

GEOTECHNICAL INVESTIGATION

PROPOSED BRIDGE SITE
LOWER BLACKSTONE RIVER, MILE 72.8
DEMPSTER HIGHWAY Km 117.1

E-3098

August 1, 1975

GR 05-036

CAN-1975-22



R.M. HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING



LIBRARY

GEOTECHNICAL INVESTIGATION

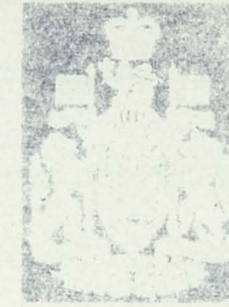
PROPOSED BRIDGE SITE
LOWER BLACKSTONE RIVER, MILE 72.8
DEMPSTER HIGHWAY *Km 117.1*

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GR 05-036

*Rec'd
DEC. 24/76*



Department of Public Works
Ministère des Travaux publics

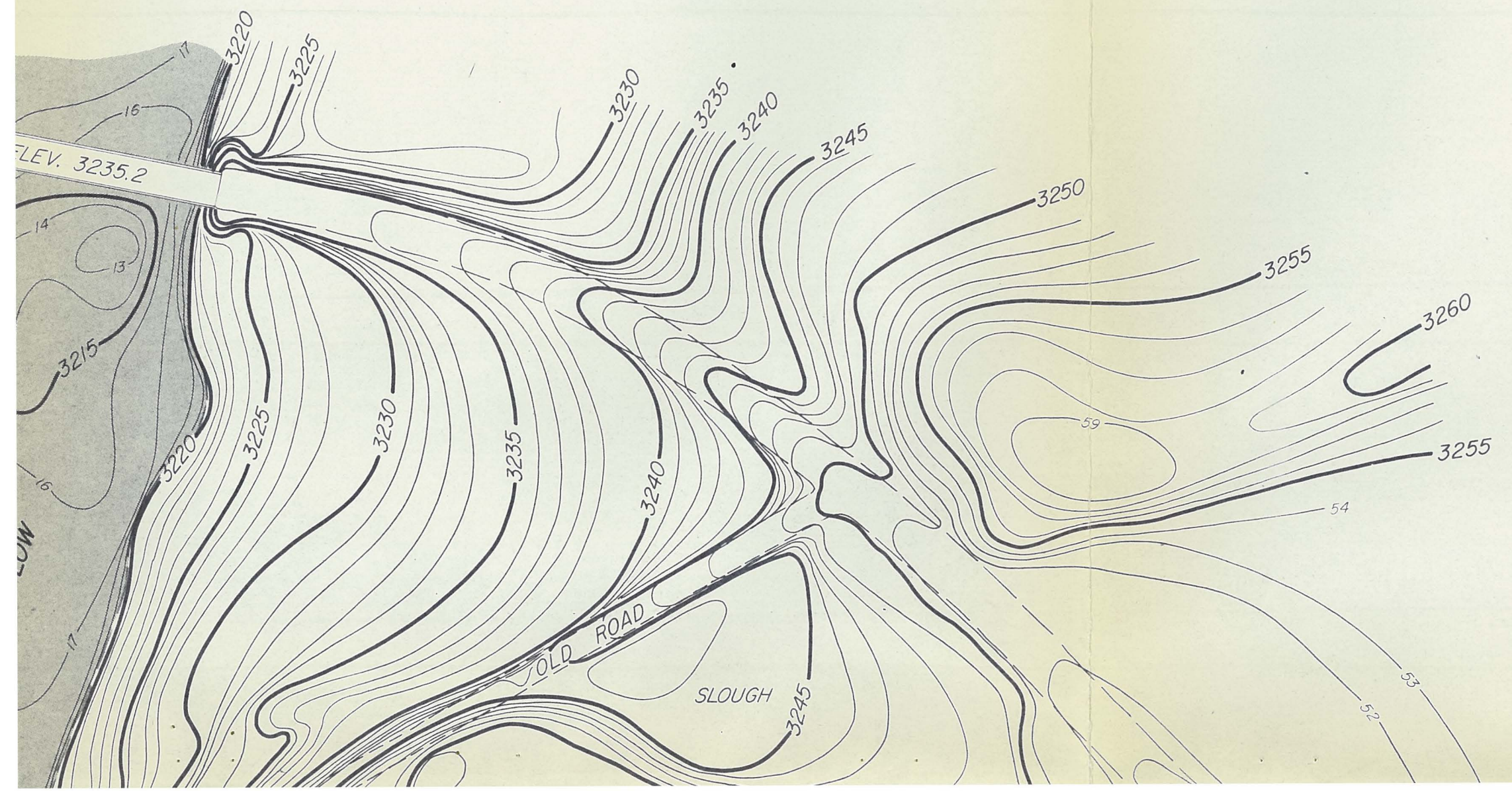
WHITEHORSE, YUKON

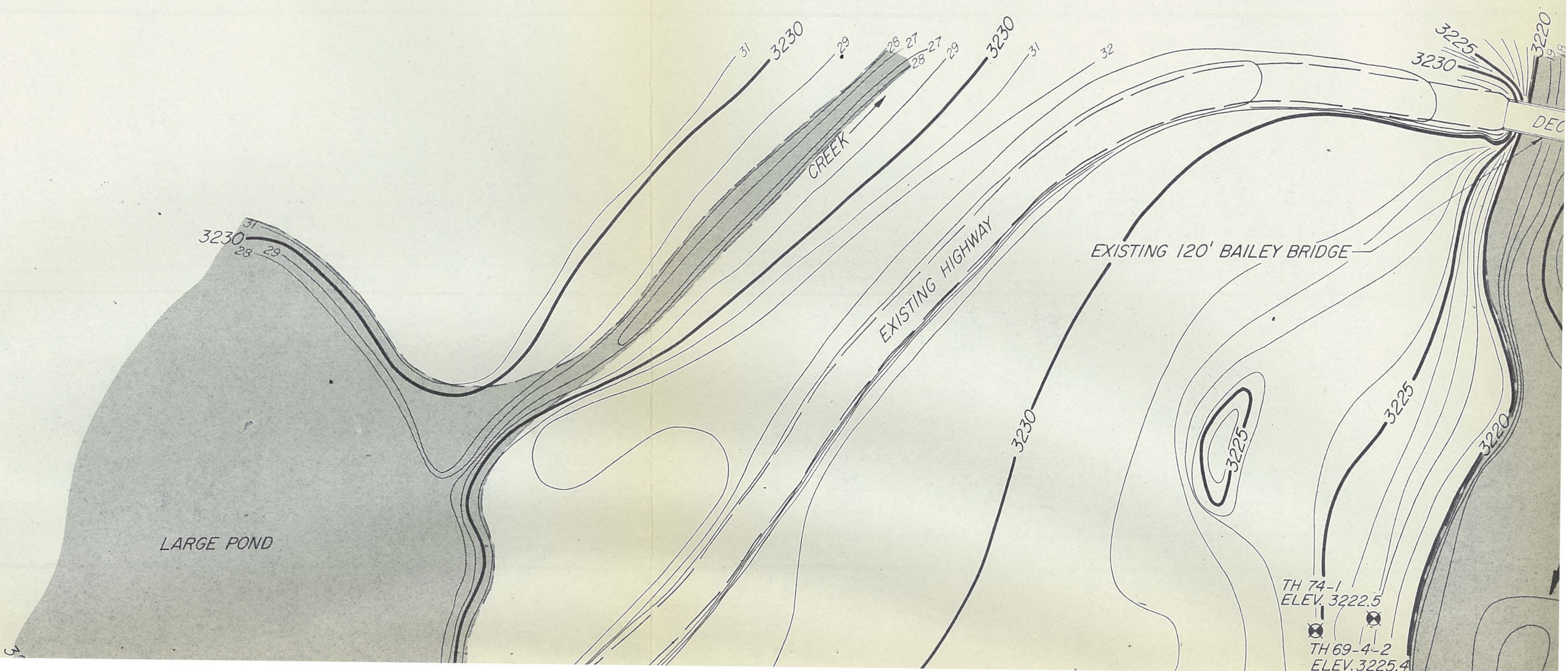
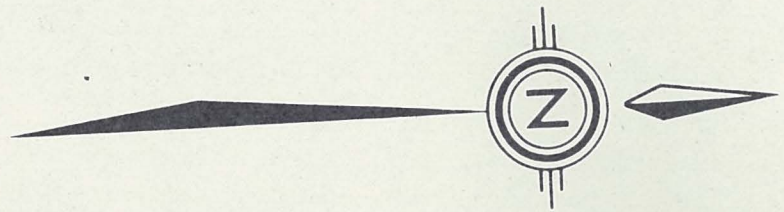
LEGEND

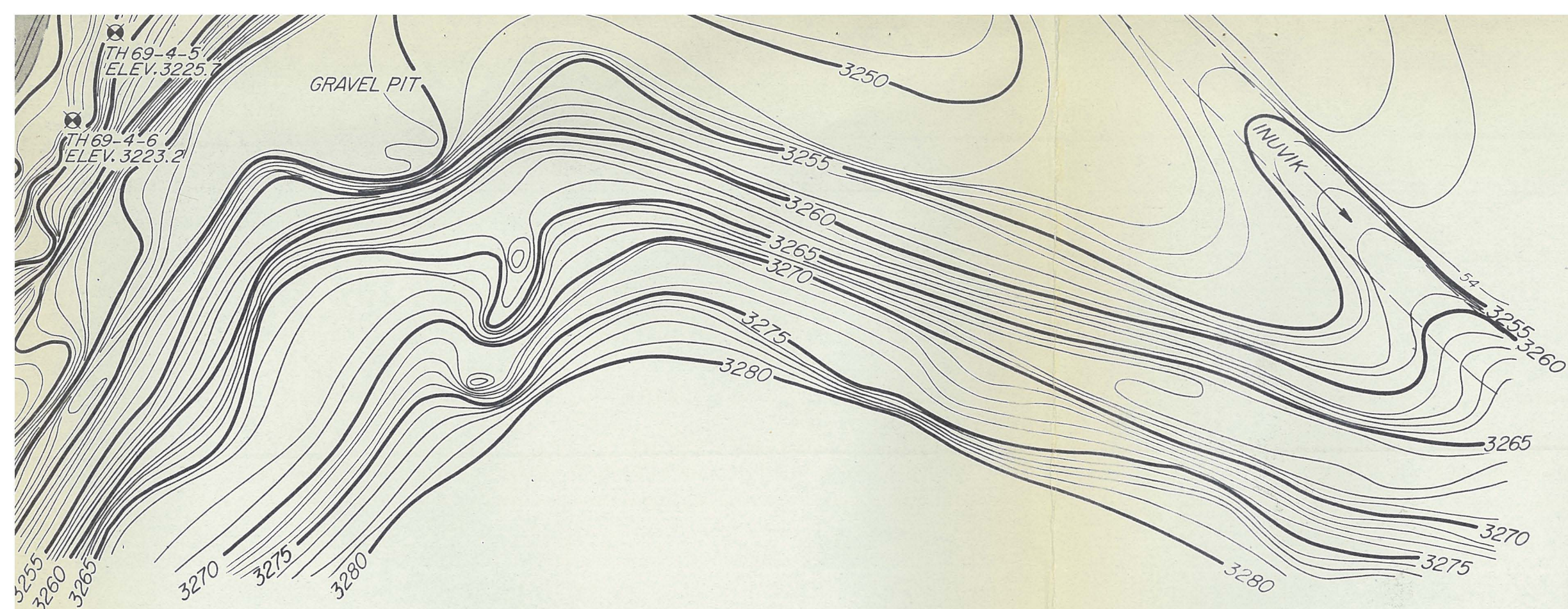
-EDGE OF WATER
-TEST HOLES



A. project no. 00731. 16
B. location drawing no. sur dessin no.
C. drawing no. dessin no.
DATE







REC'D DEC. 24/76

project title / titre du projet
**RECONSTRUCTION
 DEMPSTER HIGHWAY
 MILE 53-78**

drawing title / titre du dessin
**SITE PLAN
 LOWER BLACKSTONE
 RIVER
 MILE 72.8**

designed by / conçu par
 date

drawn by E.LESLIE / dessiné par
 date DEC., '76

reviewed by / examiné par
 date

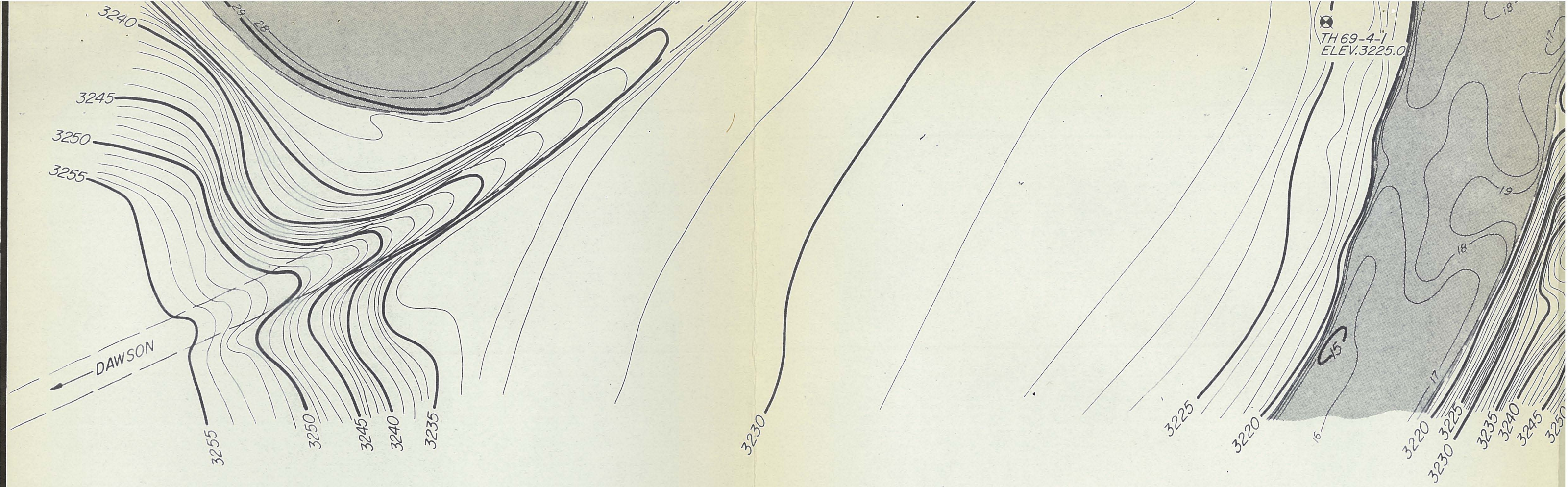
approved by / approuvé par
 date

Tender / Soumission
 D.P.W. Project Manager / Administrateur du projet M.T.P.

