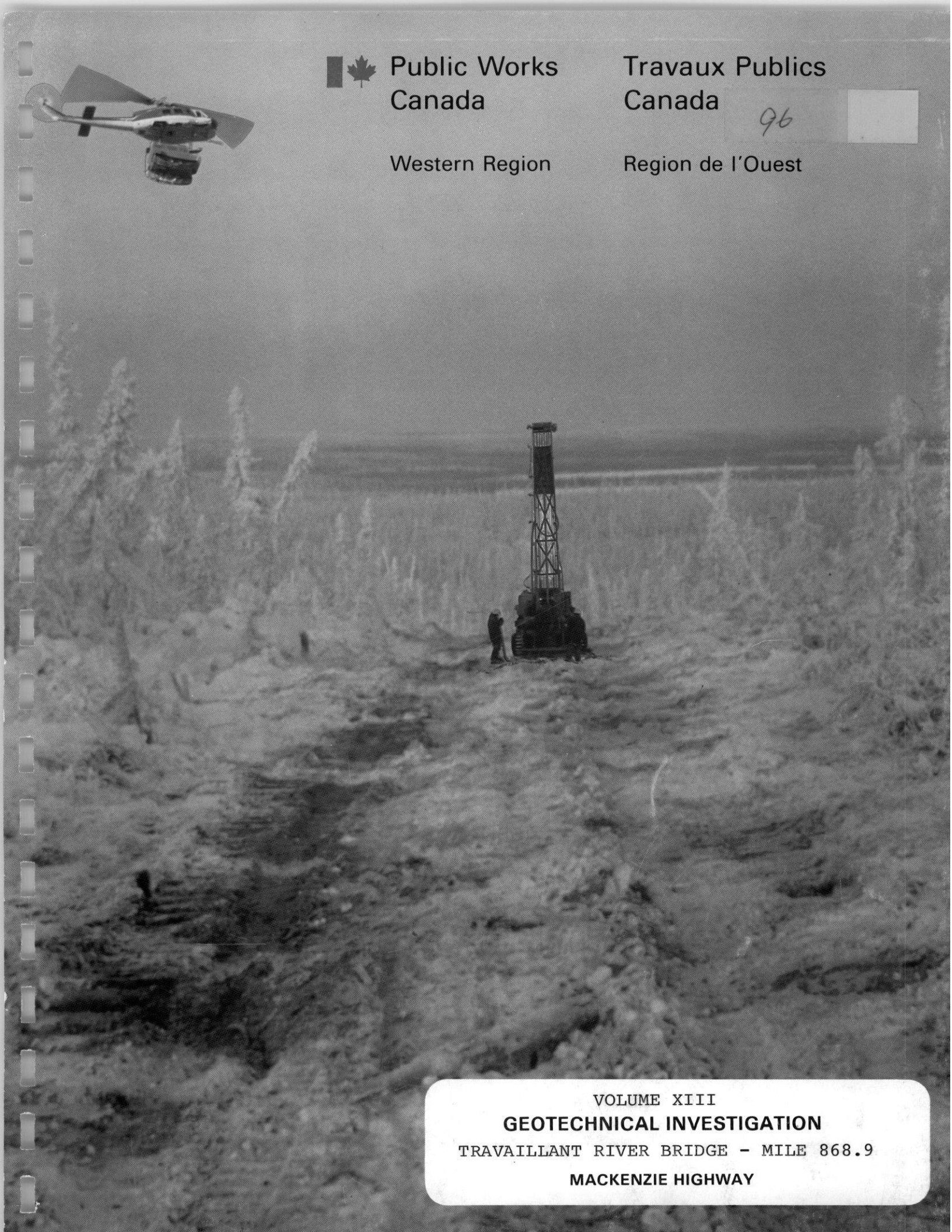

Public Works Canada

Travaux Publics Canada

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Western Region

Region de l'Ouest

VOLUME XIII

GEOTECHNICAL INVESTIGATION

TRAVAILLANT RIVER BRIDGE - MILE 868.9

MACKENZIE HIGHWAY

000022

PUBLIC WORKS CANADA

WESTERN REGION

REPORT ON
GEOTECHNICAL INVESTIGATION
MILE 725 TO MILE 936
MACKENZIE HIGHWAY

VOLUME XIII
FOUNDATION INVESTIGATION
TRAVAILLANT RIVER CROSSING
MILE 868.9

Submitted by R. D. Cook, P. Eng.
Quality Control Engineer
Special Services
Western Region

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APPENDICES

I INTRODUCTION

The subsoil investigation at the Travaillant River was undertaken as part of the overall geotechnical investigation on the Mackenzie Highway between Ft. Good Hope (Mile 725), and the junction with the Dempster Highway (Mile 936), in the winter of 1973-74. This crossing site was one of five major stream crossings which were investigated in detail during the course of the field work. General terrain analysis and borrow evaluation along the Highway has been submitted earlier in Volumes I to VIII of a report entitled Geotechnical Investigation - Mile 725 to Mile 936, Mackenzie Highway. This report on the Travaillant River crossing comprises Volume XIII of that overall report.

All field and laboratory work associated with this investigation was carried out by the Special Services Section, Design and Construction Branch, Western Region, Public Works Canada.

II SITE CONDITIONS

The proposed bridge site is located approximately 6 miles downstream of where the River exits from Travaillant Lake, and is at approximately Mile 689 of the proposed Mackenzie Highway. The geographic location of the crossing is shown on the 1" = 90 miles key plan, Drawing No. A-1, Appendix A. Drawing No. A-2, Appendix A, outlines the upstream drainage

area of the Travaillant River, and Drawing No. A-3 is a detailed, 1"=1000' mosaic of the proposed crossing site.

The Travaillant River drains an area of roughly 850 sq. miles to the Highway in the north-western portion of the Anderson Plain - a vast, broadly rolling, till plain. The River and much of the catchment area is located in an extensive lowland which extends from the Mackenzie River northerly into the Plain uplands. Relief on the lowland is very subdued and surficial deposits consist primarily of hummocky moraine with some glacial lake sediments. There are numerous lakes, ponds and depressions on the lowland, many of which are thought to be of thermokaret origin.

In the area of the Highway crossing the Travaillant River has emerged from a long, relatively straight, well defined, channel and commenced a meander pattern on the surface of the lowland. At the selected crossing site the River has formed a shallow (25-30'), narrow (500') trough in the surficial hummocky moraine. There are alluvial meander plain deposits on both sides of the present channel which offer stable approaches to the crossing. As the River trough is shallow, approach cuts are not required and the proposed grade line does not exceed 1.5%. Permafrost is continuous throughout the area.

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The stream channel at the crossing is roughly 80' in width, and 50 year return flows have been estimated by others (3.4)*at roughly 4,400 c.f.s. with maximum water levels near elevation 401.9 (approximately 8' above stream bed). Flows to this elevation would extend 35-40' back from the west bank of the present channel. There is little fluctuation between flow in summer or winter due to the control provided by Travaillant Lake.

No bridge design details are available at present although a 260' structure has been recommended by the hydrological consultants (3.4). Excerpts from the hydrological reports are included in Appendix C.

A minor revision has been made in the alignment in the area of the proposed crossing site since this investigation, however no significant change in the bridge location has resulted, and no significant changes are expected in the subsoil conditions between the alignment drilled and the proposed revision - see Drawing No. A-3. The immediate area of the crossing is shown in profile on Drawing No. A-4.

III EVALUATION OF SUBSOIL CONDITIONS

A. Field and Laboratory Analysis

A total of 10 test holes were drilled in the immediate vicinity of the crossing site. Hole locations are shown on Drawing No. A-3, Appendix A, and borehole logs are included in Appendix B.

* Numbers in parenthesis refer to the List of References presented at the end of this report.

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All holes were drilled by means of a Mayhew 1000 drill rig using compressed air as the drilling fluid. Disturbed samples were obtained at frequent intervals in all holes for water content determinations, ice descriptions and material identification. In addition several Shelby tube samples were attempted in the frozen subsoil, however recovery was poor. All samples were returned to Edmonton for analysis in the Departmental Laboratory.

B. Subsoil Profile

The boreholes and the inferred stratigraphic sections are shown on Drawing No. A-4 in Appendix A. This subsoil profile presents a generalized grouping of the soil types encountered and individual borehole logs should be consulted for detail.

Glacial till underlies the crossing site at relatively shallow depths (8-12'). Above the till are alluvial meander plain deposits consisting primarily of stratified sands and gravels. The sand and gravels are most extensive on the western side of the River where a 'bench' of granular material rises approximately 25' above the level of the stream. On the eastern side the alluvial deposits are thin (5-10'). These sands and gravels contain little visible ice and are normally moist to wet on thawing, with moisture contents in the order of 10%.

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River bed material is primarily sands and gravels but with an extensive cobble 'pavement' on the surface.

The till surface conforms approximately to the ground surface contours in the immediate area of bridge site. In composition the till is a low to medium plastic, sandy, silty, clay with pebbles, and occasional cobbles or boulders. Permafrost is present throughout with the exception of a small thaw zone immediately below the River channel. There is little visible ice in the till, and, upon thawing the material is described as 'damp' with moisture contents varying around 15% and close to the plastic limit. One Shelby tube sample from hole #TR-6 was suitable for testing following thaw and yielded an unconfined compressive strength of 7.9 kips/sq. ft., and an in-situ unit weight of 137 lbs./sq. ft. This indicates a very stiff, dense deposit.

Permafrost was encountered in all holes with the exception of two shallow holes (TR#2 and TR#4) on the edges of the channel which were terminated due to water and sloughing gravels below the active zone. A sketch of the inferred thaw zone below the river has been prepared and is included as Drawing No. A-5 Appendix A. The depth of thaw below the channel was not verified by drilling but is based upon theoretical analysis of thaw zones below water bodies (1, 2). Note that the permafrost profile below the river's edge has been shown as almost vertical which is a situation confirmed in the field by many investigations.

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IV FOUNDATION SUPPORT OF BRIDGE STRUCTURE

A. Abutment and Pier Foundations

The permanently frozen glacial till provides the obvious bearing stratum for the foundation elements, and it is recommended that steel piles frozen into the till be utilized for support of piers and abutments.

Design details for the proposed structure are not available, however an overall bridge length of 260' has been suggested by the hydrology consultants (3, 4). Foundation elements should be located as far back from the present river channel as possible in order to provide ample clearance from the thaw zone directly below the river channel. It is recommended the structure consist of a long center span with a minimum length of roughly 150', with shorter end spans as required. Piers should be placed at approximately station 3548+85 and station 3550+35, or roughly 35' on either side of the present channel limits. With the exception of some warming of the permafrost soils during pile freeze-back, in the area of the piles, and possibly some surface degradation of permafrost during construction, it is not considered that any significant change in the permafrost conditions will occur as a result of a bridge at this site. Piles installed no closer than 30-35' to the present channel should not be affected by the thaw zone below the channel as there is no reason to expect any significant change in the thaw zone with time. It is recommended the foundation elements consist of

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either steel H-piles (BP 12 @ 53 lbs./ sq. ft.), or closed and steel pipe piles (10" diameter @ 40 lbs./ft.). The piles should be placed in pre-bored holes, the void space backfilled with a sand slurry, and allowed to freeze into place. If H-piles are employed the piles should be driven approximately 10 feet below the depth of pre-boring to provide some immediate load-carrying capacity. Pipe piles should be driven to practical refusal or 5-6' below the pre-boring depth. Load transfer will initially be by end-bearing and friction on the lower part of the pile in the frozen till, and, following freezeback, by tangential adfreezing along the pile surface.

