MACKENZIE HIGHWAY

preliminary engineering - phase 1B

SHALE CREEK BRIDGE

mile 361.0

Reid, Crowther & Partners Limited

CONSULTING ENGINEERS
AND PLANNERS

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PLEASE REFER TO FILE No. 9554-3

February 8, 1974

Department of Public Works
10th Floor, One Thornton Court
P.O. Box 488
Edmonton, Alberta
T5J 2K1

Attention Mr. F. E. Kimball
Project Manager NWT Roads
Western Region

Gentlemen:

Mackenzie Highway - Preliminary Engineering Phase 1B Report
Shale Creek Bridge Mile 331.0

We are pleased to present herein our Phase 1B Report on the Shale Creek Bridge which has been prepared in accordance with Mr. Kimball's letter of October 3, 1973.

As instructed, the Report includes a summary of the hydrology and geotechnical investigations; impact statements on the permanent crossing by the environmental consultant; and, a brief description of the proposed structure and alternate systems considered, together with preliminary drawings and cost estimates.

We trust that the content of our Report provides a basis for approval in principle and authorization to proceed with final design.

Yours very truly,

R. C. Aitken, P. Eng.
Manager, Transportation Division

RCA/mm
Enclosure

MACKENZIE HIGHWAY

PRELIMINARY ENGINEERING PHASE 1B

SHALE CREEK BRIDGE MILE 331.0

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MACKENZIE HIGHWAY

PRELIMINARY ENGINEERING PHASE 1B

SHALE CREEK BRIDGE MILE 331.0

INTRODUCTION:

The proposed crossing is in a short reach of Shale Creek approximately 1-1/4 miles upstream from the Mackenzie River. At this location the valley is relatively narrow with high, steep, tree-covered banks. The vegetation in the area consists of aspen and black spruce up to 60-feet in height and sparse to moderate shrub, herb and grass cover.

Shale Creek drains a catchment area of 106 square miles and, at the calculated design discharge of 6,800 c.f.s., the average velocity through the bridge opening will be 9 f.p.s., but, because the creek bed is armoured with very heavy boulders, general bed scour will not occur during flows of this magnitude. Backwater conditions on the Mackenzie will not affect water levels at this site and it is anticipated that ice runs in the creek will not be severe.

The impact of the structure on the environment is classified as moderate to low by the environmental consultant. There is no information available relating to fish in the creek but it is assumed that species similar to those found in the

Martin River will also be found here. This stream appears to have a good spawning potential.

Clearing operations to date have uncovered no archaeological artifacts; however, Shale Creek was probably used as an access route from the Mackenzie River to Little Doctor, Cil and Sibbeston Lakes and therefore surveillance should be maintained during construction.

Comments by F. F. Slaney & Company Limited on the environmental impact of the proposed structure are included in Appendix B of this report.

Geotechnical information for this site was obtained by the Department of Public Works and, while not comprehensive, it is generally adequate for the design of the bridge substructure. Stratigraphy below the river consists of clay till with boulders and cobbles underlain by shale bedrock at a depth of 7 to 10-feet. Borehole logs, prepared from information received from the Department are included in Appendix C of this report.

The highway profile controls the elevation of the bridge at this crossing. Approach grades have been designed to leave adequate cover over permafrost material in the banks, resulting in a grade line approximately 27-feet above the design high water level.

The previous submission of December, 1973 proposed a three span, steel plate girder bridge with relatively high cast-in-place concrete piers. Span ratios were proportioned to produce a balanced structural system and piers were located within the active river channel.

Subsequent studies indicate that a steel rigid frame structure with a longer centre span will be more economical at this location because pier quantities will be substantially reduced. In the original submission, the bridge piers located in the active channel were designed for stream flow, ice and drift forces whereas in the solution now proposed, the piers are located outside the normal channel and are considerably lower because of the rigid frame design, illustrated on Dwg. P201. Concrete piers extend above design high water so that the structural steel and bearings will be in the dry.

