

.

Ċ

ISSUE #23

FOUNDATION REPORT FOR CROSSING

AΤ

RIVER BETWEEN TWO MOUNTAINS MILE 411 MACKENZIE HIGHWAY NORTHWEST TERRITORIES

ACRES CONSULTING SERVICES LIMITED Suite 990 - 125 - 9 Ave. S.E. Calgary, Alberta T2G OP6

TABLE OF CONTENTS

		Page No.
1.	INTRODUCTION	1
2.	SITE AND GEOLOGY	1
3.	FIELD INVESTIGATION AND LABORATORY TESTING	2
4.	FOUNDATION CONDITIONS	3
5.	RECOMMENDATIONS AND CONCLUSIONS	5
5.1	Abutment and Pier Foundation Design	5
5.2	Lateral Abutment Loads	7
5.3	Bridge Approach Embankments	8

APPENDIX

LEGEND			A-1
NOTES REI	LATING	TO PHOTOMOSAICS	A-2
DEFINITI	ONS		A-3
Figure l	-	MOSAIC AND TESTHOLE LOCATION PLAN	
Figure 2	-	SITE CROSS SECTION AND BOREHOLE PROFILES	
Figure 3	-	UNIFIED SOIL CLASSIFICATION SYSTEM	
Figure 4	-	NRC/ACFEL ICE CLASSIFICATION SYSTEM	
	-	TESTHOLE LOGS:	
		411-C-H	
		411-C-I	
		411-S-J	
		411-S-K	
		411-S-M	
		411-C-N	
		411-C-0	

1.0 INTRODUCTION

This report contains the results of the foundation investigation and recommendations for foundation and embankment design for the River Between Two Mountains crossing at Mile 411 on the Mackenzie Highway, Northwest Territories. The field investigation at this site was part of the overall geotechnical investigation conducted by Acres Consulting Services from Mile 346 to Mile 450 on the Mackenzie Highway for the Department of Public Works, Government of Canada.

The purpose of the investigation was to determine the site foundation, permafrost and groundwater conditions and to provide recommendations on the design and construction of the proposed bridge piers and abutments, and approach embankments.

2.0 SITE AND GEOLOGY

The River Between Two Mountains crossing site is located at Mile 411.6 (chainage 874 + 00) on the Mackenzie Highway. This site is approximately 1/2 mile upstream from the junction of the River Between Two Mountains with the Mackenzie River.

The crossing site is located at the mouth of the River Between Two Mountains valley where it enters the valley of the Mackenzie. Borings to a maximum depth of 60 feet revealed very dense, alluvial, sand, gravel, cobbles and boulders as the foundation material indicating the bridge site is located on coarse fluvial fan. Although bedrock was not encountered at this site, bedrock in the

2.0 SITE AND GEOLOGY - Continued

area is horizontally bedded shale, siltstone, sandstone, and limestone of the Fort Simpson Formation of Devonian age. The stream bed elevation at the proposed crossing site is approximately 276 feet (D.P.W. datum). The length of the bridge is 260 feet and 3 spans are proposed by the bridge consultants.

3.0 FIELD INVESTIGATION AND LABORATORY TESTING

A total of seven testholes were drilled at the crossing site along centreline to depths ranging from 8 to 60 feet at locations shown in Figure 1. Holes were drilled on the bridge abutment sites to depths of 40 to 60 feet. One hole was drilled in the river bottom to a depth of 60 feet. Four holes were drilled on the floodplain for the approach embankments to depths ranging from 8 to 15 feet. Figure 2 shows a centreline section of the site.

The drilling and sampling at the crossing site was done between February 9 and February 11, 1973 by Kenting Big Indian of Calgary utilizing a Gardner-Denver 200 "helidrill" mounted on a Foremost 60 tracked vehicle.

Sampling was done using the air recovery percussion method for disturbed samples, 3 inch thin-walled Shelby tubes for undisturbed cohesive soil samples and the standard split spoon for granular soil samples. Standard Penetration blow counts were taken with the split spoon sampler.

Samples were logged in the field and classified according to the Unified Soil Classification System as shown in Figure 3.

3.0 FIELD INVESTIGATION AND LABORATORY TESTING - Continued

Ice contents were classified according to the N.R.C. Technical Memorandum No. 75 "Guide to the Field Description of Permafrost" as shown in Figure 4.

Moisture contents were obtained for all samples returned to the laboratory and the samples were subjected to routine classification tests including grain size distribution and Atterberg limits. The results of all laboratory and field tests are included in the testhole logs appended to this report.

4.0 FOUNDATION CONDITIONS

The following boreholes were drilled to investigate the foundation conditions at the bridge abutment and pier locations:-

HOLE NUMBER	LOCATION
411-S-K	South Abutment
411-S-J	River Centre
411-S-M	North Abutment

The detailed soil descriptions for these holes is given in the borehole logs appended to this report. Only one testhole was drilled in the centre of the river to provide data for the piers. A review of the testholes drilled at this site showed an additional pier hole was not warranted due to the uniform foundation conditions encountered throughout the area.

4.0 FOUNDATION CONDITIONS - Continued

Testhole 411-S-J was drilled to a depth of 60 feet into the riverbed. The soil was unfrozen throughout the entire depth of the hole and consisted of very dense sand, gravel, and boulders with a trace of silt. Blow counts from the Standard Penetration test ranged from 46 per foot to 50 blows per 4 inches or virtual refusal.

Testhole 411-S-K was drilled to a depth of 60 feet on the site of the south abutment. The soil was unfrozen throughout the entire depth of the hole and consisted of very dense sand and gravel with boulders and a trace of silt. Blow counts from the Standard Penetration test were very high and ranged from 50 blows per 6 inches to 50 blows per 1 inch or virtual refusal.

