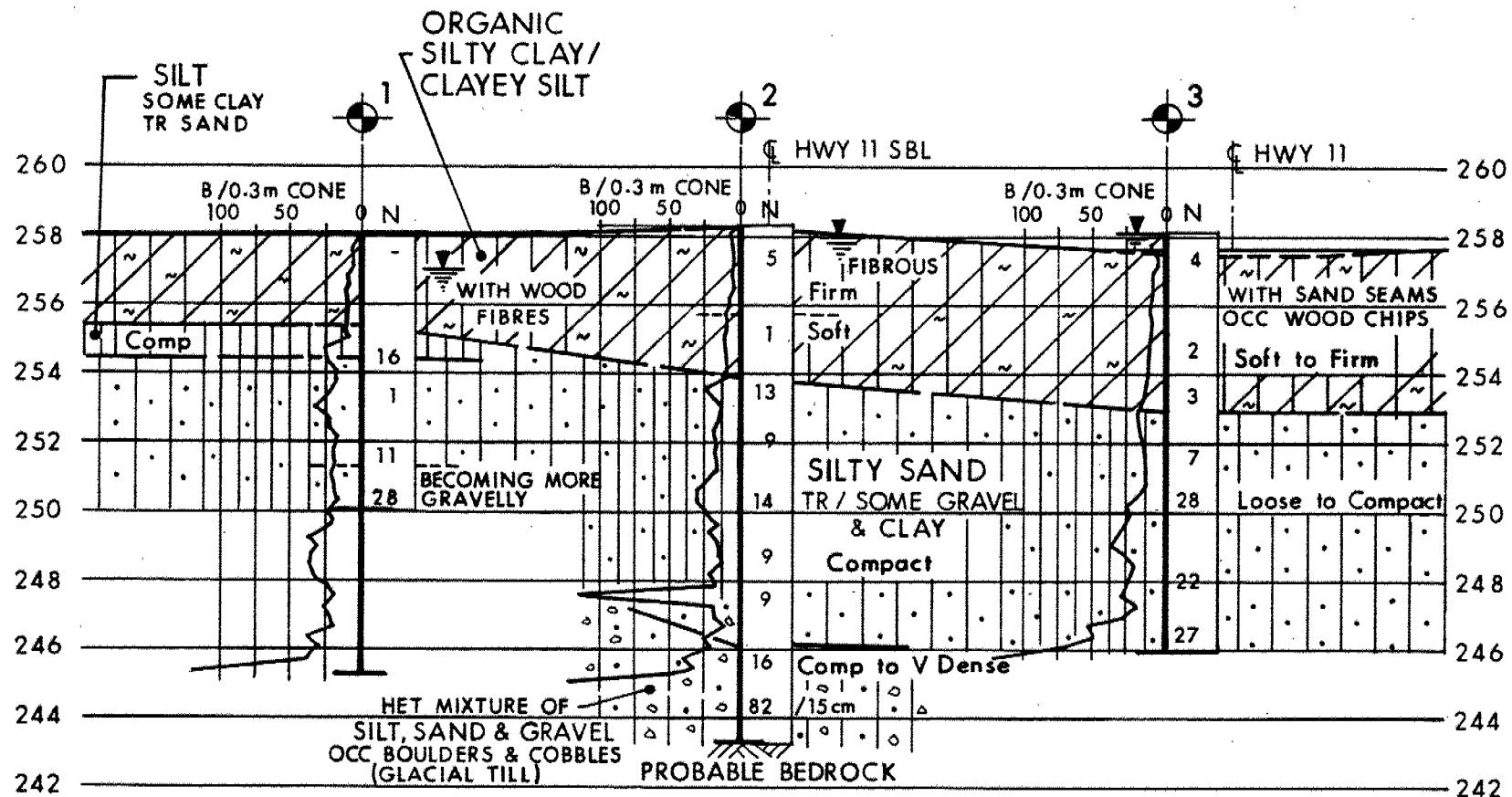
W.P. 589-92-01 LOCATION Co-ords : N 5 100 560.4 E 316 895.7 ORIGINATED BY DK/LS
DIST 13 HWY 11 BOREHOLE TYPE H.S. Auger, Cone Test COMPILED BY LS
DATUM Geodetic DATE 93 02 05 CHECKED BY BI

SOIL PROFILE			SAMPLES			GROUND WATER * CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT 7 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)		
								20 40 60 80 100							w _p w w _L		
258.3	Ground Surface							○ UNCONFINED	+ FIELD VANE								
								● QUICK TRIAXIAL	× LAB VANE								
								10 20 30 40 50				20 40 60					
0.0	Organic Silty Clay Fibrous Firm, Grey ----- Soft Dark Brown		1	SS	5		258										
			2	TW	PH		256						15.8	0 1 81 18			
			3	SS	1		254										
253.9																	
4.4	Silty Sand Trace Gravel and Clay Pink to Brown Loose to Compact		4	SS	13		252										
			5	SS	9		250							9 75 9 7			
			6	SS	14		248										
			7	SS	9		246										
			8	SS	9		244										
246.1			9	SS	16												
12.2	Heterogeneous mixture of Silt, Sand and Gravel Occasional Boulders and Cobbles Pink to Brown (Glacial Till) Compact to Very Dense		10	SS	82 /15cm												
243.3																	
15.0	End of Borehole Auger Refusal Probable Bedrock • Water level recorded 2 hours after the completion of augering.																

METRIC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT	PLASTIC LIMIT w_p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w_L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100					
258.1	Ground Surface												
0.0	Organic Clayey Silt With Sand Seams Occasional Wood Chips Grey, Soft to Firm	[Strat Plot]	1	SS	4								0 22 72 6
			2	TW	PH								0 4 78 18
			3	SS	2								0 44 50 6
			4	TW	PH								0 29 61 10
252.9			5	SS	3								
5.2	Silty Sand Some Gravel Loose to Compact Pink to Brown	[Strat Plot]	6	SS	7								
			7	SS	28								
			8	SS	22								
245.9			9	SS	27								
12.2	End of Borehole Auger Refusal + 93 02 05								120/25cm				

20
15-5 (%) STRAIN AT FAILURE
10



Note :

For Plan refer to 5899201-A