Tangential adfreezing is dependent upon temperature of the permafrost soils and composition of the backfill material. There is no detailed temperature data with depth for the Travaillant River area, however the National Research Council working in conjunction with D.P.W., has installed thermistors at the Eagle River in the Yukon which is at a latitude slightly south of the Travaillant River. Available readings from the Eagle River are included in Appendix C and it is considered that temperature data obtained at the North abutment (cable #1) can conservatively be applied to the Travaillant River (cable #2 at the South abutment is in a thaw zone of a former channel of the Eagle River). This data shows a consistent temperature near 28^{o}F with depth.

Test data obtained by the U.S. Army Cold Regions Research and Engineering Laboratory from pile load tests in Alaska, indicate

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a sustained adfreeze strength for a silt-water slurry backfill and steel of more than 25 psi. at 28°F. In addition, adfreeze strengths for a saturated, well-graded sand slurry, vibrated in place, are at least 50% higher. Therefore, if a design adfreeze strength of 10 psi. is assumed, the factor of safety will be at least 3 for a sand slurry backfill. Twelve inch steel H-piles would therefore develop a load carrying capacity of 12" x 12" x 10 psi. x 4 = 5760 lbs. per lineal foot of pile, and 10" diameter pipe piles would develop π x 10" x 12" x 10 psi. = 3870 lbs. per foot.

In order to accommodate a 12" H-pile, an 18" diameter borehole is required, and to accommodate a 10" diameter pipe pile, at least a 14" diameter hole would be required to ensure pile alignment and adequate placement of slurry backfill. Thus the void space, and the slurry requirement, for a pipe pile would be significantly less than for an H-pile. This is important as the slurry introduces heat into the ground and should be kept to a minimum.

It is recommended the backfill consist of a well-graded sand with 100% passing the #4 sieve, and less than 15% passing the #200 sieve. Sufficient water should be added to completely saturate the sand but excess water should be avoided. A concrete mixer will serve to mix the slurry and the temperature of the

slurry should be as cold as possible to avoid introducing any unnecessary heat into the ground. It is estimated the water content of a well-saturated, well-graded sand will be in the order of 25% and the volumetric latent heat will be in the order of 3000 BTU/cu. ft. For an 18" diameter H-pile hole, the latent heat per foot of pile will be approximately 5500 BTU/foot. In comparison the volumetric latent heat for a 14" diameter pipe pile hole would be approximately 2000 BTU/foot. Based upon CRREL test data, a single H-pile installed in an 18" diameter hole with a slurry as outlined above, would require probably 9-10 days to completely freeze-back at a permafrost termperature of 28^{o}F, whereas a 10" pipe pile in a 14" diameter hole would completely freeze-back in probably 3-4 days. Thus there are obvious advantages to using pipe piling.

Freeze-back time for a group of piles would be greater as more heat is introduced into the subsoil, and therefore the minimum number of piles possible should be used - i.e., the design should utilize heavily loaded, widely spaced piles, as opposed to closely spaced, lightly loaded members. Pile groupings increase the overall temperature of the permafrost within the area of the piles and if spacings are small, the temperature will be raised to the point that freeze-back will cease until the permafrost is made colder - i.e., until winter, if construction is in summer. For 12" H-piles in 18" diameter holes, the pile spacing should be not less than approximately 8' to

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obtain full freeze-back without having to wait a winter season; for 10" pipe piles in 14" diameter holes a pile spacing of not less than approximately 5 feet would be required.

Following are recommended pile lengths and depths of pre-boring for 10" pipe and 12" steel H-piles, assuming a design load in the order of 100 kips per pile. The pipe piles are preferred.

Pile	Effective length below pier or abutment	Depth of Pre-boring	Hole Size
10" pipe @40#/ft.	35'	30'	14-15"
BP12@53#/ft.	30'	20'	18"

Piles should be driven with a fairly high energy hammer below the depth of pre-boring as penetration is expected to be difficult in the dense frozen till - an energy in the order of 20,000 pf. lbs. per blow is recommended. Detailed driving records should be maintained.

B. Bridge Approach Fills

Fill heights immediately adjacent to the abutments in the 'trough' of the River will be in the order of 20 to 25', but decrease rapidly on the alluvial flood plain deposits to less than 10'. The permafrost table will likely rise in the embankment where the height of fill is greater than 10' and stability of the approaches within the 'trough' will not be a problem. Some very minor subsidence may occur where fill heights are less than 5' on the flood plain deposits, however as the subsoil is granular and contains low ice, stability problems

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should not develop.

Backfill immediately adjacent to abutments should be well compacted shale borrow which is readily available approximately 2 miles to the south - see Section 21 of Volume I of Report on Geotechnical Investigation, Mile 725-936, Mackenzie Highway. Field compaction control is recommended on all backfill associated with piers and abutments. The closest source of granular materials suitable for concrete aggregate is located near mile 896 roughly 30 miles distant, thus bridge construction at the Travaillant River should ideally be delayed until construction of the Highway north of the River is complete or underway (see Section 28 - Surfacing Materials - Volume I of Geotechnical Report).

R. D. Cook
Quality Control Engineer
Special Services
Western Region

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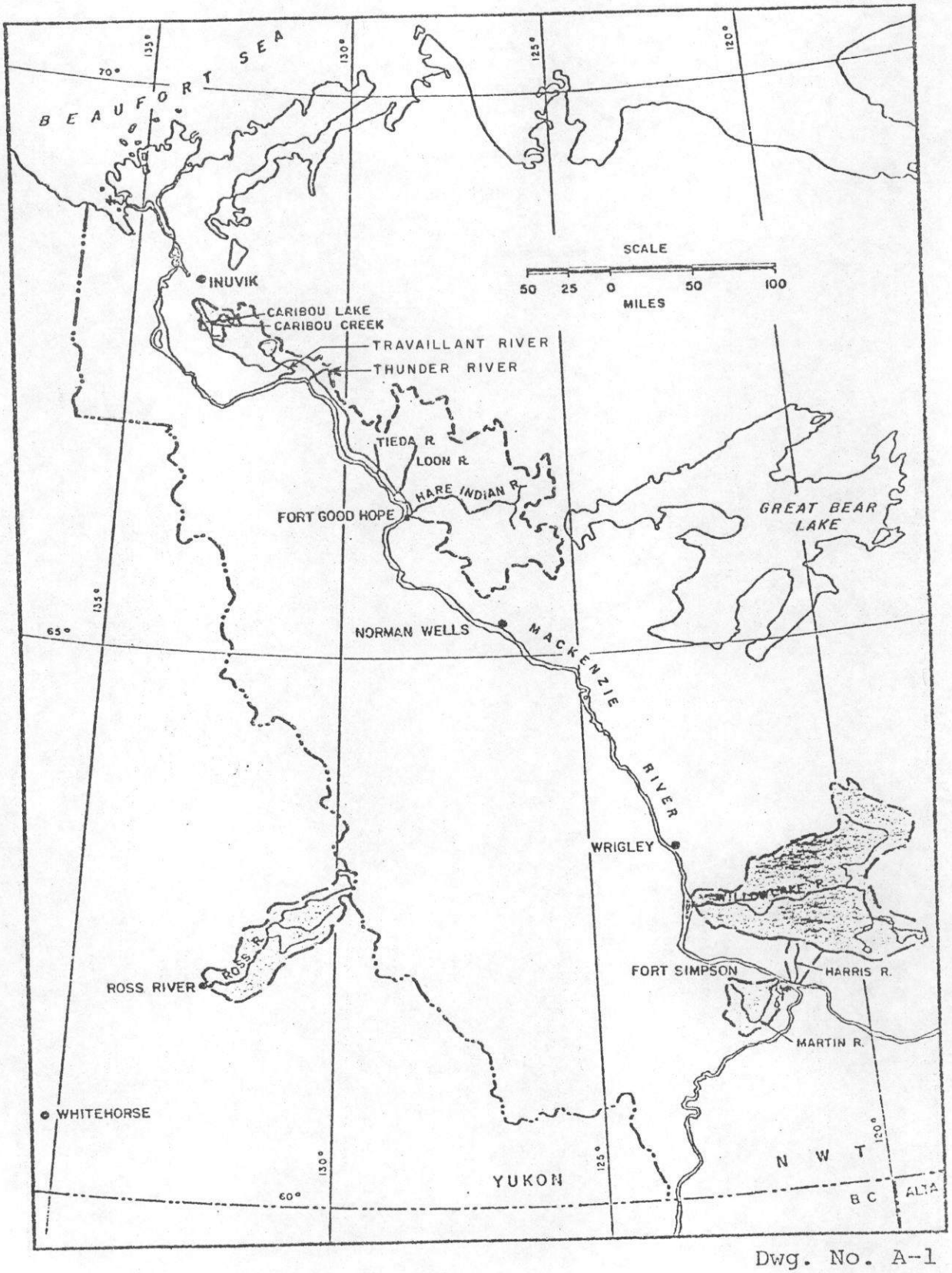
2. Brown, W. G. Graphical Determination of Temperature Under Heated or Cooled Areas on the Ground Surface. Technical National Research Council, October, 1963.

3. Bridge and Culvert Hydraulics, Mackenzie Highway, Fort Good Hope to Dempster Highway, March 1974. Fenco Foundation of Canada Engineering Corporation Limited.

4. Hydrology Study, Mackenzie Highway, Fort Good Hope to Dempster Highway, March 1974. Fenco Foundation of Canada Engineering Corporation Limited.

5. Crory, Frederick E. CRREL Pile Foundations in Permafrost. International Conference on Permafrost, Purdue University, November 1963.