Testhole 411-S-M was located on the site of the north abutment and was drilled to a depth of 40 feet. The foundation conditions were similar to the previous two holes and consisted of very dense, unfrozen, sand and gravel with cobbles throughout the full depth of the hole. Blow counts ranged from 82 per foot to 20 per zero penetration or refusal.

The testholes drilled on the floodplain on both sides of the river showed dense sand and gravel overlain locally by 1 to 4 feet of peat and several feet of fine siltysand.

The peat and silty-sand are characterized by high water contents and hence have a low, undrained shear strength. The soils in these holes were frozen throughout with the exception of testhole 411-C-N where the soil was unfrozen from 13 feet to the end of hole at 15 feet.

5.0 RECOMMENDATIONS AND CONCLUSIONS

The following conclusions and recommendations are made, based upon the results of the investigation program, for the design and construction of the River Between Two Mountains bridge foundations and approach fills.

5.1 Pier and Abutment Foundation Design

The subsurface investigation program previously described shows that the foundations at this site are composed of uniform, unfrozen, very dense sand and gravel with cobbles and boulders. It is recommended that consideration be given to founding the abutments and piers on spread footings in the dense granular alluvium below the depth of seasonal frost penetration. An allowable bearing capacity of 3 tons per square foot is recommended.

If however, due to considerations of river scour, frost penetration, and lateral pier and abutment loads, a more conservative foundation method is considered necessary, a driven friction pile foundation is recommended for the bridge piers and abutments.

Friction pile types include precast concrete and steel pipe and H piles. Steel H piles are recommended primarily for their high driving strength, high load capacity and ease of splicing. The pile section selected should have a flange and web thickness no less than 9/16 inch.

It is recommended that all piles be driven to a depth of 30 feet or "refusal". As an initial guide, it is recommended that "refusal" be considered to be 360 blows per foot (30 blows per inch) under a hammer rated at 15,000 ft-lb.

5.1 Pier and Abutment Foundation Design - Continued

Ultimate capacity should be established in the field by use of dynamic pile driving formulae. The Janbu formula (Terzaghi and Peck, 1967¹) should be used with a factor of safety of 3 to establish an allowable load per pile.

If refusal is not achieved during driving, the capacity of the pile can be calculated based upon friction between the pile and the granular soil.

It is recommended that for initial design purposes, the allowable bearing capacity be based upon a friction of 800 psf over the surface area of the H pile. Thus an HP 10 x 57 pile would have an allowable bearing capacity of approximately 50 tons if driven to a depth of 30 feet. This figure should be confirmed by use of dynamic pile formula during pile driving and modified, if necessary, to correspond with field results.

Premature refusal may occur during pile driving if large boulders are encountered which cannot be penetrated. Load tests may be required to establish allowable loads per pile if this occurs.

Settlement of the foundation under the weight of the approach embankments will not be significant, hence negative skin friction need not be considered in the pile design.

¹Terzaghi K., and Peck, R.B., 1967. <u>Soil Mechanics in</u> <u>Engineering Practice</u>, John Wiley and Sons, 2nd Edition, p. 229.

5.2 Lateral Abutment Loads

The approach cuts will have a maximum height of approximately 25 feet and it is recommended that they be constructed of fill compacted to a minimum of 98 percent Standard Proctor density of material from the adjacent borrow pits and approach cuts. Due to compaction, earth pressures against the concrete abutment and wing walls will be larger than the active case and will approach the earth pressure at-rest case.

It is recommended that the lateral earth pressure design should use a triangular load distribution using a coefficient of earth pressure at-rest (K_0) of 0.50 with due allowance for any surcharge or live loads acting near the wall.

Either the Coulomb or the Rankine method of calculation of earth pressure against the wall may be used. It is recommended that the angle of shearing resistance of the compacted fill be taken as 30 degrees and the dry density of the granular fill be taken as 120 pcf. If the Coulomb method is adopted, the angle of wall friction between the concrete and the granular fill should be 15 degrees.

Extensive use of measures to ensure proper drainage of the backfill behind the abutment wall, to prevent the development of hydrostatic pressure against the wall, is strongly recommended. The measures adopted should include the use of perforated steel pipe drains at the base of the wall, weep holes through the wall, and the use of select, freedraining, granular fill immediately behind the wall.

5.3 Bridge Approach Embankments

The grades presently proposed for the River Between Two Mountains bridge will result in embankments with a maximum height in the order of 25 feet. These embankments will generally overlie dense granular material and excavation of the surficial materials is not recommended. Some settlement of the surficial peat and silty-sand deposits can be expected but this should be significant only in the region of Station 867 + 00 where 4 feet of peat and silty-sand overlie the dense sandy-gravel.

Settlement of the embankment in the order of 9 inches can be expected in this area and it is recommended that the approach embankments be constructed a minimum of 6 summer weeks prior to the bridge construction.

The embankment should be compacted to a minimum density of 98 percent Standard Proctor density. The maximum lift thickness recommended is 9 inches.

Data from the project hydrology consultants (Bolter, Parish, Trimble Ltd. of Edmonton) shows that occasional abnormally high water levels will occur due to ice jams on the Mackenzie River. Hence, the approach embankments must be designed for stability against rapid drawdown conditions. If the embankments are constructed from free-draining granular fill containing a minimum of fines, embankment slopes as steep as 2.5 horizontal to 1 vertical may be used. However, a study of the material in the approach cuts and adjacent borrow pits (borrow pits 410-No. 1, 411-No. 1 and 412-No. 1) shows that mainly clayey-silt till is available as borrow material. If this material is used for embankment fill, the maximum recommended embankment sideslopes are 3.5 horizontal to 1 vertical.