project number / no. du projet

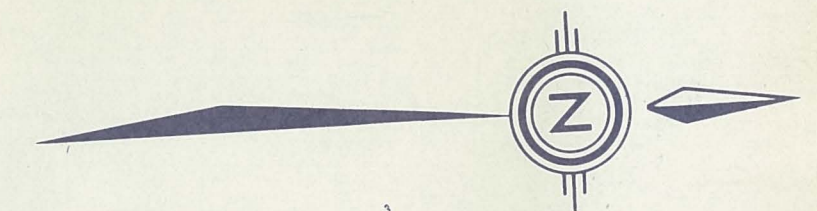
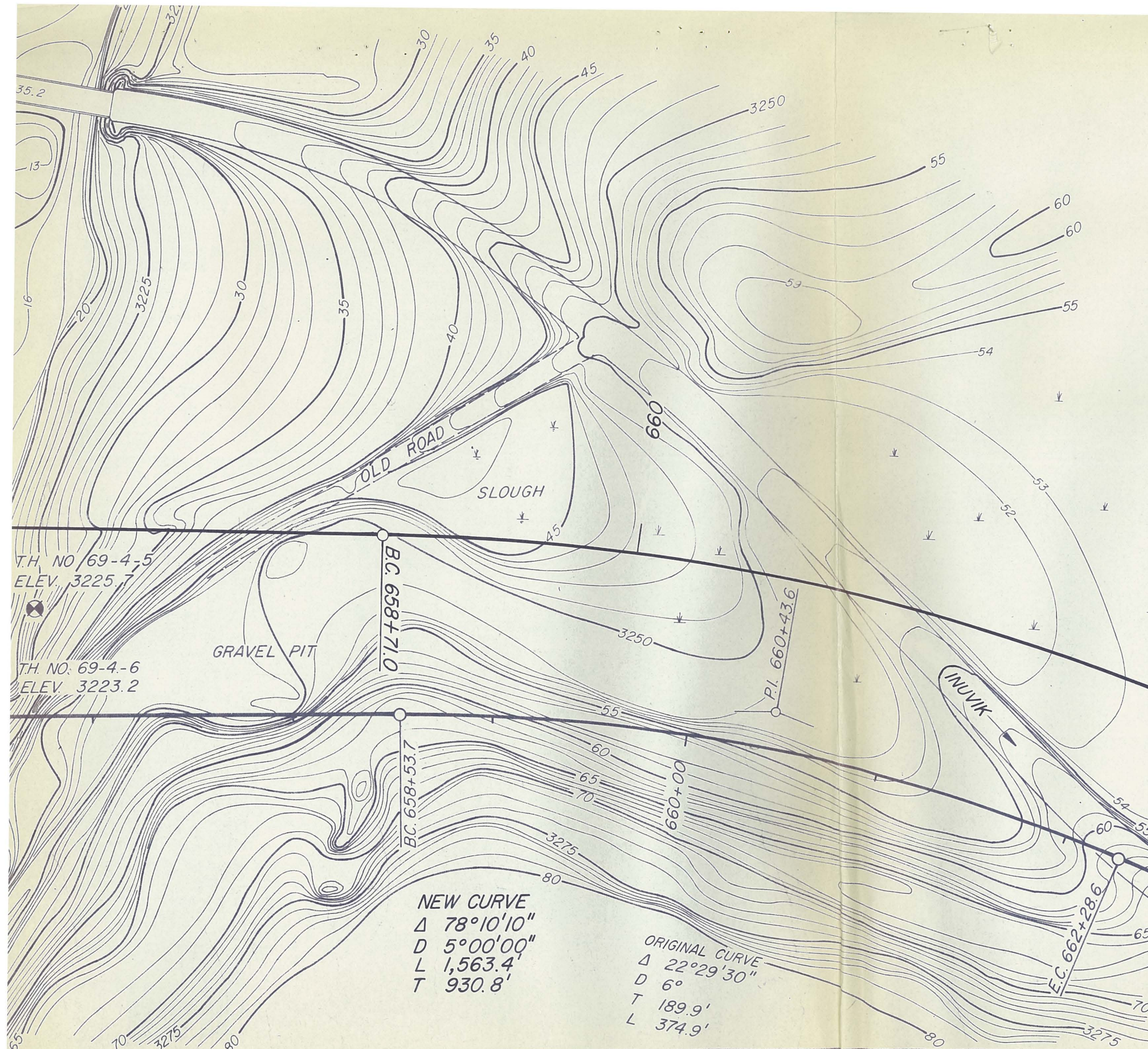
drawing no / dessin no

LOWER BLACKSTONE



SITE PLAN

SCALE: 1" = 50.0'
CONTOUR INTERVAL: 1'



REC'D.
DEC. 24/76

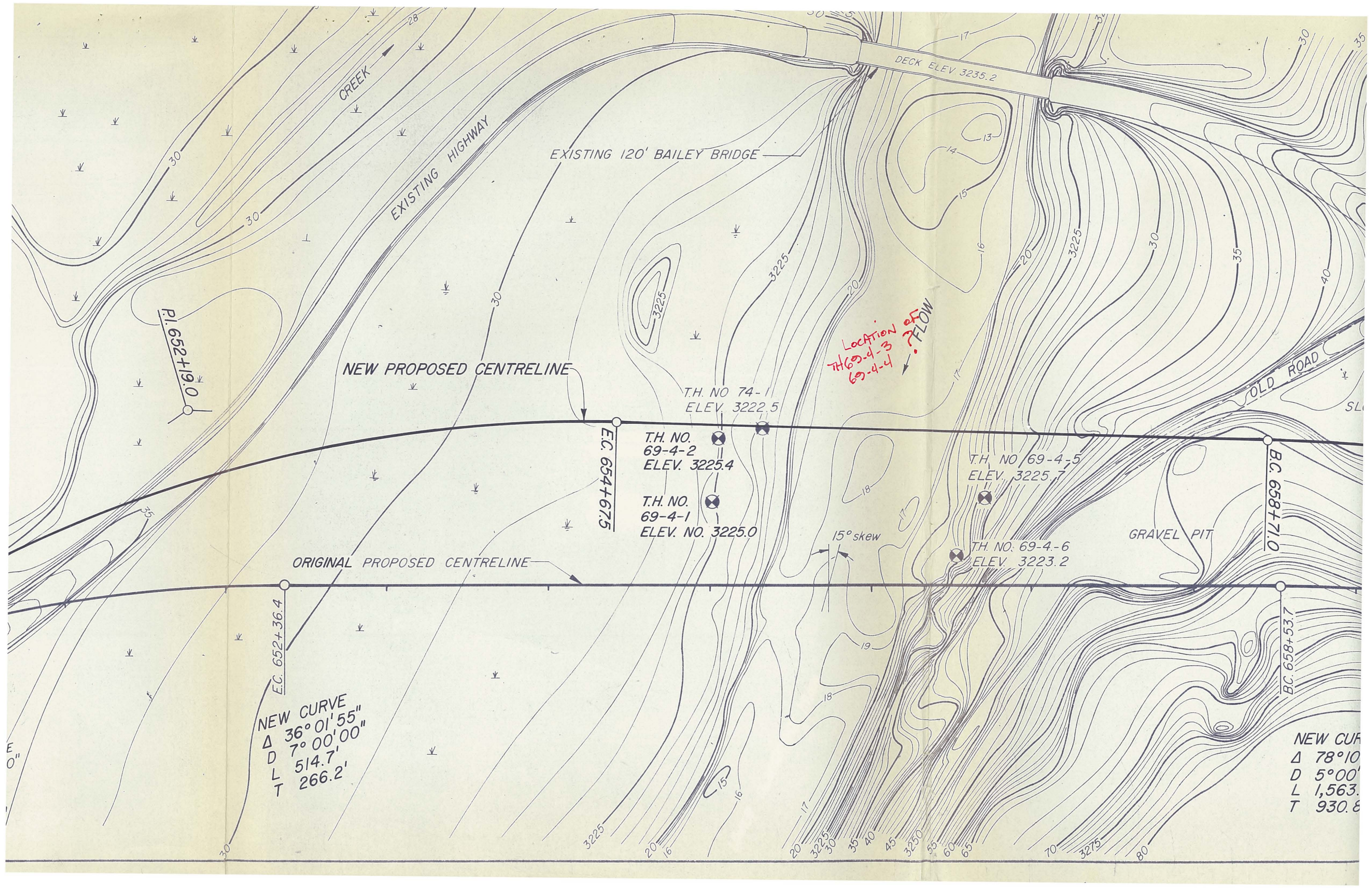
REVISED OCT. 1976
SCALE: 1" = 50'

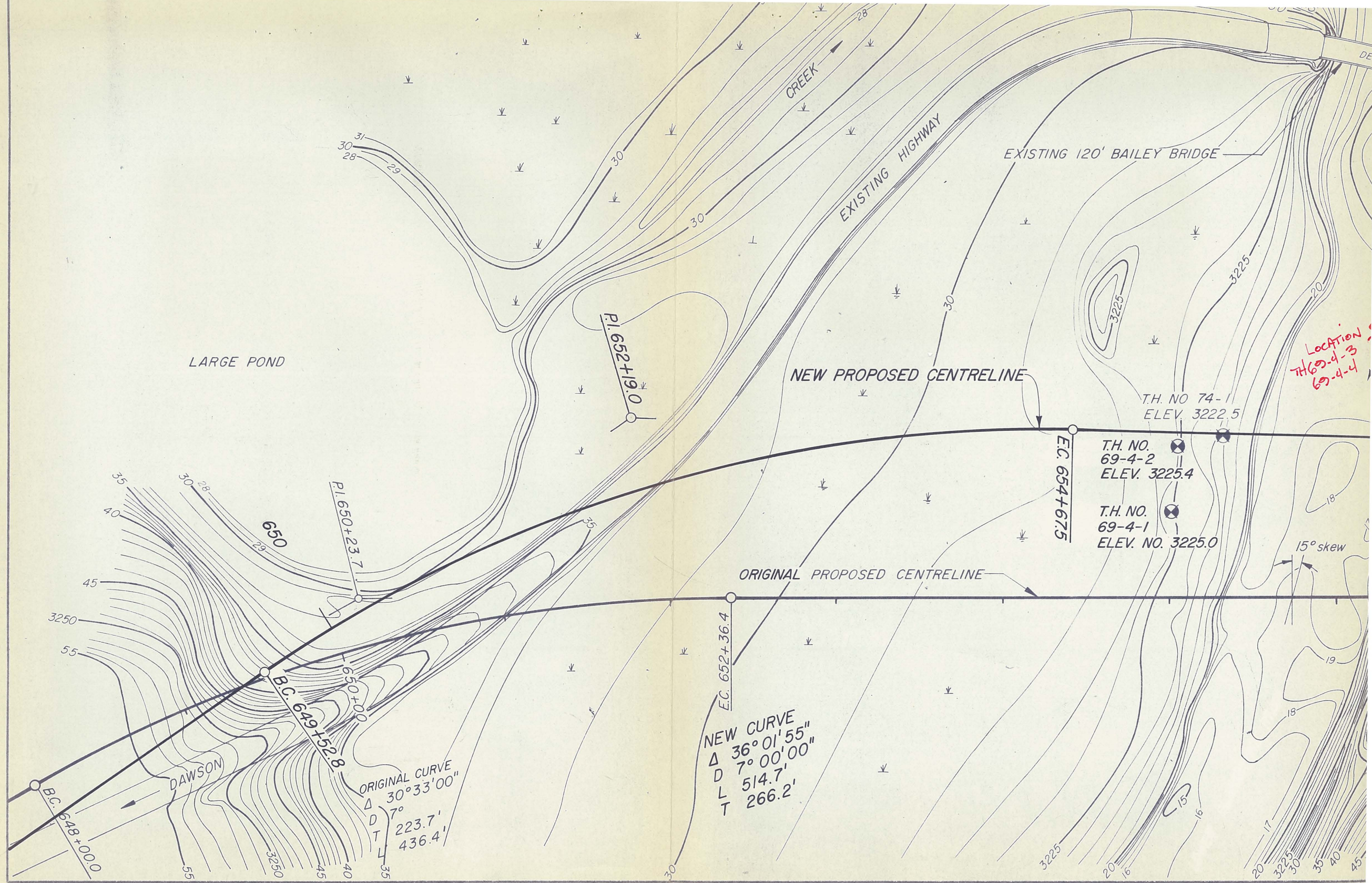
PUBLIC WORKS, CANADA			
PACIFIC REGION DESIGN / CONSTRUCTION WHITEHORSE, Y.T.			
LOCATION		DEMPSTER HIGHWAY - MILE 72.8	
DRWG. TITLE		LOWER BLACKSTONE RIVER SITE PLAN	
SCALE: AS SHOWN		APPROVED	
DATE: JAN. 75			
DESIGN: J. FOX	CHECKED		
DRAWN: F. V.	CHECKED		
REDRAWN:	CHECKED	TS. NO.	DRWG. NO.
SHEET 2 OF 2			7008-7-2a