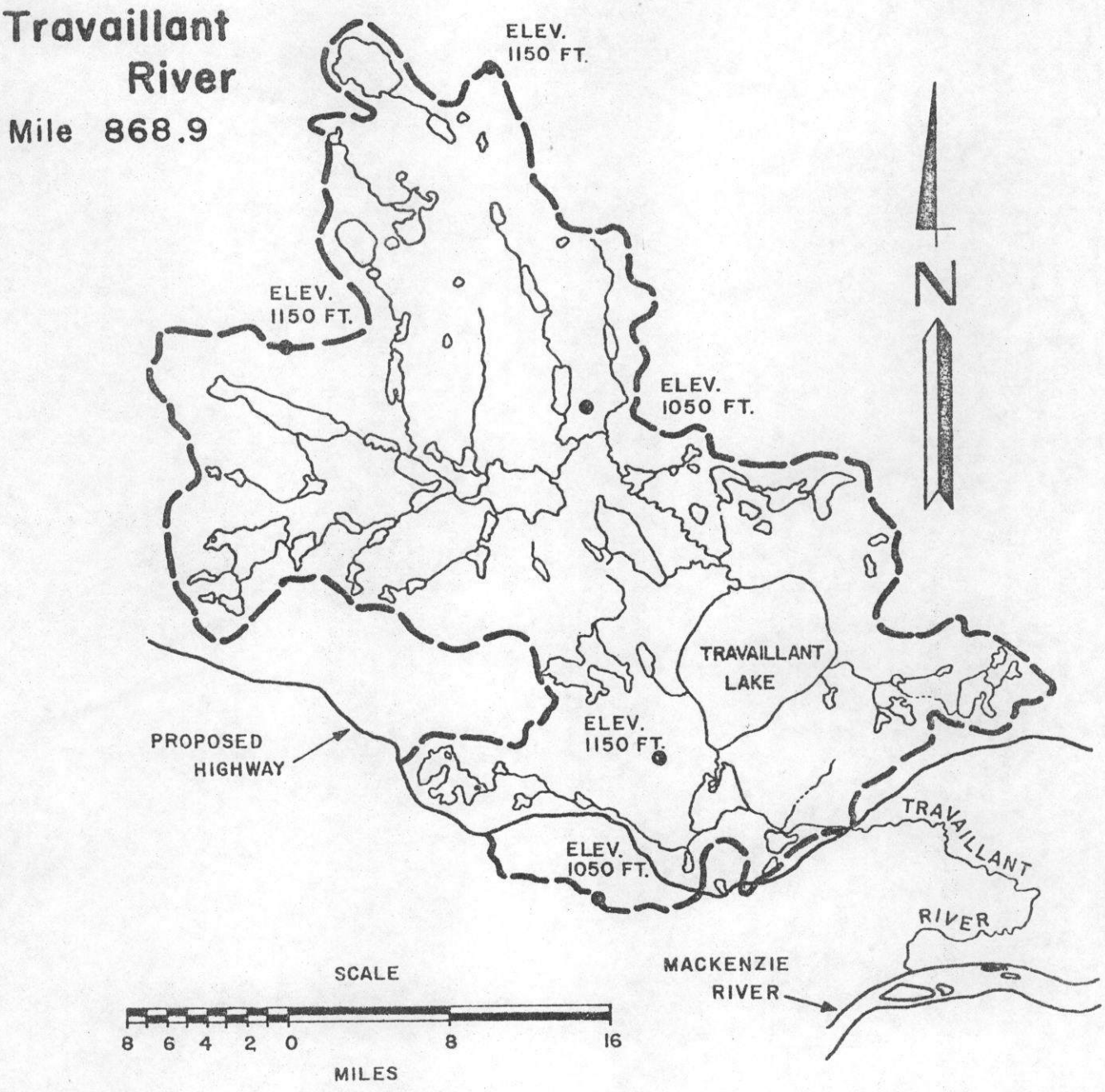


Dwg. No. A-1

KEY PLAN

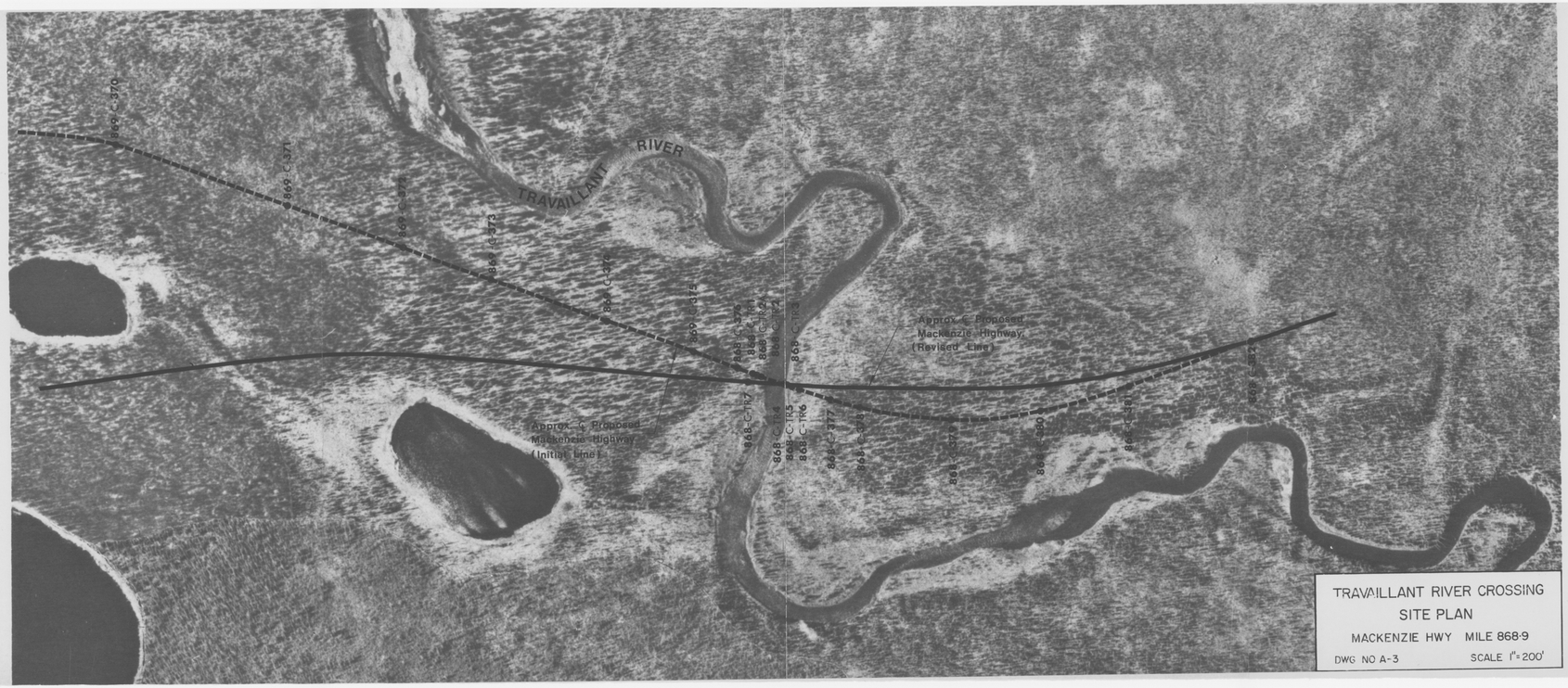
MACKENZIE RIVER, N.W.T.

1" = 90 MILES



Travaillant River Basin

Drawing No. A-2


TRAVAILLANT RIVER
868-C-370
868-C-371
868-C-372
868-C-373
868-C-374
868-C-375
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868-C-377
868-C-378
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868-C-382
868-C-383
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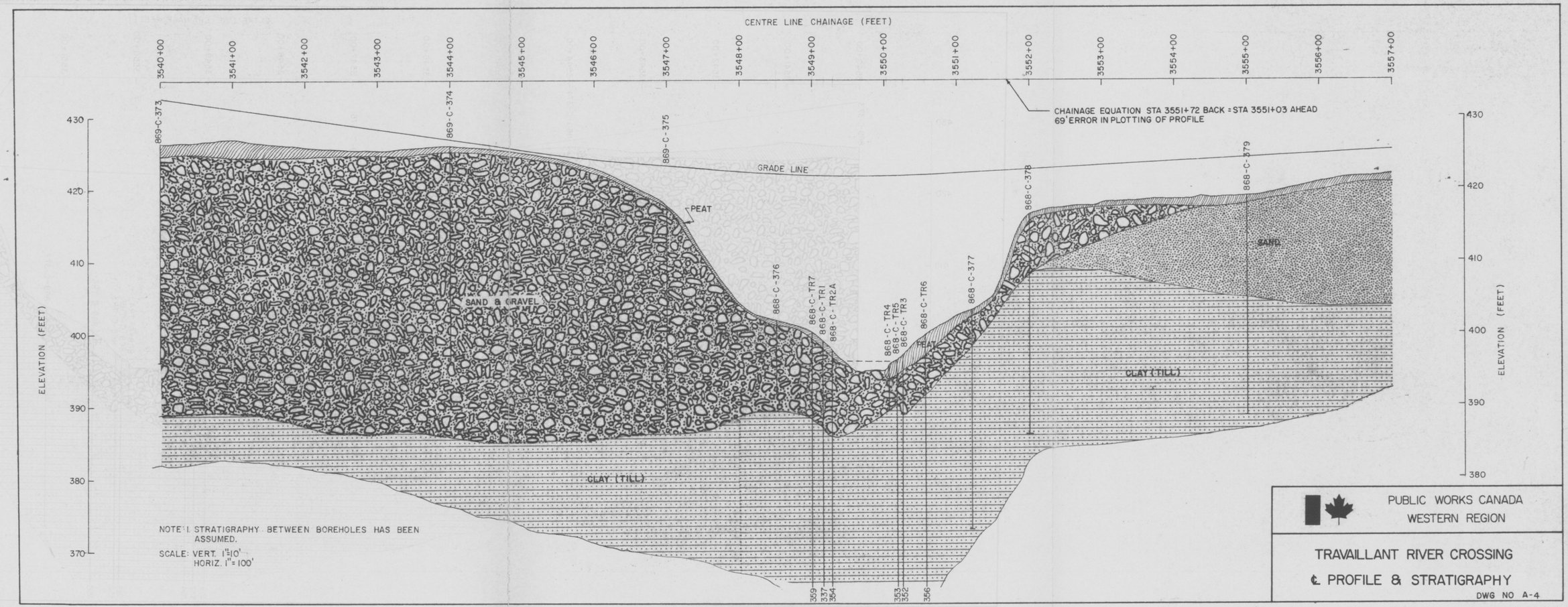
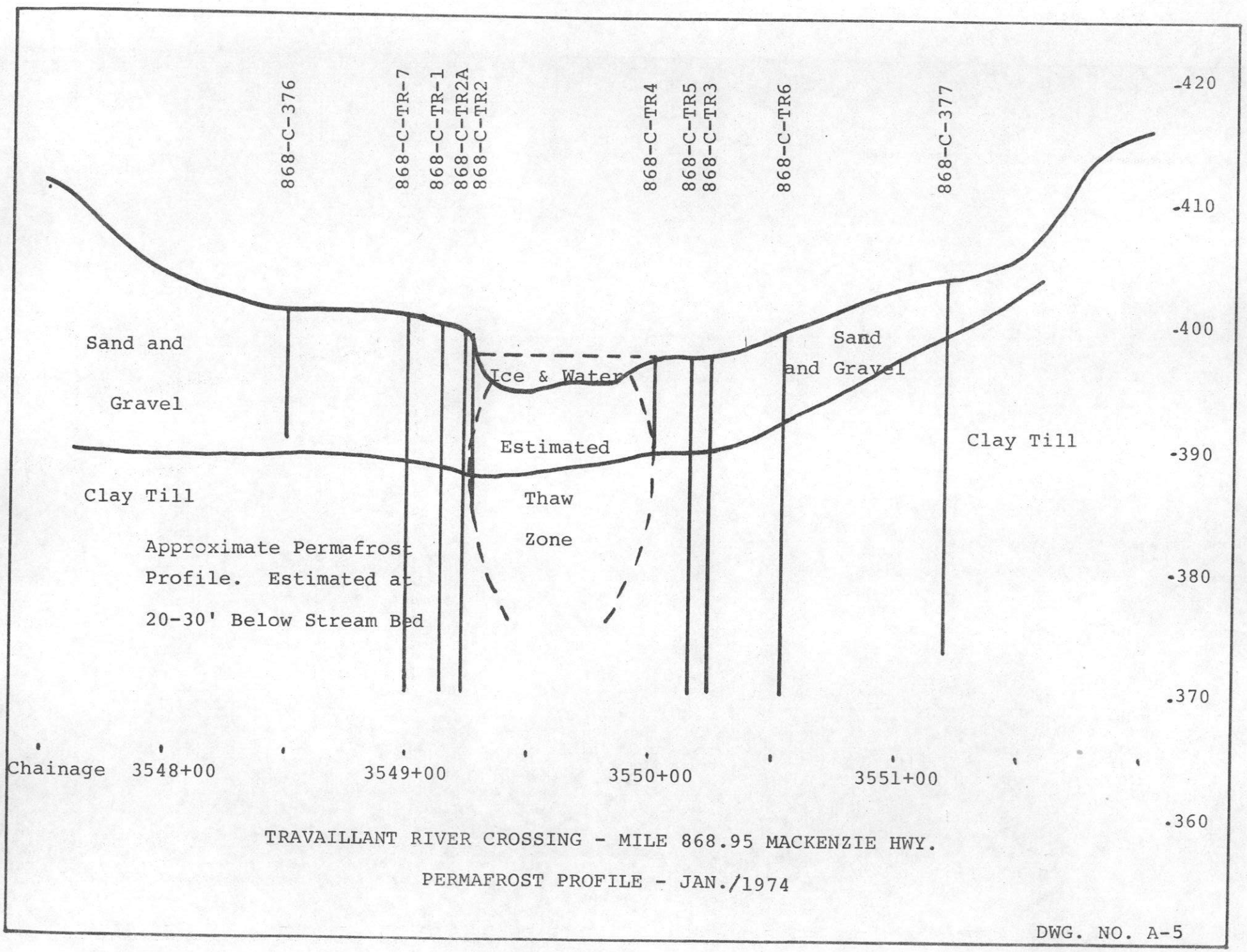
868-C-385
868-C-386
868-C-387
868-C-388
868-C-389
868-C-390
868-C-391
868-C-392
Approx. ℄ Proposed Mackenzie Highway (Initial Line)
Approx. ℄ Proposed Mackenzie Highway (Revised Line)
TRAVAILLANT RIVER CROSSING
SITE PLAN
MACKENZIE HWY MILE 868·9
DWG NO A-3
SCALE 1"=200'