DESIGN CONSIDERATIONS:

Proposed Structure.

The proposed bridge is a three span rigid frame structure with spans of 48'-130'-48'; the deck is cast-in-place concrete supported by two welded plate girders with composite action in areas of positive moment. Cast-in-place concrete is recommended for the abutments and the foundation structures supporting the steel frame legs. Loads from the superstructure are transmitted to the bedrock by short piles at the abutments and by spread footings cast directly on the shale at the piers.

The abutments are conventional cast-in-place concrete structures and since there is evidence of permafrost at this site, they are supported on steel H-piles driven to bedrock.

The riverbanks adjacent to the bridge piers will be protected by riprap as indicated on the drawings - limits of riprap will be determined during the final design phase of the project. It is understood that embankments will be grassed except beneath the structure where slope protection will be provided.

Design Criteria.

Specifications:	C.S.A. S6	- Standard Specifications for Highway Bridges
	A.A.S.H.O.	- Design of Highway Bridges
	A.W.S. D1.1	- Structural Welding Code
Materials:	Structural Steel	- C.S.A. G40.21 Grade 50A
	Reinforcing Steel	- C.S.A. G30.12 60 Grade
	Deck Concrete	- f'c - 4,000 p.s.i.
	Substructure Concrete	- f'c - 3,000 p.s.i.
Loading:	Live Load	- H.S. 25 + Impact
	Future Wearing Surface	- 30 p.s.f.
	Ice Pressure	- 250 p.s.i.
	Ice Thickness	- 3'-0"
Piles:	70 Ton Compression (Group I, C.S.A. S6)	
Pier Footings:	Design Pressure on Rock - 10 k.s.f.	

Alternate Systems.

Before selecting the three span structure, four deck systems and a three span cantilever structure were evaluated. Deck systems considered were:

- concrete deck, three girders;
- concrete deck, two girders with transverse floor beams;
- concrete deck, two girders without transverse floor beams; and,
- open steel deck, two girders with transverse floor beams.

The concrete deck/two girder system without transverse floor beams proved to be more economical than the other concrete deck systems and the welded steel deck; in estimating the cost of the open steel deck system, a 6½-inch Armco welded deck was considered. From discussions with the manufacturer, it appears that a steel deck could be installed for around $12.00/sq. ft.; however, the plate girders and floor beams required to support a steel deck would be in the order of 10 lbs./sq.ft. heavier than the plate girders required to support the concrete deck so that the relative cost of a steel deck would be in the order of $19.00 - $20.00/sq. ft. (assuming structural steel at $0.75/lb.). Therefore deck concrete could cost up to $500.00/ cu. yd. including formwork (but excluding reinforcing steel) before the steel deck would be economically competitive.

From this preliminary investigation it is evident that the steel deck, although structurally adequate, will be considerably more expensive than a concrete deck and, in addition, the riding qualities of the steel deck will be inferior to those of a concrete deck. The alternate concrete and steel deck two girder systems with floor beams are shown on Dwg. P203.

An alternate rigid frame system with cantilevered end spans, varying in length from 1/4 to 1/5 of the overall bridge length, and with the centre span increased from 130 to 155-feet was investigated. However, the geometry of the proposed structure is such that, as the centre span increases, the pier heights decrease and the horizontal reactions from frame action increase significantly; the theoretical live load deflection of the cantilever was in the order of 3-inches or 1/150 of the span which was considered to be excessive; and, in the final analysis, there did not appear to be an economic advantage in this particular system since the longer centre span increased the weight of structural steel and required larger pier foundations, the additional cost of which offsets savings realized by the reduced scale of the abutments. This system was therefore discarded in favour of the more conventional structure proposed, although it should be noted in passing that the cantilever system would be a suitable arrangement for shorter structures in the order of 175-feet overall in which the girders are supported by conventional piers.

