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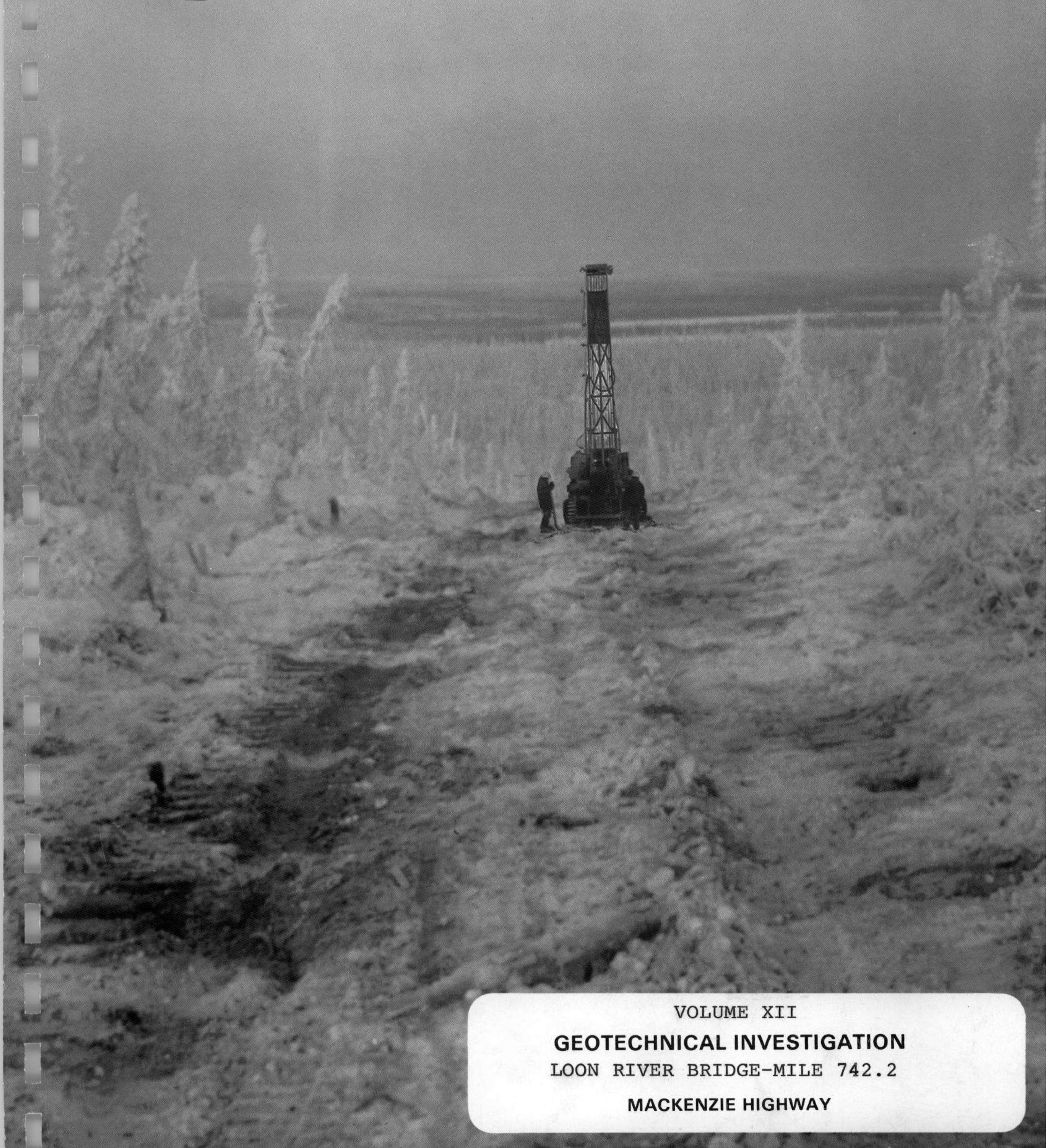

VOLUME XII

GEOTECHNICAL INVESTIGATION

LOON RIVER BRIDGE-MILE 742.2

MACKENZIE HIGHWAY

PUBLIC WORKS CANADA

WESTERN REGION

REPORT ON GEOTECHNICAL INVESTIGATION MILE 725 TO MILE 936 MACKENZIE HIGHWAY

VOLUME XII FOUNDATION INVESTIGATION LOON RIVER CROSSING MILE 742.2

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TABLE OF CONTENTS

APPENDICES

I INTRODUCTION

The subsoil investigation at the Loon 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 Loon River crossing comprises Volume XII 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 4 miles upstream of where the Loon River empties into the Mackenzie River, and is at approximately Mile 742.2 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 Loon River, and Drawing No. A-3 is a detailed, 1"=1000' mosaic of the proposed crossing site.

The Loon River drains an area of roughly 1200 square miles in the southern portion of the Anderson Plain - a vast, broadly rolling, till plain. Major depressions and valleys in the Plain are developed into underlying shale and siltstone of the Hare Indian Formation, and the Loon Lake - Rorey Lake depression, which constitutes the main drainage basin of the Loon River, is no exception.

At the proposed crossing site, the Loon River is entrenched in the Plain and has formed a relatively broad (3500') valley, roughly 170' below the level of the surrounding terrain. The floor of the valley is a flat, wide, flood plain, and the River is presently at the southern edge of the flood plain in the area of the crossing, and close to the south valley wall. There are a series of glacio-fluvial and alluvial terraces on both sides of the flood plain - on the south the terraces are of limited extent due to the close proximity of the valley wall, however, on the north the terraces are broad and offer a gradual and relatively stable

.... 3

route location out of the valley. Permafrost is continuous throughout the area and the south valley wall contains ice rich materials which are potentially thaw unstable. To avoid a massive cut here the descent into the valley has been located within a small tributary creek valley. The crossing site over the Loon is slightly upstream of the mouth of the tributary creek. Photos #1 and #2 in Appendix A are low angle oblique photographs of the crossing and illustrate the salient topographic features.

An aerial photographic interpretation of the surficial geology of the general area of the Loon River crossing is shown on Drawing No. A-3, and the terrain legend describing the symbols used is presented as Drawing No. A-3a. The immediate area of the crossing is shown in profile on Drawing No. A-4.

The stream channel at the crossing is roughly 100' in width, and 50 year return flows have been estimated by others (3.4)* at roughly 13,000 c.f.s. with maximum water levels near elevation 201 (approximately 11 feet above stream bed). Flows to this elevation would partially

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

inundate the flood plain to the north of the River.

No bridge design details are available at present although a 380' structure has been recommended by the hydrological consultants - (3.4) . Excerpts from the hydrological report are included in Appendix C.

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. 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 a core sample of shale was obtained in hole #L-3. 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.

.... 5

Shale underlies the river bed at relatively shallow depths (5' - 10'), with the river bed material consisting of sands, gravels, cobbles and boulders. Immediately adjacent to the river channel are alluvial meander plain deposits consisting of stratified clay, silt, and, primarily, sand and gravelly sand. Clay and silt strata tend to be ice rich and are wet or exhibit free water on thawing; sandy strata contain little visible ice and are normally moist to wet on thawing, with moisture contents in the order of 10%.

The shale surface is relatively flat lying in comparison with the ground surface profile, hence overburden thicknesses are variable, especially on the south side of the River where the surface rises 40-50' in a series of alluvial benches within a lateral distance of 700'. Near the river channel, thaw zones and free water were encountered at or slightly below the level of the stream bed - i.e., see logs for holes #1A, #2, #3, #4, #4A and #5. In most instances the thaw zones were shallow, however, because of the absence of visible ice in the shale bedrock, it was difficult to accurately determine the permafrost profile below the River. It has been

.... 6

assumed that the shale is frozen at depth. A sketch of the inferred thaw zone adjacent to and 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. The thin thaw zones on both sides of the River are attributed to the warming effect of river water in the permeable granular subsoil, and on the south side, also possibly to some effect from water in the tributary creek.

IV FOUNDATION SUPPORT OF BRIDGE STRUCTURE

A - General

The shale bedrock provides the obvious bearing stratum for the foundation elements, and either concrete spread footings, or pile foundations, are considered suitable for abutments and piers.

Design details for the proposed structure are not available, however, it is assumed the design will attempt to clear-span the present river channel, and thus will likely consist of a long center span, with a short approach span at each end. If this layout is effected all piers and abutments will be located outside of the thaw zone below the river channel and will be founded on frozen shale. Construction on frozen shale is not considered detrimental - the shale contains low moisture (ice) content and there was no evidence of ice filled joints or cracks during test drilling. It is expected that there will be minor permafrost degradation during and shortly after construction, however, it is not considered that any <u>significant</u> change in the permafrost profile will occur as a result of the bridge construction, and further, even should permafrost degradation occur into the shale it is not considered that it will adversely affect the bearing of the foundation elements whether spread footings or piles.

.... 8

There is concrete aggregate available near Ft. Good Hope, a haul distance of roughly 20 miles, and possibly much closer in the alluvial terraces on the north side of the Loon Valley, although tentative borings here indicate the materials are dirty and would require washing for use in concrete. Thus construction of large concrete abutments and piers on the shale could be economically feasible providing the highway is constructed south to Ft. Good Hope before bridge construction.

B - <u>Bridge Foundations</u>

It is assumed the bridge piers will be located within the river's ice range and thus will be designed to resist ice thrust and will likely be solid shaft piers. The shale has the least overburden immediately adjacent to the river and spread footings should be considered for the pier foundations. Scour calculations (3) are included in Appendix C and it is recommended the piers be placed at sufficient depth to satisfy scour requirements or a minimum of 4' below the shale surface. An allowable assumptive bearing capacity of 20 kips per sq. foot may be employed on undisturbed intact bedrock.

Abutments should be set back as far as practicable and because of increased depths of overburden over shale and the height of approach embankments, it is recommended the abutments be supported on steel H-piles driven to refusal into shale. Piles may also be utilized for the bridge piers, however, spread footings may be advantageous due to the shallow overburden near the stream channel.

If steel H-piles are utilized they should be seated directly upon the shale surface either on the bottom of an excavation, or in a pre-bored hole, before pile driving commences. This will ensure that the full energy of the hammer can be utilized for pile penetration into the frozen shale. The weight of the pile driving hammer should be at least twice the weight of the pile being driven, except that in the case of a diesel hammer the weight of the hammer should be at least equal to the weight of the pile. To prevent damage to the points of the piles it should be reinforced with flange plates for a distance equal to 1.5 times the size of the pile. Alternately points may be reinforced with a driving shoe. A heavy section pile - minimum 12BP53 is recommended and it is believe the frozen shale can be penetrated to a depth of approximately 10' if an adequate hammer is utilized - a Delmag D-12 diesel hammer or equivalent is recommended (approx. 22,000 ft. lbs.). Piles should be driven to practical refusal which may be assumed at 0.25 inches per

........10

blow measured over the last foot of driving. It is recommended that attempts be made to redrive a few piles at the start of the job, two or three days after initial refusal has been reached, as driving of sheet piles in shales and limestones has shown a stress release with time which will permit additional penetration. If significant (1' +) additional penetration is obtained, it is recommended that all piles be redriven two or three days after initial refusal. Piles driven to practical refusal as outlined above may be designed on the basis of an allowable static load in the order of 100 kips per pile.

Void spaces in pre-bored pile holes should be filled with dry, free-running sand following completion of pile-driving.

Detailed records of pile driving should be maintained for all piles. As an alternate to steel H-piles, pre-bored, driven, closed-end pipe piles may be utilized. Preboring of closed-end pipe piles into the shale is considered necessary to facilitate the driving operation and to maintain alignment of the piles. The prebored hole size should be larger than the pile diameter in overburden soils and should be 85 to 90 percent of the outside pile diameter in the shale and should extend to almost the full length of the intended pile penetration - i.e., it is anticipated that practical refusal will occur for pipe piles only

........11

slightly below the depth of preboring. It is recommended that closed-end pipe piles extend approximately 15' into the shale and that a minimum nominal diameter of 10 inches and a minimum weight of 40 lbs. per foot be used. The piles should be driven with a fairly high energy hammer - Delmag D-12 or equivalent - and should be driven to refusal below the prebored level. Piles reaching refusal should be capable of supporting allowable loads in the order of 100 kips - refusal may be assumed as a set of 0.25 - 0.4" per blow measured over the last foot of driving.

The prebored pipe piles offer an advantage over steel H-piles in that a predetermined penetration depth can be assumed. As with steel H-piles, detailed driving records should be maintained.

C <u>Bridge Approach Fills</u>

Fill heights immediately adjacent to abutments will be in the order of 15 to 25' and will be placed upon permafrost terrain. The permafrost table will likely rise into these fills hence stability of approach fills will not be a problem. Backfill immediately adjacent to the abutments should be either well compacted granular or bedrock material which will require relatively long hauls - see Volume I of Report on Geotechnical Investigation, Mile 725-936, Mackenzie Highway. Field compaction control is recommended on all backfill associated with bridge piers and abutments.