5.3 Bridge Approach Embankments

The embankment sideslopes should be armoured against the effects of high water levels with a minimum thickness of 18 inches of rip-rap having a minimum diameter of 6 inches. Size and thickness of the rip-rap should be increased in those areas of the embankment subject to high velocity water flow. If the embankment fill contains a high percentage of clay and silt-sized particles, a properly designed filter layer will be required between the rip-rap and the underlying embankment material.

Potential sources of rip-rap recommended for consideration are the floodplain of the River Between Two Mountains and potential rock quarry and talus slope sites along Bell Ridge of the Franklin Mountains, lying approximately 3 miles east of the crossing site.

APPENDIX

1

2 1 • •

1

÷.,

LEGEND

PHOTOGEOLOGIC AND BOREHOLE MAPPING

F	- Frictional soils (sand, gravel)
T	- Transitional soils (silt, mixed silty soils)
C	- Cohesive soils (clay)
0	- Organic soils (peat)
R	 Bedrock, outcrop or under shallow overburden
ICE	- Massive ground ice
. /	- Example - O/T organics overlying transitional soils
- ()	- Example - (ICE) possible or occasional ground ice
	- Beach
	- Slides or slumping of slopes
- ×	- Spring
₩ 421-BT-1	- Test Trenches
• 421-C-D	- Centreline boreholes
• 421-B-J	- Borrow source boreholes
	- Outline of potential borrow sources

NOTES RELATING TO PHOTOMOSAICS

- 1. The drill hole locations marked on the photomosaics are transferred from the locations marked on the airphotos used in the field and have been plotted relative to the topographic features and not in accordance with the actual mile posts. In some instances the borehole chainages as determined from field surveys do not agree with the mileages noted on the drawings.
- The photomosaics on which the data has been plotted were those supplied to Acres by D.P.W. on February 8, 1973.

DEFINITIONS

SYMBOL	
wl	- Liquid limit
w p	- Plastic limit
w _n	- Natural water content
Ip	- Plasticity index
psf	- pounds per square foot
pcf	- pounds per cubic foot
к _о	- Coefficient of earth pressure at rest



1		
PROPOSED		
↓ T . 		
<u>sm</u>		
	-	
<u>SM</u>	•	
.*		
r		
†		
	 860+00	
NS TO D.PW. D	DATUM.	
RILLED FEBUAR	24 9-11,	
ING BIG INDIAN ARDNER-DENVER	J DRILLING 200	
	LADI	
	ASIL	3
MACKENZIE Department of	E HIGHWAY	
		-
IVER BETWEEN TWO TE CROSS SECTION &	MOUNTAINS CROSSING Borehole profiles	
N JC SCALE D	DRAWING NO.	
JUNE / 73 SHOWN	FIGURE 2	

UNIFIED SOIL CLASSIFICATION SYSTEM

SOIL CLASSIFICATION CHART

MA	JOR DIVISIONS	5	LETTER SYMBOL	TYPICAL DESCRIPTIONS
	GRAVEL AND	CLEAN GRAVELS	GW	WELL-GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES
COARSE	GRAVELLY SOILS	(little or no fines)	GP	POORLY-GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES
SOILS	more than 50% of coarse fraction	GRAVELS WITH FINES	GM	SILTY GRAVELS, GRAVEL-SAND- SILT MIXTURES
	RETAINED on no. 4 sieve	amount of fines)	GC	CLAYEY GRAVELS, GRAVEL-SAND- CLAY MIXTURES
	SAND AND	CLEAN SAND	sw	WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
more than 50% of material is LARGER	SANDY SOILS	fines)	SP	POORLY-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
rhan no. 200 sieve size	more than 50% of coarse fraction	SANDS WITH FINES	SM	SILTY SANDS, SAND-SILT MIXTURES
	PASSING no.4 sieve	amount of fines)	sc	CLAYEY SANDS, SAND-CLAY MIXTURES
			ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY
FINE GRAINED SOILS	SILTS AND CLAYS	liquid limit LESS than 50	CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
			OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
			мн	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILTY SOILS
of material is SMALLER than no. 200	SILTS AND CLAYS	liquid limit GREATER than 50	СН	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS
sieve size			он	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
HIG	HLY ORGANIC SOI	LS	PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

- - - -

NRC/ACFEL ICE CLASSIFICATION SYSTEM

ICE CLASSIFICATION CHART

	MAJOR GR	OUP		SUB-GROUP		
	DESCRIPTION	DESIGNATION	DESCR	IPTION	DESIGN	ATION
	SEGREGATED		POORLY OR FR	BONDED IABLE	N	f
	ICE IS NOT VISIBLE BY EYE	N	WELL	NO EXCESS		n
			BONDED	EXCESS ICE	NB	•
FROZEN SOIL			INDIVID CRYSTA INCLUS	UAL ICE ILS OR SIONS	V	x
	SEGREGATED ICE IS VISIBLE BY EYE	v	ICE CO ON PA	ATINGS RTICLES	v	:
	(ICE 1 INCH OR LESS IN THICKNESS)		RAND IRREGULAR ICE FOR	OM OR LY ORIENTED MATIONS	V	r
			STRATII DISTINCTL ICE FOR	FIED OR Y ORIENTED MATIONS	v	5
DESCRIPTION OF	ICE (GREATER THAN 1 INCH	ICE	ICE WI INCLU	TH SOIL DSIONS	ICE 4	SOIL PE
STRATA	IN THICKNESS)		ICE W SOIL INC		ю	E