SCHEDULING:

The following schedule assumes that bridge construction will commence in the spring of 1975. However, the relatively good access and proximity of the site to Fort Simpson will allow the scheduling of this structure to be flexible.

Allowing six months for structural steel delivery the tentative schedule will require bridge drawings and contract documents to be completed not later than November, 1974 and possibly sooner depending on the period of time required for approvals.

Schedule.

- Construct temporary bridge - Winter 1973-74.
- Deliver concrete aggregates - Fall 1974 or Early Winter 1975.
- Start abutment construction - March, 1975.
- Start pier construction - April, 1975.
- Erect structural steelwork - May - June, 1975.
- Place deck and complete structure - July - September, 1975.

COST ESTIMATE:

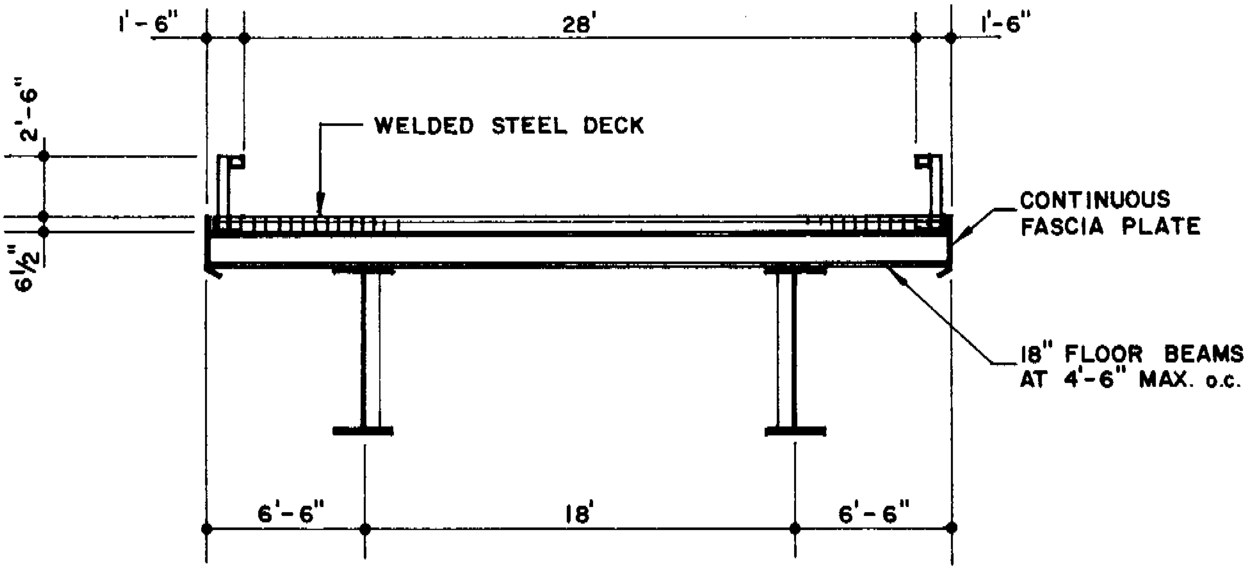
Estimating costs at this stage of the project has proved to be even more difficult than it was one year ago, when the Interim Report was prepared, because of the unstable prices which are currently being experienced throughout the construction industry.

We have reviewed the unit prices which were developed for the Interim Report and, while some of the units now appear to have been on the low side, they were generally speaking quite realistic at that time. These unit prices have therefore been used as a basis for the present estimate but increased to reflect current prices (December, 1973). A detailed breakdown of the estimate is given on the following page.