NEW CURVE
 Δ 78°10'10"
 D 5°00'00"
 L 1,563.4'
 T 930.8'

ORIGINAL CURVE
 Δ 22°29'30"
 D 6°
 T 189.9'
 L 374.9'

LOWER BLACKSTONE





LARGE POND

CREEK
EXISTING HIGHWAY

EXISTING 120' BAILEY BRIDGE

NEW PROPOSED CENTRELINE

ORIGINAL PROPOSED CENTRELINE

LOCATION
TH 69-4-3
69-4-4

T.H. NO 74-1
ELEV. 3222.5

T.H. NO.
69-4-2
ELEV. 3225.4

T.H. NO.
69-4-1
ELEV. NO. 3225.0

15° skew

ORIGINAL CURVE
Δ 30° 33' 00"
D 7°
L 223.7'
T 436.4'

NEW CURVE
Δ 36° 01' 55"
D 7° 00' 00"
L 514.7'
T 266.2'

B.C. 648+00.0
B.C. 649+52.8
P.I. 650+23.7
P.I. 652+19.0
E.C. 652+36.4
E.C. 654+67.5

DAWSON

31
30
28
29

30

30

3225

35

30-28

650

P.I. 650+23.7

35

650+00

3250

55

B.C. 648+00.0

55

3250

45

40

35

30

3225

20

16

15

16

20

3225

30

35

40

45

18

19

18

17

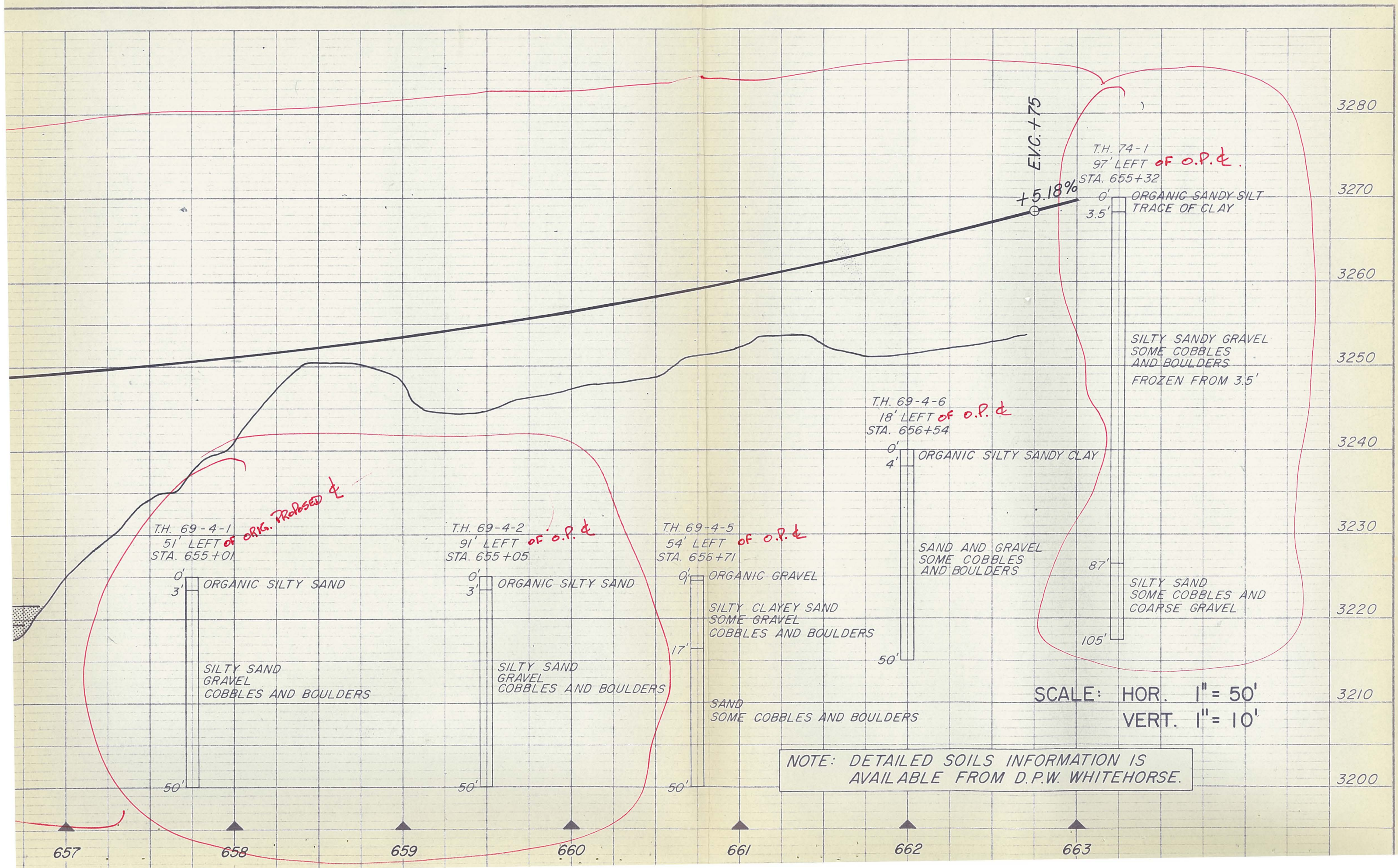
20

30

35

40

45



T.H. 69-4-1
51' LEFT OF ORIG. PROPOSED G.
STA. 655+01

0'
3'
ORGANIC SILTY SAND

SILTY SAND
GRAVEL
COBBLES AND BOULDERS

50'

T.H. 69-4-2
91' LEFT OF O.P. G.
STA. 655+05

0'
3'
ORGANIC SILTY SAND

SILTY SAND
GRAVEL
COBBLES AND BOULDERS

50'

T.H. 69-4-5
54' LEFT OF O.P. G.
STA. 656+71

0'
9'
ORGANIC GRAVEL

SILTY CLAYEY SAND
SOME GRAVEL
COBBLES AND BOULDERS

17'

SAND
SOME COBBLES AND BOULDERS

50'

T.H. 69-4-6
18' LEFT OF O.P. G.
STA. 656+54

0'
4'
ORGANIC SILTY SANDY CLAY

SAND AND GRAVEL
SOME COBBLES
AND BOULDERS

50'

T.H. 74-1
97' LEFT OF O.P. G.
STA. 655+32

0'
3.5'
ORGANIC SANDY SILT
TRACE OF CLAY

SILTY SANDY GRAVEL
SOME COBBLES
AND BOULDERS
FROZEN FROM 3.5'

87'

SILTY SAND
SOME COBBLES AND
COARSE GRAVEL

105'

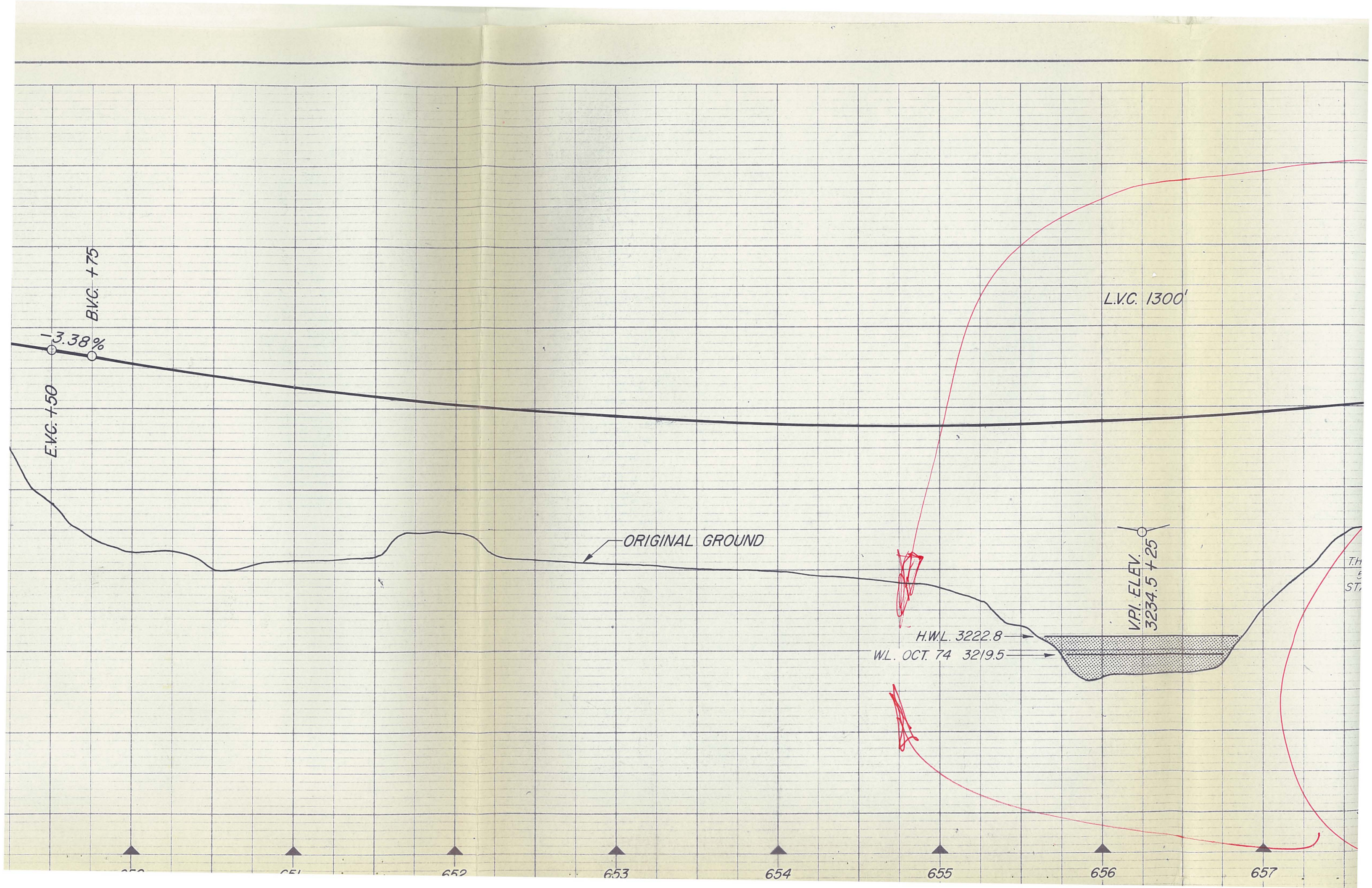
E.V.G. +75
+5.18%

SCALE: HOR. 1" = 50'
VERT. 1" = 10'

NOTE: DETAILED SOILS INFORMATION IS AVAILABLE FROM D.P.W. WHITEHORSE.