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

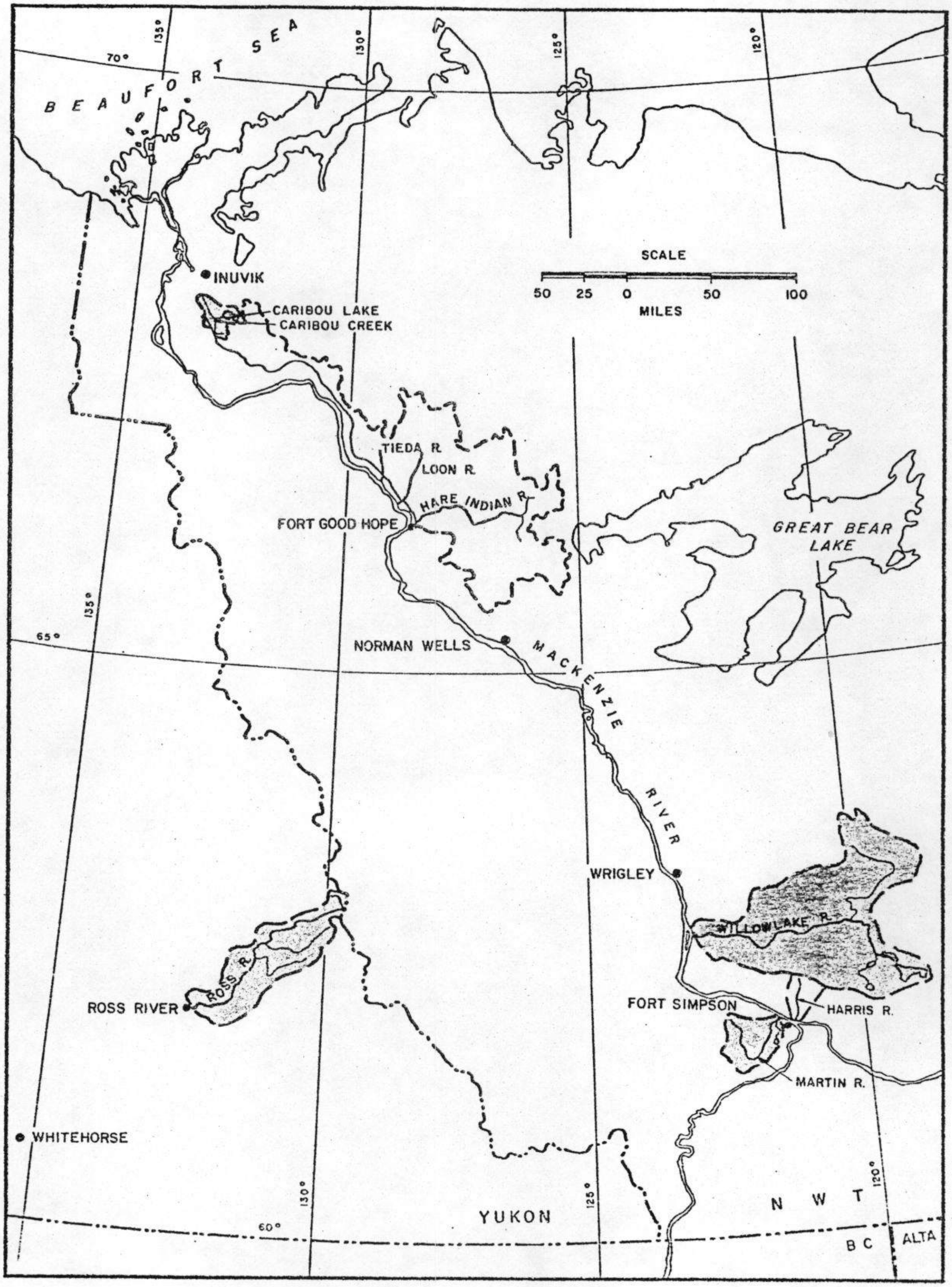
REFERENCES

1. Brown, W. G. et al "Comparison of Observed and Calculated Ground Temperatures with Permafrost Distribution Under a Northern Lake", Canadian Geotechnical Journal, Vol. 1, No. 3, July 1964.

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.



Dwg. No. A-1

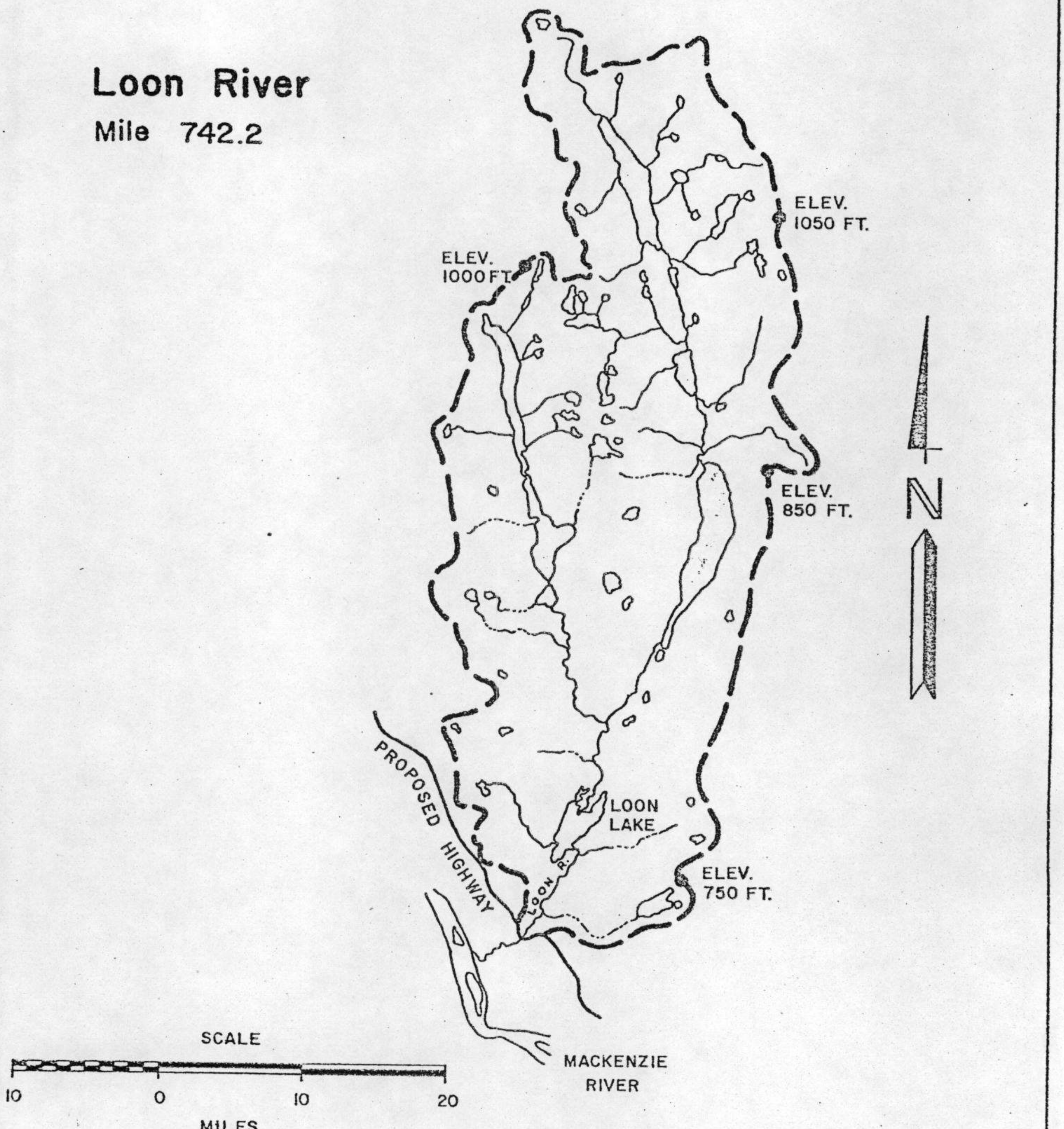
KEY PLAN

MACKENZIE RIVER, N.W.T.

1" = 90 MILES

Loon River

Mile 742.2



Drainage Area to Proposed Highway Crossing 1126 sq. miles

Dwg. No. A-2

MAP 4 Loon River Basin

LOON RIVER CROSSING
SITE PLAN
MACKENZIE HWY MILE 742·2
DWG NO A-3 SCALE 1" = 200'

TERRAIN TYPING LEGEND

Symbol	Terrain Types
AMP	Alluvial meander plain: ice-rich stratified clay, silt, and fine sand over thin, discontinuous layer of sand and/or gravel over till or glaciolacustrine silt and clay
FFP	Fossil flood plain: ice-rich silty topstratum over sand and/or gravel below the inactive floodplain of relatively high-energy streams
HT	High terraces: silt-covered stratified fluvial and/or outwash sand and gravel along the sides of present river valleys and abandoned melt-water channels
RKM	Ridge-and-knoll moraine: largely rolling ground moraine with and without drumlinoid forms; low to medium plastic till with shallow peat and ponded sediments in depressions

PHASES AND FEATURES

Topographic and drainage features

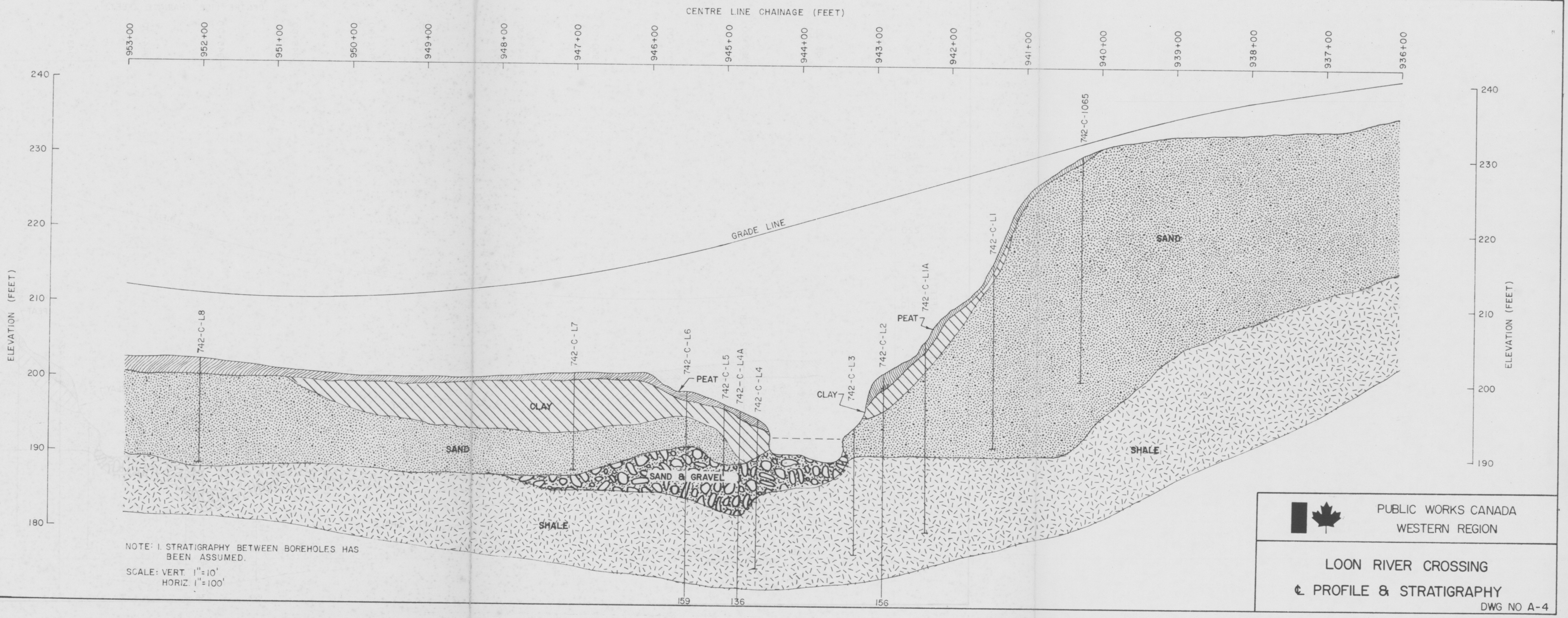
DR	Drumlinoid forms, including fluting and glacial grooves with linear ridges
EVB	Eroding valley sides and escarpment slopes; mixed clay to boulders and/or bedrock

Topstratum phases associated with main terrain types

SL	Slopewash deposits and associated sheetwash drainage: top stratum of ice-rich, poorly sorted silty clay and silty sand layers with some gravel sizes and thin organic layers; generally less than 5 ft. thick but may reach 10 ft. locally

COMPLEXES

Complexes are shown as combinations of two terrain types, with or without phases that pertain to the parent type.