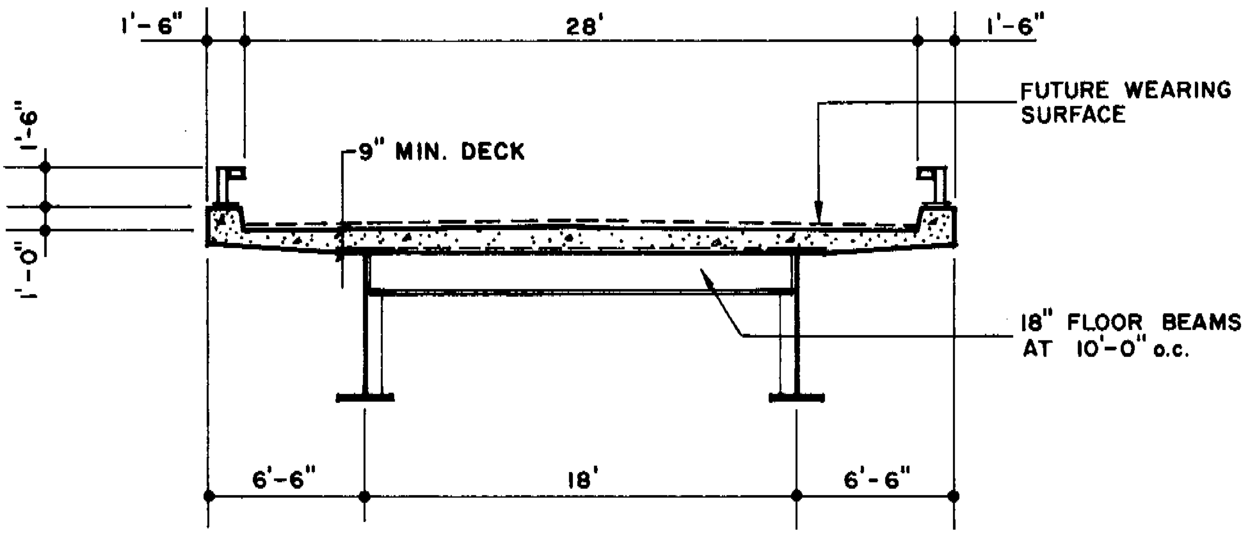
SHALE CREEK BRIDGE MILE 331.0

COST ESTIMATE - DECEMBER, 1973

Item	Quantity	Unit	Unit Price	Amount
Excavation & Backfill				
- Rock	60	cu.yd.	$ 80.00	$ 5,000
- Gravel	800	cu.yd.	50.00	40,000
- Riprap	600	cu.yd.	25.00	15,000
Piles	700	lin.ft.	30.00	21,000
Concrete				
- Foundations	290	cu.yd.	300.00	87,000
- Piers & Abutments	100	cu.yd.	300.00	30,000
- Deck	240	cu.yd.	350.00	84,000
- Approach slab	45	cu.yd.	300.00	13,500
Reinforcing Steel	160,000	lb.	0.40	64,000
Structural Steel	100	ton	1,500.00	150,000
Handrail	500	lin.ft.	30.00	15,000
Expansion Joint	65	lin.ft.	100.00	6,500
Bearings	8	each	1,250.00	10,000
Sub-Total				$541,000
15% Contingency				$ 81,000
7% Engineering & Administration				$ 43,000
TOTAL				$665,000



STEEL DECK



CONCRETE DECK

ALTERNATE DECK SYSTEMS

9554 – P203

SHALE CREEK BRIDGE:

Introduction.

The preliminary bridge design for Shale Creek is a three span design with two piers 110-feet apart encroaching on the creek channel. A similar design with a pier spacing of 150-feet would eliminate any encroachment on the creek channel.

Environmental Impact.

Other than for fish, the environmental impacts for both designs are negligible and equal.

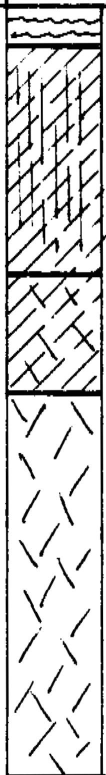
The on-shore piers could be constructed during any season. The piers which encroach on the creek cross section should be constructed from November to April because of high fish activity from May to October. By erecting the spans when the river is frozen the least possible disturbance will be caused to the river bed and banks.