657 658 659 660 661 662 663

3280
3270
3260
3250
3240
3230
3220
3210
3200



E.V.C. +50
3.38%
B.V.C. +75

L.V.C. 1300'

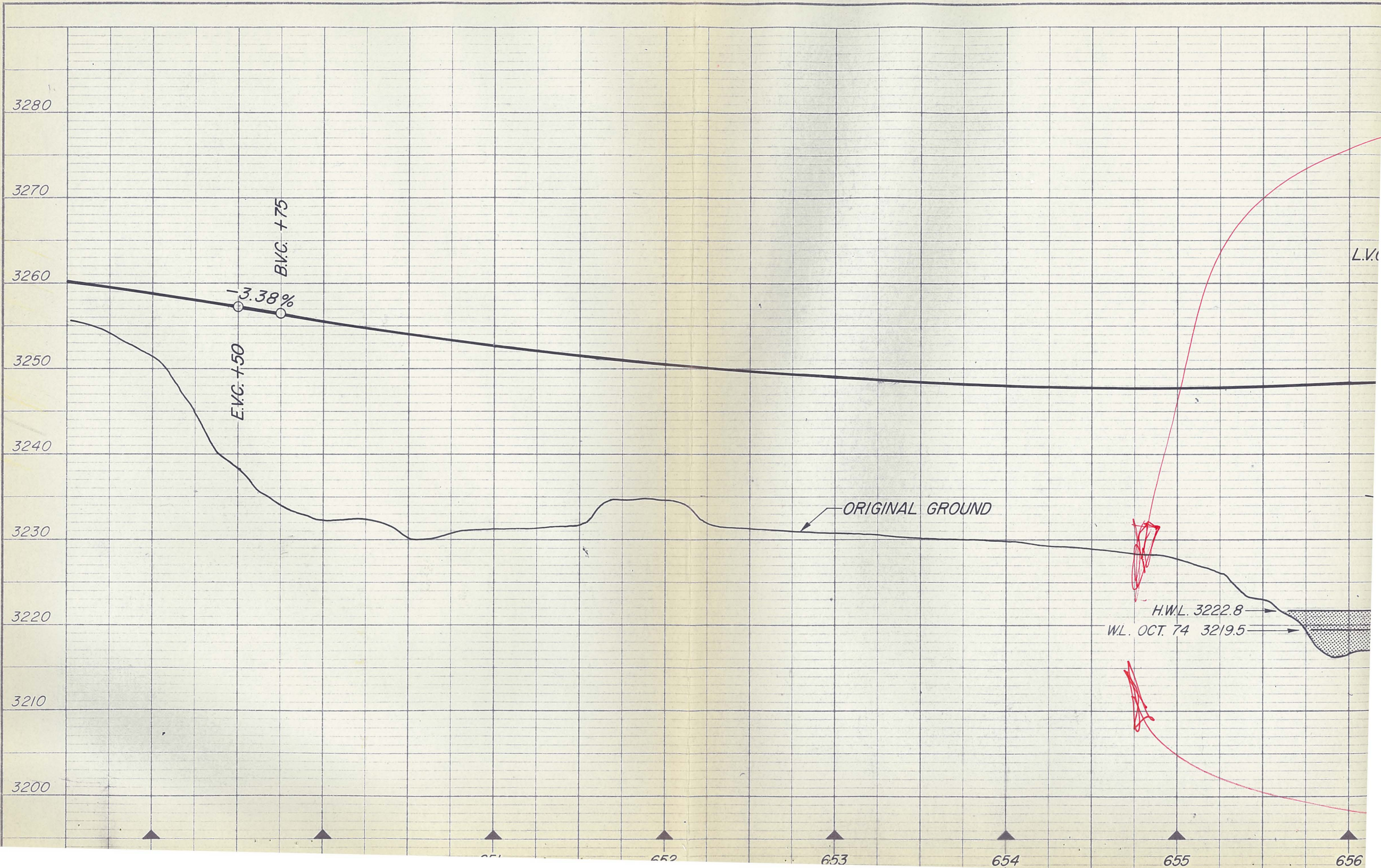
ORIGINAL GROUND

H.W.L. 3222.8
W.L. OCT. 74 3219.5

V.P.I. ELEV.
3234.5 +25

T.H.
&
ST.

650 651 652 653 654 655 656 657





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INTRODUCTION

At the request of Mr. J. Quong, P.Eng., Manager of Technical Services, Department of Public Works of Canada, Whitehorse, Yukon Territory, R. M. Hardy & Associates Ltd. undertook a geotechnical investigation along part of the existing Dempster Highway between Mile 0 and Mile 78. This report deals only with the site of the proposed bridge over the Lower Blackstone River.

The location of the bridge is shown on Drawing No. 7008-7-2 "Lower Blackstone River, Site Plan" dated January, 1975. The site is covered by Aerial Photographs No. A18137-56 and -57. *on ORIGINAL PROPOSED &*
The crossing is located approximately 320 feet downstream from the existing bridge.

A report entitled "Geotechnical Investigations, Dempster Highway, Mile 0-78" has been previously submitted to the Department. The geotechnical conditions along this section of the route are discussed in Volume I while Volume II contains information on permafrost in the area of a more general nature. We recommend that these volumes be read in conjunction with the text of this report.

DRILLING AND TESTING

Six test holes were drilled at the site during 1969 and a further test hole was drilled, on the *SOUTH.* right bank, in the fall of 1974. The locations of these test holes are shown on the above mentioned Drawing NO. 7008-7-2. The drill rig used



during the 1969 program was a rotary drill rig using diamond bits and NX rod. No other details on this equipment are available. The drill rig used during the 1974 program was a Mobile B-40L auger with a 20 foot stroke which was modified for rotary drilling using water and mud as the drilling fluid. Samples were obtained at frequent intervals using a split-spoon penetrometer and these samples were used for water content determinations and material identification.

All samples were shipped to the Department's laboratory in Whitehorse for laboratory testing. Logs of the test holes and laboratory data sheets are included in Appendix A.

TOPOGRAPHY

The proposed bridge is to cross the Lower Blackstone River approximately 1500 feet upstream from the confluence of the Upper and Lower Blackstone Rivers. The southerly approach to the bridge site lies across a flat, low-lying area while the northerly approach will require a cut, of approximately 23 feet in depth, through higher ground. Gravel pits have been developed on the northerly side of the river.

The width of the Lower Blackstone River, measured at the water line, was approximately 125 feet at the indicated high water level. According to the above mentioned drawing, the maximum depth of water observed in the water course was approximately 6 feet. No information is available from the width of depth of the water course during the height of spring

WHAT'S THIS THEN?

OR?



runoff or during heavy rain. The vertical distance from the proposed bridge deck to the bottom of the creek is approximately 16 feet.

SOIL AND PERMAFROST CONDITIONS

The typical soil profile at this bridge site consists of organic material overlying coarse granular material ranging in size from sand to boulders with much of the material being silty. There is some indication of stratification which was probably due to sorting by running water during the deposition of the material. However, it should be noted that cobbles and boulders were reported from very shallow depths down to 87 feet in Test Hole 74-1.

Because of the type of drilling carried out, and the difficulty of obtaining representative samples, the precise extent of frozen ground could not be determined. However, from the drill hole information available and an examination of the aerial photographs and other information available on the area, we believe it would be safe to assume that permafrost extends to depths of at least 100 feet on either side of the river and, very possibly, to depths of several hundred feet. It should be noted that ground polygons can be observed quite close to the bridge site on both the north and south sides of the river. Furthermore, the location of the site, the elevation (3220 feet) and the conditions of the local vegetation all indicate severe permafrost conditions. It is probable that the permafrost



table has been degraded within the river bed although the depth of permafrost degradation cannot be determined.

DISCUSSION AND RECOMMENDATIONS

The results of the drilling program, other observations in the field and theoretical calculations lead us to conclude that permafrost extends to considerable depths in this area. The size gradation of the soil material and the ground temperature conditions combine to produce a dense hard material into which it would be practically impossible to drive steel piles using conventional methods and equipment. As shown on Page 34, Volume II, of our general report on the Dempster Highway, the strength of frozen granular soils increases very rapidly with decreases in temperature.

It is probable that the soils at this site are thaw-stable that is, "no detrimental settlement of structures would normally be anticipated if thawing occurred." (See Page 15, Volume II). However, should the bridge be placed on piers and abutments supported by conventional strip or spread footings, we believe there is a possibility of differential settlement occurring and that it is impossible, at this time, to estimate the probable magnitude of such settlements.

We therefore recommend that two possible foundation systems be considered for this bridge site. The first system would consist of steel H piles which would have to be placed by means of a procedure combining both conventional driving



and steam thawing. We believe it would be possible to drive such piles by pre-thawing the ground using steam jetting and then driving the steel H piles using a conventional pile driver. Using this method, it is commonly found that the operator of the steaming equipment will create a thawed zone around the center of the pile location which is much larger than would be required. Very often, excessive thawing may be required to penetrate past a boulder. Furthermore, difficulties in keeping the steam point at the required location would be experienced due to the presence of the boulders mentioned above. Therefore, constant supervision will be required preferably by a supervisor who has previous experience of steam thawing techniques.

Experience has shown that pile holes which are formed by steaming may take several months to freeze back. It would therefore be preferable to have the pile foundation placed at least six months before commencement of construction on the bridge superstructure. However, such a schedule may not be possible.

The capacity of piles driven into thawed permafrost cannot be computed by means of any known formula. The preferable system of determining the capacity of such a pile would be by means of carrying out several load tests but the cost of carrying out such tests would almost certainly be excessive. We therefore recommend that the capacity of the piles be computed by assuming an allowable shaft friction of 1000 psf on the gross perimeter



of the pile. (That is, a 9 inch by 9 inch steel H pile would have a gross perimeter of 36 inches). The top 10 feet of pile, in the case of piles driven on the shore, should be assumed to carry no load. In the case of piles driven to support piers in the water, the probable depth of scour should be determined.

In northern locations, jacking of piles due to seasonal freezing is often experienced. This situation can occur in the case of piles driven into thawed holes where the soil surrounding the pile has not refrozen at the onset of the first winter following installation. Jacking of piles can also occur where the ground has refrozen but the ratio of the length of pile embedded in permafrost to the depth of seasonal froze penetration is too small. We recommend that the minimum length of piles driven on land be 30 feet, measured from the ground surface. In the case of piles driven in the water bed, the minimum length of embedment should be 20 feet plus the depth of scour.

Piers and abutments could be placed on spread footings but some differential movement should be expected. It may be economical to follow this type of design and make provision for adjusting the height of the bridge girders as required. Spread or strip footings placed in the gravel on dry land should have a minimum depth of cover of 8 feet measured from the bottom of the footing to finished grade. An allowable soil bearing pressure of 8 ksf can be used. In the case of strip or spread



footings placed in the river bed, the allowable soil bearing pressure should be 4 ksf with the base of the footings placed at least 5 feet below the bottom of estimated scour depth.

In the case of abutments, the lateral force exerted against the back of an abutment by fill can be computed by assuming the backfill to be a fluid with a density of 60 pounds per cubic foot, where the backfill is not compacted, and 75 pounds per cubic foot where the backfill is compacted.

In driving steel H piles in pre-thawed holes it will probably be found that the piles will drive more easily than in conventional soil conditions. However, because of the presence of boulders and cobbles, we recommend that the weight of the pile driving hammer should be at least twice the weight of the pile being driven. (If a diesel hammer is used, the weight of the hammer should be at least equal to the weight of the pile). We suggest that the points of the piles be reinforced with flange plates for a distance equal to 1.5 times the size of the pile. Alternatively, the points can be reinforced with driving shoes.

Piles may be designed for the full structural strength of the pile section acting as a column for that portion of the pile above final ground surface. The design load will depend on the allowable stresses in the pile above grade, the length of pile above grade and the arrangement of lateral bracing. Consideration should be given to using battered piles on the outside of the pile bents in order to provide increased lateral



resistance.

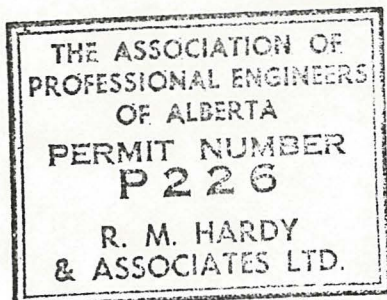
If a drop hammer is used in driving piles, care should be taken that the energy delivered to the pile is not greater than 50,000 foot pounds per blow unless calculations show that the pile can safely take higher impact stresses.

One of the problems faced by bridges is the possibility of log jams occurring which can cause partial or complete failure of the bridge. Log jams are only likely occur where trees travelling down the river have a greater length than the clear span of the bridge. It is extremely unlikely that trees of sufficient height are growing upstream of this bridge site. However, we suggest that the height of trees growing adjacent to the river upstream of the bridge site should be checked and, should it be observed that there is a possibility of trees of sufficient size being washed downstream, such information should be considered by the bridge designer.