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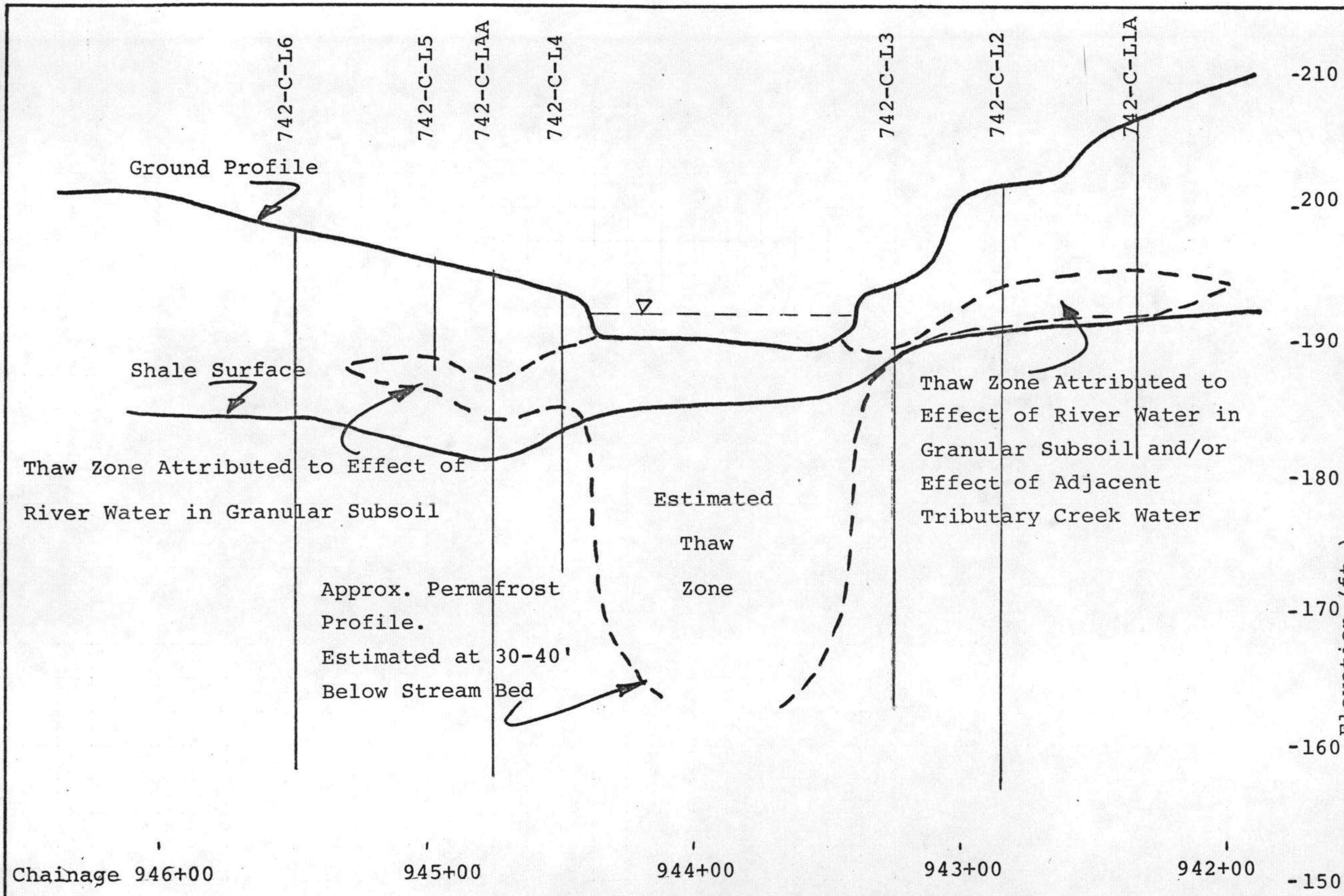
LOON RIVER CROSSING

℄ PROFILE & STRATIGRAPHY

DWG NO A-4



LOON RIVER CROSSING - MILE 742.2 MACKENZIE HWY.

PERMAFROST PROFILE - MARCH/1974.

Dwg. No. A-5

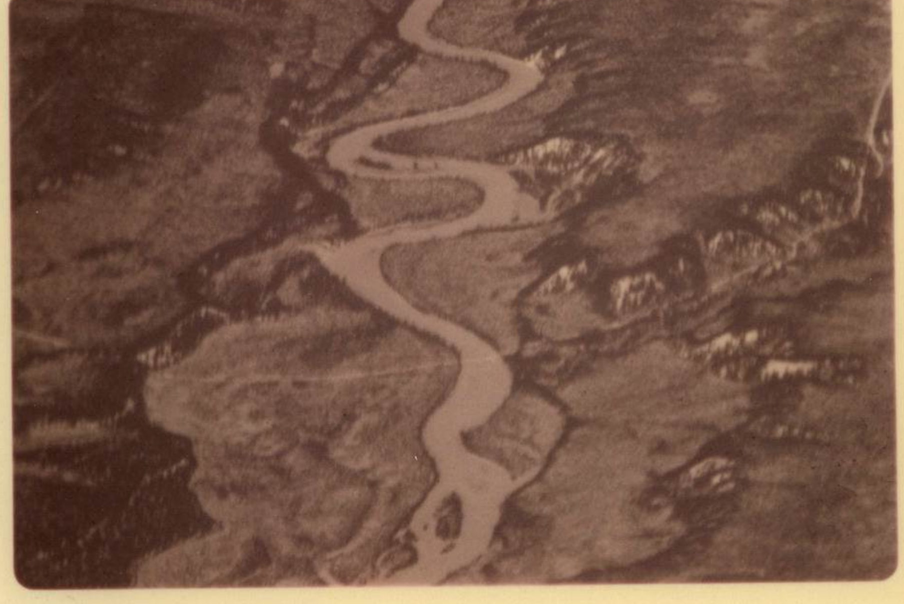


PHOTO No. 1

Loon River looking upstream. Cutline is proposed route location. Note descent along tributary creek on South, Alluvial Terraces, and Flood Plain.

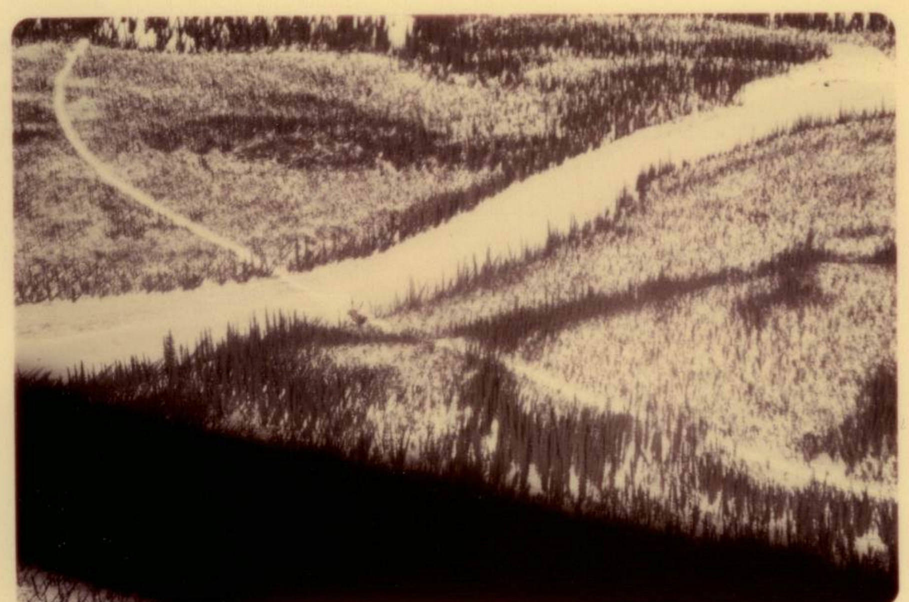


PHOTO No. 2

Loon River looking northerly. Note Flat Flood Plain adjacent to rider on the North and Alluvial Terraces adjacent on the South.

TEST HOLE LOG

hole no. 1

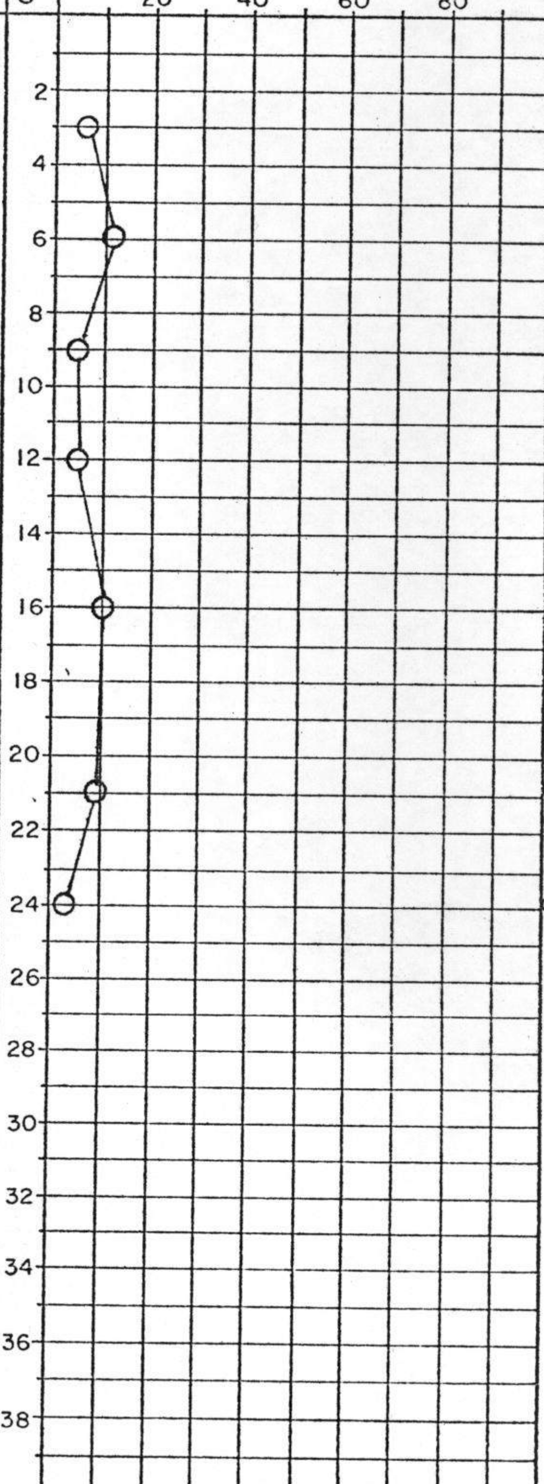
SAMPLE DATA	
weight hammer	
height drop	
elev. ground	
drill rig	Mayhew
date	4/4/74

depth/ft.	o.d./i.d.	blows/foot	symbols	DESCRIPTION OF MATERIALS	depth
			Pt	Peat	1'
			Cl	Clay - Silty, sandy	2'
			Sc Gc Gp	Sand and Gravel - silty - some clay content - very low plastic - frozen throughout - moist to wet on thawing	17'
			Sc	Sand - silty - gravel layers - low plastic - frozen throughout - damp on thawing	25'
				Bottom of Hole - 25'	

unconfined strength - kips/ft.^{2} (1.0, 2.0, 3.0, 4.0)

⊙ water content (% of dry weight)

plastic limit ├──┤ liquid limit (20, 40, 60, 80)



depth - feet	relative moisture content
3	damp
6	wet
9	moist
12	moist
16	damp
21	damp
24	damp

Public Works Canada / Travaux publics Canada

project: Loon River Bridge

location: Mile 742 Mackenzie Highway

TEST HOLE LOG

hole no. 1A

SAMPLE DATA

weight hammer	
height drop	

elev. ground

drill rig: Mayhew

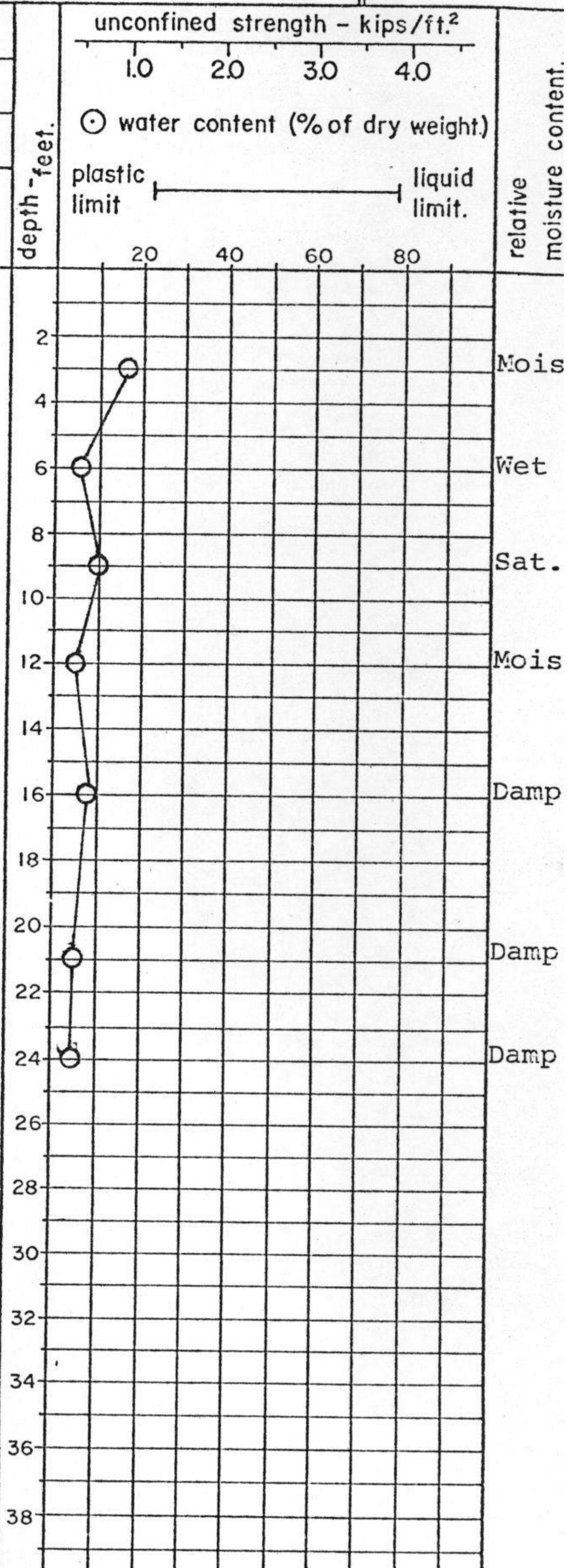
date: 4/4/74

depth/ft.	o.d./i.d.	blows/foot.	symbols	DESCRIPTION OF MATERIALS
0–1'			Pt	Peat - organic — 1'
1'–3'			Cl	Clay - sandy, silty - frozen — 3'
3'–15'			Sc Gp	Sand and Gravel -silty, clayey - low plastic - frozen to 11' - wet during drilling from 11'-15' — 15'
15'–25'				Shale - siltstone - soft to medium hard - unable to determine if frozen — 25'

Bottom of Hole - 25'