Summary.

The construction of a bridge design with piers located so that there is no encroachment on the creek channel cross section has minimal environmental effects and should be given primary consideration.

TEST HOLE LOG

LOCATION	SHALE CREEK	STATION	1902+35
PROJECT No.	9554	OFFSET	ON CENTRE LINE
DATE DRILLED	31/8/73	HOLE No.	157



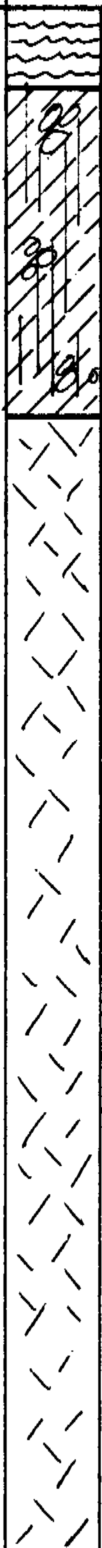
DEPTH (FEET)	DESCRIPTION AND REMARKS
1'	ORGANIC
7'	CLAY TILL MOIST BOULDERS COBBLES SILTY, SANDY MEDIUM PLASTIC, BROWN BOULDERS AT 4' AND 6'
10'	ALTERNATING LAYERS OF SHALE AND CLAY SHALE NUGGET TEXTURE 8½'
	SHALE WATER BEARING SHALE AT 16'
20'	END OF HOLE

NOTE

THIS LOG COMPILED FROM
D.P.W. FIELD NOTES

TEST HOLE LOG

LOCATION	SHALE CREEK	**STATION**	1903+75
PROJECT No.	9554	**OFFSET**	20' S OF CENTRE LINE
DATE DRILLED	31/8/73	**HOLE No.**	158



DEPTH (FEET)	DESCRIPTION AND REMARKS
2'	ORGANIC
10½'	CLAY TILL - ORGANIC TO 5' COBBLES, BOULDERS, MOIST SILTY, SANDY. MEDIUM-LOW PLASTIC BROWN GREY AT 4'
40'	SHALE FREE WATER AT 16' DRY AT 17½'
	END OF HOLE