CENTRE LINE CHAINAGE (FEET)
3540+00
3541+00
3542+00
3543+00
3544+00
3545+00
3546+00
3547+00
3548+00
3549+00
3550+00
3551+00
3552+00
3553+00
3554+00
3555+00
3556+00
3557+00
CHAINAGE EQUATION STA 3551+72 BACK = STA 3551+03 AHEAD
69' ERROR IN PLOTTING OF PROFILE
869-C-373
869-C-374
869-C-375
GRADE LINE
PEAT
SAND & GRAVEL
868-C-376
868-C-TR7
868-C-TR1
868-C-TR2A
868-C-TR4
868-C-TR5
868-C-TR3
868-C-TR6
868-C-377
868-C-378
868-C-379
SAND
CLAY (TILL)
CLAY (TILL)
359
337
364
353
352
356
ELEVATION (FEET)
430
420
410
400
390
380
370
NOTE: 1. STRATIGRAPHY BETWEEN BOREHOLES HAS BEEN ASSUMED.
SCALE: VERT. 1"=10'
HORIZ. 1"=100'
PUBLIC WORKS CANADA
WESTERN REGION
TRAVAILLANT RIVER CROSSING
℄ PROFILE & STRATIGRAPHY
DWG NO A-4



TRAVAILLANT RIVER CROSSING - MILE 868.95 MACKENZIE HWY.

PERMAFROST PROFILE - JAN./1974

DWG. NO. A-5

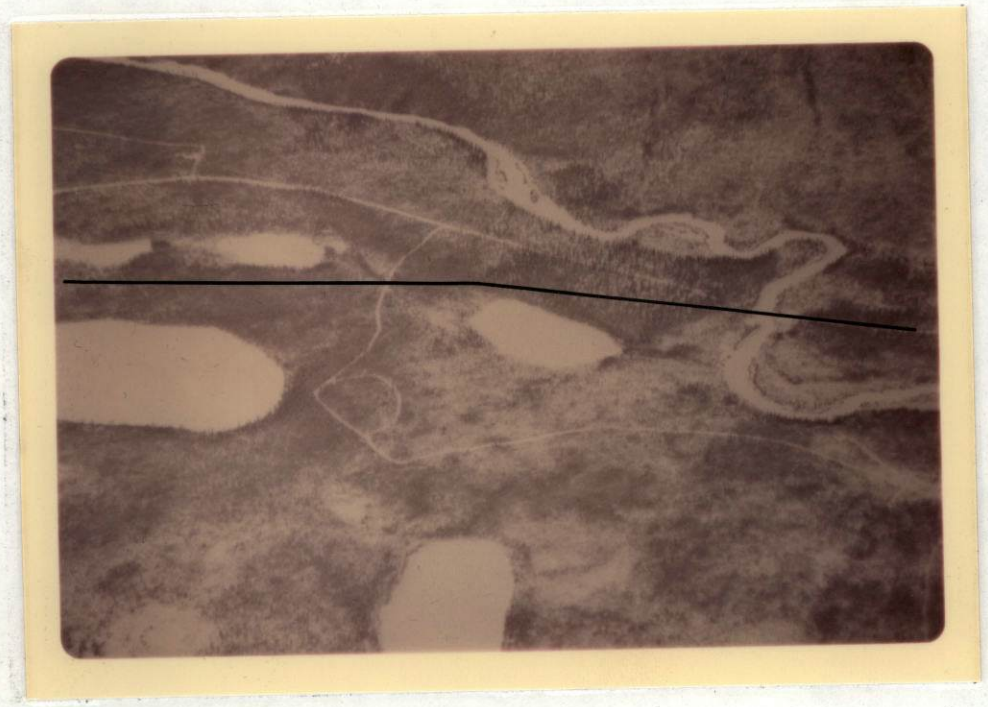


PHOTO No. 1

Travaillant River looking upstream. Cutline is original Route location. Black Line is revised location.

PHOTO No. 2

Travaillant River.

Drilling Rig on North Bank on centerline.

DEPARTMENT OF PUBLIC WORKS, CANADA
MACKENZIE HIGHWAY

DRILL HOLE REPORT

SITE:

FIELD ENG. A. HANNA | DATE DRILLED. 20/1/74 | AIRPHOTO NO. A 22855-83 | CHAINAGE. 3544+00 | OFFSET. ℄

TECH. McINTOSH | RIG. MAYHEW - #2 | SURFACE DRAINAGE. FAIR | VEGETATION. SPRUCE MAX. 6" | ELEV.

TEST HOLE 374

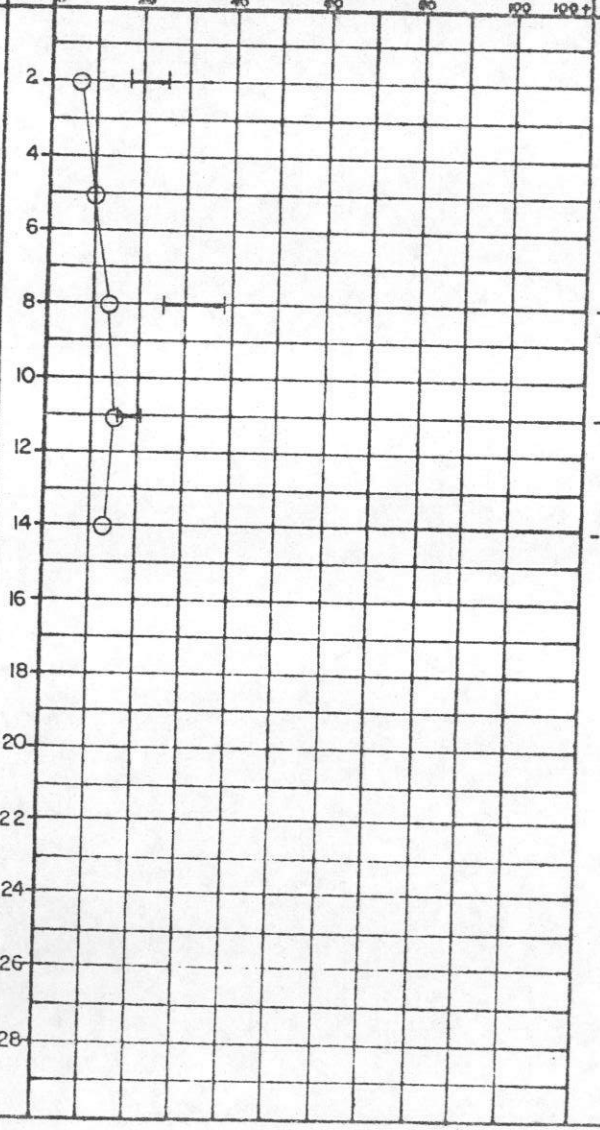
MILE 869

DEPTH (FEET)	SAMPLE NUMBER	SAMPLE TYPE	% RECOVERY	PENETRATION RESISTANCE	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION
					Pt	PEAT .5'		
2						SAND -Gravelly Coarse Clayey		Low Ice Vx
4								
6								
8					SC	Some org. mat. 8'-10'		Moderate Ice
10							F	
12								
14						14'		Vc - Vr
16					GP GW	SAND-GRAVEL MIXTURE		
18								
20								
22								
24								
26								
28						30'		

BOTTOM OF HOLE - 30'

▲ DRY DENSITY (lbs./ Ft.³)
⊙ WATER CONTENT (% of dry weight)
△ ICE CONTENT (% of sample volume)

PLASTIC LIMIT — LIQUID LIMIT



DEPTH (FEET)	GRAIN-SIZE ANALYSIS CLAY %	SILT %	SAND %	GRAVEL %	RELATIVE THAWED MOISTURE CONTENT	REMARKS
2	-13-		60	27	Damp	
6	-15-		67	18	Moist	
8	-10-		63	27	Wet	
12	-11-		65	24	Wet	
14	-11-		64	25	Sat.	

D3-14-5-74 b

DEPARTMENT OF PUBLIC WORKS, CANADA
MACKENZIE HIGHWAY

DRILL HOLE REPORT

SITE:

FIELD ENG. A. HANNA | DATE DRILLED. 20/1/74 | AIRPHOTO NO. A 22855-83 | CHAINAGE. 3547+00 | OFFSET. ℄

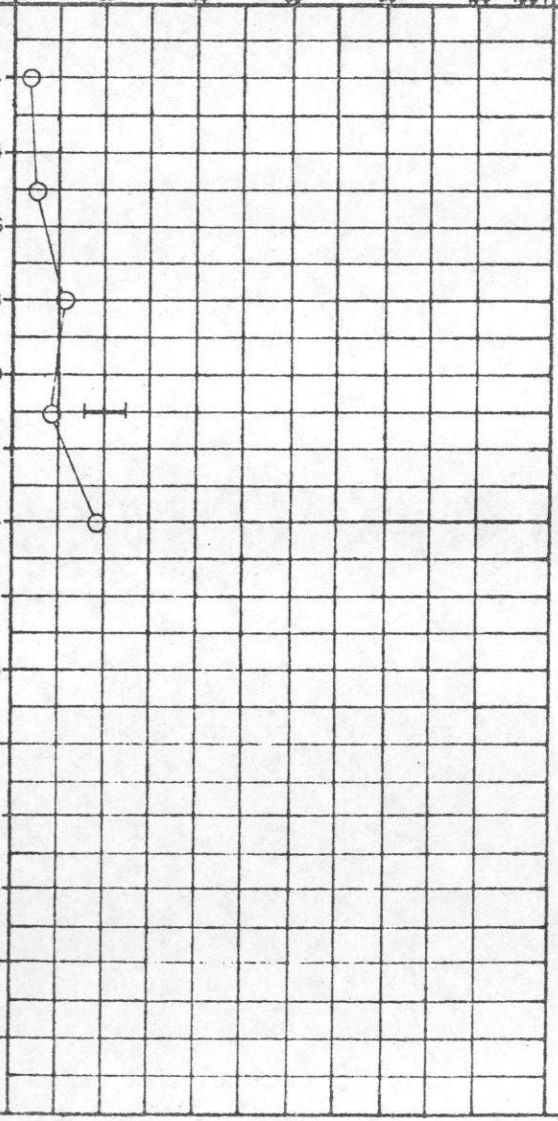
TECH. McINTOSH | RIG. MAYHEW - #2 | SURFACE DRAINAGE. GOOD | VEGETATION. SPRUCE MAX. 8" | ELEV.

TEST HOLE 375

MILE 869

DEPTH (FEET)	SAMPLE NUMBER	SAMPLE TYPE	% RECOVERY	PENETRATION RESISTANCE	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION
					Pt	PEAT — .5'		Low Ice
2					GC	GRAVEL -Sandy Clayey		Vx
6						— 7'		
8					SC	SAND -Gravelly Clayey	F	Moderate Ice
14						GRAVEL-SAND MIX ?		Vc - Vr
28						30'		

DRY DENSITY (lbs./ Ft.³)
WATER CONTENT (% of dry weight)
ICE CONTENT (% of sample volume)
PLASTIC LIMIT — LIQUID LIMIT



GRAIN-SIZE ANALYSIS CLAY %	SILT %	SAND %	GRAVEL %	RELATIVE THAWED MOISTURE CONTENT	REMARKS
-11-		32	57	Damp	
-12-		48	40	Moist	
-13-		51	36	Sat.	
-21-		49	30	Wet	
-20-		49	31	Sat.	