Note

Frozen from 0-11'
Thawed 11'-15'
Unable to determine if shale frozen below 15'



project: Loon River Bridge

Public Works Canada Travaux publics Canada

location: Mile 742
Mackenzie Highway

TEST HOLE LOG

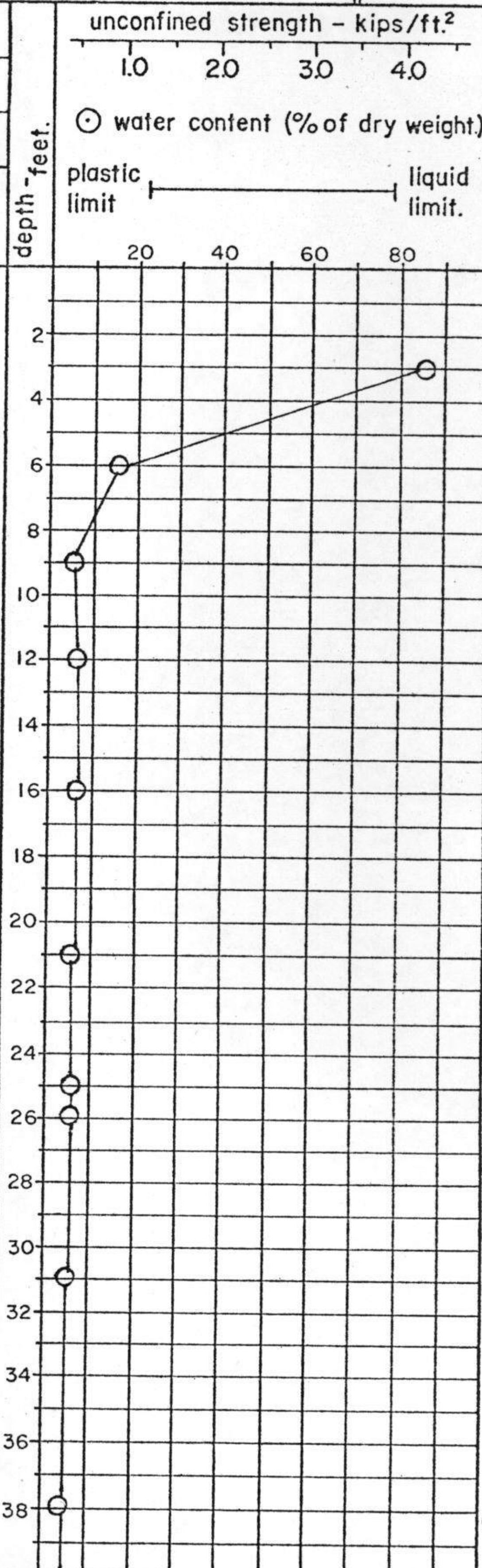
hole no. 2

SAMPLE DATA

weight hammer:
height drop:

elev. ground:
drill rig: Mayhew
date: 4/4/74

depth/ft.	o.d./i.d.	blows/foot.	symbols	DESCRIPTION OF MATERIALS
0–2			Pt	Peat - organic — 2'
2–5			Cl	Clay - silty, sandy - low plastic - frozen — 5'
5–11			Sc Gp Gc	Sand and Gravel - silty, clayey - low plastic - wet during drilling below 7' — 11'
11–13				Shale- clay-gravel mix - frozen? — 13'
13–				Shale- siltstone - soft to medium hard - unable to determine if shale frozen
				Bottom of Hole - 45'



depth (ft.)	relative moisture content
3	free water
6	wet
9	mois
12	damp
16	damp
21	damp
25	damp
26	damp
31	damp
38	damp

project: Loon River Bridge

location: Mile 742
Mackenzie Highway

Public Works Canada — Travaux publics Canada

TEST HOLE LOG

hole no. 3

SAMPLE DATA	
weight hammer	
height drop	
elev. ground	
drill rig	Mayhew
date	3/4/74

depth/ft.	o.d./i.d.	blows/foot.	symbols	DESCRIPTION OF MATERIALS	depth
0–1				Ice	1'
1–5			Gc	Clay - sand - gravel - low plastic - frozen to about 5'	5'
5–29				Shale - siltstone - soft to medium hard - water entering hole @ 5' level - unable to determine if shale frozen - core obtained from 14'-17'	29'
				Bottom of Hole - 29'	

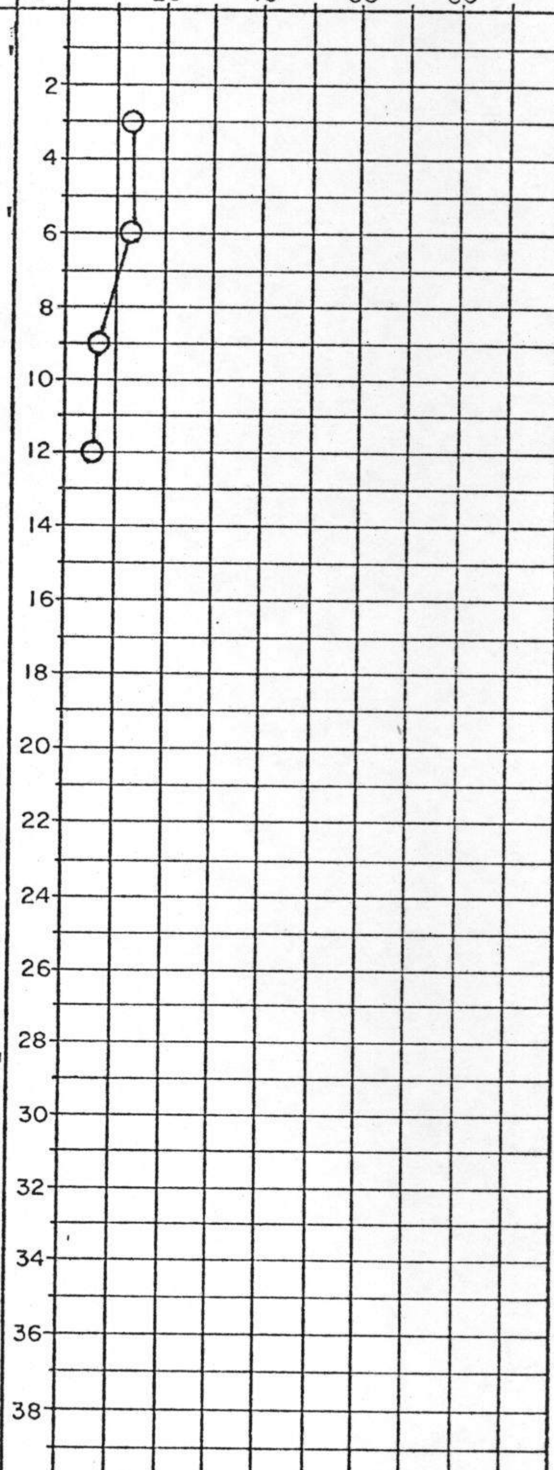
depth - feet.

unconfined strength - kips/ft.²: 1.0, 2.0, 3.0, 4.0

⊙ water content (% of dry weight)

plastic limit ⊢——⊣ liquid limit.

20, 40, 60, 80



relative moisture content.

mois
mois
mois
mois

project: Loon River Bridge

Public Works Canada / Travaux publics Canada

location: Mile 742
Mackenzie Highway

TEST HOLE LOG

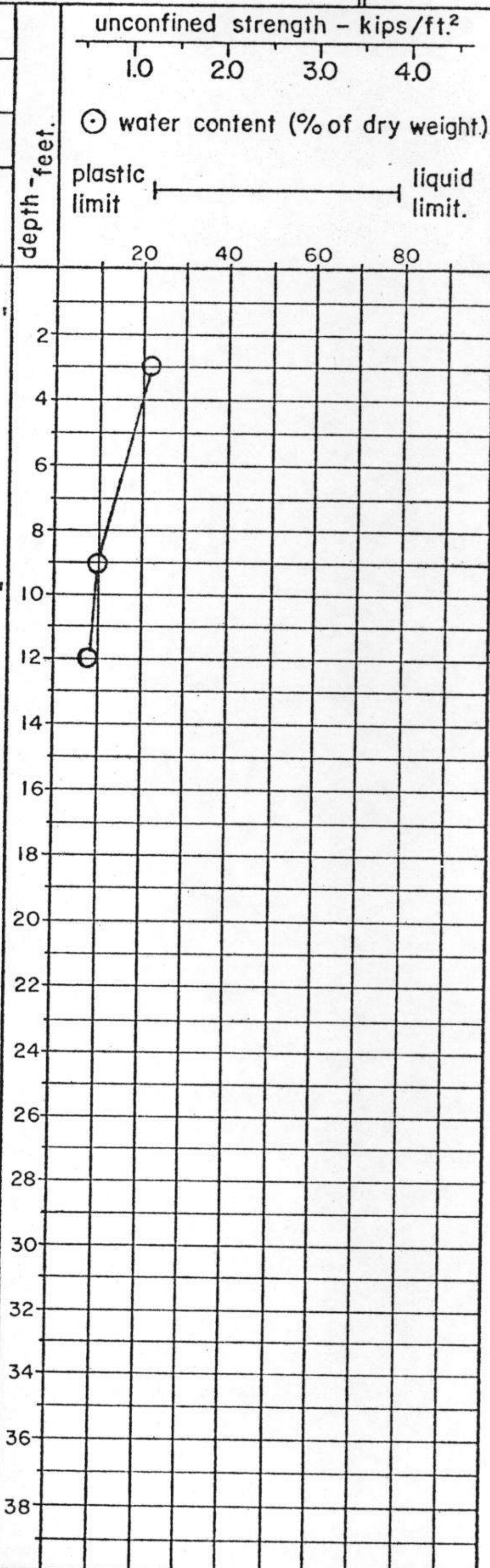
hole no. 4

SAMPLE DATA	
weight hammer	
height drop	
elev. ground	
drill rig	Mayhew
date	3/4/74

depth/ft.	o.d./i.d.	blows/foot.	symbols	DESCRIPTION OF MATERIALS
			Pt	Peat — 1'
			Gc Sc	Sand and Gravel - silty, clayey - some cobbles from 4'-8' - frozen 0-4' - wet during drilling 4'-8' - frozen below 8' — 10'
				Shale - siltstone - soft to medium hard - water entering hole from 4'-8' - shale probably frozen — 20'
				Bottom of Hole - 20'

Note

Thaw zone from 4'-8'



relative moisture content.

mois

mois

mois

project: Loon River Bridge

location: Mile 742
Mackenzie High...

Public Works Canada Travaux publics Canada

TEST HOLE LOG

hole no. 4A

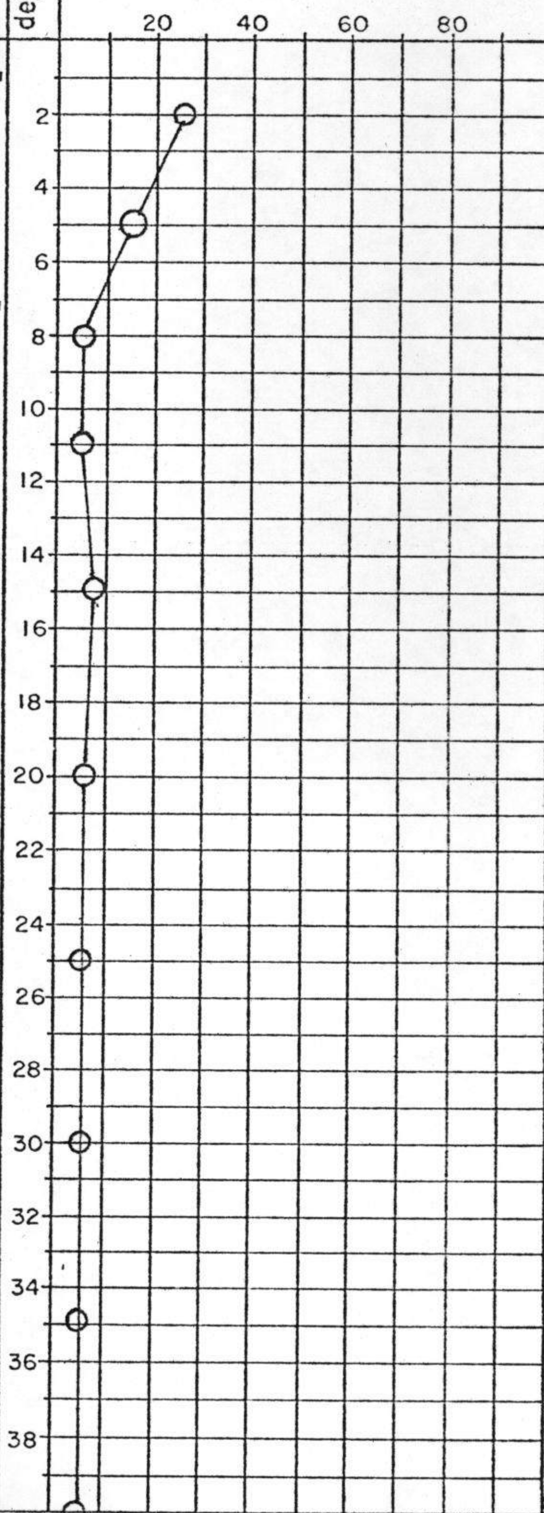
SAMPLE DATA	
weight hammer	
height drop	
elev. ground	
drill rig	Mayhew
date	3/4/74

depth/ft.	o.d./i.d.	blows/foot	symbols	DESCRIPTION OF MATERIALS
0–1'			Pt	Peat
1'–7'			Cl Sc	Clay - sandy - silty - low plastic - frozen - moist to wet on thawing
7'–14'			Sc Gc	Sand and Gravel - silty and clayey - cobbles - thaw zone near 10'
14'–				Shale - siltstone - soft to medium hard - probably frozen
				Bottom of Hole - 60'

unconfined strength - kips/ft.² (1.0, 2.0, 3.0, 4.0)

⊙ water content (% of dry weight.)

plastic limit ├──┤ liquid limit.