		AC	RES	c			S SERVICES LIMITED		DRILL	но	LE F	REPO	ORT		DE	PAR		OF	PU NZ	BLI	C V HIG	VOF	RKS ,	, CAN	ADA	
DWN			FIEL	DE	NG G	.P.S.	DATE DRILLED 8/2/73 AIR	PHOT	0 NO: A2277	$\frac{2-1}{2}$	07 СН	AINAG	E: 865	+ 70	7	<u>.</u>	OF	FSET	EL EL	2.29	81 7	2		TEST	HOLE	
CKD			IEC	Z	54	VAND			ICE				VEGEN			·		GR A	AIN- S	IZE		TY	7	MILE	B,C,S	NUMBER
DEPTH FEET)	MPLE MBER	APLE APLE	re cove	STANCE	IFIED SYMB	SOII	L DESCRIPTION	TS OF	DESCRIPTION	DEPTH FEET)	() = ₩4 () = IC	E CON	CONTENT	" (% 01 % OF S	F DRY	VOLUM) E }	CLAY	SILT	SAND	GRAVEL	DENSI	DENSI P.C.F.)	411	С	Н
	SA	SAN	ж	PENE	SOIL			LIMI1 FROZ				PI 20	LASTIC	60	LIQ 5		100 100	+ %	%	%	%	¥ET (Υ ^B C	R	EMARKS	
2.	1				SM	Brc san	own fine silty d '		Nbn	2	φ															
4					SW	Bro wit	own sand and grave th some silt	l F	Nf	4																
6	2				0.01					6	¢															
10	2				Sw					10																
12	3				รพ					12	Ø															
14										14			$\left \right $		_		+	_								
16						End	i of hole at 15'			16																
18										18																
20-										20								-								
22										22								_								
24										24								-								

*

	ß	,	ACF	RES	C	ONS		TING GARY	S , A			LIMI	TED		DRILL	но	LE	RE	PO	RT				DE	PAF	RTN	ENT MA	OF CKE	PU NZ	BLI IE	C V HIC	NOF SHV	RKS	, CAI	NADA	
DW	N:			FIEL	DE	NG: (<u>G.</u> F	•.s.	DAT	EDR	ILLED	8/2/73		рнот	O NO: A2277	2-1	07	CHAI	AGE	E: (866	5 +	95				OFF	SET		<u> </u>				TES	T HOLE	
СК): T		\rightarrow	TEC	H: F	₹• SZ	AVA	ARD	RIG	:	1		SUP	FACE	DRAINAGE	<u>GOO</u>	D			VEGE	TAT	10 N		<u>A</u>				+	ELE	V 2	75.	<u>5</u>				
E		r	ľ	VERY	TI ON VCE	NB01		SOIL	D	ESCR	RIPTIO	N		0F SROUND	ICE DESCRIPTION		0	= WATE	RC	ONTEN	іт (% 01	FDR	17 W	EIGH	т)		GRA	IN- S	IZE S		SITY	SITY)	MILE	B,C,S	NUMBER
DEP	MPL.			RCO	ETRA	E E			_					S N		FEE.		= ICE	CON	TENT	(%	OF S	AMP	LE V	VOLU	ME)		CLAY	SILT	SAND	RAVE	0EA C F	DEN C.F.	411	C	I
	SA		, i	%	PEN	N O								FROZ				20	PL. Ł	ASTIC		60	1	LIQUIO LIMII 80	r 	100	100+	%	%	%	%	ТЩ Ш	0RY (P		REMARK	S
1.5		.Λ				<u>Pt</u>				PEA	<u>T</u>				Nbn										_			-						Hit	a har	d
			\setminus			БМ		Sil	ty	San	nd					2					-						/	Ģ						bou so l	lder a Nole w	t 8' as
						GM										4										4								aban shi	doned	and 0'
	-	\mathbf{k}	. 1			+	-	Gra som	vel e c	ly obb	sand les	l wit and	th a	F	Nf						+		\rightarrow	\checkmark	-			-						hole	a whe 411-	re C-Ia
	2	2	\setminus					few	bc	ould	lers					6				- 6	1													Was	arttr	ea
8		+				+	+	End	of	ho	ole a	at 8'				+ 8		╉┈╂			-					+										
10			ľ													10																				
																		┼──┼										-	-							
																						_														
14																14			_		_							1								
16																16																				
																10	-											-								
"	']															1.9										\square		-								
20																20-												1								
22																22			\neg					_				-								
																20																				
24	1															24	Γ	T										1								

	5	AC	RES	C	ONSI		SERVICES			DRILL	но		ER	EPO	DR1	r	-,		DE	PA	RTN		OF CKE	PU NZ	BLI	C V HIC	VOF	RKS	, CAN	ADA	
DWI	l:		FIEL	DE	NG		DATE DRILLED	9/2/ AIR	PHOT	O NO: A2277	2-1	08	CHA	INAG	E		8	73+	-12			OFF	SET						TEST	HOLF	
CKD	: T		TEC	H :	м.	н.к.	RIG 2	SUF	FACE	DRAINAGE	<u>GOO</u>	D			VEC	ETA	TION	:	A	F				ELE	V: :	274	.0				
			RY	8 u	ior.				OND ON	ICE													GRA	IN- S	IZE S		Ł	Ł	MILE	B,C,S	NUMBER
EPTH EET)	PLE	5	COVE	TANC	SYMB	SOIL	DESCRIPTION		N GR	DESCRIPTION	PTH EET)) = WAT			ENT	(%) 6 OF	OF D			HT) LIME)		AY	L	Ň	AVEL	ENSI	ENSI	411	s	J
105	SAMUN	SAME	a.	ENET	S N				NITS OZE					PL	ASTI	c .	0 01	0	LIQU		UNC /		อี	s	SA	GR	ET (Х - С			
			%		S				5 6				2	0		<u>ہ</u>	60)	LIM	IT)	100	100 +	%	%	%	%	3	ă	R	EMARKS	
		N																													
		$ \rangle$				BROW	N SAND AND	GRAVEL															1								
۲ (1	$ \rangle$			GM	WITH	BOULDERS				2	\vdash											1								
		$ \rangle$									ĺ	\vdash	1					-					1								
4		$ \rangle$									4	\vdash	-								+		1								
												\vdash						-	+		-+		1								
6											6	+	-							- †			1								
												\vdash	-							-+			1				1				
8											8.	╋	+									·····	1								
												\vdash								-+	-+		1								
סו	2	Ρ		46			DO-				10	┢							\rightarrow	-+	-+		{								
																			\rightarrow	-			{								
12											12	┢											-								
																							-								
14											14	+							$ \rightarrow $												
													_	-						_											
16											16	L											ļ								
													_														1				
18											18-																				
20.	3	ъ		50		_	DC				20																				
20	5			4"							20.																				
20																															
22.											22	Г	1						- +				1								
													1				_						1								
24											24	\top	1										1								