BOTTOM OF HOLE - 30'

DS-14-5-74 b

DEPARTMENT OF PUBLIC WORKS, CANADA
MACKENZIE HIGHWAY

DRILL HOLE REPORT

SITE:

FIELD ENG. A. HANNA | DATE DRILLED. 21/1/74 | AIRPHOTO NO. A 22855-83 | CHAINAGE. 3548+50 | OFFSET. ℄

TECH. McINTOSH | RIG. MAYHEW - #2 | SURFACE DRAINAGE. GOOD | VEGETATION. SPRUCE MAX. 8" | ELEV.

TEST HOLE 376

MILE 868

DEPTH (FEET)	SAMPLE NUMBER	SAMPLE TYPE	% RECOVERY	PENETRATION RESISTANCE	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION	GRAIN-SIZE ANALYSIS CLAY %	SILT %	SAND %	GRAVEL %	RELATIVE THAWED MOISTURE CONTENT	REMARKS
0					Pt	PEAT — ¼'								
2					GC	GRAVEL -Sandy Clayey	F	Low Ice					Moist	Hole in Bag
4													Moist	Hole in Bag
6														
8								Vc - Vr					Wet	
10						10'								
12						BOTTOM OF HOLE - 10'								
14						ROCK @ 10'								
16														
18														
20														
22														
24														
26														
28														

DRY DENSITY (lbs./ Ft.³)
WATER CONTENT (% of dry weight)
ICE CONTENT (% of sample volume)
PLASTIC LIMIT — LIQUID LIMIT
40 60 80 100 120 140 102+
0 20 40 60 80 100

DS-14-5-74 b

NORTH BANK TRAVAILLANT RIVER CROSSING

DEPARTMENT OF PUBLIC WORKS, CANADA
MACKENZIE HIGHWAY

DRILL HOLE REPORT

SITE:

FIELD ENG.

TECH. W. Baine

DATE DRILLED. 21/2/74

RIG. Mayhew #1

AIRPHOTO NO.

SURFACE DRAINAGE.

CHAINAGE. 3549+14

VEGETATION.

OFFSET.

ELEV.

TEST HOLE 1

MILE 868

REMARKS

DRY DENSITY (lbs./ Ft.^{3})
WATER CONTENT (% of dry weight)
ICE CONTENT (% of sample volume)
PLASTIC LIMIT — LIQUID LIMIT
40 60 80 30 40 100 60 120 80 140 100 100+

DEPTH (FEET)	SAMPLE NUMBER	SAMPLE TYPE	% RECOVERY	PENETRATION RESISTANCE	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION	GRAIN-SIZE ANALYSIS CLAY %	SILT %	SAND %	GRAVEL %	RELATIVE THAWED MOISTURE CONTENT
0					Pt	PEAT — 1'							
						GRAVEL - Sandy - Clayey			-11-	27	62		Wet
4					GC	Boulders @ 6'		Low	-15-	27	58		Wet
									-13-	25	62		Moist
8								Ice	-26-	40	34		Wet
									-15-	31	54		Moist
12						— 12'			-26-	29	45		Moist
					GC CI	GRAVEL-CLAY MIXTURE			-62-	27	11		Damp
16						— 14'		Vx	-51-	14	35		Damp
						CLAY - Gravelly			-64-	12	24		Damp
					CL CI	- Sandy, silty Low-med. plastic Till			-71-	13	16		Damp
20						— 20'			-77-	20	3		Damp
					CL CI	CLAY - Sandy, silty - Pebbles Low-med. plastic			-74-	21	5		Damp
24						CLAY			-69-	20	11		Damp
						- Sandy		Low	-73-	22	5		Damp
28						- Silty			-73-	21	6		Damp
						- Pebbles		Ice	-72-	21	7		Damp
32						Boulders @ 33'			-75-	18	7		Damp
						45'	F		-77-	18	5		Damp
36					CI	Med. plastic			-81-	17	2		Damp
						- Till			-83-	13	4		Damp
40													
44									-87-	12	1		Damp
48									-74-	16	10		Damp
52													
56									-80-	18	2		Damp
						Bottom of Hole - 62'							
						Could be through frost @ 62'			-79-	15	6		Moist

D3-14-5-74 a

NORTH BANK TRAVAILLANT RIVER CROSSING

DEPARTMENT OF PUBLIC WORKS, CANADA
MACKENZIE HIGHWAY

DRILL HOLE REPORT

SITE:

FIELD ENG.

TECH.

DATE DRILLED. 22/1/74

RIG. Mayhew #2

AIRPHOTO NO.

SURFACE DRAINAGE.

CHAINAGE. 3549+28

VEGETATION.

OFFSET.

ELEV.

TEST HOLE 2

MILE 868

DEPTH (FEET)	SAMPLE NUMBER	SAMPLE TYPE	% RECOVERY	PENETRATION RESISTANCE	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION
						PEAT — 1'		
4					GC	GRAVEL - Sandy - Clayey		Not
8								
12						- wet at 10'		frozen
						— 14'		
16						Bottom of Hole - 14'		
20						Hole caving in Unable to add stem		
24								
28								
32								
36								
40								
44								
48								
52								
56								

DEPTH (FEET)

▲ DRY DENSITY (lbs./ Ft.^{3})

⊙ WATER CONTENT (% of dry weight)

△ ICE CONTENT (% of sample volume)

PLASTIC LIMIT — LIQUID LIMIT

0 40 | 20 60 | 40 80 | 60 100 | 80 120 | 100 140 | 100+

GRAIN-SIZE ANALYSIS				RELATIVE THAWED MOISTURE CONTENT
CLAY %	SILT %	SAND %	GRAVEL %	

REMARKS

No samples taken

D3-14-5-74 a

NORTH BANK TRAVAILLANT RIVER CROSSING

DEPARTMENT OF PUBLIC WORKS, CANADA
MACKENZIE HIGHWAY

DRILL HOLE REPORT

SITE:

FIELD ENG.

DATE DRILLED. 21/1/74

AIRPHOTO NO.

CHAINAGE. 3549+24

OFFSET.

TECH. W. Baine

RIG. Mayhew #1

SURFACE DRAINAGE.

VEGETATION.

ELEV.

TEST HOLE 2A

MILE 868

DEPTH (FEET)	SAMPLE NUMBER	SAMPLE TYPE	% RECOVERY	PENETRATION RESISTANCE	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION
					Pt	PEAT — 1'		
4					GC	GRAVEL - Sandy - Clayey		
8							F	
12						— 12'		
					CL	CLAY - Silty, sandy - Gravelly — 15'		Low Ice
16						CLAY - Silty - Sandy - Pebbles		
20					CI	- Med. Plastic - Till		Vx
24						CLAY - Silty, sandy - Pebbles		Low
28					CI	- Med. Plastic		Ice
32							F	Vx
36								
40								
44						— 44'		
						Bottom of Hole - 44'		
48								
52								
56								

▲ DRY DENSITY (lbs./ Ft.^{3})
⊙ WATER CONTENT (% of dry weight)
△ ICE CONTENT (% of sample volume)

PLASTIC LIMIT — LIQUID LIMIT

40 0 | 60 20 | 80 40 | 100 60 | 120 80 | 140 100 | 100+

DEPTH (FEET)	GRAIN-SIZE ANALYSIS CLAY %	SILT %	SAND %	GRAVEL %	RELATIVE THAWED MOISTURE CONTENT	REMARKS
16	77	19	4		Moist	
20	81	18	1		Damp	
24					Moist	
28	75	23	2		Moist	
32					Damp	
36	78	21	1		Damp	
40	74	25	1		Moist	

DS-14-5-74 a

NORTH BANK TRAVAILLANT RIVER CROSSING

DEPARTMENT OF PUBLIC WORKS, CANADA
MACKENZIE HIGHWAY

DRILL HOLE REPORT

SITE:

FIELD ENG.

DATE DRILLED. 20/1/74 | AIRPHOTO NO. | CHAINAGE. 3550+24 | OFFSET.

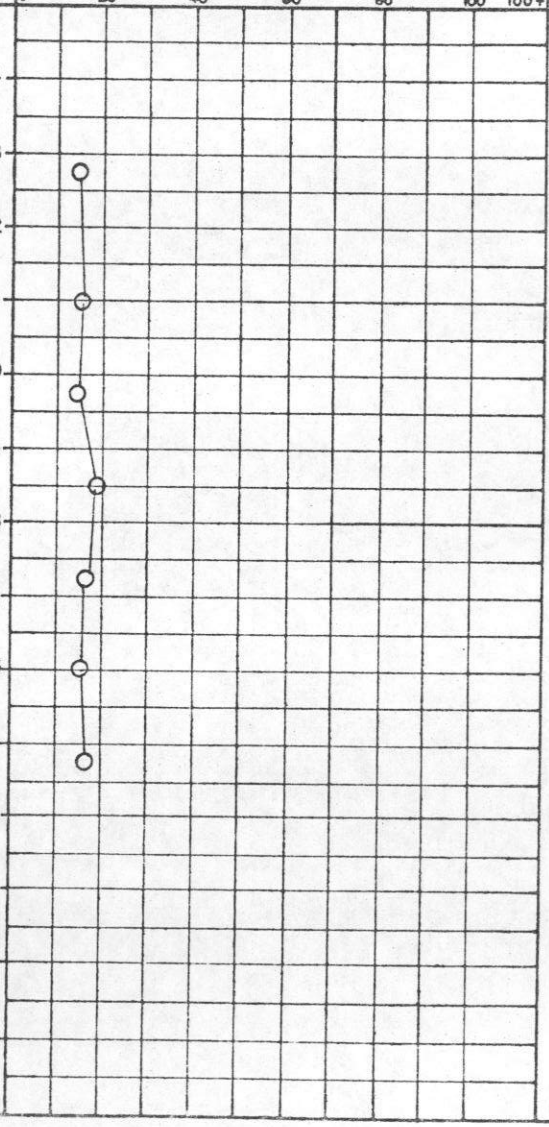
TECH. W. Baine | RIG. Mayhew #1 | SURFACE DRAINAGE. | VEGETATION. | ELEV.

TEST HOLE 3

MILE 868

DEPTH (FEET)	SAMPLE NUMBER	SAMPLE TYPE	% RECOVERY	PENETRATION RESISTANCE	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION
					Pt	PEAT 2'		
4						GRAVEL - Sandy - Clayey		
8					GC	8'		
12						CLAY - Silty - Sandy - Pebbles Med. Plastic	F	Low Ice Vx Nbn
16					CI			
20								
24								
28						CLAY - Silty - Sandy - Pebbles Med. Plastic	F	Low Ice Vx
32					CI			
36								
40								
44						44'		
48						Bottom of Hole - 44'		
52								
56								

DRY DENSITY (lbs./ Ft.^{3})
WATER CONTENT (% of dry weight)
ICE CONTENT (% of sample volume)
PLASTIC LIMIT — LIQUID LIMIT



GRAIN-SIZE ANALYSIS CLAY %	SILT %	SAND %	GRAVEL %	RELATIVE THAWED MOISTURE CONTENT	REMARKS
-69-		31	0	Damp	
-84-		15	1	Damp	
-76-		20	4	Damp	
-76-		21	3	Moist	
-84-		16	0	Damp	
-82-		16	2	Damp	
-77-		20	3	Moist	

DS-14-5-74a

NORTH BANK TRAVAILLANT RIVER CROSSING

DEPARTMENT OF PUBLIC WORKS, CANADA
MACKENZIE HIGHWAY

DRILL HOLE REPORT

SITE:

FIELD ENG.