depth - feet	relative moisture content
2	wet
5	moist
8	wet
11	moist
15	moist
20	damp
25	damp
30	damp
35	damp
40	damp

project: Loon River Bridge

location: Mile 742
Mackenzie Highway

Public Works Canada Travaux publics Canada

TEST HOLE LOG

hole no. 5

SAMPLE DATA	
weight hammer	
height drop	

elev. ground

drill rig: Mayhew

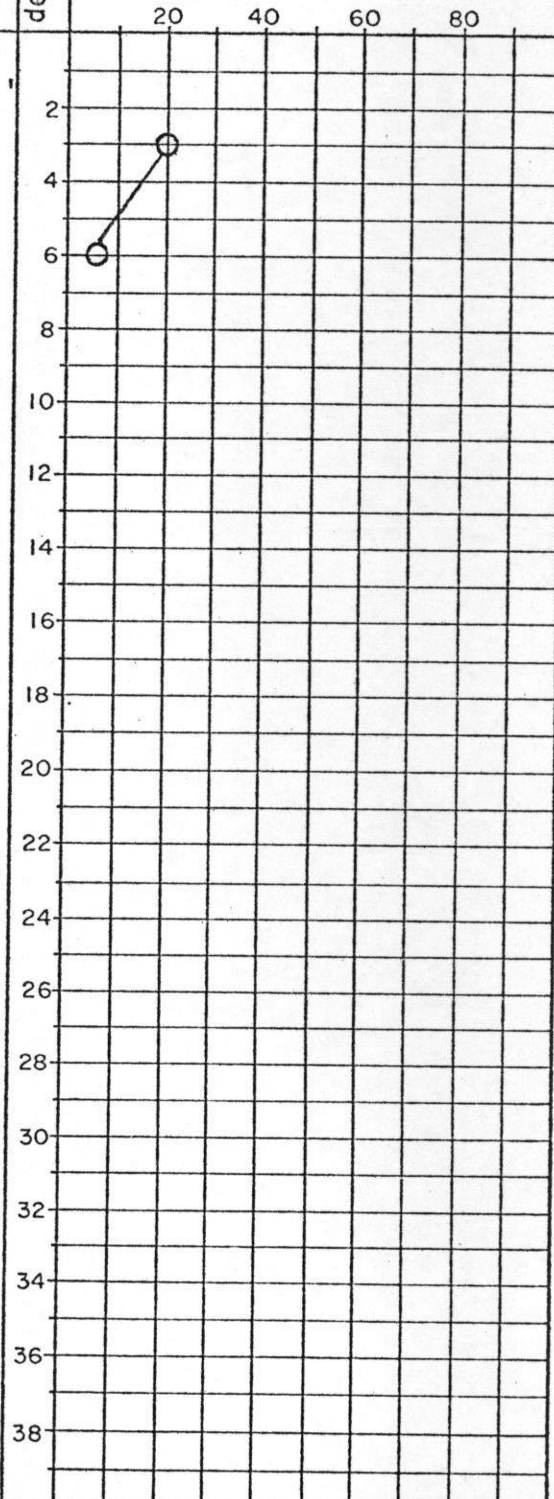
date: 4/4/74

depth/ft.	o.d./i.d.	blows/foot	symbols	DESCRIPTION OF MATERIALS	depth
			Pt	Peat - organic	.5'
			Cl Sc	Clay - silt - sand - low plastic - frozen	4'
			Sc Gc	Sand and Gravel - cobbles - silt and clay - water @ 7'	8'
				Bottom of Hole - 8'	
				Water blowing with air	
				Rig - hole abandoned	

unconfined strength - kips/ft.² (1.0, 2.0, 3.0, 4.0)

⊙ water content (% of dry weight)

plastic limit ⊢—⊣ liquid limit.



depth - feet	relative moisture content
3	wet
6	wet

project: Loon River Bridge

location: Mile 742
Mackenzie Highway

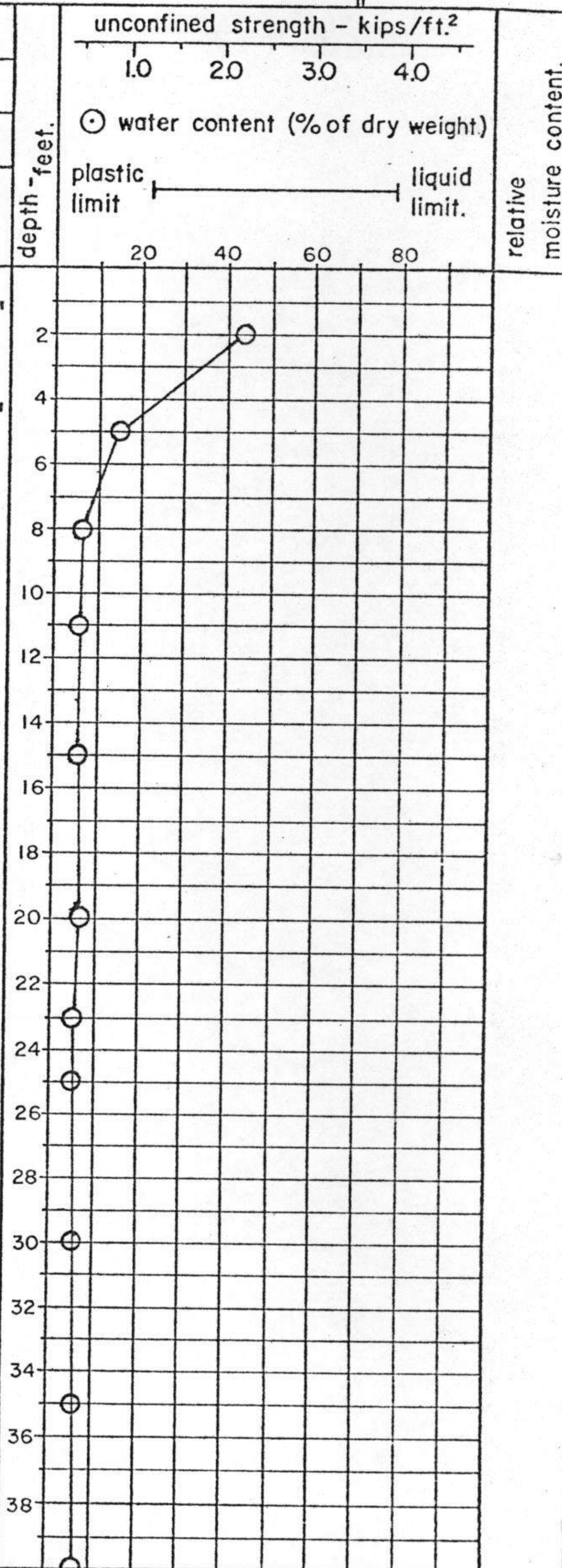
Public Works Canada Travaux publics Canada

TEST HOLE LOG

hole no. 6

SAMPLE DATA	
weight hammer	
height drop	
elev. ground	
drill rig	Mayhew
date	4/4/74

depth/ft.	o.d./i.d.	blows/foot	symbols	DESCRIPTION OF MATERIALS
			Pt	Peat — 1'
2, 4			Ml	Clay - silt - sand - frozen — 3'
6, 8, 10, 12, 14			Sc Gc	Sand and Gravel - silt and clay throughout - low plastic - some cobbles or boulders - frozen to 6' - unable to confirm permafrost below 6' — 14'
16–38				Shale - siltstone - soft to medium hard - unable to determine if frozen
				Bottom of Hole - 40'



project: Loon River Bridge

location: Mile 742 Mackenzie Highway

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TEST HOLE LOG

hole no. 7

SAMPLE DATA	
elev. ground	
weight hammer	drill rig: Mayhew
height drop	date: 3/4/74

depth/ft.	o.d./i.d.	blows/foot.	symbols	DESCRIPTION OF MATERIALS	depth - feet	relative moisture content
			Pt	Peat	1'	
			Cl	Clay - silty, sandy, pebbles - low plastic - frozen - very wet on thawing	8'	free water (3') sat. (6') wet (9')
			Gc	Sand and Gravel - clayey, silty - frozen	11'	moist (12')
			Cl CI	As above but more clay - frozen	13'	

Bottom of Hole - 13'

Hole caving - abandoned

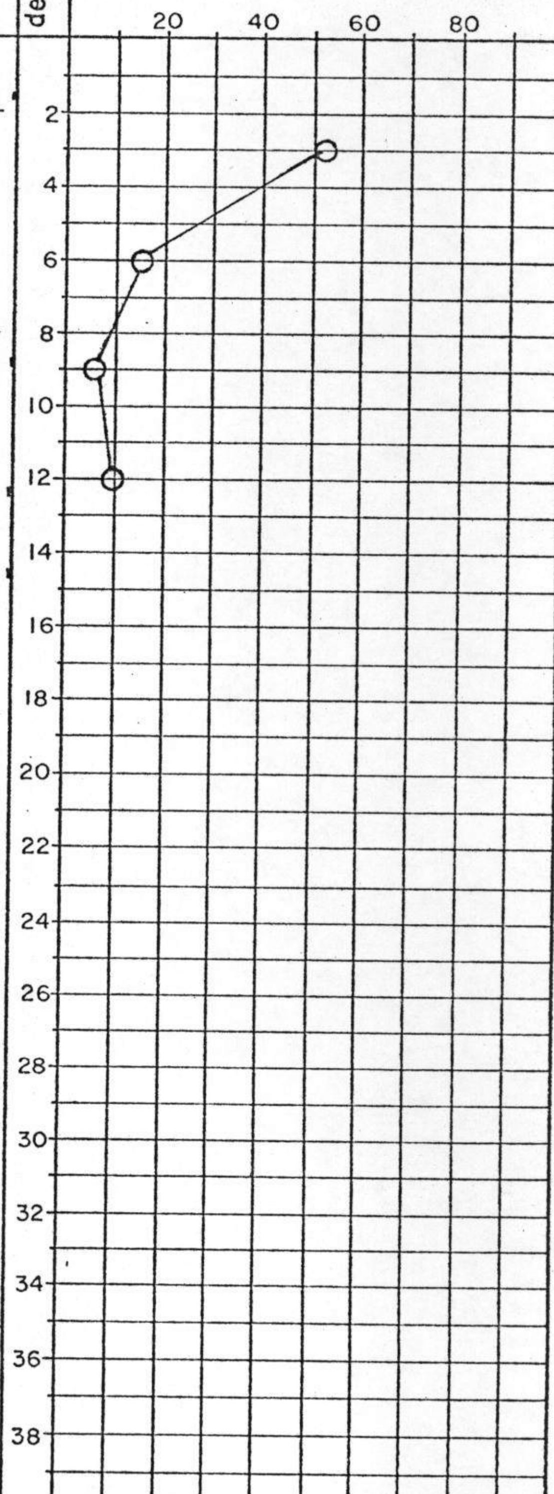
Note

Permafrost throughout

unconfined strength - kips/ft.^{2} (1.0, 2.0, 3.0, 4.0)

⊙ water content (% of dry weight)

plastic limit ⊢——⊣ liquid limit.



Public Works Canada Travaux publics Canada

project: Loon River Bridge

location: Mile 742
Mackenzie Highway

TEST HOLE LOG

hole no. 8

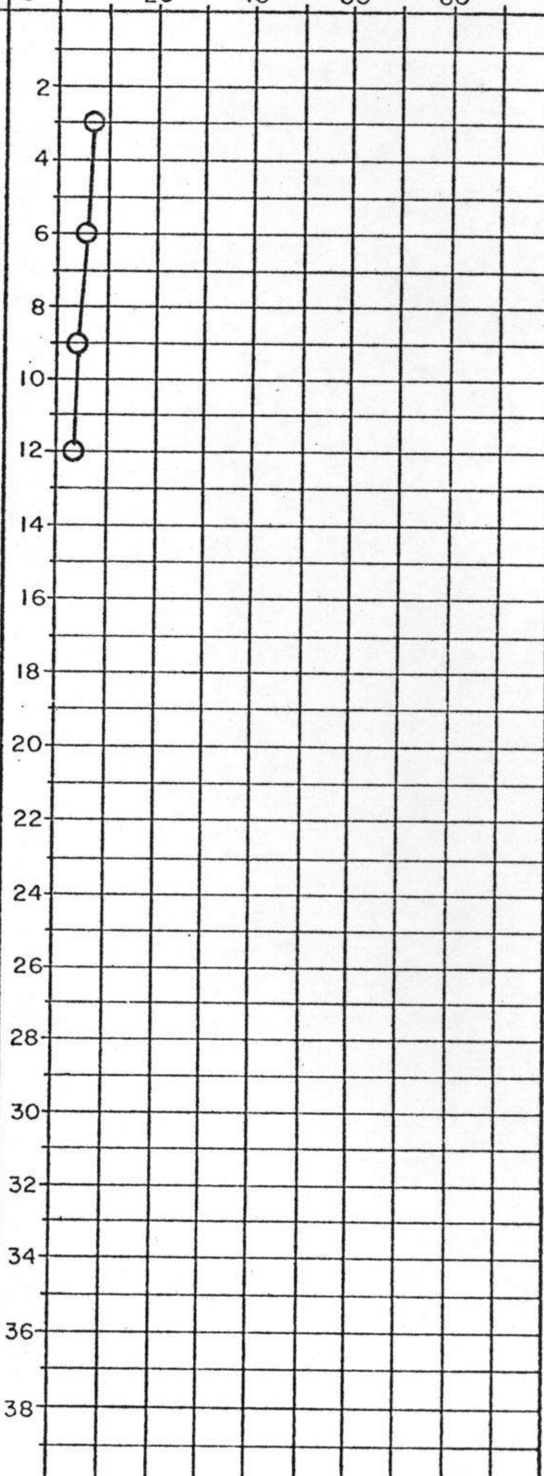
SAMPLE DATA	
weight hammer	
height drop	
elev. ground	
drill rig	Mayhew
date	3/4/74