		A		S C	ONS		S SERV	ICES L	IMITED		DRILL	HO)LE	RE	EPC	RT			D	EPA	RTN		OF CKE	PU NZ	IBLI IE		NOF	RKS	, CAN	ADA	
CKE	:		TE		4.H	.R.	RIG:	2		PHOT	O NO:A22772	-10	8	CHA	NAGE		87	3+12	?		<u>ज</u>	OFF	SET			274			TEST	HOLE	
			ERY	N UN	BOL		·		1	ONNO	ICE					VLOL					<u> </u>		GRA ANA	IN- S	SIZE	2/4		۲	MILE	B,C,S	NUMBER
DEPTI (FEET	SAMPLE	AMPLE	RECOV	NETRAT	INIFIED	SOI	_ DESCF	RIPTION		TS OF	DESCRIPTION	DEPTH (FEET)		= WAT = ICE	ER C	ONTEN TENT	т (% (% 0	D OF	DRY MPLE	WEIG	HT) UME)		CLAY	SILT	SAND	RAVEL	DENSI7	DENSI'	411	S	J
<u> </u>	•, z	s	8		ŝ					L IM F RO				2(PL)	ASTIC H		60	, LIQ LI	NID MIT	100	100+	%	%	%	%	WET (F	Σ ΒΟ Υ	R	EMARKS	
25						GRE WIT	Y SAND H SILT	AND AND	GRAVEL COBBLE:	6		2																	AT P RIVE TWO	IER L R BET MOUNT.	OCATION WEEN AINS
30	4	P	4	67/ 67/	GP					UF		6																			
												8-			-+	_															
												10-																			
	ĺ											12									+										
14 40	5	P		80	GP							14																			
16												16																			
18-												18-					-				_										
45												20-					1														
22	6				GP							22-			_								0	5	30	65					
24						-						24																			

		AC	RES	С	ONS		; с У, А		ES L	IMITED		DRILL	нс	LE	R	EP	OR	Γ			DE	PAF	RTN	MENT	OF CKE	PU NZ	IBL IE	IC N HIC	NOF	RKS	, CAN	ADA	
CKD			FIEL	DE M	NG:	R.	DAT		ED	A	RPHOT	TO NO: A2277	2-1	08	СНА	INAG	E:		873	+	12			OFF	SET	:					TEST	HOLE	
							INIG		-	3		DRAINAGE	<u>GQO)</u> 	<u> </u>		_	VEC	ETA	TION	A	<u>F</u>					ELE		274	<u>, 6</u>				
			ERY	N N N	BOL						INNO	ICE													AN	ALYS	IS		₹	Ţ	MILE	B,C,S	NUMBER
EETH	PLE	щщ	COVI	TAT	IED SYM	SOIL		DESCRIP	TION		5 6	DESCRIPTION	ET H	0	= WA1	TER	CONT	ENT	(%)	OF D		WEIGH	HT)		ž	F	9	VEL	ENSI	ENSI	411	6	.
	NUN	AMP	RE	NET SIS	IL N						DZEA		E E		- 102	COr P	ASTI	r (9 c	6 UF	SAM	IPLE	VOLU	INE	,	C	SIL	SAI	GRA			411	5	5
-	_		*	a. 2	Ň	l									2	20	LIMIT	° —	60	,			100	0 100+	%	%	%	%	۳.	RQ ~	R	EMARKS	
50		N											Ι			Γ										1		1					
									ı		ł				\mathbf{t}								+										
2	7	$ \rangle$			GP								2	†	!	<u> </u>							-+										
														<u> </u>	+								-+		0	5	55	40					
4		$ \rangle$											4	<u> </u>	+	<u> </u>	+				\rightarrow	-+	-+										
55											UF.					-	$\left \right $						\rightarrow						1				
6													6	<u> </u>		<u> </u>							_										
														L	L	-							$ \downarrow$										
8													8																				
60																									1		į –						
						El	ND	OF HO	LE	AT			יטי ך												1								
								60'							<u>†</u>								-+		1								
12													12		<u>†</u>						-+		-+		1								
															\vdash		+						+		1								
14													14		<u> </u>	<u> </u>							-										
														<u> </u>	 		┥								{								
16													16							$ \rightarrow $			_										
18													18															ļ	Ì				
													1.0										T										
20																									1								
201													20-												1								
																							+		t								
22													22.			-			\vdash				+										
																		_					+			1							
24													24	-											-								
										_																1	1		I I				ļ