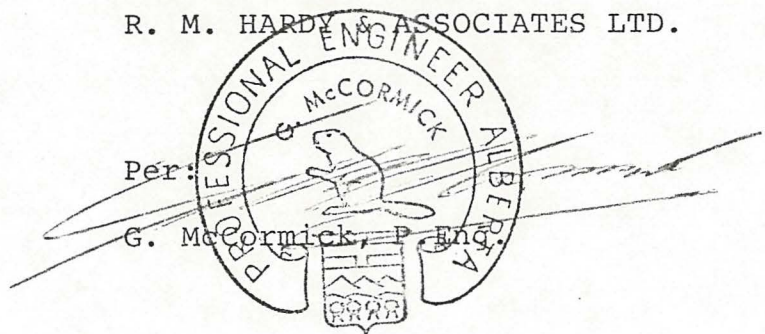
Embankments constructed below the highest expected flood level should be protected with riprap.

Respectfully submitted,

R. M. HARDY & ASSOCIATES LTD.



GM:cmg





APPENDIX A

Test Hole Logs and Laboratory Test Data

PUBLIC WORKS, CANADA

PACIFIC REGION
 DESIGN / CONSTRUCTION
 CIVIL ENGINEERING - YUKON

Diamond Drill NX Rod

DRILLING RECORD

Dempster Hwy. Mile 72.8
 PROJECT Lower Blackstone River
 HOLE NO. 69-4-1 DATE July 21-30 /66
 LOCATION See Plan
 ELEVATION _____ DEPTH 50'

DRILLING NOTES			SAMPLE RECORD					
DEPTH FROM	TO	SOIL DESCRIPTION	DEPTH FROM	TO	NO.	TYPE	% RECOV.	N VALUE
0	1½'	Organic material						
1½'	50'	Silty sand, grey Gravel & cobbles, some boulders up to 2'						

PUBLIC WORKS, CANADA

**PACIFIC REGION
DESIGN / CONSTRUCTION
CIVIL ENGINEERING - YUKON**

Diamond Drill NX Rod

DRILLING RECORD

PROJECT Dempster Hwy. Mile 72.8
Lower Blackstone River
HOLE NO. 69-4-2 DATE July 21-30 /6
LOCATION See Plan
ELEVATION _____ DEPTH 50'

DRILLING NOTES			SAMPLE RECORD					
DEPTH FROM TO		SOIL DESCRIPTION	DEPTH FROM TO		NO.	TYPE	% RECOV.	N VALUE
0	1/2'	Organic material						
1/2'	50'	Silty sand (grey) Gravel & cobbles Cobbles 3-8" Some boulders up to 1 1/2' Medium to coarse gravel						

PUBLIC WORKS, CANADA

PACIFIC REGION
 DESIGN / CONSTRUCTION
 CIVIL ENGINEERING - YUKON

DRILLING RECORD

PROJECT Dempster Hwy. Mile 72.8
Lower Blackstone River
 HOLE NO. 69-4-3 DATE July 21-30/69
 LOCATION See Plan
 ELEVATION _____ DEPTH 25'

Diamond Drill NX Rod

DRILLING NOTES			SAMPLE RECORD					
DEPTH FROM	TO	SOIL DESCRIPTION	DEPTH FROM	TO	NO.	TYPE	% RECOV.	N VALUE
0'	1'	Organic material & sand (silty)						
1'	7'	Fine to coarse sand, brown (Frozen)	5'	6'	-	SPT	-	81 for 6'
7'	25'	Fine to coarse sand & gravel Sand-brown Cobbles 3-8" Some boulders up to 1½'						

PUBLIC WORKS, CANADA

PACIFIC REGION
 DESIGN / CONSTRUCTION
 CIVIL ENGINEERING - YUKON

DRILLING RECORD

PROJECT Dempster Hwy. Mile 72.8
Lower Blackstone River
 HOLE NO. 69-4-4 DATE July 21-30/69
 LOCATION See Plan
 ELEVATION _____ DEPTH 25'

Diamond Drill NX Rod

DRILLING NOTES			SAMPLE RECORD					
DEPTH FROM	DEPTH TO	SOIL DESCRIPTION	DEPTH FROM	DEPTH TO	NO.	TYPE	% RECOV.	N VALUE
0	1/2'	Organic material						
1/2'	5'	Sand (brown)						
5'	25'	Fine to coarse sand (brown) Some fine to medium gravel Cobbles 3-8" Some boulders up to 1 1/2'						

PUBLIC WORKS, CANADA

PACIFIC REGION
 DESIGN / CONSTRUCTION
 CIVIL ENGINEERING - YUKON

Diamond Drill NX Rod

DRILLING RECORD

DEMPSTER HWY. Mile 72.8

PROJECT Lower Blackstone River

HOLE NO. 69-4-5 DATE July 21-30 /6

LOCATION See Plan

ELEVATION _____ DEPTH 50'

DRILLING NOTES			SAMPLE RECORD					
DEPTH FROM	TO	SOIL DESCRIPTION	DEPTH FROM	TO	NO.	TYPE	% RECOV.	N VALUE
0	½'	Organic material (Reddish brown)						
½'	2'	Sand & gravel. Cobbles 3-5" Frozen						
2'	4'	Sand & clay mixture. Clay-grey to light brown, frozen						
4'	17'	Gravel & silty sand. Cobbles 3-6"						
17'	50'	Silty, sandy gravel Cobbles 3-6" Some boulders up to 2½' Very hard drilling						

PUBLIC WORKS, CANADA

PACIFIC REGION
 DESIGN / CONSTRUCTION
 CIVIL ENGINEERING - YUKON

Diamond Drill NX Rod

DRILLING RECORD

Dempster Hwy. Mile 72.8

PROJECT Lower Blackstone River

HOLE NO. 69-4-6 DATE July 21-30 /69

LOCATION See Plan

ELEVATION _____ DEPTH 50'

DRILLING NOTES			SAMPLE RECORD					
DEPTH FROM	TO	SOIL DESCRIPTION	DEPTH FROM	TO	NO.	TYPE	% RECOV.	N VALUE
0	4'	Silty, sandy clay with some organic material mixed in. Frozen						
4'	25'	Sand & gravel. Cobbles 3-5" Water loss at 12'						
25'	35'	Gravel, some sand. Cobbles 3-5" Some boulders up to 2½' Hard layer from 28'-29' Water loss stops at 29½'						
35'	50'	Sand & gravel. Cobbles 3-8" Some boulders up to 2½' Very hard drilling						

GRAIN SIZE ANALYSIS

SIEVE SIZE	% FINER BY WEIGHT	SIEVE SIZE	% FINER BY WEIGHT
1/2"	100.0	11.40	17.0
3/8"	94.2	75	5.0
1/4"	70.3	30	2.4
1/2	25.3		
1/8"	8.9		
1/4"	71.2		
20	52.8		
30	30.3		

SAMPLE NO.	CLASSIFICATION	L.L.	P.L.	P.I.	NAT. %W	S.G.
	SW				N.P.	
	GRACELLY SAND					

CRUSH COUNT %

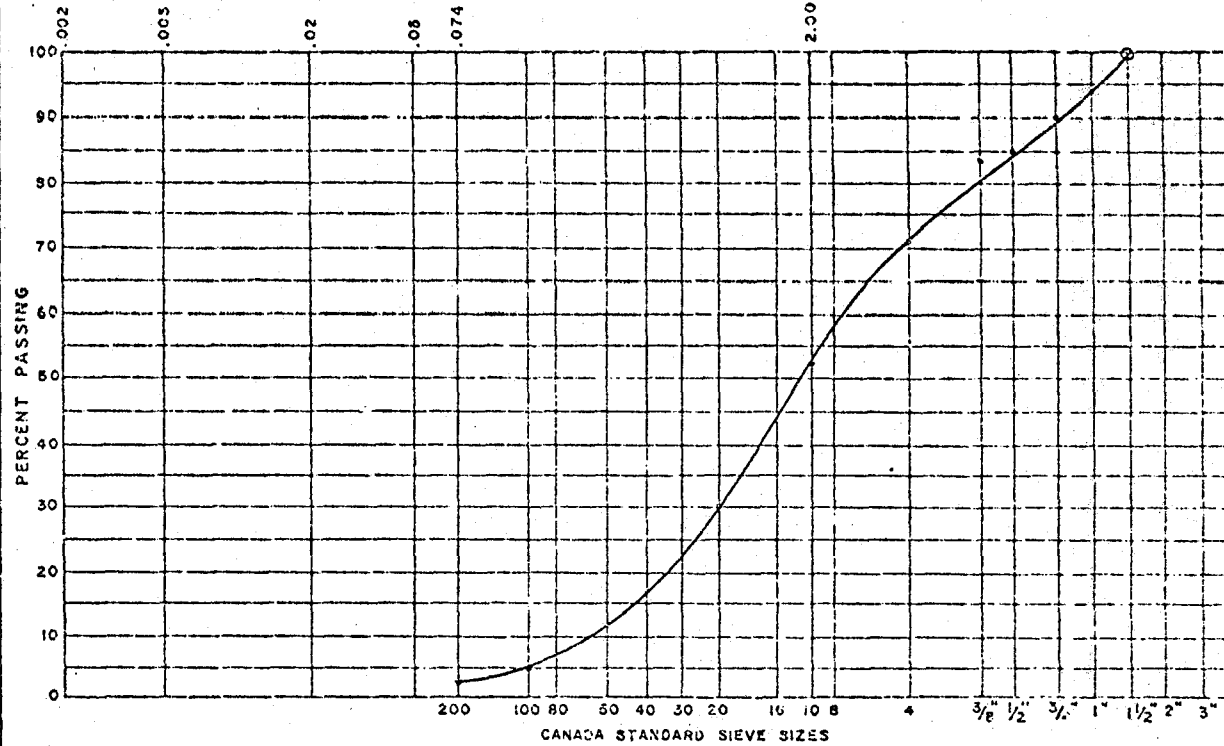
PETROGRAPHIC ANALYSIS

MATERIAL TYPE	% OF TOTAL SAMPLE
ASALT	
LIMESTONE	
GRANITIC	
SANDSTONE	
SHALE	
CHRIST	
QUARTZITE	
OTHERS	

PARTICLE SHAPE ANALYSIS

ROUND	
SUB-ROUND	
ANGULAR	
SUB-ANGULAR	
FLATS	
SPINDLES	

GRAIN SIZE IN MILLIMETERS



CLAY	SILT	SAND	GRAVEL
------	------	------	--------

PROJECT BLACKSTONE RIVER BRIDGE
 LOCATION MILE 73.8 DENBSTER HWY.
 HOLE NO. 1
 DEPTH 9'-10 1/2' FIELD NO. 1
 SAMPLE TYPE SPT

LAB. NO.
8171

LABORATORY'S REMARKS

DATE SAMPLED 1-8-74
 DATE RECEIVED 26-8-74
 DATE RECORDED 14-1-75
 TESTED BY RK JEDH GISE

GRAIN SIZE ANALYSIS

SIEVE SIZE	% FINER BY WEIGHT	SIEVE SIZE	% FINER BY WEIGHT
47.5	100.0	75	100.0
42.5	100.0	63	100.0
37.5	100.0	53	100.0
30.0	100.0	42.5	100.0
25.0	100.0	35.4	100.0
20.0	100.0	29.7	100.0
15.0	100.0	25.0	100.0
11.8	100.0	20.0	100.0
7.5	100.0	15.0	100.0
4.75	100.0	10.0	100.0
2.0	100.0	7.5	100.0
0.75	100.0	4.75	100.0
0.425	100.0	2.0	100.0
0.25	100.0	0.75	100.0
0.075	100.0	0.25	100.0