unconfined strength - kips/ft.^{2} : 1.0 · 2.0 · 3.0 · 4.0

⊙ water content (% of dry weight)

plastic limit ├──┤ liquid limit. 20 40 60 80

depth/ft.	o.d./i.d.	blows/foot.	symbols	DESCRIPTION OF MATERIALS	relative moisture content.
2			Pt	Peat 2'	
4			SM	Sand - Coarse to Med. Silty Gravelly - frozen - low visible ice (Vx) 8'	wet
6					mois
8					damp
10			GC	Gravel-Sand Mix Silty Clayey -frozen -low visible ice (Vx) 14'	
12					humi
14					
16				Bottom of Hole 14'	
18					
20				Hole Caving in Permafrost Throughout	



project: Loon River Bridge

location: Mile 742 Mackenzie Highway

Public Works Canada Travaux publics Canada

TEST HOLE LOG

hole no. 9

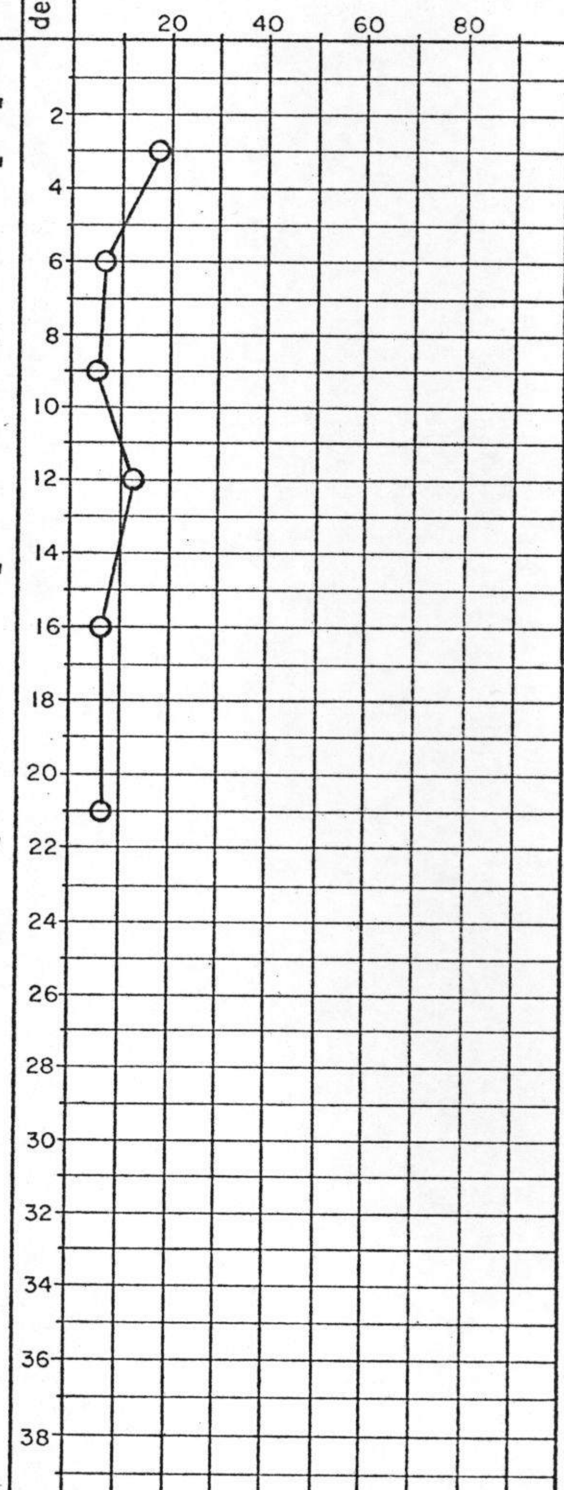
SAMPLE DATA	
weight hammer	
height drop	
elev. ground	
drill rig	Mayhew
date	3/4/74

depth/ft.	o.d./i.d.	blows/foot.	symbols	DESCRIPTION OF MATERIALS	depth - feet.	relative moisture content.
2			Pt	Peat	2'	
3–4			CL	Clay - organic Sandy - silty gravelly	4'	wet
4–15			SC	Sand - Gravelly Clayey Silty - frozen - low visible ice (Vx)	15'	wet (6) moist (9) moist (12)
15–22			GC	Gravel - Clayey Silty Sandy - frozen - low visible ice (Vx)	22'	wet (16) wet (21)
22				Bottom of Hole 22' Boulders Permafrost Throughout		

unconfined strength - kips/ft.^{2} (1.0, 2.0, 3.0, 4.0)

⊙ water content (% of dry weight)

plastic limit ├──┤ liquid limit.



project: Loon River Bridge

location: Mile 742
Mackenzie Highway

Public Works Canada Travaux publics Canada

TEST HOLE LOG

hole no. 10

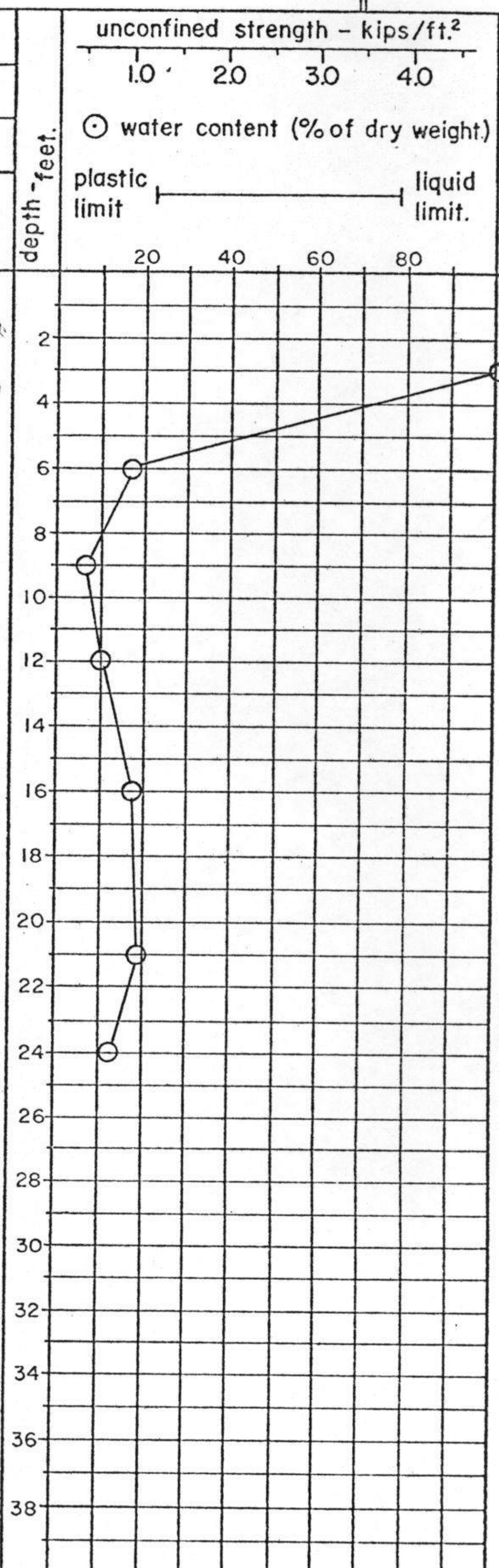
SAMPLE DATA	
weight hammer	
height drop	
elev. ground	
drill rig	Mayhew
date	3/4/74

depth/ft.	symbols	DESCRIPTION OF MATERIALS	relative moisture content
0 – 2'	Pt	Peat	Free Water
2' – 4'	ML	Silt - organic sandy	
4' – 11'	SM	Sand - Clayey - silty - gravelly - frozen - high ice to 7' (Vs) - moderate below 7' (Vc)	sat wet
11' – 15'	CL	Clay - Silty, Sandy - moderate ice (Vc-Vr) Pebbles Low Plastic	wet
15' – 28'	SM	Sand - Silty Fine - Medium Pebbles - frozen - moderate ice (Vc-Vr)	wet wet
	SC	Clayey	wet

Bottom of Hole - 28

Boulders at 28'

Permafrost Throughout



Public Works Canada / Travaux publics Canada

project: Loon River Bridge

location: Mile 742
Mackenzie Highway

DEPARTMENT OF PUBLIC WORKS, CANADA
MACKENZIE HIGHWAY

DRILL HOLE REPORT

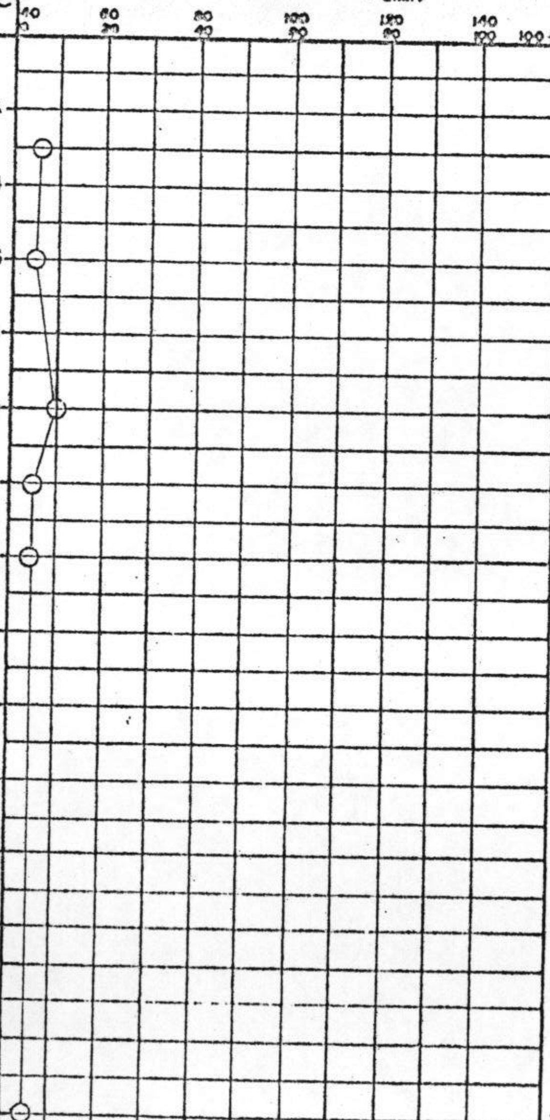
SITE: SECTION D

FIELD ENG. A. TENOUE	DATE DRILLED. 31/3/74	AIRPHOTO NO. A22762 - 137	CHAINAGE. 940 + 25
TECH. McINTOSH	RIG. Mayhew #2	SURFACE DRAINAGE. Good	VEGETATION. Spruce 8" Alder
OFFSET. ḇ	ELEV.	TEST HOLE 1065	MILE 742

DEPTH (FEET)	SAMPLE NUMBER	SAMPLE TYPE	% RECOVERY	PENETRATION RESISTANCE	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION
0–.5'					Pt	PEAT .5'		
.5'–7'					Sp	SAND - SILTY - GRAVELLY TO 4 7'		LOW TO MODERATE ICE
7'–30'					Gc	GRAVEL - SAND - SILT MIXTURE CLAYEY	F	Vx Vc - Vr

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)	CLAY %	SILT %	SAND %	GRAVEL %	RELATIVE THAWED MOISTURE CONTENT	REMARKS
3	14	-	60	26	WET	
6	32	-	68	0	WET	
10	21	-	47	32	WET	
12	27	-	32	41	WET	
14	15	-	39	46	WET	
29	18	-	42	40	WET	

D3·14·5·74 b

DEPARTMENT OF PUBLIC WORKS, CANADA
MACKENZIE HIGHWAY

DRILL HOLE REPORT

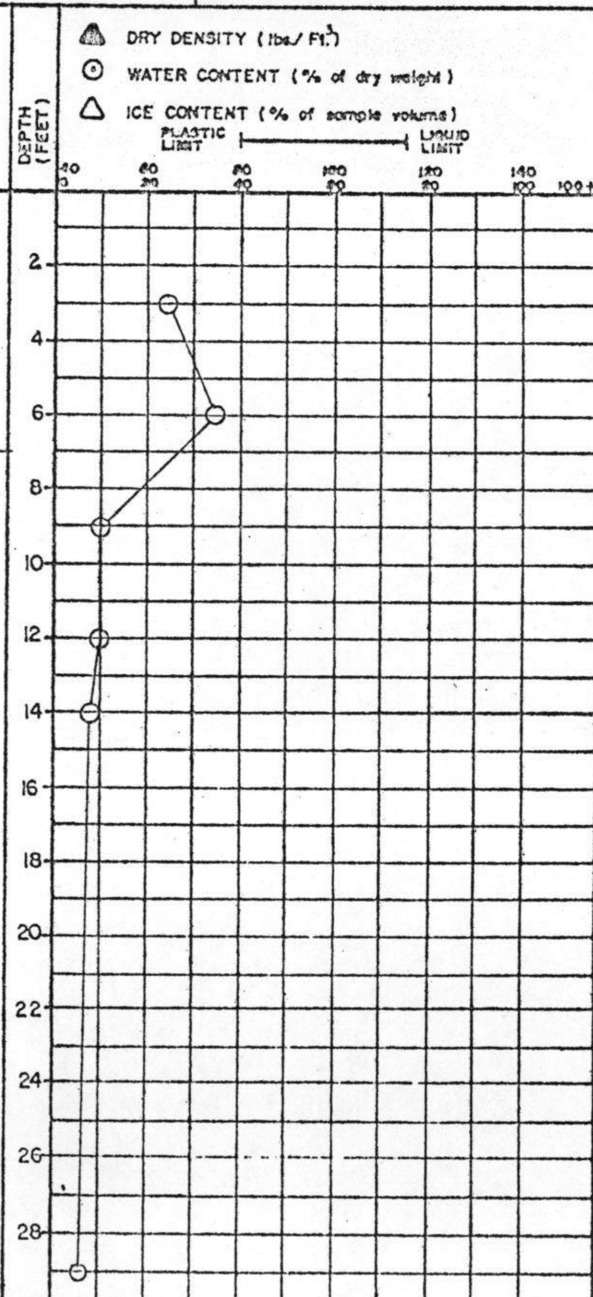
SITE: SECTION D

FIELD ENG. A. TENOUE	DATE DRILLED. 1/4/74	AIRPHOTO NO. A22762 - 137	CHAINAGE. 933 + 00	OFFSET. ℄
TECH. McINTOSH	RIG. Mayhew #2	SURFACE DRAINAGE. Good	VEGETATION. Spruce Max. 7"	ELEV.