NOTE

THIS LOG COMPILED FROM
D.P.W. FIELD NOTES

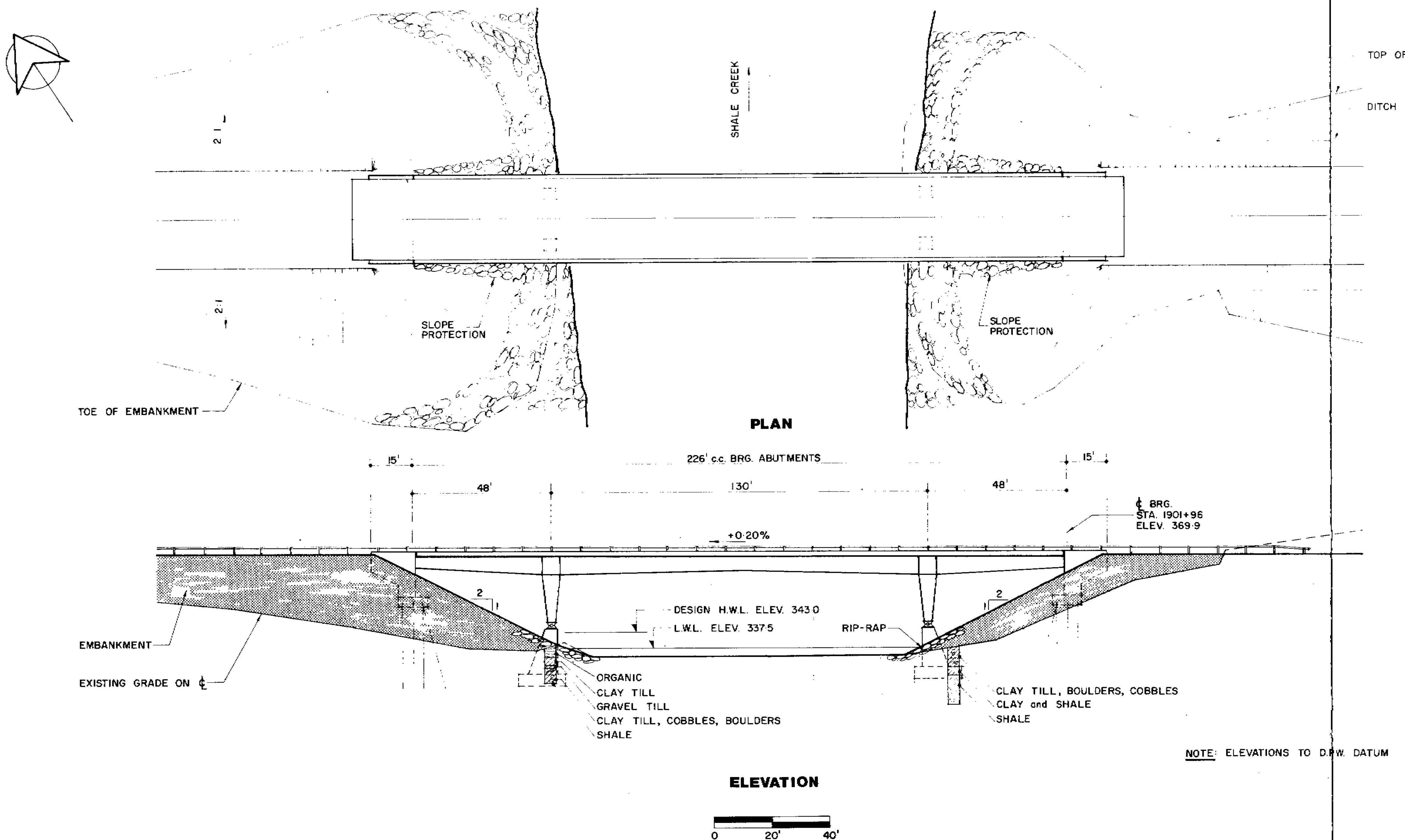
TEST HOLE LOG

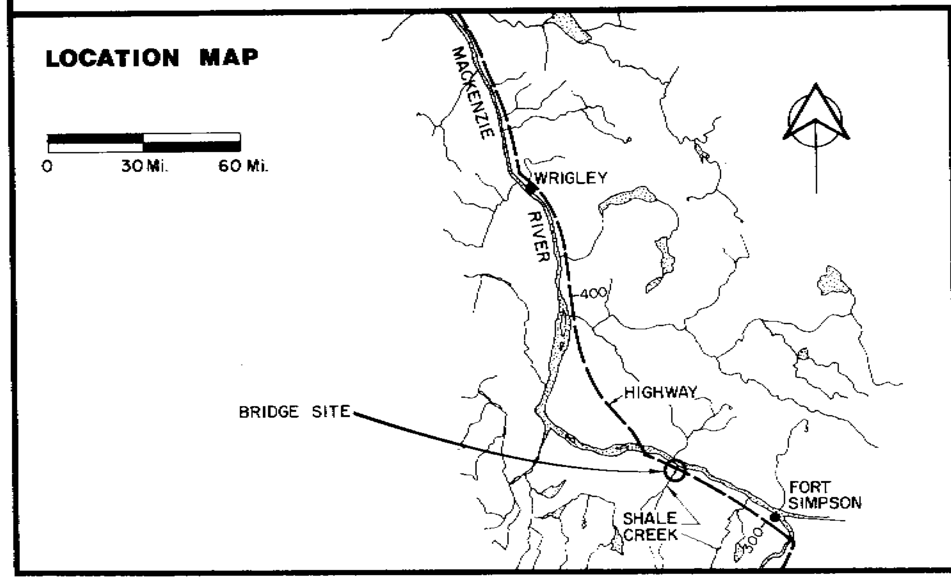
LOCATION	SHALE CREEK	STATION	1903+75
PROJECT No.	9554	OFFSET	10' N OF CENTRE LINE
DATE DRILLED	31/8/73	HOLE No.	159