UNIFORMITY COEFFICIENT	CLASSIFICATION	L.L.	P.L.	P.I.	NAT. %W	S.G.
	SP-GM				N.P.	
	SILTY-SANDY GRAVEL					

CRUSH COUNT

%

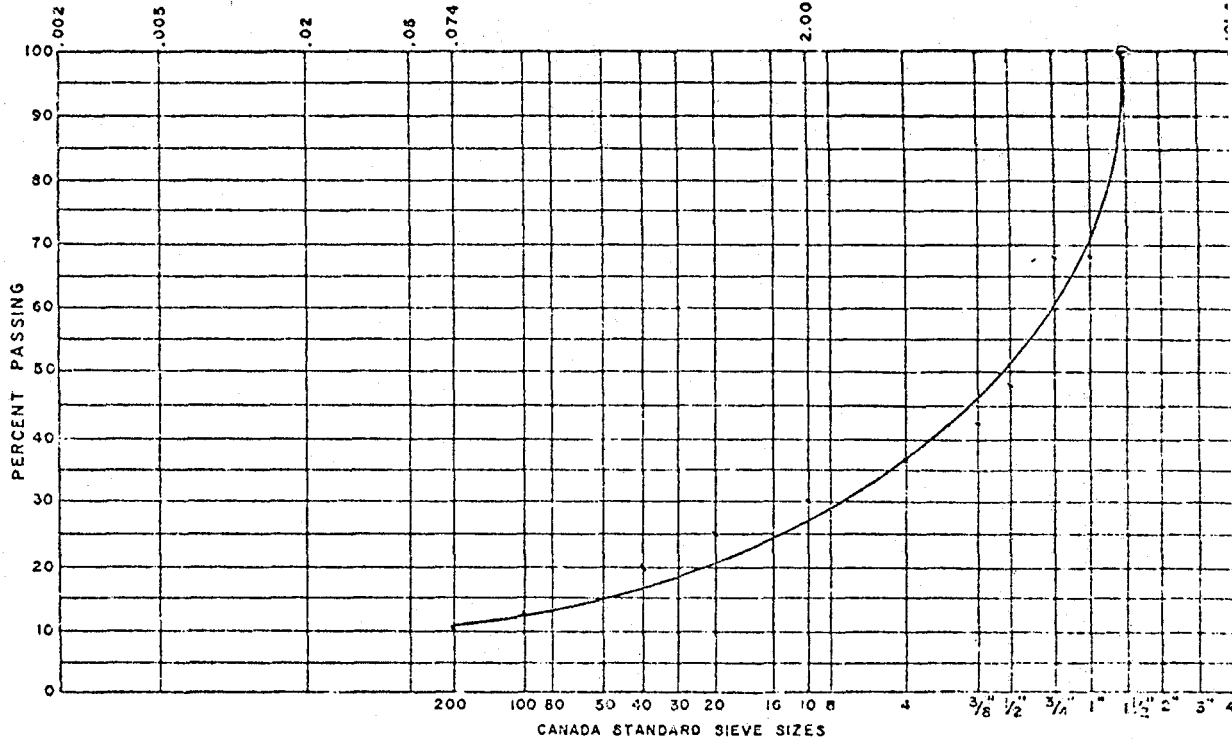
PETROGRAPHIC ANALYSIS

MATERIAL TYPE	% OF TOTAL SAMPLE
ASALT	
MESTONE	
ANTIC	
ANDSTONE	
HALE	
CHIST	
JARTZITE	
OTHERS	

PARTICLE SHAPE ANALYSIS

OUND	
2B-ROUND	
NGULAR	
3B-ANGULAR	
ATS	
EDLES	

GRAIN SIZE IN MILLIMETERS



GRAIN SIZE ANALYSIS

EVE SIZE	% FINER BY WEIGHT	SIEVE SIZE	% FINER BY WEIGHT	SIEVE SIZE	% FINER BY WEIGHT	SIEVE SIZE	% FINER BY WEIGHT
11	100	4.75	100				
7A	96.5	20	96.5				
12	96.5						
8	88.5						
4	73.2						
0	60.7						
0	34.9						
0	23.0						

MPLE NO.	CLASSIFICATION	L.L.	P.L.	P.I.	NAT. %W	S.G.
	SW-SM				N.P.	
	(SPECIALLY SAND)					

CRUSH COUNT %

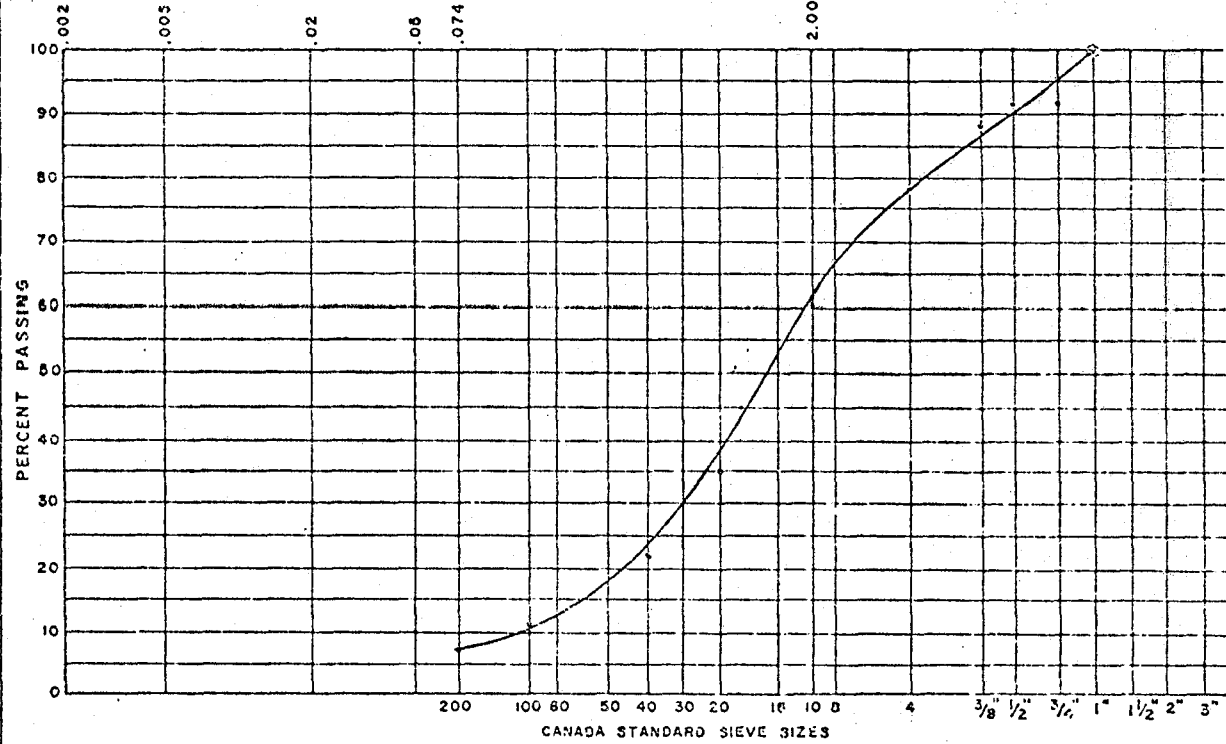
PETROGRAPHIC ANALYSIS

MATERIAL TYPE	% OF TOTAL SAMPLE
ASALT	
IMESTONE	
RAHITIC	
ANDSTONE	
HALE	
CHIST	
UARTZITE	
OTHERS	

PARTICLE SHAPE ANALYSIS

OUND	
UB-ROUND	
NGULAR	
UB-ANGULAR	
LAYS	
EEPLES	

GRAIN SIZE IN MILLIMETERS



CLAY	SILT	SAND	GRAVEL
------	------	------	--------

PROJECT BLACKSTONE RIVER BRIDGE
 LOCATION MILE 73.8 DENVER HWY.
 HOLE NO. 1
 DEPTH 19'-20 1/2' FIELD NO. 3
 SAMPLE TYPE S.P.T.

LAB. NO.
8173

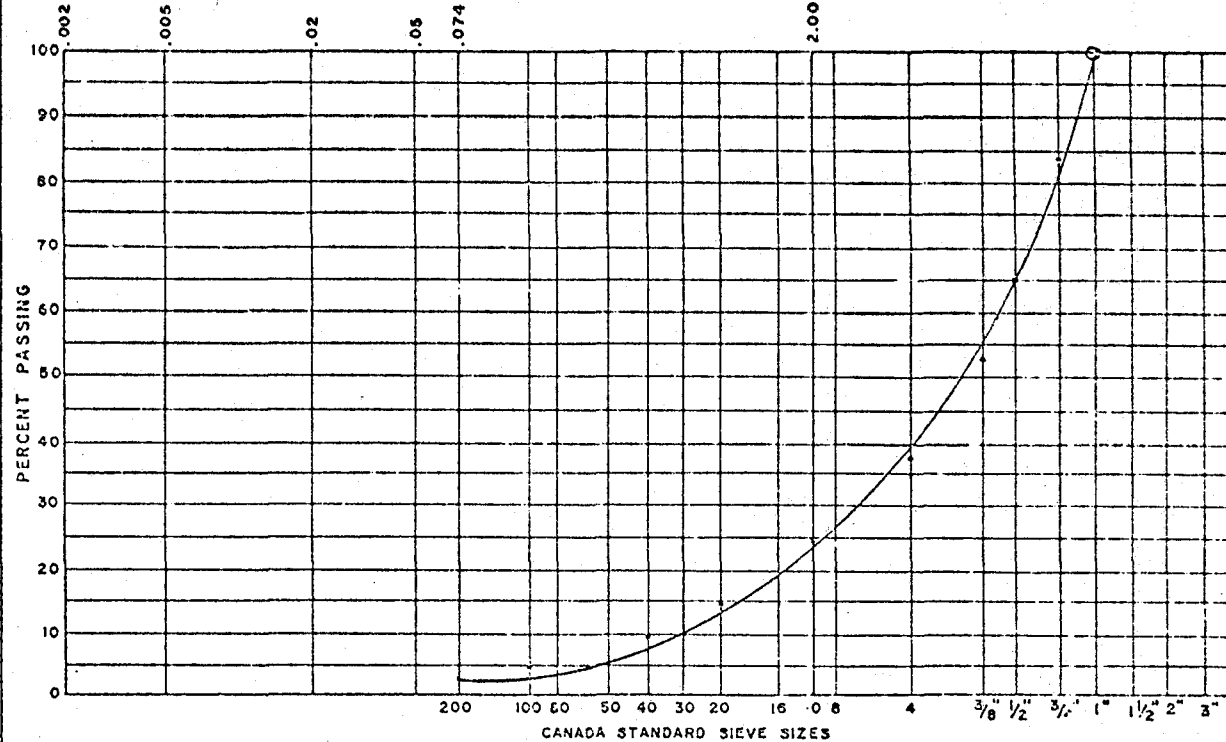
LABORATORY'S REMARKS

DATE SAMPLED 1-8-74
 DATE RECEIVED 26-8-74
 DATE RECORDED 14-1-75
 TESTED BY KK DE M...

GRAIN SIZE ANALYSIS

GRAIN SIZE IN MILLIMETERS

EVE IZE	% FINER BY WEIGHT	SIEVE SIZE	% FINER BY WEIGHT	SIEVE SIZE	% FINER BY WEIGHT	SIEVE SIZE	% FINER BY WEIGHT
11	12.0	1/10	4.5				
9/4	84.2	200	2.6				
12	65.0						
8	53.6						
14	37.2						
10	24.7						
20	14.6						
10	9.4						



MPLE NO.	CLASSIFICATION	L.L.	P.L.	P.I.	NAT. %W	S.G.
	GW			12.2		
WELL GRADED GRAVEL						
CRUSH COUNT %						

CLAY	SILT	SAND	GRAVEL
------	------	------	--------

PETROGRAPHIC ANALYSIS

MATERIAL TYPE	% OF TOTAL SAMPLE
BASEALT	
LIMESTONE	
GRANITIC	
SANDSTONE	
SHALE	
SCHIST	
QUARTZITE	
OTHERS	

PROJECT BLACKSTONE RIVER BRIDGE
 LOCATION MILE 72.8 DEMETER HWY.
 HOLE NO. 1
 DEPTH 30'-31' FIELD NO. 4
 SAMPLE TYPE SPT.

LAB. NO.
8174

PARTICLE SHAPE ANALYSIS

ROUND	
SUB-ROUND	
ANGULAR	
SUB-ANGULAR	
FLATS	
NEEDLES	

LABORATORY'S REMARKS	DATE SAMPLED
	1-8-74
	DATE RECEIVED 26-8-74
	DATE RECORDED 14-1-75
	TESTED BY <u>RK JEMH BT SE</u>

GRAIN SIZE ANALYSIS

SIEVE SIZE	% FINER BY WEIGHT	SIEVE SIZE	% FINER BY WEIGHT
1/2"	100.0	#40	16.7
1	74.6	100	8.5
3/4	88.9	200	6.2
1/2	84.6		
1/8	70.2		
#4	61.9		
#10	44.8		
#20	27.0		