		AC	RES	co		JLTING	SERV	ICES LIMITE	ED	DRILL	но	LE	REI	POR	Т		DE	PAR	TMEI	NT (MAC)F KE	PU NZI	BLI	C V HIC	VOR	RKS	, CAN	ADA	
DWN			FIEL	DEN	IG:		DATE DR	ILLED 9/2/73	AIRPHOT	0 NO A22772	-10	8	CHAIN	AGE		873	3 <u>+</u> 7	0		OFFS	ET :						TES	T HOLE	
T					M.	R.	RIG	2	SURFACE	DRAINAGE	<u>1N</u>	RIVE	R	VE	GETA	TION	NIL	<u>- RIV</u>	/ER			ELE	V: 2	268				1	
PTH ET)	E B	Ψ	OVERY	ATION	ED YMBOL	SOIL	DESCR	RIPTION	OF GROUND	ICE DESCRIPTION	H L	0 =	WATE	RCON	TENT	(% OF	DRY W	WEIGHT)				S S	ĒL	NSITY 5)	NSITY =_)	MILE	B,C,S	NUMBER
DEI DEI	U MB	AMPL	BEC	NETR	INIF S				ITS		DEP		ICE C	ONTE	NT (9	OF SA	MPLE	VOLUM	E)		CLA	SIL	SAN	GRAV	P C F	P.C.F	411	S	K
	v, z	ŝ	%	PE	°°°				FRC				20	LIMI	r° ⊢	60		IT	1 0 0	100+	%	%	%	%	× ×	, БР С	F	REMARKS	5
						Brow with	n sand some	ly gravel silt and											-								Dri	lled c	on
2					GP	boul	ders		UF		2																Riv Two	er Bet Mount	tween ains,
4											4																Hol 25	e Case Et.	ed to
6											6																		
8											8.		+	-			+-+												
10						Sand	and g	ravel wit	:h		10								1										
12	Í				GP	trace	e of s	ilt											+										
12											12.																		
14-											14								-	_									
16											16-			-					ļ										
																	+		+										
18-											18-																		
20					GP						20-		-																
22											22																		
~~																			-										
24		Y									24-			_			+		+										

ici e	\$	AC	RES	cc	DNSL c		SERV	ICES LIMI	TED		DRILL	но	LE	RE	POR	т			DEF	PART		OF CKE	PU NZ	BLI IE		VOR	KS	, CAN	ADA	
DWN	<u> </u> ;		FIEL	DEM	NG:		DATE DR	ILLED 9/2/7	7 3 AIRE	рнот	O NO A2277	2-1	08	CHAIN	AGE		373	+ 7	0		OF	SET	1					TEST	HOL	Ξ
CKD	:		TEC	H:	M.	R.	RIG	2	SUR	FACE	DRAINAGE IN	<u>, RI</u>	VER		VE	GETA	TION	:				1.004	ELE		266					
				z	4					Ñ	ICE											ANA	LYSI	S		۲۲	7	MILE	B,C,S	NUMBER
ΞĒ	ωœ		VER	NCE	aW	SOIL	DESCR	RIPTION		GRO	DESCRIPTION	₹£	0 =	WATE	R CON	TENT	(%	OF DI	RY WI	EIGHT)		2	-	9	VEL	NSI I	EN SI	411	S	К
OEP (FEE	MPL	MPL	REC	ETR	L S'					TS		DEP		ICE C	ONTE	NT (9	6 OF	SAMI	PLE V	OLUMI	E)	5	SIL	SAP	GRA	10 L	ōυ ≻∎			
	S S	¢ ⊾	%	PEN	5 os					F B				20	LIMI					! •	00 100	• %	%	%	%	¥ ₹	5	R	EMARK	S
26		P		59 / 3'	GP											Ť.		Ť	Ť									Dril	led	on
20-]	1				Sand	and g	Jrave ₁ w	itn a		ł	2									l							Rive	er Be	tween
2,						trac	e of s	silt														_						Two	Moun	tains
4										UF																				
30-	1																			Į			Ì		i					
6	1					r						0			1															
																						1								
8				1								6				1	†					1								
					 												ł				1	1		ĺ						
35	4	\geq	ľ	246	GP							10				+	<u> </u>			-	-	-								
		$\frac{P}{P}$		Þ%	1												1	-		-	1	1								
12	F											12	+					<u>├</u>				-								
													<u> </u>					<u> </u>				-								
14												14					<u> </u>													
													 		_						+	4								
16	1											16	_				<u> </u>	 												
																	ļ	╞╴╺╽			_	4								
1.0										}		18					L				ļ	_								
10]																			_	_		1			}	1			
												0										0	3	90	7					
20	5	\vdash		50/	, GP	·						20	T																	
				+'1	+																									
22	1											22	†		1	-	1				1	7								
																	1				1							1		
24												24	\vdash		-+-						1	1			1					
50-	1		1			<u> </u>				L	<u> </u>		<u>, </u>					<u>ا ا</u>					- L			A		I		

	3	AC	RES	C	ONS c		SERVICE	S LIMITED		DRILL	но	LE	REP	ORT	-		[DEPA	ART	MENT	OF CKE	PUE	3LI E	C W HIG	VOR	KS AY	, CANADA	
DW	V:		FIEL	D EI	NG:	<u> </u>	DATE DRILLE	ED 9/2/73 A	IRPHOT	O NO: A2277	2-10	28 0	CHAINAG	E:		8	/3 +	- 70		OFF	SET						TEST HOLI	
CKL]			Z	к.	6.	RIG Z	S			<u>N R</u>	IVER		VEG	ETAT	101			<u> </u>		GRA	IN- SU	ZE	266	×	7	MILE B,C,S	NUMBER
DEPTH FEET)	MPLE MBER	APLE PE	ECOVER	STANCE	IFIED SYMB	SOIL	DESCRIPT	ION	S OF EN GRO	DESCRIPTION	EPTH FEET)	0 ⁼ ∆⁼	WATER	CONT	ENT (T (%	% 01 OF S	F DRY	WEI	GHT) LUME)	CLAY	11	DND	RAVEL	DENSIT C F.)	DENSIT C.F.)	411 S	K
50	A U S D	SAL	%	PENE	Soll				LIMIT FROZ		B C		20P	LASTH	° — > —	80	4 ^L i	IQUID LIMIT BO	10	0 100+	%	%	%	°	WET (P	γ <u>я</u> α 9	REMARK	s
2						Sand some trace	and Gra cobbles e of sil	vel with and a t			2															-	Drilled (River Be Two Moun	on tween tains
4									UF		4																Hole Star To Cave a	cting at 60'
6	6	\sum			GP						6.						_	1			0	3	94	3				
8	•										8.							+										
60											10																	
12	4					End o	of Hole a	at 60'			12.									·····								
14	-										14										•							
16											16-					+-		-										
18	-										18-										4							
20											20-			∳ }														
22											22-																	
24	-										24																	

