APPENDIX A

BOREHOLE LOGS

EXPLANATION OF TERMS USED IN REPORT

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

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

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

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

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

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

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

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

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

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

R Q D (%)	0 - 25	25 - 50	50 - 75	75 - 90	90 - 100
	VERY POOR	*POOR*	*FAIR*	*GOOD*	*EXCELLENT*

JOINTING AND BEDDING:

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

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

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

STRESS AND STRAIN

u_w	kPa	PORE WATER PRESSURE
r_u	1	PORE PRESSURE RATIO
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_t	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

PHYSICAL PROPERTIES OF SOIL

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

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RECORD OF Borehole No 106

1 OF 1 **METRIC**

W.P. 6031-03-00 PROJECT Foundation Investigation SITE NO. ORIGINATED BY HF

DIST 61 HWY 102 LOCATION 13+474.5 o/s 6.2m LT TBTE JOB# 08-011 COMPILED BY TB

DATE May 28, 2008 BOREHOLE TYPE Hollow Stem Auger DATUM Geodetic CHECKED BY GM

SOIL PROFILE ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED, ■ SPT (N), ✖ FIELD VANE, ★ LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
348.6								20 40 60 80 100	20 40 60		
348.5 / 0.1	ASPHALT - 80 mm										Dry on completion.
	FILL - SAND - Gravelly, trace silt, occasional cobbles, brown		1	AS			348				23 70 (7)
347.4											
1.2	CLAY - Silty, red, high plastic, very stiff		2	SS	10		347				
			3	SS	6		346				
			4	SS	7		345				
			5	SS	8		344				
343.3											
5.3	End of Borehole @ 5.3 m.										

✖³, ★³: Numbers refer to Sensitivity
NP Non Plastic
○³% STRAIN AT FAILURE

TBT Engineering Consulting Group

RECORD OF Borehole No 107

1 OF 2 **METRIC**

W.P. 6031-03-00 PROJECT Foundation Investigation SITE NO. ORIGINATED BY HF

DIST 61 HWY 102 LOCATION 13+475.0 o/s 11.9m LT TBTE JOB# 08-011 COMPILED BY TB

DATE May 30, 2008 BOREHOLE TYPE Hollow Stem Auger DATUM Geodetic CHECKED BY GM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS
347.7						
0.0 / 347.0	FILL - SAND - Gravelly, numerous cobbles, brown		1	AS		
0.7	CLAY - Silty, trace sand, red, high plastic, very stiff		2	SS	3	
			3	SS	5	
			4	TW		
			5	SS	6	
			6	TW		
			7	SS	6	
340.1						
7.6	SILT - some sand, trace clay, grey, compact to dense		8	SS	16	
	- - - - -					
	- occasional gravel layers		9	TW		
			10	SS	39	
	- - - - -		11	SS	45	
334.2	- trace sand					
13.5	SAND - Silty, grey, very dense to dense		12	SS	79	
			13	SS	46	

ELEVATION SCALE: 347, 346, 345, 344, 343, 342, 341, 340, 339, 338, 337, 336, 335, 334, 333, 332

DYNAMIC CONE PENETRATION RESISTANCE PLOT — 20 40 60 80 100

SHEAR STRENGTH kPa — 20 40 60 80 100
- ○ UNCONFINED
- ■ SPT (N)
- ✖ FIELD VANE
- ★ LAB VANE

PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L

WATER CONTENT (%) — 20 40 60

UNIT WEIGHT γ kN/m³

REMARKS & GRAIN SIZE DISTRIBUTION (%)

GR SA SI CL

Dry on completion.

0 6 (94)

0 67 (33)

Continued Next Page

✖3, ★3: Numbers refer to Sensitivity
NP Non Plastic
○3% STRAIN AT FAILURE

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RECORD OF Borehole No 107

2 OF 2 **METRIC**

W.P. **6031-03-00** PROJECT **Foundation Investigation** SITE NO. ORIGINATED BY **HF**

DIST **61** HWY **102** LOCATION **13+475.0 o/s 11.9m LT** TBTE JOB# **08-011** COMPILED BY **TB**

DATE **May 30, 2008** BOREHOLE TYPE **Hollow Stem Auger** DATUM **Geodetic** CHECKED BY **GM**

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED, ■ SPT (N), ✖ FIELD VANE, ★ LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	- - - - - - SAND & SILT		14	SS	56		331				0 47 (53)
							330				
329.0	- - - - - - SAND - Silty		15	SS	72						0 74 (26)
18.7	End of Borehole @ 18.7 m.						329				

✖³, ★³: Numbers refer to Sensitivity
NP Non Plastic
○ 3% STRAIN AT FAILURE

ON_MOT_BH-10 08-011 REVISED.GPJ ON_MOT.GDT 3/12/09

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RECORD OF BOREHOLE No 1-2005 1 OF 2 METRIC

W.P. _____ PROJECT Hwy 102 - Slope Indicator Installation SITE NO. _____ ORIGINATED BY SP

DIST 61 HWY 102 LOCATION Sta 13+478, o/s 17 m Rt TBTE JOB# J03-124-6 COMPILED BY SP

DATE 10 January 2005 BOREHOLE TYPE HS Auger - 105 mm ID DATUM Geodetic CHECKED BY WH