MPLE NO.	CLASSIFICATION	L.L.	P.L.	P.I.	NAT. %W	S.G.
	SW-SM				N.P.	
	GRAVELLY SAND					

CRUSH COUNT %

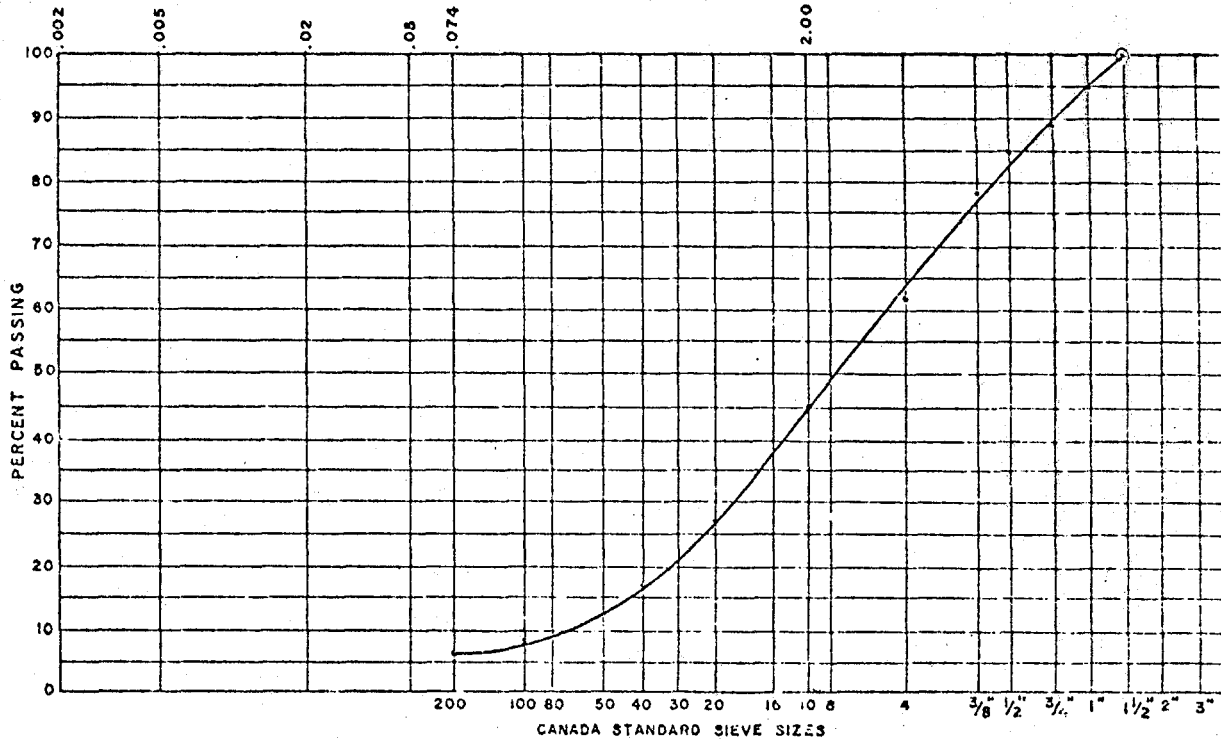
PETROGRAPHIC ANALYSIS

MATERIAL TYPE	% OF TOTAL SAMPLE
ASALT	
IMESTONE	
GRANITIC	
SANDSTONE	
SHALE	
SCHIST	
QUARTZITE	
OTHERS	

PARTICLE SHAPE ANALYSIS

ROUND	
SUB-ROUND	
ANGULAR	
SUB-ANGULAR	
FLATS	
NEEDLES	

GRAIN SIZE IN MILLIMETERS



CLAY	SILT	SAND	GRAVEL
------	------	------	--------

PROJECT BLACKSTONE RIVER BRIDGE
 LOCATION MILE 72.8 DEMPSTER HWY.
 HOLE NO. 1
 DEPTH 40'-41 1/2' FIELD NO. 5
 SAMPLE TYPE S.P.T.

LAB. NO.
8175

LABORATORY'S REMARKS	DATE SAMPLED
	1-8-74
	DATE RECEIVED 26-8-74
	DATE RECORDED 14-1-75
	TESTED BY <u>RK JE H-155</u>

GRAIN SIZE ANALYSIS

EVE IZE	% FINER BY WEIGHT	SIEVE SIZE	% FINER BY WEIGHT	SIEVE SIZE	% FINER BY WEIGHT	SIEVE SIZE	% FINER BY WEIGHT
72	100.0	#40	12.4				
1	92.5	100	5.3				
74	77.3	200	3.3				
12	70.8						
18	64.8						
24	57.4						
30	51.6						
36	46.4						

MPLE VO.	CLASSIFICATION	L.L.	P.L.	P.I.	NAT. %W	S.G.
	SW				N.P.	
	GRAVEL-SAND MIXTURE					

CRUSH COUNT %

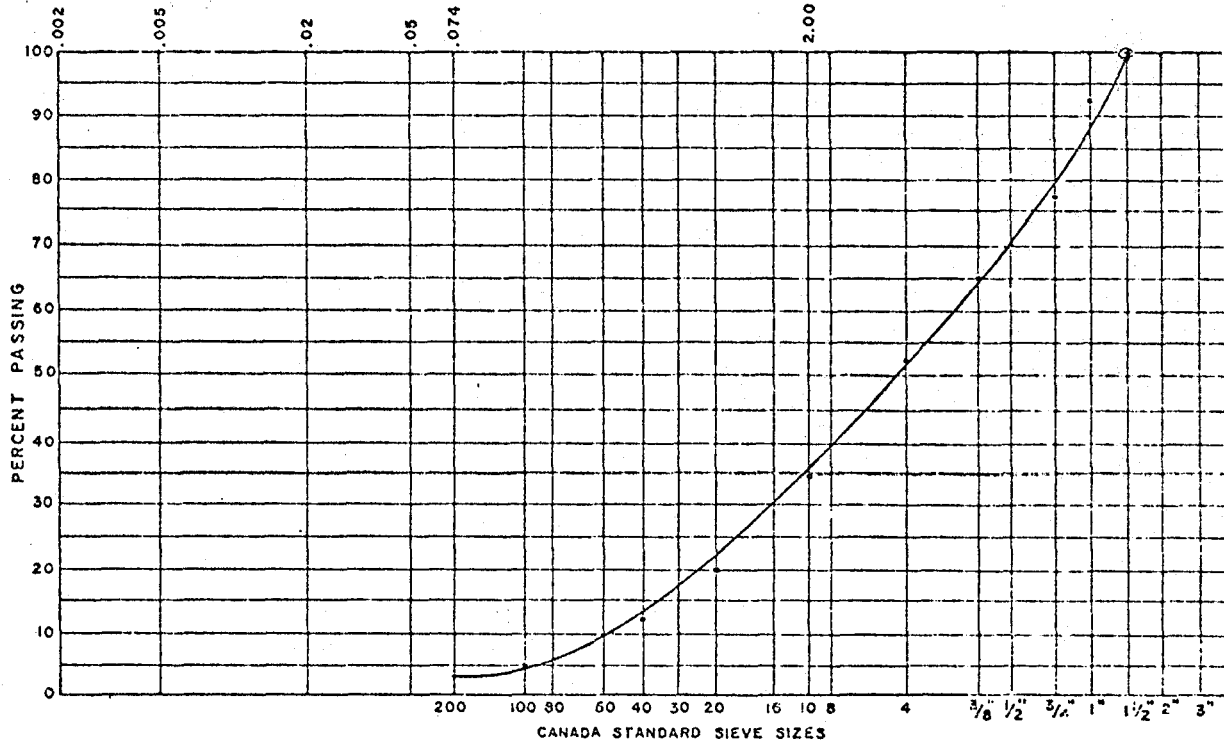
PETROGRAPHIC ANALYSIS

MATERIAL TYPE	% OF TOTAL SAMPLE
ASALT	
IMESTONE	
RANITIC	
ANDSTONE	
HALE	
CHIST	
UARTZITE	
TERS	

PARTICLE SHAPE ANALYSIS

OUND	
UB-ROUND	
NGULAR	
UB-ANGULAR	
LATS	
EDLES	

GRAIN SIZE IN MILLIMETERS



CLAY	SILT	SAND	GRAVEL
------	------	------	--------

PROJECT BLACKSTONE RIVER BRIDGE
 LOCATION MILE 72.8 DEMPSTER HWY.
 HOLE NO. 1
 DEPTH 50'-51 1/2' FIELD NO. 6
 SAMPLE TYPE SPT.

LAB. NO.
8176

LABORATORY'S REMARKS	DATE SAMPLED
	<u>1-8-74</u>
	DATE RECEIVED <u>26-8-74</u>
	DATE RECORDED <u>14-1-75</u>
	TESTED BY <u>RK JE. N. ST. S.</u>

GRAIN SIZE ANALYSIS

EVE IZE	% FINER BY WEIGHT	SIEVE SIZE	% FINER BY WEIGHT	SIEVE SIZE	% FINER BY WEIGHT	SIEVE SIZE	% FINER BY WEIGHT
1/2"	100.0	140	14.1				
1"	91.8	100	7.0				
1/4"	82.0	200	4.4				
2"	72.2						
1/8"	65.6						
1/4"	50.3						
1"	37.2						
2"	20.3						

AMPLE NO.	CLASSIFICATION	L.L.	P.L.	P.I.	NAT. %W	S.G.
	EW				N.P.	
	WELL GRADED GRAVEL					

CRUSH COUNT %

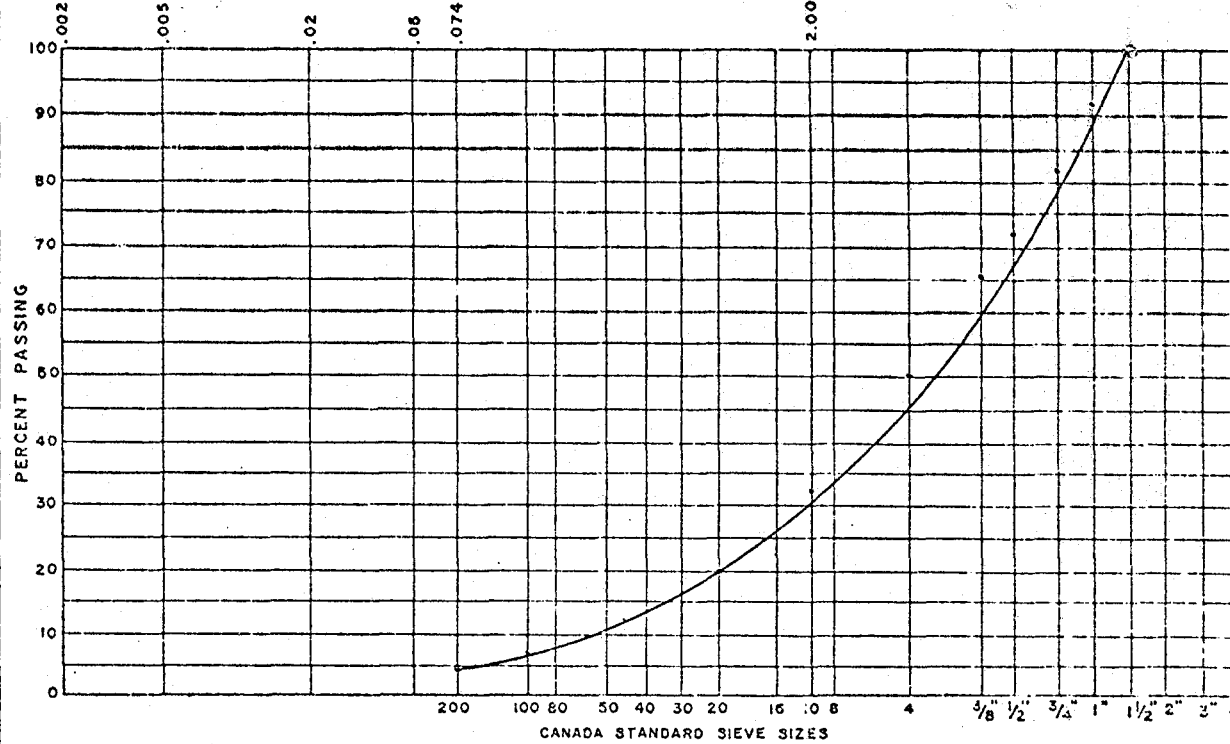
PETROGRAPHIC ANALYSIS

MATERIAL TYPE	% OF TOTAL SAMPLE
ASALT	
IMESTONE	
RANITIC	
ANDSTONE	
HALE	
CHRIST	
UARTZITE	
THERS	

PARTICLE SHAPE ANALYSIS

OUND	
UB-ROUND	
NGULAR	
UB-ANGULAR	
LATS	
EDDLES	

GRAIN SIZE IN MILLIMETERS



CANADA STANDARD SIEVE SIZES

CLAY	SILT	SAND	GRAVEL
------	------	------	--------

PROJECT BLACKSTONE RIVER BRIDGE
 LOCATION MILE 72.8 DEMPSTER HWY.
 HOLE NO. 1
 DEPTH 67'-68 1/2' FIELD NO. 7
 SAMPLE TYPE SPT.

LAB. NO.
8177

LABORATORY'S REMARKS

DATE SAMPLED 1-2-74
 DATE RECEIVED 26-8-74
 DATE RECORDED 14-1-75
 TESTED BY RK JE JH GS SE



APPENDIX B
Explanation Sheets



EXPLANATION OF TERMS AND SYMBOLS
USED ON TEST HOLE LOG SHEETS

Depth

This column refers to the depth below the ground surface in feet.

Sample Number

Tube and core samples were numbered consecutively from the surface. Grab samples were not numbered.

Sample Type

This column indicates the depth interval and condition of each sample attempted. Undisturbed samples in this program were obtained with Shelby tubes of 18 inches length and 3 inches diameter, manufactured from 11 gauge steel, or by core drilling. Cores were of 2.85 inch diameter and up to 36 inches long.

Disturbed samples were obtained from the returned cuttings.

T indicates tube sample

C indicates core sample

indicates large grab sample

Note: Grab samples taken for water content and visual examination are not indicated in this column.