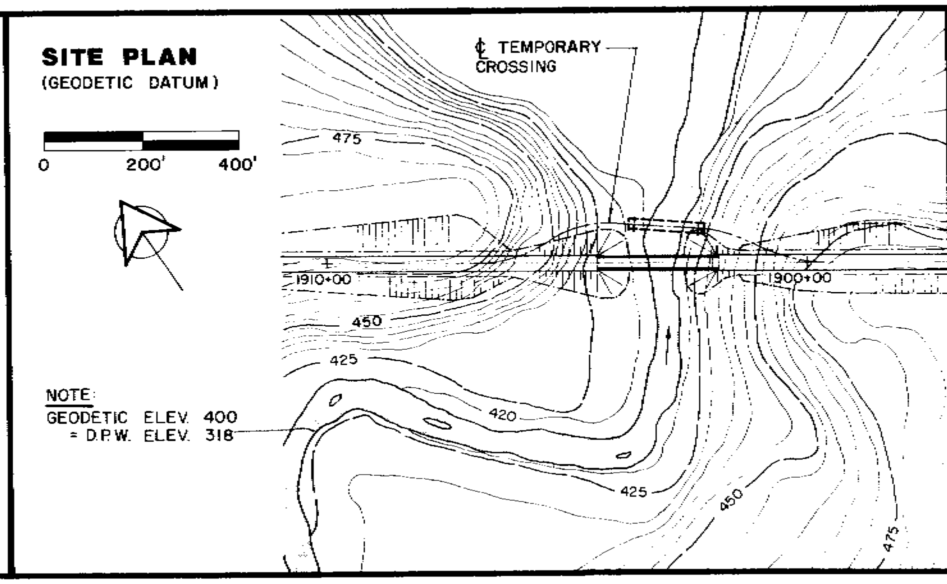
DEPTH (FEET)	DESCRIPTION AND REMARKS
	ORGANIC
3½'	ROCK AT 3½' CLAY TILL, SILTY, SANDY LOW PLASTIC, GREY
6½'	FREE WATER AT 6½' GRAVEL TILL, CLAYEY, SANDY COBBLES AND BOULDERS
7½'	CLAY TILL, SILTY, SANDY COBBLES, BOULDERS, WET MEDIUM-LOW PLASTIC GREY
12½'	SHALE