TEST HOLE 1066

MILE 741

DEPTH (FEET)	SAMPLE NUMBER	SAMPLE TYPE	% RECOVERY	PENETRATION RESISTANCE	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION	CLAY %	SILT %	SAND %	GRAVEL %	RELATIVE THAWED MOISTURE CONTENT	REMARKS
0–1					Pt	PEAT 1'								
1–7						CLAY - SILTY - SANDY LOW PLASTIC 7'		HIGH ICE Vs						
3									-73	-	27	0	WET	
6									-43	-	57	0	FREE WATER	
7–30					Sp	SAND - SILTY GRAVELLY	F	MODERATE ICE Vc - Vr						
9									-21	-	69	10	WET	
12									-28	-	61	11	WET	
14									-21	-	62	17	WET	
29									-15	-	72	13	WET	



BOTTOM OF HOLE - 30'

DS-14-5-74

DEPARTMENT OF PUBLIC WORKS, CANADA
MACKENZIE HIGHWAY

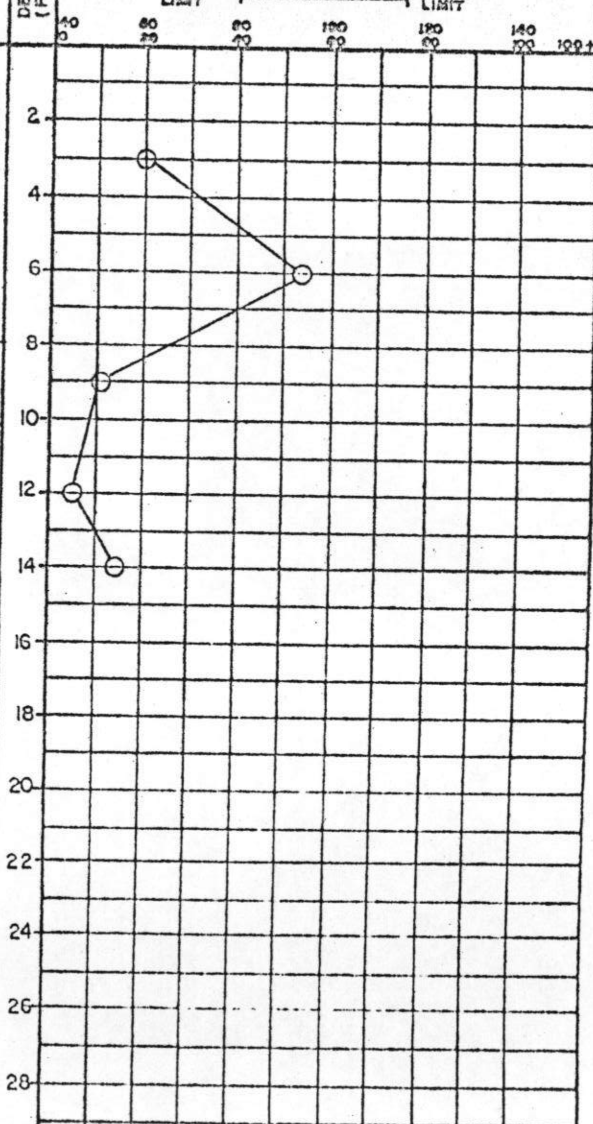
DRILL HOLE REPORT

SITE: SECTION D

FIELD ENG. A. TENOUE	DATE DRILLED. 1/4/74	AIRPHOTO NO. A22762 - 137	CHAINAGE. 928 + 00
TECH. McINTOSH	RIG. Mayhew #2	SURFACE DRAINAGE. Good	VEGETATION. Spruce, Tamarack 5"
OFFSET.	ELEV.	TEST HOLE 1067	MILE 741

DEPTH (FEET)	SAMPLE NUMBER	SAMPLE TYPE	% RECOVERY	PENETRATION RESISTANCE	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION	CLAY %	SILT %	SAND %	GRAVEL %	RELATIVE THAWED MOISTURE CONTENT	REMARKS
0–1'					Pt	PEAT 1'								
1'–8'						CLAY - SILTY - SANDY - PEBBLES 8'		HIGH ICE Vs						
~3									-47	-	53	0	SAT.	
~6									-55	-	40	5	FREE WATER	
8'–30'					Sc, Sm	SAND - GRAVELLY - SILTY CLAYEY TO 10'	F	MODERATE TO LOW ICE Vc - Vr Vx						
~9									-23	-	50	27	WET	
~12									-12	-	49	39	WET	
~14									-13	-	71	16	MOIST	

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



BOTTOM OF HOLE - 30'

D3·14·5·74 b

DEPARTMENT OF PUBLIC WORKS, CANADA
MACKENZIE HIGHWAY

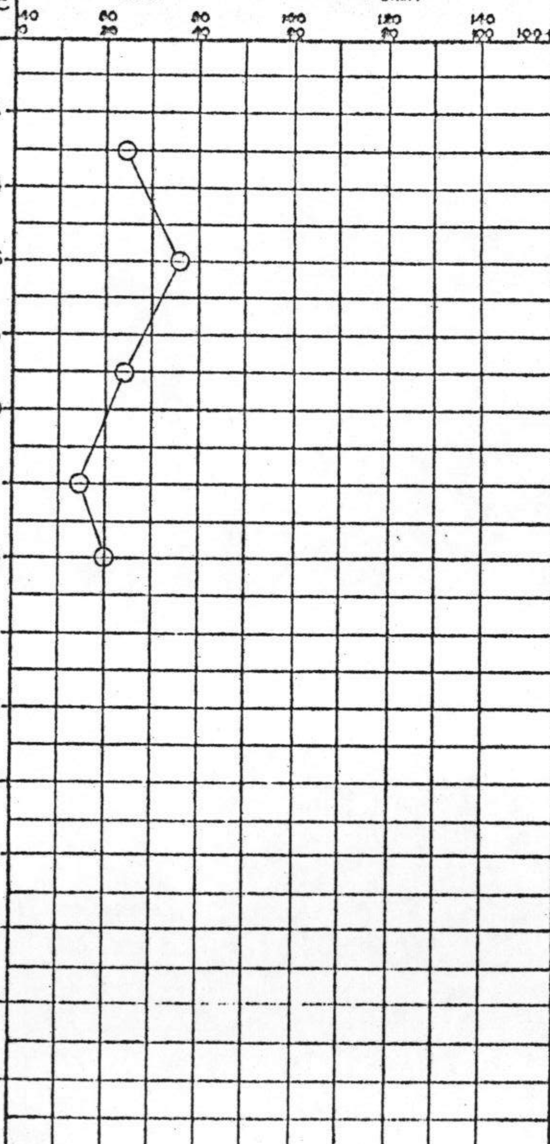
DRILL HOLE REPORT

SITE: SECTION D

FIELD ENG. A. TENOUE	DATE DRILLED. 1/4/74	AIRPHOTO NO. A22762 - 137	CHAINAGE. 923 + 00	OFFSET. ℄
TECH. McINTOSH	RIG. Mayhew #2	SURFACE DRAINAGE. Good	VEGETATION. Spruce Max. 4"	ELEV.

TEST HOLE: 1068
MILE: 741

▲ DRY DENSITY (lbs/Ft.³)
⊙ WATER CONTENT (% of dry weight)
△ ICE CONTENT (% of sample volume)
PLASTIC LIMIT ├──┤ LIQUID LIMIT



DEPTH (FEET)	SAMPLE NUMBER	SAMPLE TYPE	% RECOVERY	PENETRATION RESISTANCE	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION	CLAY %	SILT %	SAND %	GRAVEL %	RELATIVE THAWED MOISTURE CONTENT	REMARKS
0–1'					Pt	PEAT 1'	F							
1'–12'					Cl	CLAY - SANDY - SILTY - PEBBLES LOW PLASTIC 12'		HIGH ICE Vs						
3									59	-	40	1	WET	
6									64	-	35	1	FREE WATER	
								MODERATE ICE Vc - Vr						
9									63	-	36	1	WET	
12									49	-	45	6	WET	
12'–30'					Cl	SAND - CLAY - SILT MIXTURE LOW PLASTIC								
14									50	-	50	0	WET	

BOTTOM OF HOLE - 30'

D3·14·5·74

2. Loon River

The drainage area of Loon River, is 1,126 square miles. The peak discharge estimated from the ice marks is found to be 9,800 c.f.s. This corresponds to approximately a 12 year water elevation. No back water effect from the Mackenzie River is indicated. The fifty year return design discharge is determined to be 12,700 c.f.s. The average velocity estimated for that discharge is 6.8 feet per second.

III.2 LOON RIVER

2.1 Bridge Setting

The recommended bridge length is 380 feet, based on the position of the grade line as shown on Fig. 11.

On the north side of the river the flood plain would be partially inundated by the fifty year design high water. The proposed bridge approach fill will be constructed over the flood plain on the north side. Therefore, the toe of the embankment across the flood plain will require some protection as described later on.

2.2 Scour Computation

The riverbed material is composed of small boulders with mean diameter of 80 m.m. The average velocity and water depth at design discharge of 12,700 cfs are 7.2 fps. and 8.2 feet respectively. Corresponding to these bed material and water depths, the minimum velocity required to move the bed material is 10.5 fps. (Table 1). Since the required minimum water opening to start the general scour is 202 feet, as suggested by Lacey [8], and therefore less than the 212 feet width of the water opening for the design discharge at the bridge crossing, no general scour is expected.

The south bank forms the outer part of a very flat curve in the river. There is a fairly uniform velocity distribution throughout the cross-section of the stream under normal circumstances.

The local scour depths around bridge piers were calculated to be 5 feet, 7 feet and 10 feet for pier widths of 4 feet, 6 feet and 8 feet respectively (Appendix II). The mean size of riprap of 15 inches is required for the local velocity[7] around the pier of 10.8 fps (Table 2).

2.3 Ice Considerations

The most numerous ice marks were found along the Loon River. The ice level was found one foot below the 50 year design level which supports the idea that ice tends to pile up on the shore of the river. Further evidence of ice piling up was found 250 feet downstream from centreline where ice marks were found at an elevation four feet higher on the left bank (outside part of the river bend) than on the right bank; this is a confirmation of the effect of the high average velocity estimated to be 6.8 feet per second.

Therefore, special care should be taken in order to insure sufficient opening at the bridge for the ice flow passage. Any channel constriction can lead to an increase of the ice problems and jammings. Moreover, a pointed nose pier with a sloped face is recommended in order to reduce the ice pressure on the bridge piers.

I.2 LOON RIVER

Design discharge: 12,700 cfs

Elevation at design discharge: 201.1 feet

Natural channel width at design discharge: 212 feet

Low water elevation: 192.23 feet

Riverbed material: small boulder, D_{50} = 80 m.m.

Average water depth at design discharge: 8.2 feet

Cross-section area at design discharge: 1,760 sq. ft.

Mean velocity at design discharge: 7.2 fps

Competent velocity for bed movement under conditions of bed material size = 80 m.m. and water depth = 8.2 feet

$$V_c = 10.5 \text{ fps}$$

which is much larger than the mean velocity of 7.2 fps

The required water opening, W, is calculated by Lacey's equation,

$$W = 1.8 \times (12{,}700)^{0.5} = 202.8 \text{ feet}$$

which is less than natural channel width of 212 feet.

Therefore, no general scour is expected.