Percent Recovery

This column shows the length of sample recovered as a percentage of the length attempted. 100% recovery is not indicated and may be assumed where no value is shown.



Penetration Resistance

Unless otherwise noted this column refers to the number of blows (N) of a 140 pound hammer dropping 30 inches required to drive a 2 inch O.D. open end sampler a distance of one foot from 0.5 to 1.5 feet into the soil. This is the standard penetration test referred to in ASTM, D1586.

Unified Soil Symbol

The soil symbols used are explained in full on page 5 of this appendix.

Soil Description.

Soils of different engineering classification are grouped generically for ease of reference. The system used is the Modified Unified Classification System for Soils.

Frozen Ground

The depth intervals over which frozen and unfrozen ground were encountered are indicated by F and UF respectively. No attempt was made to differentiate between seasonal frost and permafrost.

Ice Description

The ice content of permafrost soils has been classified according to the National Research Council System for describing permafrost. A brief review of the NRC System is contained on page 9 of this appendix. Where no entry is made, the type was not recorded in the field.



Water Content

The natural water content of the soil at the time of drilling is plotted against depth on the chart at the right hand side of the log. The water content, which is indicated by a circle, is expressed as a percentage of the dry weight of the soil. It will be observed that water contents in excess of 100% are indicated in the column at the right of the chart by figures.

Volume of Ice

The total volume of ice in undisturbed samples is indicated on the same chart as water contents. The value is indicated by a triangle. This volume is the total volume of ice in an undisturbed sample and includes interstitial ice, as well as excess ice, and is expressed as a percentage of the total volume of the sample.

Grain Size Analysis

The proportions of clay, silt, sand and gravel in a sample are summarized. Grain size curves for each sample so analyzed are on separate sheets.

Wet Density

The wet in situ density of undisturbed samples is the total weight of the sample in pounds (including ice and water) divided by the volume of the sample in cubic feet.



Dry Density

The dry in situ density of undisturbed samples is the weight of dry soil divided by the volume of the sample in cubic feet.

Atterberg Limits

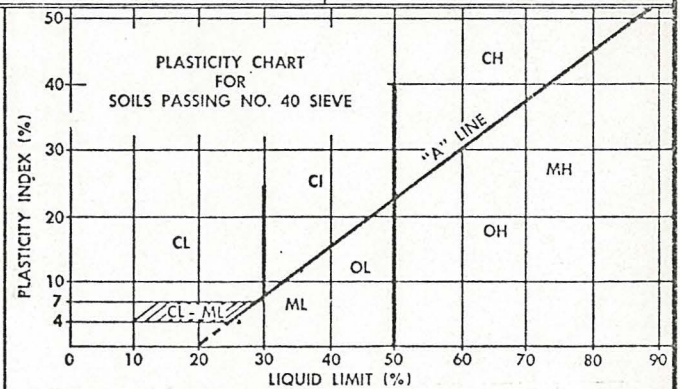
The plastic and liquid limits are shown on the water content chart by a horizontal bar. The Atterberg system is discussed in the following section.

NOTES ON ATTERBERG LIMITS

Soils which possess a significant fraction of clay can exist in liquid, plastic or solid states according to the water content. Where the water content is very high, so that the soil is in the form of a slurry, the soil behaves as a liquid. If the water content is reduced, for example through evaporation, the clay will enter into a plastic state. If the water content is reduced yet further, the clay will become a solid. The transition from one state to another occurs gradually over a range of water content. Atterberg, a Swedish agronomist, developed a method for delineating the boundaries between the three states. If his method is used, the water content which marks the dividing line between the plastic and liquid state is known as the Liquid Limit. These water contents are all expressed as percentages of the dry weight of soil. The range of water content between the plastic

MODIFIED UNIFIED CLASSIFICATION SYSTEM FOR SOILS

MAJOR DIVISION			GROUP SYMBOL	GRAPH SYMBOL	COLOR CODE	TYPICAL DESCRIPTION	LABORATORY CLASSIFICATION CRITERIA			
COARSE-GRAINED SOILS (MORE THAN HALF BY WEIGHT LARGER THAN 200 SIEVE)	GRAVELS MORE THAN HALF COARSE GRAINS LARGER THAN NO. 4 SIEVE	CLEAN GRAVELS (LITTLE OR NO FINES)	GW		RED	WELL GRADED GRAVELS, LITTLE OR NO FINES	$C_u = \frac{D_{60}}{D_{10}} > 6$ $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}} = 1 \text{ to } 3$			
			GP		RED	POORLY GRADED GRAVELS, AND GRAVEL-SAND MIXTURES, LITTLE OR NO FINES	NOT MEETING ABOVE REQUIREMENTS			
		DIRTY GRAVELS (WITH SOME FINES)	GM		YELLOW	SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURES	CONTENT OF FINES EXCEEDS 12%	ATTERBERG LIMITS BELOW "A" LINE P.I. LESS THAN 4		
			GC		YELLOW	CLAYEY GRAVELS, GRAVEL-SAND-(SILT) CLAY MIXTURES		ATTERBERG LIMITS ABOVE "A" LINE P.I. MORE THAN 7		
	SANDS MORE THAN HALF FINE GRAINS SMALLER THAN NO. 4 SIEVE	CLEAN SANDS (LITTLE OR NO FINES)	SW		RED	WELL GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES	$C_u = \frac{D_{60}}{D_{10}} > 4$ $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}} = 1 \text{ to } 3$			
			SP		RED	POORLY GRADED SANDS, LITTLE OR NO FINES	NOT MEETING ABOVE REQUIREMENTS			
		DIRTY SANDS (WITH SOME FINES)	SM		YELLOW	SILTY SANDS, SAND-SILT MIXTURES	CONTENT OF FINES EXCEEDS 12%	ATTERBERG LIMITS BELOW "A" LINE P.I. LESS THAN 4		
			SC		YELLOW	CLAYEY SANDS, SAND-(SILT) CLAY MIXTURES		ATTERBERG LIMITS ABOVE "A" LINE P.I. MORE THAN 7		
FINE-GRAINED SOILS (MORE THAN HALF BY WEIGHT PASSES 200 SIEVE)	SILTS BELOW "A" LINE NEGLECTIBLE ORGANIC CONTENT	$W_L < 50\%$	ML		GREEN	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY SANDS OF SLIGHT PLASTICITY	CLASSIFICATION IS BASED UPON PLASTICITY CHART (see below)			
		$W_L > 50\%$	MH		BLUE	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS, FINE SANDY OR SILTY SOILS				
	CLAYS ABOVE "A" LINE ON PLASTICITY CHART NEGLECTIBLE ORGANIC CONTENT	$W_L < 30\%$	CL		GREEN	INORGANIC CLAYS OF LOW PLASTICITY, GRAVELLY, SANDY, OR SILTY CLAYS, LEAN CLAYS				
		$30\% < W_L < 50\%$	CI		GREEN-BLUE	INORGANIC CLAYS OF MEDIUM PLASTICITY, SILTY CLAYS				
		$W_L > 50\%$	CH		BLUE	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS				
	ORGANIC SILTS & CLAYS BELOW "A" LINE ON CHART	$W_L < 50\%$	OL		GREEN	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY			WHENEVER THE NATURE OF THE FINE CONTENT HAS NOT BEEN DETERMINED, IT IS DESIGNATED BY THE LETTER "F", E.G. SF IS A MIXTURE OF SAND WITH SILT OR CLAY	
		$W_L > 50\%$	OH		BLUE	ORGANIC CLAYS OF HIGH PLASTICITY				
HIGHLY ORGANIC SOILS			Pt		ORANGE	PEAT AND OTHER HIGHLY ORGANIC SOILS	STRONG COLOR OR ODOR, AND OFTEN FIBROUS TEXTURE			



1. ALL SIEVE SIZES MENTIONED ON THIS CHART ARE U.S. STANDARD, A.S.T.M. E.11.
2. BOUNDARY CLASSIFICATIONS POSSESSING CHARACTERISTICS OF TWO GROUPS ARE GIVEN COMBINED GROUP SYMBOLS. E.G. GW-GC IS A WELL GRADED GRAVEL SAND MIXTURE WITH CLAY BINDER BETWEEN 5% AND 12%.



and liquid limit is known as the plastic range and the numerical difference between the liquid and plastic limits is called the Plasticity Index.

It will be appreciated that where the natural water content is in excess of the liquid limit, the soil mass will be most unstable and will readily flow into excavations or trenches. Such considerations will not apply where the soil mass is kept frozen. However, in cases where the frozen soil is allowed to thaw, the relationship between the natural water content and liquid limit becomes critical.

On page 5 there is a chart showing the relationship between the Plasticity Index, the Liquid Limit and the group symbols of the Unified Classification System. The Atterberg Limit system is extremely useful for identifying and classifying soils.

NOTES ON THE RADFORTH SYSTEM
FOR CLASSIFYING PEAT

The Radforth classification system for describing muskeg (organic terrain) is a method for classifying the three elements of vegetation, topography and organic surface cover using letter and figure symbols. Height and type of vegetation is described by using capital letters (A through I). Topography is described by using lower case letters (a through p) Organic cover type if described by using figures (1 through 16).



Table I outlines these figure symbols and the peat structure and type represented by them. A complete description of the Radforth system is contained in "Guide to a Field Description of Muskeg" published by National Research Council, Ottawa, from which has been copied Table I.



TABLE I
SUBSURFACE CONSTITUTION

<u>Predominant Characteristic</u>	<u>Category</u>	<u>Name</u>
	1.	Amorphous-granular peat
	2.	Non-woody, fine-fibrous peat
	3.	Amorphous-granular peat containing woody fine fibres
	4.	Amorphous-granular peat containing woody fine fibres
	5.	Peat, predominantly amorphous-granular, containing non-woody fine fibres, held in a woody, fine fibrous framework.
	6.	Peat, predominantly amorphous-granular containing woody fine fibres, held in a woody, coarse-fibrous framework.
	7.	Alternate layering of non-woody, fine fibrous peat and amorphous-granular peat containing non-woody fine fibres.
	8.	Non-woody, fine-fibrous peat containing a mound of coarse fibres.
	9.	Wood, fine fibrous peat held in a woody, coarse-fibrous framework.
	10.	Woody particles held in a non-woody, fine-fibrous peat.
	11.	Woody and non-woody particles held in fine-fibrous peat.
	12.	Woody, coarse-fibrous peat.
	13.	Coarse fibres criss-crossing fine-fibrous peat.
	14.	Non-woody and woody fine-fibrous peat held in a coarse-fibrous framework.
	15.	Woody mesh of fibres and particles enclosing amorphous-granular peat containing fine fibres.
	16.	Woody, coarse-fibrous peat containing scattered woody chunks.



NOTES ON THE NATIONAL RESEARCH COUNCIL
SYSTEM FOR DESCRIBING PERMAFROST

Ground ice occurs in three conditions. Non-visible, visible (but less than one inch in thickness) and clear ice. Non-visible ice is designated N with an added suffix of one or two lower case letters. Visible ice is designated V with an added suffix of one lower case letter. Clear ice is designated ICE with notes on ice type.

TABLE IV

<u>Symbol</u>	<u>Description</u>
Nf	Non-visible ice, frozen soil in friable condition.
Nbn	Non-visible ice, frozen soil well bonded, no excess ice.
Nbe	Non-visible ice, frozen soil well bonded, excess ice revealed on melting sample.
Vx	Visible ice crystals.
Vc	Ice coatings on soil particles.
Vr	Ice formations irregularly orientated.
Vs	Stratified ice lenses.
ICE	Clear ice over one inch in thickness.
ICE + soil	Ice over one inch thick with soil inclusions.

A complete description of this system is contained in "Guide to a Field Description of Permafrost" published by National Research Council, Ottawa.



APPENDIX C

Recommended Construction Procedures



RECOMMENDED CONSTRUCTION PROCEDURES

The following construction procedures are recommended to ensure the satisfactory performance of the structures. The recommendations are to be read in conjunction with the text of the report.

1. DRIVEN STEEL PILES

1.1 Piles shall be driven by equipment having a striking weight not less than one-third of the driven weight of the piles. The driver should be capable of delivering at least 15,000 ft. lbs. of energy.

1.2 The number of blows required to drive the pile each foot should be recorded for every pile as an indication of the satisfactory carrying capacity of the pile and as an indicator of potential tip damage.

1.3 After each pile is driven to its required depth an elevation should be taken of the pile top or on a suitable mark on the side of the pile. This elevation should be checked periodically to ensure that it is not heaved by the driving of adjacent piles. Piles that are heaved must be redriven.

1.4 For piles which displace a considerable amount of soil during driving, such as closed-end pipe piles, care must be taken that the driving does not cause damaging horizontal displacement of existing structures or foundations.



1.5 Where piles are designed to gain support by skin friction in the soil it is essential that the pile have ends and walls free from protrusions which could cause voids or disturbance of the adjacent soil during driving.