DATE DRILLED. 20/1/74 | AIRPHOTO NO. | CHAINAGE. 3550+04 | OFFSET.

TECH. W. Baine | RIG. Mayhew #1 | SURFACE DRAINAGE. | VEGETATION. | ELEV.

TEST HOLE 4

MILE 868

DEPTH (FEET)	SAMPLE NUMBER	SAMPLE TYPE	% RECOVERY	PENETRATION RESISTANCE	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION
						ICE 1'		ICE
					Pt	PEAT 3'		Low Ice Vx
4					CI	CLAY - Sandy, silty, gravelly, med. plastic 7'		
8						Bottom of Hole - 7'		
12						No return after 7'		
16						Probably thawed below 7'		
20								
24								
28								
32								
36								
40								
44								
48								
52								
56								

DEPTH (FEET)

▲ DRY DENSITY (lbs./ Ft.^{3})

⊙ WATER CONTENT (% of dry weight)

△ ICE CONTENT (% of sample volume)

PLASTIC LIMIT ⟷ LIQUID LIMIT

40 0 | 60 20 | 80 40 | 100 60 | 120 80 | 140 100 | 100+

GRAIN-SIZE ANALYSIS				RELATIVE THAWED MOISTURE CONTENT	REMARKS
CLAY %	SILT %	SAND %	GRAVEL %		
-3	2-	45	23	Moist	

D3-14-5-74 a

NORTH BANK TRAVAILLANT RIVER CROSSING

DEPARTMENT OF PUBLIC WORKS, CANADA
MACKENZIE HIGHWAY

DRILL HOLE REPORT

SITE:

FIELD ENG.

DATE DRILLED. 21/1/74 | AIRPHOTO NO. | CHAINAGE. 3550+16 | OFFSET.

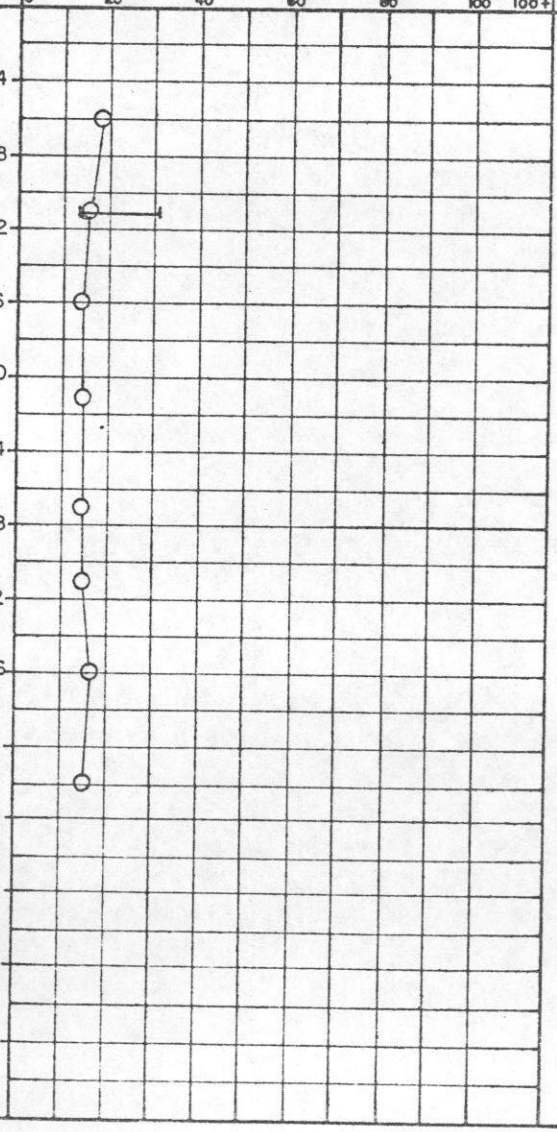
TECH. W. Baine | RIG. Mayhew #1 | SURFACE DRAINAGE. | VEGETATION. | ELEV.

TEST HOLE 5

MILE 868

DEPTH (FEET)	SAMPLE NUMBER	SAMPLE TYPE	% RECOVERY	PENETRATION RESISTANCE	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION
					Pt	PEAT — 1'		
4					GW	GRAVEL - Sandy - Silty — 6'		Low
8					CI	CLAY - Sandy - Silty - Pebbles - Med. Plastic		Ice
12								
16						- Till		Vx
20								
24						Boulders @ 25'		
28					CI	CLAY - Sandy - Silty - Pebbles - Till - Med. Plastic	F	Low Ice
32								
36								Vx
40								
44						— 43'		
48						Bottom of Hole - 43'		
52								
56								

DRY DENSITY (lbs./ Ft.^{3})
WATER CONTENT (% of dry weight)
ICE CONTENT (% of sample volume)
PLASTIC LIMIT — LIQUID LIMIT



DEPTH (FEET)	CLAY %	SILT %	SAND %	GRAVEL %	RELATIVE THAWED MOISTURE CONTENT	REMARKS
8	79	15	6		Moist	
12	76	23	1		Damp	
16	75	23	2		Damp	
20	79	15	6		Damp	
28	81	18	1		Damp	
32	79	18	3		Damp	
36	79	19	2		Damp	
44	76	18	6		Damp	

DS-14-5-74 e

SOUTH BANK TRAVAILLAND RIVER CROSSING

DEPARTMENT OF PUBLIC WORKS, CANADA
MACKENZIE HIGHWAY

DRILL HOLE REPORT

SITE:

FIELD ENG.

DATE DRILLED. 22/1/74 | AIRPHOTO NO. | CHAINAGE. 3550+55 | OFFSET.

TECH. W. Baine | RIG. Mayhew #1 | SURFACE DRAINAGE. | VEGETATION. | ELEV.

TEST HOLE 6

MILE 868

DEPTH (FEET)	SAMPLE NUMBER	SAMPLE TYPE	% RECOVERY	PENETRATION RESISTANCE	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION
					Pt	PEAT AND ICE — 2.5'		ICE
4					GC	GRAVEL - Sandy - Clayey — 7.5'		
8					CI	CLAY - Silty - Sandy - Pebbles	F	Low Ice
12						- Med. Plastic		
16						- Till		Vx
20								
24								
28					CI	CLAY - Silty - Sandy - Gravelly - Med. Plastic	F	Low Ice
32								
36								Vx
40								
44						43'		
48						Bottom of Hole - 43'		
52								
56								

DRY DENSITY (lbs./ Ft.^{3})
WATER CONTENT (% of dry weight)
ICE CONTENT (% of sample volume)
PLASTIC LIMIT — LIQUID LIMIT
40 0 60 20 80 40 100 60 120 80 140 100 100+

GRAIN-SIZE ANALYSIS				RELATIVE THAWED MOISTURE CONTENT
CLAY %	SILT %	SAND %	GRAVEL %	
-76-	21	3		
-67-	27	6		
-84-	15	1		Damp
-41-	12	47		Damp
-59-	16	25		Damp
-66-	19	15		Moist
-61-	18	21		Damp

REMARKS

Unconfined compressive strength test- 7.9 KIPS/FT^2

γ_w = 137 #/FT.^{3}

γ_d = 120 #/FT.^{3}

DS-14-5-74 a

NORTH BANK TRAVAILLANT RIVER CROSSING

DEPARTMENT OF PUBLIC WORKS, CANADA
MACKENZIE HIGHWAY

DRILL HOLE REPORT

SITE:

FIELD ENG.

DATE DRILLED. 20/1/74 | AIRPHOTO NO. | CHAINAGE. 3549+00 | OFFSET.

TECH. W. Baine | RIG. Mayhew #1 | SURFACE DRAINAGE. | VEGETATION. | ELEV.

TEST HOLE 7

MILE 868

DEPTH (FEET)	SAMPLE NUMBER	SAMPLE TYPE	% RECOVERY	PENETRATION RESISTANCE	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION
					Pt	PEAT — 1'		
4						GRAVEL - Sandy - Clayey - Silty		
8					GC			
12						— 12'	F	
						GRAVEL - CLAY		
16					GC	SAND MIX — 16'		Low
						CLAY		Ice
20						- Silty - Sandy - Pebbles		Vx
24					CI	Med. Plastic - Till		
28								Low
32					CI		Fj	Ice
36								Vx
40						— 41'		
44						Bottom of Hole - 41'		
48								
52								
56								

DRY DENSITY (lbs./ Ft.^{3})
WATER CONTENT (% of dry weight)
ICE CONTENT (% of sample volume)
PLASTIC LIMIT — LIQUID LIMIT
40 0 | 60 20 | 80 40 | 100 60 | 120 80 | 140 100 | 100+

GRAIN-SIZE ANALYSIS	CLAY %	SILT %	SAND %	GRAVEL %	RELATIVE THAWED MOISTURE CONTENT
-28-			19	53	
-77-			22	1	
-72-			22	6	
-69-			19	12	
-76-			13	11	

REMARKS

DS-14-5-74 8

DEPARTMENT OF PUBLIC WORKS, CANADA
MACKENZIE HIGHWAY

DRILL HOLE REPORT

SITE:

FIELD ENG. A. HANNA | DATE DRILLED. 21/1/74 | AIRPHOTO NO. A 22855-83 | CHAINAGE. 355[illegible]00 | OFFSET. ℄

TECH. McINTOSH | RIG. MAYHEW - #2 | SURFACE DRAINAGE. GOOD | VEGETATION. SPRUCE MAX. 5" | ELEV.

TEST HOLE 377

MILE 868

DEPTH (FEET)	SAMPLE NUMBER	SAMPLE TYPE	% RECOVERY	PENETRATION RESISTANCE	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION	GRAIN-SIZE ANALYSIS CLAY %	SILT %	SAND %	GRAVEL %	RELATIVE THAWED MOISTURE CONTENT	REMARKS
					Pt	PEAT .5'								
2					GC	GRAVEL -Sandy Clayey		Moderate Ice					Moist	
4														
6						5'							Wet	
8						CLAY -Silty Sandy Gravelly	F	Vc - Vr					Wet	
10						Pebbles Med. plastic								
12					CI								Wet	
14													Wet	
16														
18														
20														
22														
24														
26														
28						30'								

DEPTH (FEET) 2 4 6 8 10 12 14 16 18 20 22 24 26 28

▲ DRY DENSITY (lbs./ Ft.³)
⊙ WATER CONTENT (% of dry weight)
△ ICE CONTENT (% of sample volume)
PLASTIC LIMIT — LIQUID LIMIT
40 60 80 100 120 140 100+
0 20 40 60 80 100

BOTTOM OF HOLE - 30'

DS-14-5-74 à

DEPARTMENT OF PUBLIC WORKS, CANADA
MACKENZIE HIGHWAY

DRILL HOLE REPORT

SITE:

FIELD ENG. A. HANNA | DATE DRILLED. 21/1/74 | AIRPHOTO NO. A 22855-83 | CHAINAGE. 3552+00 | OFFSET. ℄

TECH. McINTOSH | RIG. MAYHEW - #2 | SURFACE DRAINAGE. GOOD | VEGETATION. SPRUCE MAX. 7" | ELEV.

TEST HOLE 378

MILE 868

DEPTH (FEET)	SAMPLE NUMBER	SAMPLE TYPE	% RECOVERY	PENETRATION RESISTANCE	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION
					Pt	PEAT — .5'		
2					GC	GRAVEL -Sandy Clayey		Frozen Nbn
8					CI	CLAY -Silty Sandy Gravelly — 11'	F	Moderate Ice Vc - Vr
12					SC	SAND -Gravelly, clayey — 13'		
14					CI CH	CLAY -Silty Sandy Pebbles Med-high plastic		High Ice Vs
30								

DRY DENSITY (lbs/ Ft.³)
WATER CONTENT (% of dry weight)
ICE CONTENT (% of sample volume)
PLASTIC LIMIT — LIQUID LIMIT

GRAIN-SIZE ANALYSIS				RELATIVE THAWED MOISTURE CONTENT	REMARKS
CLAY %	SILT %	SAND %	GRAVEL %		
				Humid	
				Damp	
				Wet	
				Wet	
				Sat.	