M		AC	RES	C	ONS C		G SERVICE	ES LIMITED		DRILL	но	LE	REP	ORT			DE	PAR1		OF CKE	PU NZ	IBLI IE	C V HIC	VOR	RKS AY	, CAN	ADA	
DWN			FIEL	DE	NG: G	<u>.P.S.</u>	DATE DRILL	ED 10/2/73 AIR	РНОТ	0 NO: A2277	2-1	80	CHAINA	GE: 87	/5 +	70			OFF	SET						TEST	HOLE	
CKD			TEC	:н: †	M.	н.к. Г	RIG: 2		RFACE		GO			VEGE	TATIO	1:	ABI			+ -	ELE	V: 2	280					
IIC	~		/ERY	LION CE	ABOL	601	DESCRIPT		ROUND		+ ~	0.5	WATER	CONTEN	IT (9/.			FIGHT		GRA ANA	NN- S	SIZE		ITΥ	ΤY	MILE	B,C,S	NUMBER
DEPT (FEE1	MPLE MBEF	APLE /PE	RE COV	TRA STAN	SYN	301	L DESCRIPT		S N O		FEET	∆=	ICE CO	NTENT	(% OF	SAM	IPLE	VOLUM	, E)	LAY	Ę	AND	RAVEL	DENS C F.)	DENS C F.)	411	S	М
	SA	SAI	%	PENE	SOIL				LIMIT FROZ		02		20	LASTIC		0		D T	00 1004	%	%	° %	5 %	WET (P	ОЯУ (Р	R	EMARKS	
2.						Brow with a tr boul	n sand a some co ace of s ders	ndıgravel bbles and ilt and	UF		2															Nort Rive Two	h ban r Bet Mount	k of ween ains
4											4									-								
6	1	P		20/0	GP						6.																	
8-											8-																	
σı	2	 P		20 1''	GP						10-				_			_		-								
12											12-																	
14											 4 -																	
16	3	P		85	GP						16-						· · · ·											
18											18-																	
20				10							20-																	
22	4			10"							22-				-													
24											24-									4								

.

		AC	RES	C	ONS		S SE Y, AL	RVICE	ES LIMIT	ED	DRILL	нс	LE	R	EP	OR	T			DE	EPAF	RTN		OF CKE	PU NZ	BLI IE	C V HIC	NOF	RKS	, CAN	ADA	
CKD			TEC	D EI H :	NG: MH	G.P.S	DATE	DRILLI	ED 10/2/7	3 AIRPHO	TO NO A2277	2-1	08	СНА	INAC	SE:	8	75	+ 7	0			OFF	SET	F (F)	. 2	280			TEST	HOLE	
			ž	Nu	<u></u>		1	2			ICE	<u>G00</u>	<u> </u>			1.02	JE IA		-	ABF		_		GRA ANA	IN- S	IZE S		<u>۲</u>	2	MILE	B,C,S	NUMBER
DEPTH (FEET)	MPLE	MPLE Y PE	RECOVE	ETRATI	L SYME	SOI	L DE	SCRIPT	TION	IS OF	DESCRIPTION	DEPTH FEET)	0	= WA 3 = ICE	CO	CONT	ENT	(% 6 OF	OF D SAN	DRY IPLE	WEIGH VOLU	IT) JME)		CLAY	ארד	AND	RAVEL	DENSIT C F)	DENSI1 C F.)	411	S	м
	žõ	SA	%	PEN	ŝ					L IMI				2	P 20	LIMIT		6	0		UID AIT 0	100	100+	%	%	%	%	VET (P	DRY (P	F	EMARKS	
25-	5	Ρ		100	GW				ı				-																			
2.						Dura						2	<u> </u>	+								-+										
4						with	n sa som	ind a ie co	nd gra bbles	and		4				İ																
30-						a tr boul	ace ders	or s	ilt an	a				-																		
6	6	<u>P</u>		82	GW					UF		6	-			\vdash																
8												8																				
													-	-																		
35 •	7	P		100	GW							10			-	+					-+											
12-												12																				!
												ĺ	\vdash																			
40-												14																				
16						End	of H	ole a	at 40'			16																				
																						+										
18-	ĺ											18	1			\uparrow						-										
20												20-																				
													<u> </u>	-					_	_												
22.												22																				
24												24																				