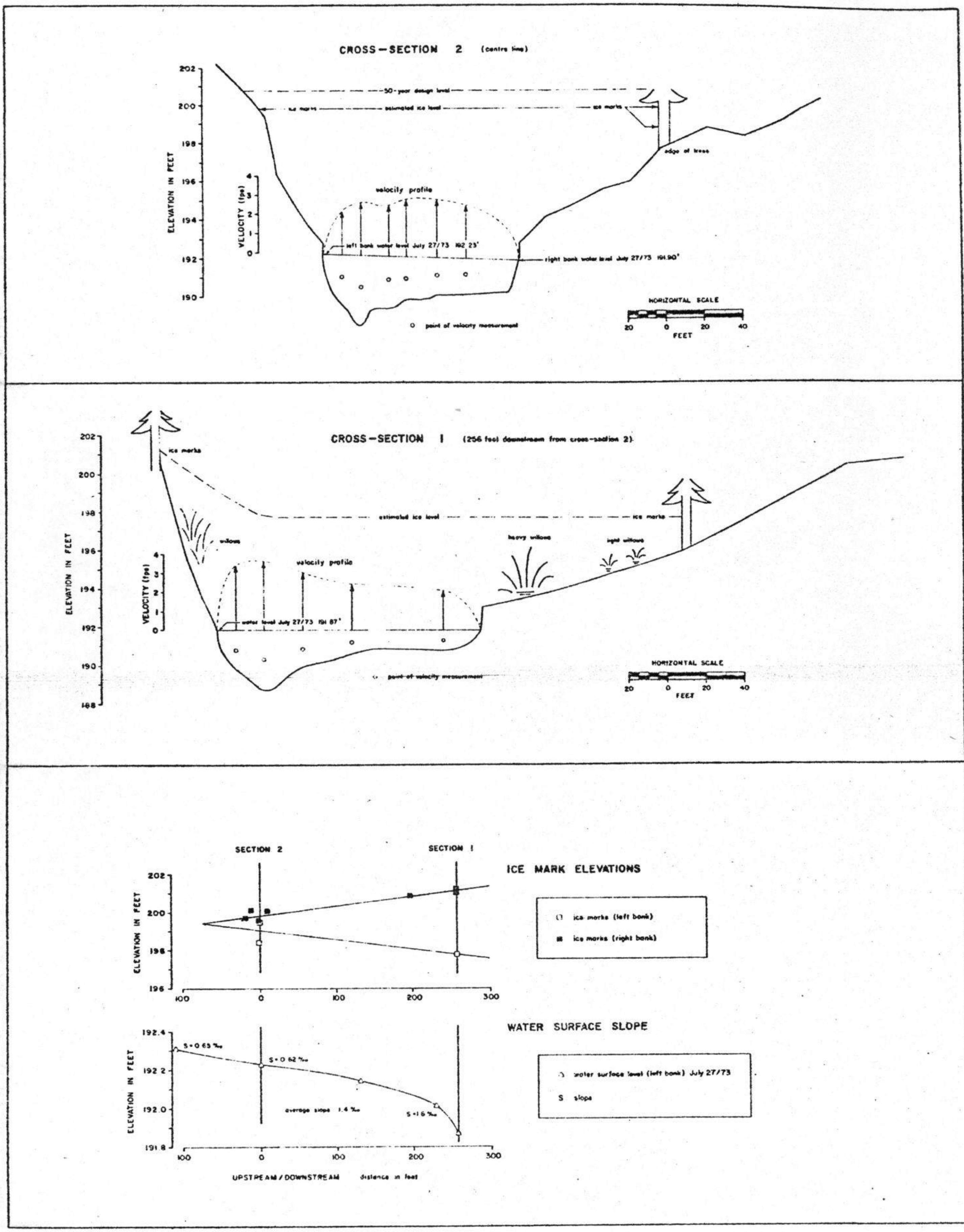


FIGURE 39 Loon River Hydraulic Data

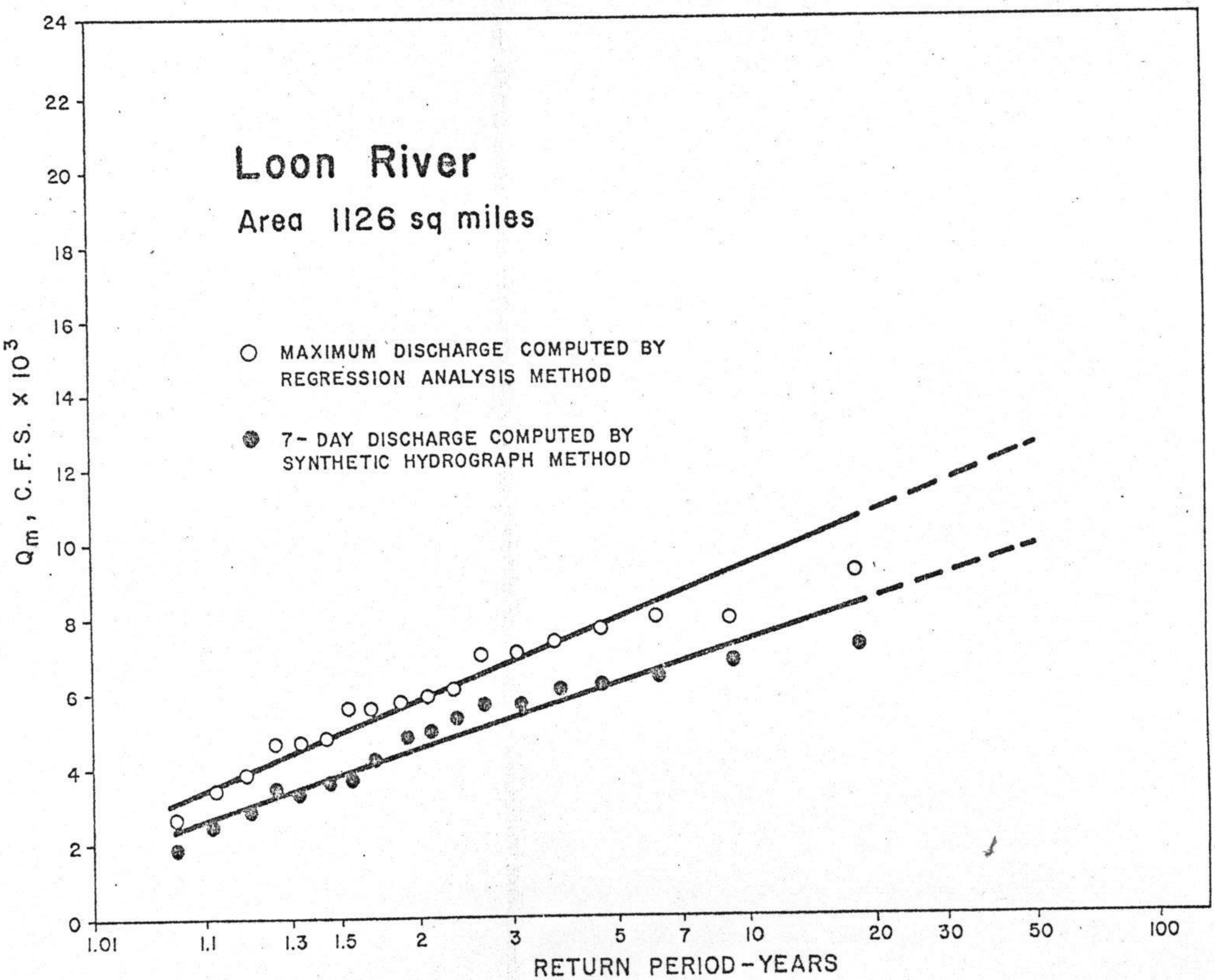


FIGURE 13 Peak and 7-day discharges of the Loon River

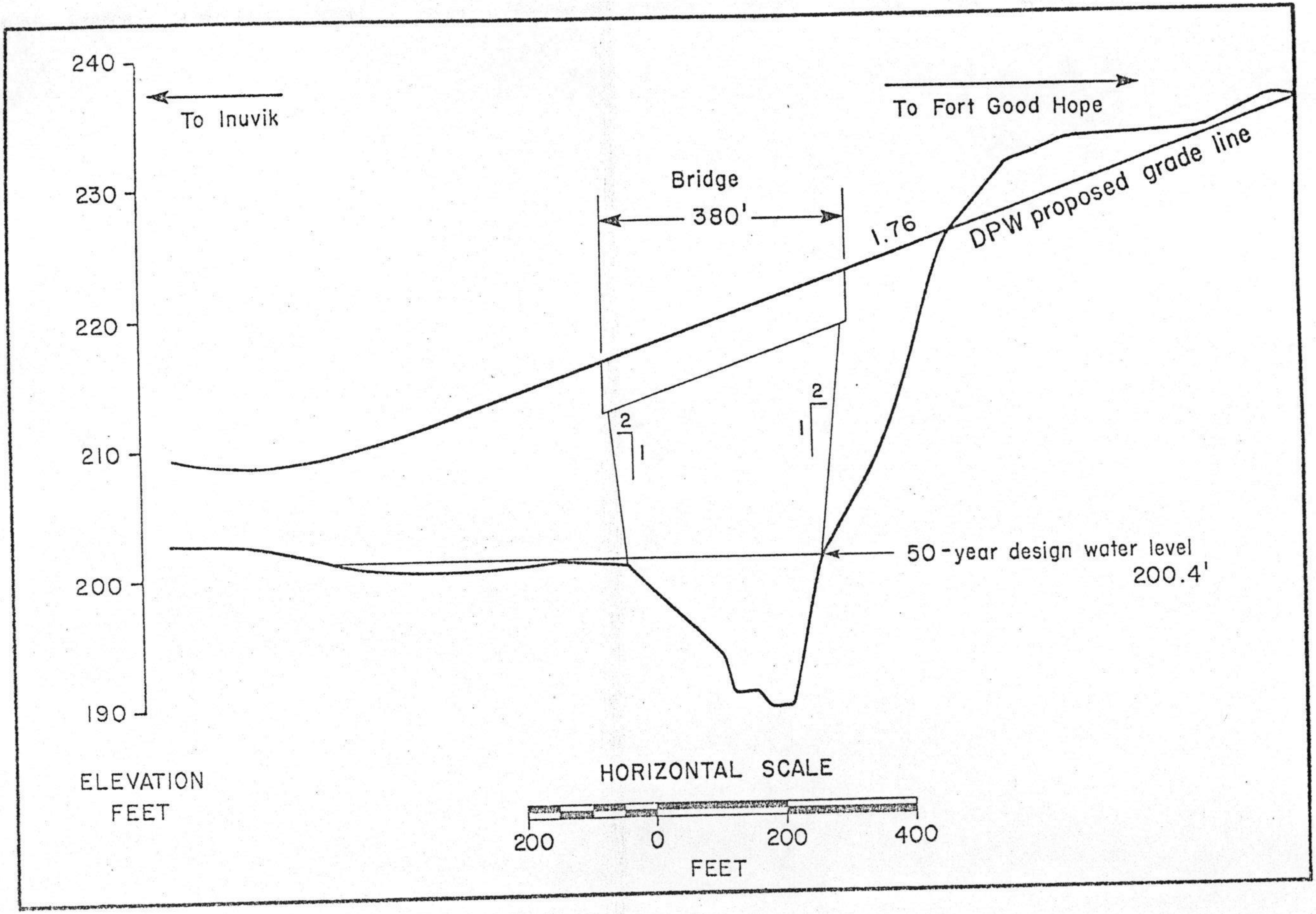


FIGURE 11 LOON RIVER BRIDGE
Preliminary Profile

LOON RIVER BASIN

TOTAL DRAINAGE AREA TO HWY 1126 SQ MI

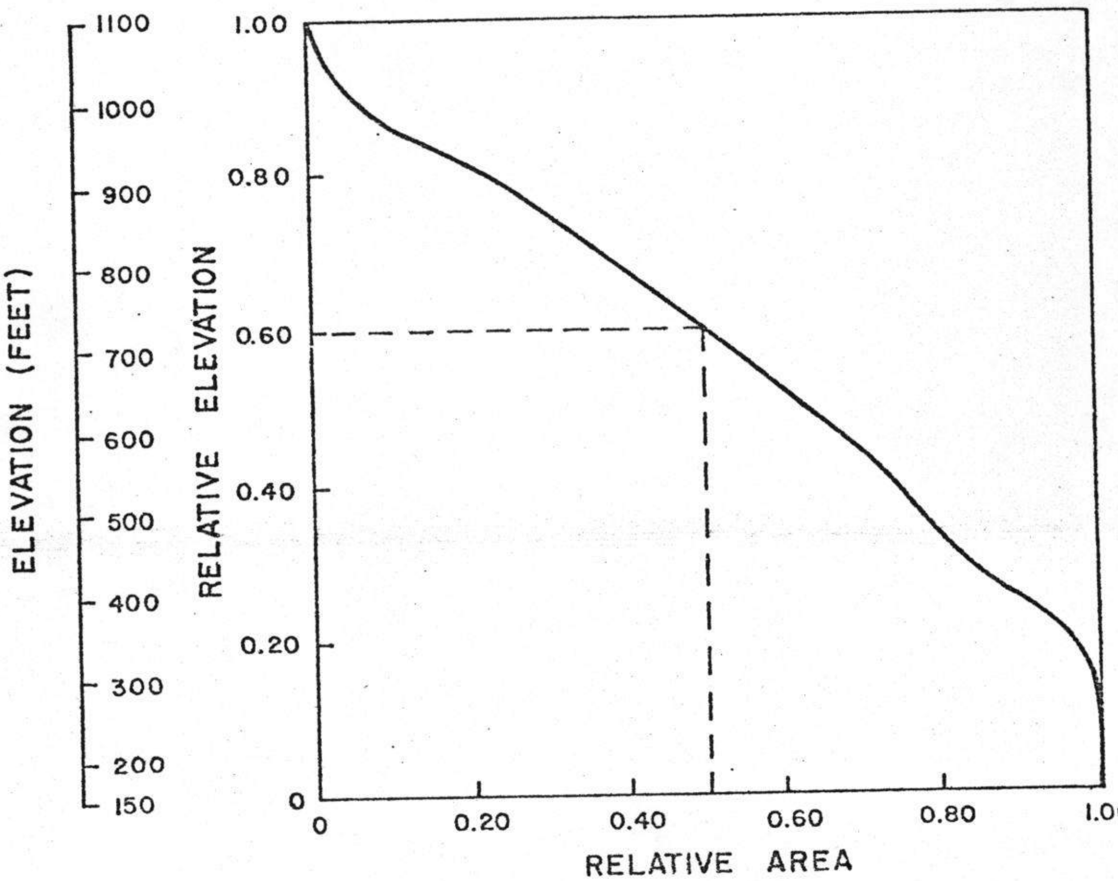


FIGURE 29

FENCO

Table B

Local Scour Depth Around Piers

at Loon River Crossing

	Scour Depth Calculated in Feet		
	Width of Pier in Feet		
Equation Used	4	6	8
Blench	4.1	5.4	6.5
Shen	7.2	9.4	11.1
Larras	5.6	7.6	9.5
Depth Recommended	6.0	9.0	11.0