BOTTOM OF HOLE - 30'

DS-14-5-74 b

DEPARTMENT OF PUBLIC WORKS, CANADA
MACKENZIE HIGHWAY

DRILL HOLE REPORT

SITE:

FIELD ENG. A. HANNA | DATE DRILLED. 21/1/74 | AIRPHOTO NO. A 22855-83 | CHAINAGE. 3555+00 | OFFSET. ℄

TECH. McINTOSH | RIG. MAYHEW - #2 | SURFACE DRAINAGE. FAIR | VEGETATION. SPRUCE MAX. 7" | ELEV.

TEST HOLE 379

MILE 868

DEPTH (FEET)	SAMPLE NUMBER	SAMPLE TYPE	% RECOVERY	PENETRATION RESISTANCE	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION
					Pt	PEAT — 1'		
2						SAND -Clayey Pebbles		Moderate Ice
4								
6								Vc - Vr
8					SC CL	CLAY-SAND MIX -Pebbles	F	
10								
12						SAND -Clayey Pebbles		
14						— 14'		
16					CL	CLAY -Silty Sandy Pebbles		
18					CI			
20								High Ice
22								Vs
24								
26								
28								
						30'		

DRY DENSITY (lbs./ Ft.³)
WATER CONTENT (% of dry weight)
ICE CONTENT (% of sample volume)
PLASTIC LIMIT — LIQUID LIMIT

DEPTH (FEET)	GRAIN-SIZE ANALYSIS CLAY %	SILT %	SAND %	GRAVEL %	RELATIVE THAWED MOISTURE CONTENT	REMARKS
2					Wet	
6					Wet	
8					Sat.	
14					Wet	

BOTTOM OF HOLE - 30'

DS-14-5-74 b

DEMPSTER HIGHWAY, Y.T.
EAGLE RIVER BRIDGE SITE

Initial Ground Temperatures at installation of thermistors- June 7, 1974.

DEPTH	TEMPERATURE ^{o}F	
	SOUTH BANK STA 5091+80	NORTH BANK STA 5094+35
5	30.6	26.0
10	30.7	22.9
20	31.95	24.4
30	32.06	27.0
40	32.2	28.2
50	32.2	28.5
60	32.1	28.6
70	32.1	28.8
80	32.0	28.7
90	32.3	29.0
100	32.1	29.1

DEMPSTER HIGHWAY, Y.T.
EAGLE RIVER BRIDGE SITE

Ground Temperatures - Sept. 29, 1974

Observer - G.H. Johnsto
DBR/NRC

(1) Thermistor Cable No. 1 - North Side - Sta. 5094 + 35
(B.H. #74-BH-Da)

Point No.	Depth Ft.	Temperature °C	Temperature °F
1	5	-0.77	30.6
2	10	-1.71	28.9
3	20	-2.55	27.4
4	30	-2.62	27.3
5	40	-2.35	27.7
6	50	-2.08	28.2
7	60	-1.91	28.6
8	70	-1.79	28.8
9	80	-1.86	28.7
10	90	-1.64	29.0
11	100	-1.72	28.9

(2) Thermistor Cable No. 2 - South Side - Sta. 5091 + 80
(B.H. #74-1)

Point No.	Depth Ft.	Temperature °C	Temperature °F
1	5	-0.14	31.7
2	10	-0.44	31.2
3	20	-0.10	31.8
4	30	+0.06	32.1
5	40	+0.12	32.2
6	50	+0.15	32.2
7	60	+0.02	32.0
8	70	+0.04	32.1
9	80	-0.10	31.8
10	90	+0.15	32.2
11	100	-0.10	31.8

NATIONAL RESEARCH COUNCIL CANADA DIVISION OF BUILDING RESEARCH

DEMPSTER HIGHWAY, Y.T.
EAGLE RIVER BRIDGE SITE

Ground Temperatures - March 21, 1975

Observers -
J.C. Plunkett, DBR/NR
T. Thompson, AES/DOE

Point No.	Depth Ft.	Cable #1 (North) °C	°F	Cable #2 (South) °C	°F
1	5	-5.53	22.0	-0.34	31.4
2	10	-3.78	25.2	-0.37	31.3
3	20	-2.15	28.1	-0.19	31.7
4	30	-2.03	28.3	-0.05	31.9
5	40	-2.11	28.2	+0.04	32.1
6	50	-2.06	28.3	+0.09	32.2
7	60	-1.95	28.5	-0.16	31.7
8	70	-1.80	28.8	0.0	32.0
9	80	-1.84	28.7	-0.23	31.6
10	90	-1.64	29.0	+0.10	32.2
11	100	-	* -	-	* -

Snow Cover - Range 27" - 39" 32" - 36"
- Avge. (~20 obser.) 32" 34"

Air Temperature - 0°C

* Unable to obtain stable reading.

3. Travaillant River

Watershed of Travaillant River is very flat. The average river slope is 0.07%. Lakes and ponds occupy about twenty-five percent of the total catchment area. The peak discharge is controlled by Travaillant Lake which is located six miles upstream from the highway crossing. This explains why the discharge estimated from high water marks, 1,960 c.f.s., is much less than the Q_{50} determined be regression analysis method, 6,600 c.f.s. Under this condition, the value of two thirds of Q_{50}, 4,400 c.f.s, is recommended as a conservative design discharge value.

3.1 Bridge Setting

The recommended bridge lenght is 260 feet based on the existing ground line profile (Fig. 13).

Although the peak flow is reduced, due to the natural storage provided by Travaillant lake, the fifty year design high water will rise over the top of the bank and into the flood plain. A water depth of 1.5 feet will cover the ground 35 feet away from the river bank along the proposed west embankment as illustrated in Fig. 13. This high water will have a low velocity and should not create any embankment stability problems. Some riprap is required only at the toe of the embankment on the flood plain. Further information on riprap recommendations is provided under the Scour Computation section.

3.2 Scour Computations

The design discharge is 4,400 cfs. At this discharge, the mean velocity and water depth at the bridge crossing site are 7.7 fps and 7 feet respectively. Stones with mean diameters of 150 m.m. are spread all over the riverbed. Under these conditions of water depth and bed material size, a velocity of 11.9 fps is required to erode the riverbed,[8] this value is much higher than the computed flood velocity of 7.7 fps (Table 1). Furthermore, the minimum channel width of 120 feet for carrying the design discharge without scour is smaller than the 150 feet channel width at the bridge crossing. Hence, there is no general scour.

The local scour depths around bridge piers were computed to be 6 feet, 9 feet and 11 feet below riverbed for pier widths of 4 feet, 6 feet and 8 feet respectively. The mean size of riprap of 18 inches is adequate for the pier protection (Table 2).

3.3. Ice Considerations

No ice marks were found on the trees along the river. Banks are clean. There is very little fluctuations of water level between winter and summer due to the strong regulation provided by Travailant lake. No specific ice problem will be expected.

I.3 TRAVAILLANT RIVER

Design discharge: 4,400 cfs

Elevation corresponding to design discharge: 401.9 feet

Natural channel width at design discharge: 180 feet

Elevation at low discharge: 396.9 feet

Riverbed material: gravel, D_{50} = 152.4 m.m.

Average water depth at design discharge: 7 feet

Cross-section area at bridge site corresponding to design discharge: 570 sq. ft.

Mean velocity at design discharge: 7.7 fps

Competent velocity suggested by Neill[7] for bed movement under conditions of bed material size of 152 m.m. and water depth of 7 feet

$$V_c = 11.5 \text{ fps}$$

which is greater than the mean velocity of 7.7 fps

The required water opening estimated by Lacey's equation is:

$$W = 1.8 \times (4{,}400)^{0.5} = 119.4 \text{ feet}$$

which is much less than the natural channel width of 180 ft.

Hence, no general scour is expected.