ACHE		AC	RES	С	ONS		3 S Y, 4	SERVICES LI	MITED		DRILL	но	LE	R	EP	ORT	-			DE	PAR	TN		OF CKE	PU NZ	BLI IE	C V HIC	VOF	RKS	, CAN	ADA	
DWN:	_		FIEL	DE	NG:		DA	TE DRILLED10/	2/ 73 AI	RPHOT	O NO: A2277	2-1	80	СНА	NAG	E:	8	78	+ 9	5			OFF	SET						TEST	HOLE	
CKD			TEC	H :	<u>w.</u>	R.	RIG	5 1	SU	RFACE	DRAINAGE	GO				VEG	ETA	TION		A	BD				ELE	V:	27	8				
			×	z	_ ا					N N	ICF													GRA	IN- S LYSI	IZE S		~	7	MILE	B,C,S	NUMBER
EE	ωœ		VER	NCE	D NB	soi	LI	DESCRIPTION		OF	DESCRIPTION	EF	0	= WAT	ER	CONT	ENT	(% (DF D	RY V	WEIGH	T)				_	ш	is -	, isit			
FEP.	N P L	31	E CO	TRA STA	S Y					S N		E 3		= ICE	CON	ITEN	т (%	5 OF	SAM	PLE	VOLU	ME))	L A	ורב	AND	RAVI	C E	DEN	411	C	N
	SAI	SAN	œ	ENE	Ni					ROZ		- C			P		°			LIQU	ID				S	s	0	۲ ۳	۳. ۲			
			e e	a a						7.5				2	0	40	2	60	<u> </u>	80	<u>, </u>	100	100+	%	%	%	%	5	<u> </u>			
lľ	$\setminus $					Bro	own	fine sil	tv																							
	$\left \right $				h.	sar	nd	with some	clay	Ì	Mha								T													
2	, N				PM	and	1 a	trace of	-		NDN	2	-	1		0			- 1			+		1								
3.5		7-		L	L	gra	ave	1		- F				<u></u> +−−+		r	-			+		-+-		{				-				
4					ļ	Sar	nd	and grave	1	-		4	<u> </u>		—					\rightarrow		-+-										
5						wit	-h	some silt	and						/																	
			\mathbb{N}	⁵⁰ /3		cob	bl	es																								
						1																										
	2				₽M						Nf			f				†				+	· · · · · · · · · · · · · · · ·	1								
8				i i								8				╞──┤	-+	+	-+	+		+		-								
													\square	ļ	-	 ∔						-										
In												10																				
												``																				
													Π											1				1				
12-	2				GW							12	\mathbf{t}	<u> </u>						-		+		1					{			
13	5				P								-			┝──┤						-+-		+								
14										नग		14	-			╞╴┤						_										
15										01		L								$ \rightarrow $							1					
						End	lo	f hole at	15'			[ļ								
"																								1								
																			-	- 1		+		1								
18												18		-		╞─┤			+			+		1								
																						+		4								
20												20-												1								
[~]																								1								
]								
22												22	<u>† </u>	-						-+		+		1								
																╞──┤				-+	-+			1								
24						1						24	┣	ł				-+						4								

1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1

	\$	AC	RES	C	ONSI c	JLTING	SERV	ICES LIN	AITED		DRILL	HO	LE	REF	POR	Г		D	EPA	RT		OF CKE	PU NZ	BLI IE		VOR	KS	, CAN	ADA	
DWM	l:		FIEL	D EI	NGG	.P.S.	DATE DR	ILLED 10/2	73 AIR	PHOT	O NO: A22772	$\frac{2-10}{200}$)8	CHAINA	GE	8	82 +	19			OFF	SET			<u>,</u>			TEST	HOLE	
CKU	:		TEC	н 	R.2	5 •	RIG	<u> </u>	SUF	RFACE		1001	, 		VEC	GETA	TION		A				ELE		202					
			ž	z.	5					UND	ICE											ANA	LYSI	S		۲۲	È	MILE	B,C,S	NUMBER
E E	۳ ۳	ш.	OVE	ANCI	ED	SOIL	. DESCA	RIPTION		P R	DESCRIPTION	ΞE	0	- WATER	CONT	ENT	(% OF	DRY	WEI	SHT)		7	F	0	/EL	NSI.	NSI.	411		0
l a f	A M P	AMPL YPE	R C	HE T F	L S					ZEN		E E		= ICE CO	DNTEN	т (%	OF S	AMPL	E VOI	LUME	.)	CLE	SIL	SAN	GRA	1 DE	00 0	111		Ŭ
	ωz	S,	8	P. S.	° °					FRO FRO				20	LIMIT	ື —	60	!	IMIT 80	10	NO 100+	%	%	%	%	× €	έ,~	R	EMARKS	
	† 1										· · · · · · · · · · · · · · · · · · ·		<u> </u>	ΓŤ	<u> </u>		Ť		Ť		1001									
						Brow	vn san	d and o	rave	1					+			+	+											
2	1				SW	with	n some	silt a	and	F	Nf	2		┨───┤──				-+				{								
ľ						trad	ces of	cobble	es			1	P	 				_	<u> </u>			-								
4												4	_	┨──┤──																
5	L												Ц			ļ											1			
6		N									,	6																		
ľ										1		ľ																		
	2				SW																	1								
8	1 -											8										1								
													\vdash		+							1								
10			 									10	┥╂	+ +	-			-	1			1								
				l									┝╌┠╴	+	+				+			-								
12	3				SW							12	$\left \right $		_				-			-								
													đ		_			_				ļ			1					
14												14									_									
						End	of Ho	le at l	L5'																					
10]											10										1								
															-							1								
18	1											18	1	++	+				1			1.	ļ							
															+				1			1								
20											1	20.		<u> </u>								1								
													<u> </u>	├					+			+								
22										1		22	<u> </u>	┟──┟─			 		- 			4								
															_										ļ					
24												24			_															1
				l																										

· · ·





PROPC	SED				
I	1 I		1	۰.	
					· · ·
				, .	
SM				.0	
			-		
SW					
	· · · · • • • • • • • • • • • • • • • •		·		
			e		
	. وي				
				,	
			860	-00	
S TO		DATU	Δ		
RILLEE	D FEBU	ARY 9-	11,		
NGE	IG IND	IAN DR	RILLING		
RDNE	R-DENV	/ER 20	00		-
				VUULO	
				APULO	
	MACKEN	ZIE HIGH	IWAY		1-
DEF	PARTMENT	OF PUBL	IC WORKS	6	
VER BE E CROS	TWEEN T	WO MOUN' N & BORE	TAINS CR Hole Pr	OSSING OFILES	
JC	SCALE	DRAWING	3 NO.	<u></u>	
U.S.M. JUNE / 73	AS SHOWN	FIG	URE 2		