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (O UNCONFINED, ▩ SPT (N), ⌘ FIELD VANE, ✲ LAB VANE)	PLASTIC LIMIT W_P / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
344.2								20 40 60 80 100	20 40 60		
0.0	CLAY - HP, red, moist, very stiff						344				50 mm Topsoil
			1	SH							
				VANE			343	⌘			Field shear strength exceeded torque wrench capacity (100 kPa +)
							342				
	--- Varved structure: HP red clay layers (10-15 mm thick) with SP - MP light brown/grey clay varves (10-12 mm thick).		2	SH							
				VANE			341	⌘			
340.6											
3.6	SILT - sandy, moist, light brown, compact, laminated structure with sandy silt & silty sand layering		3	SS	19		340		●		Rough drilling, cobble at 3.6 m.
			4	SS	17				●		
			5	SS	22		339		●		
			6	SS	18		338		●		
			7	SS	27		337		●		
							336		●		
							335				

Continued Next Page

⌘ 3, ✲ 3 Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

TBT Engineering

RECORD OF BOREHOLE No 1-2005 2 OF 2 METRIC

W.P. _____ PROJECT Hwy 102 - Slope Indicator Installation SITE NO. _____ ORIGINATED BY SP

DIST 61 HWY 102 LOCATION Sta 13+478, o/s 17 m Rt TBTE JOB# J03-124-6 COMPILED BY SP

DATE 10 January 2005 BOREHOLE TYPE HS Auger - 105 mm ID DATUM Geodetic CHECKED BY WH

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED, ▩ SPT (N), ✕ FIELD VANE, ✳ LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	SILT - sandy, moist, light brown, compact, laminated structure with sandy silt & silty sand layering		8	SS	29		334				
							333				
							332				
			9	SS	28		331				
							330				
329.2 / 15.0	End of hole. Slope Indicator Casing Installed to 15.0 m below grade (329.2 m) Annulus backfilled with cement - bentonite mixture.										SPT completed with CME automatic hammer

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: 20 40 60 80 100

WATER CONTENT (%): 20 40 60

$\times^3$ $\star^3$ Numbers refer to Sensitivity $\bigcirc^{3\%}$ STRAIN AT FAILURE

ON_MOT_NEEBING RIVER 03-124-6.GPJ ON_MOT.GDT 3/3/05

RECORD OF BOREHOLE No 1-1996 1 OF 1 METRIC

W.P. 849-97-00 LOCATION Sta 13+458.5 o/s 1.1 m Rt. from CL of Hwy. 102 ORIGINATED BY M.M.

DIST 61 HWY 102 BOREHOLE TYPE Hollow Stem Auger COMPILED BY M.M.

DATUM Geodetic DATE 1996 11 20 CHECKED BY T.K.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT W_P / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L WATER CONTENT (%) 25 50 75	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
349.7	Paved Road Surface										
0.0	Mixture of Silt, Sand and Gravel Some Cobbles and Boulders [FILL] Compact to Very Dense		1	SS	15	DRY	349				
			2	SS	8		348				22 65 10 3
347.3	Brown										
2.4	Brown/Red Clay, Some Silt Very Stiff		3	SS	27		347				
			4	SS	9		346	⊕ >100 +			
			5	TW	PH		345	* UU Test of 160 kPa ⊕ >120+		16.7	0 0 13 87
343.1	Brown/Red		6	SS	8		344	⊕ >120+			
6.8	Brown/Grey Sandy Silt Very Dense						343				
			7	SS	57		342				
340.1			8	SS	55		341				0 8 84 8
9.6	End of Borehole										

+³, ×⁵ : Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No 2-1996 1 OF 1 METRIC

W.P. 849-97-00 LOCATION Stat 13+476.5 o/s 2.1 m Rt. from CL of Hwy. 102 ORIGINATED BY M.M.

DIST 61 HWY 102 BOREHOLE TYPE Hollow Stem Auger COMPILED BY M.M.

DATUM Geodetic DATE 1996 11 20 CHECKED BY T.K.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 25 50 75	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
348.7	Paved Road Surface										
0.0	Brown Mixture of Silt, Sand and Gravel Some Cobbles and Boulders FILL 1 Compact to Very Dense		1	SS	80	DRY	348				
			2	SS	22		347				59 29 11 1
			3	SS	37		346				
345.5	Wet Zone										
3.2	Clay, Some Silt Very Stiff		4	SS	13						
			5	SS	8		345				
			6	SS	10		344	> 120+			
			7	TW	PH		343	●		17.6	0 0 17 83
340.1							342	> 120+			
			8	SS	18		341				
8.6	Sandy Silt Dense		9	SS	42		340				
			10	SS	43		339				0 17 80 3
338.1							338				
			11	SS	40		337				
12.6	End of Borehole										

+³, x⁸ ; Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No 3-1996 1 OF 1 METRIC

W.P. 849-97-00 LOCATION Sta. 13+486.0 o/s 2.5 m Rt. from CL of Hwy. 102 ORIGINATED BY M.M.

DIST 61 HWY 102 BOREHOLE TYPE Hollow Stem Auger COMPILED BY M.M.

DATUM Geodetic DATE 1996 11 20 CHECKED BY T.K.

ELEV DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 25 50 75	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
348.3	Paved Road Surface										
0.0	Mixture of Silt, Sand and Gravel Some Cobbles and Boulders [FILL] Compact to Very Dense					DRY	348				
345.1							347				
3.2							346				
							345				
	Clay, Some Silt Very Stiff		1	SS	36		344				0 8 22 70
			2	SS	12			> 120+			0 1 26 73
							343				
			3	TW	PH		342				
							341				
			4	SS	14						
339.7							340				
8.6	Sandy Silt Dense		5	SS	>120		339				
							338				
337.2			6	SS	37						1 17 78 4
11.1	End of Borehole										

+³, ×³ Numbers refer to Sensitivity

$\frac{20}{13}$ ◇ S (%) STRAIN AT FAILURE
10