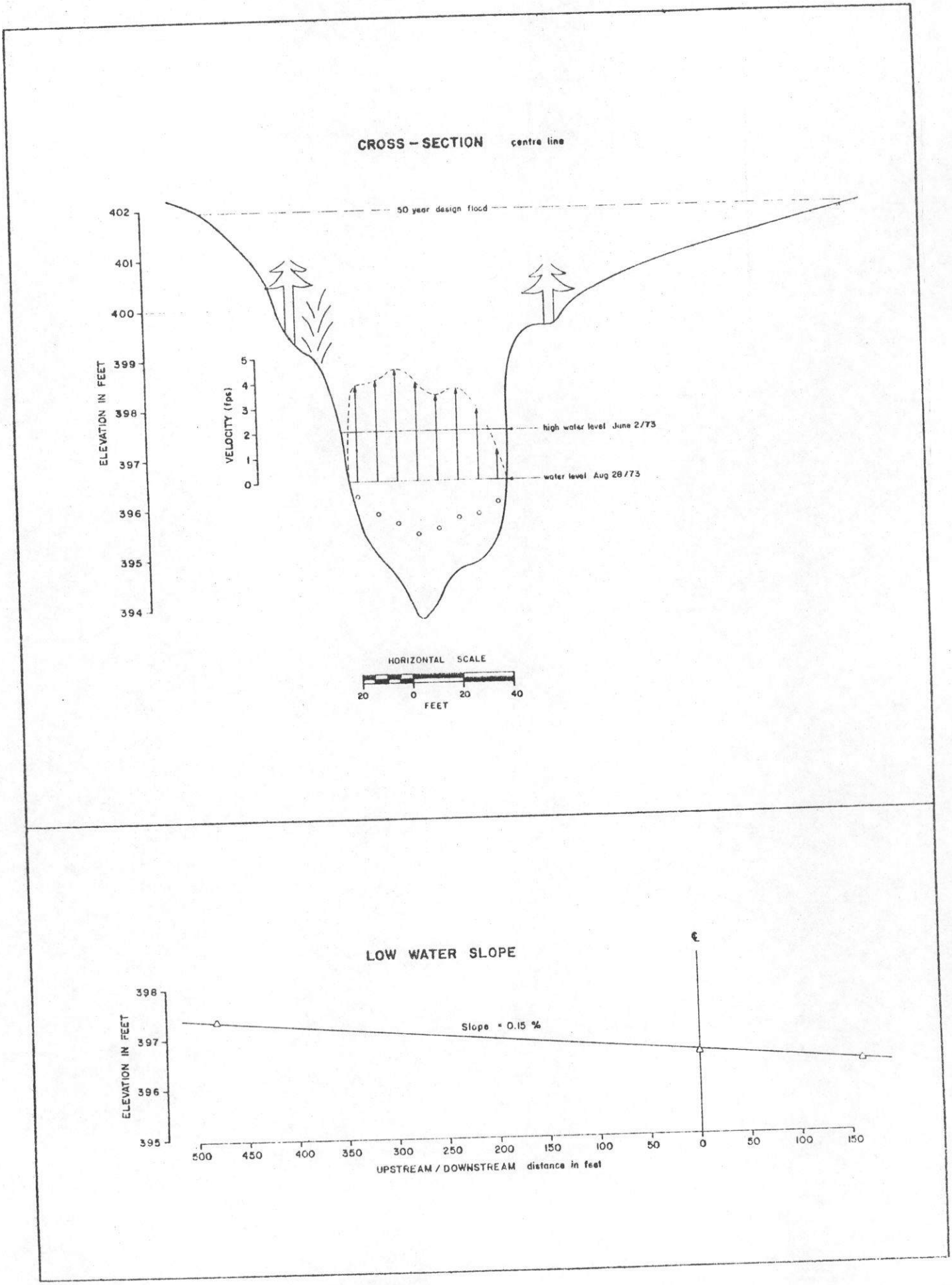


FIGURE 40 Travaillant River Hydraulic Data

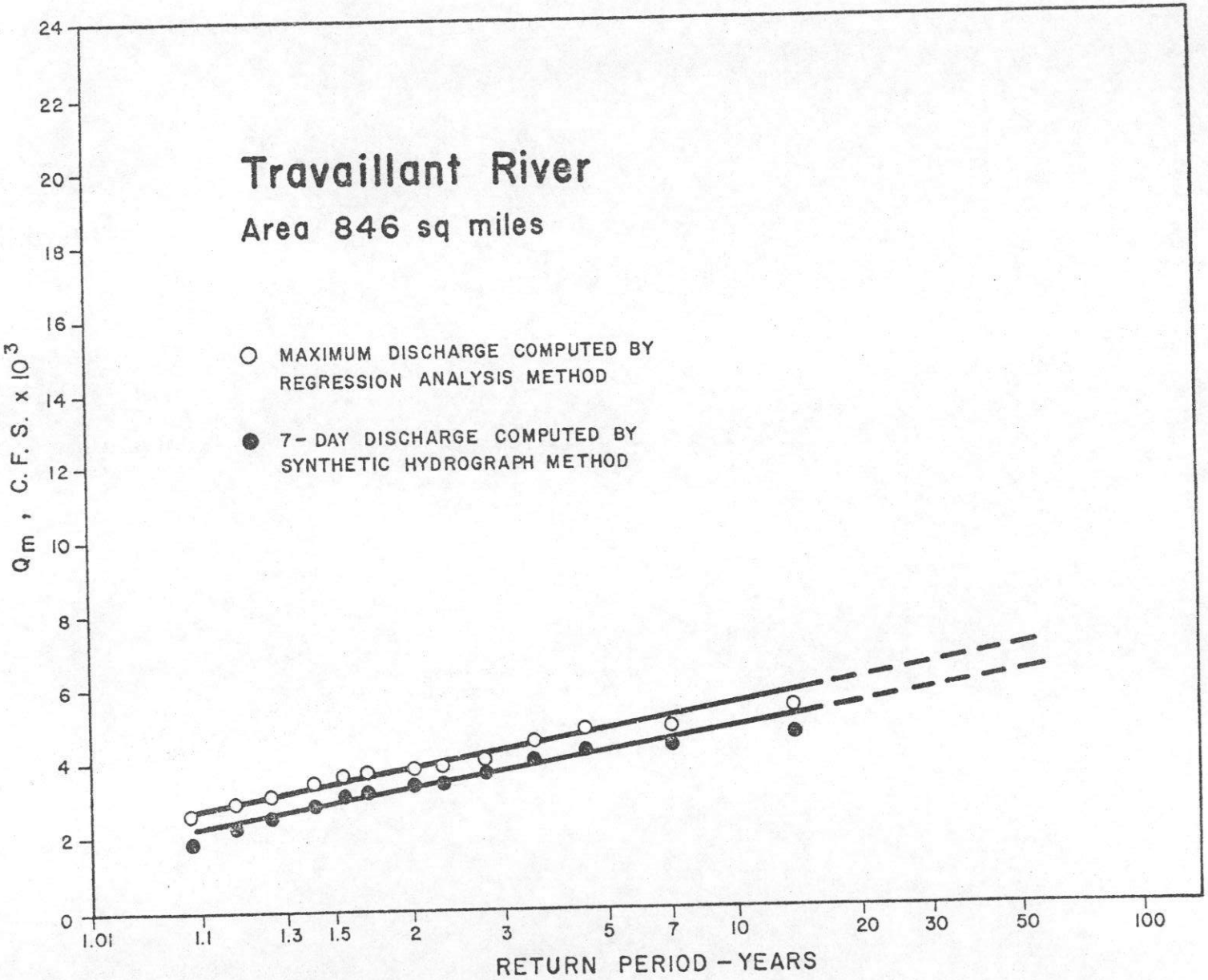


FIGURE 14 Peak and 7-day discharges of the Travaillant River

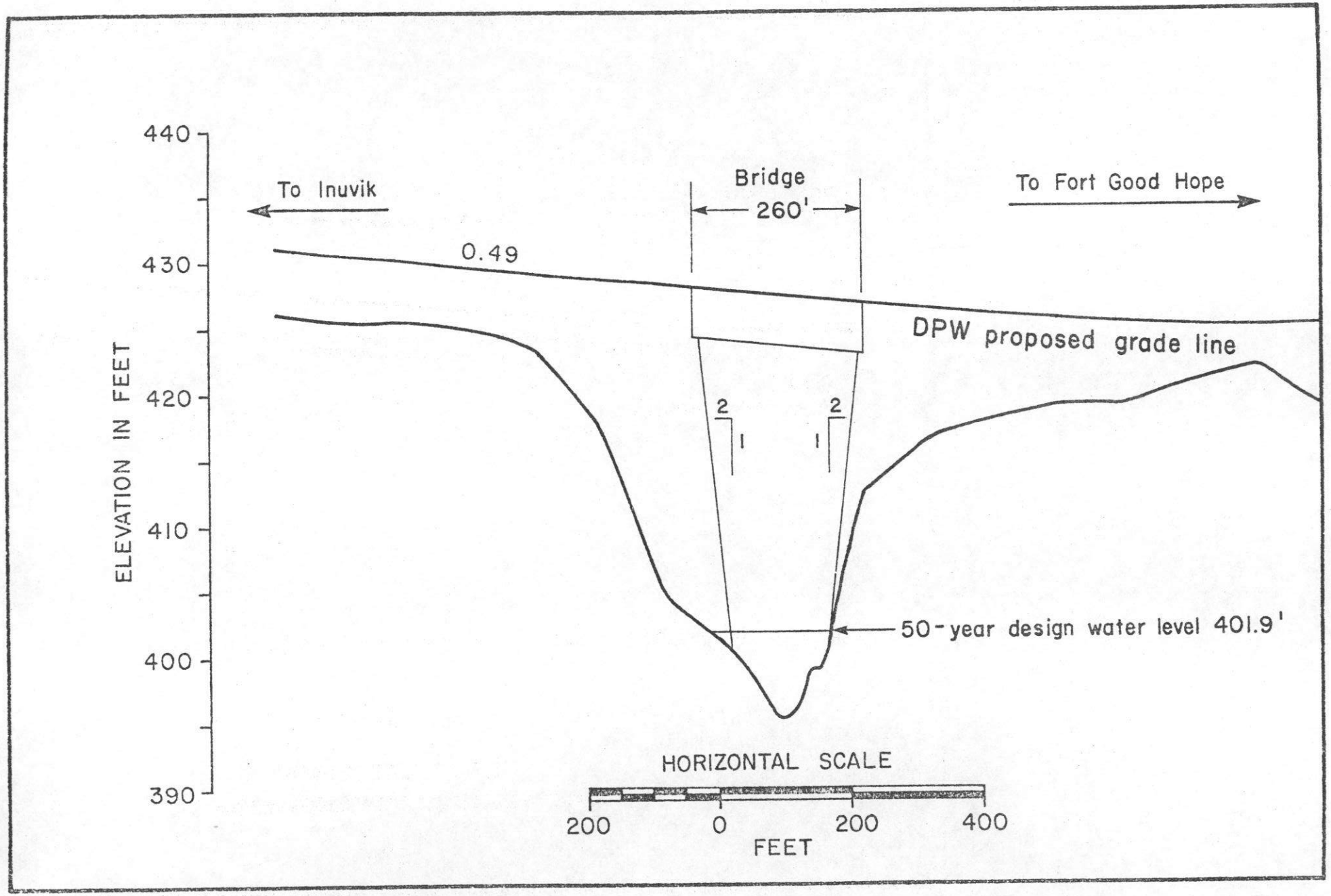


FIGURE 13 TRAVAILLANT RIVER BRIDGE
Preliminary Profile

TRAVAILLANT RIVER BASIN

TOTAL DRAINAGE AREA TO HWY 846 SQ MI

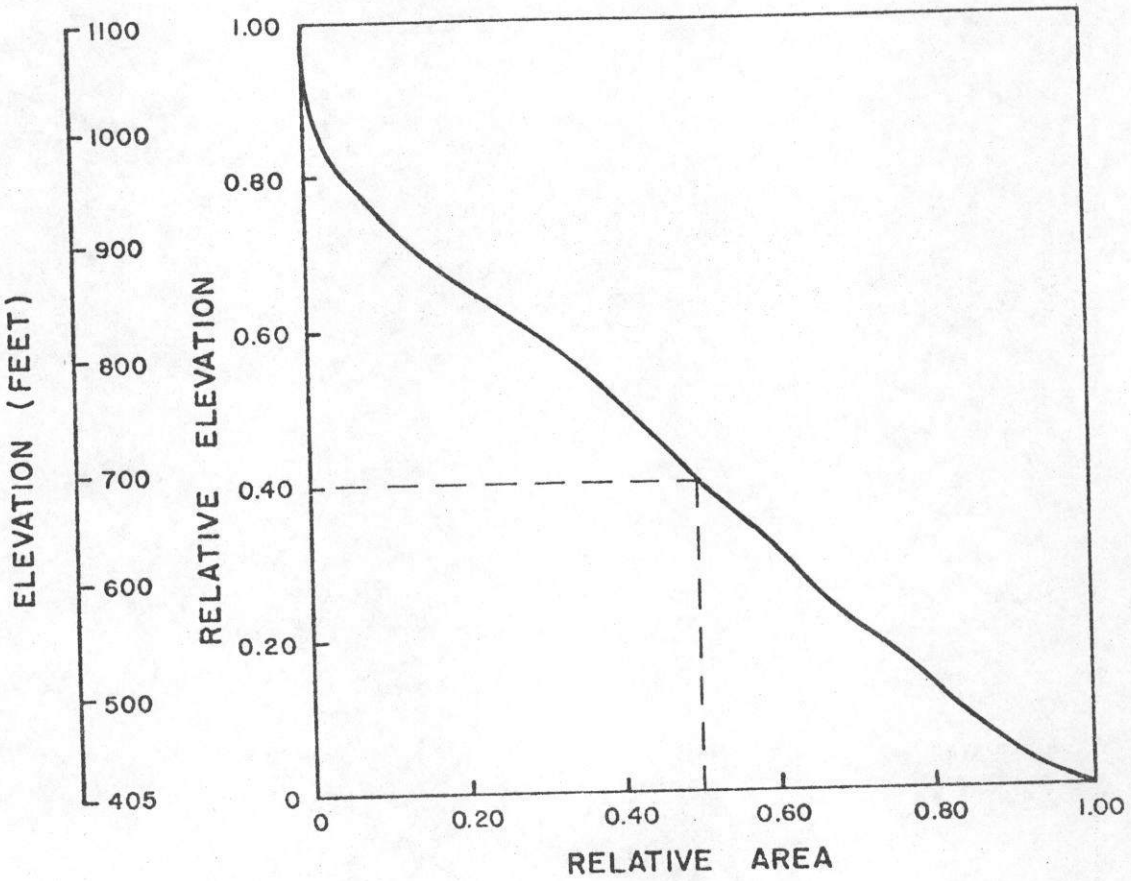


FIGURE 35

FENCO

Table C

Local Scour Depth Around Piers at

Travaillant River Crossing

	Scour Depth Calculated in Feet		
	Width of Pier in Feet		
Equation Used	4	6	8
Blench	3.0	5.1	6.1
Shen	7.5	9.7	11.6
Larras	5.6	7.6	9.5
Depth Recommended	6.0	9.0	11.0