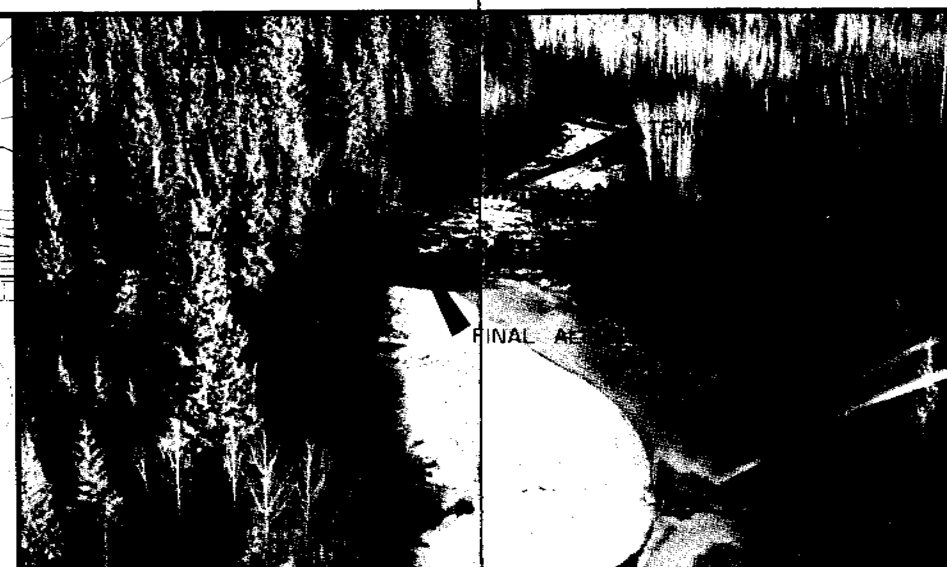
NOTE

THIS LOG COMPILED FROM
D.P.W. FIELD NOTES









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Ministère des Travaux publics

WESTERN REGION
J. A. BROWN
REGIONAL DIRECTOR

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CONSULTING ENGINEERS & PLANNERS

A detail no. / détail no.
B location drawing no. / sur dessin no.
C drawing no. / dessin no.

revisions | date

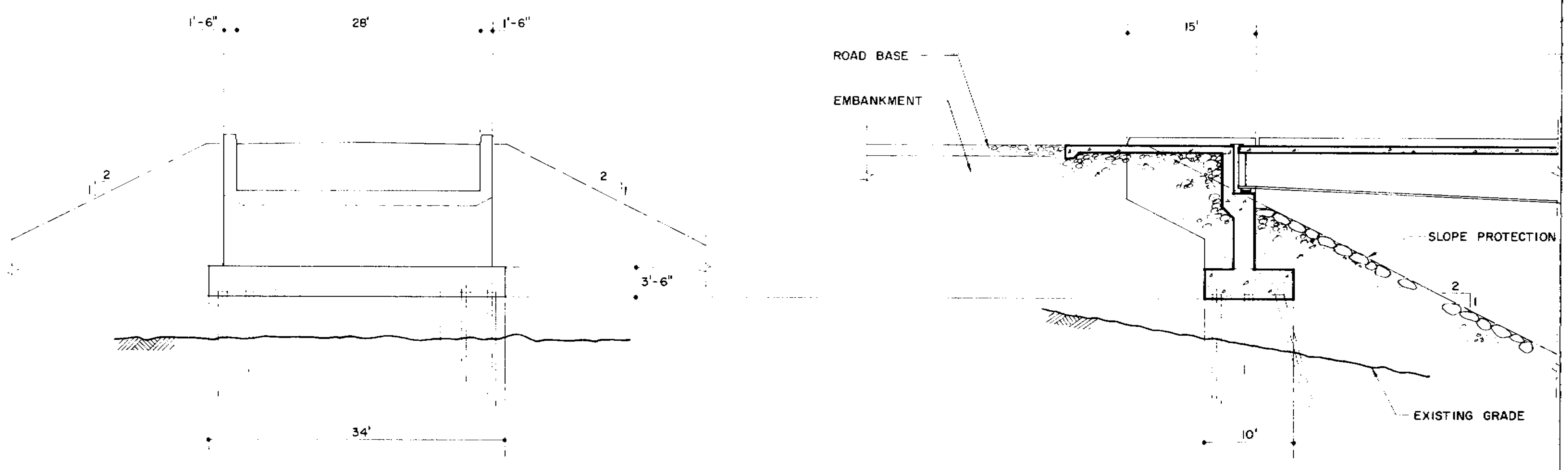
project title / titre du projet
MACKENZIE HIGHWAY

drawing title / titre du dessin
SHALE CREEK BRIDGE Mile 331.0
GENERAL LAYOUT

designed by / conçu par
date JANUARY 1974
drawn by / dessiné par
date
reviewed by / examiné par
date
approved by / approuvé par
date
Tender / Soumission
D.P.W. Project Manager / Administrateur de projets M.T.P.

project number / no. du projet
85024

drawing no. / dessin no.
9554-P 201



ABUTMENT

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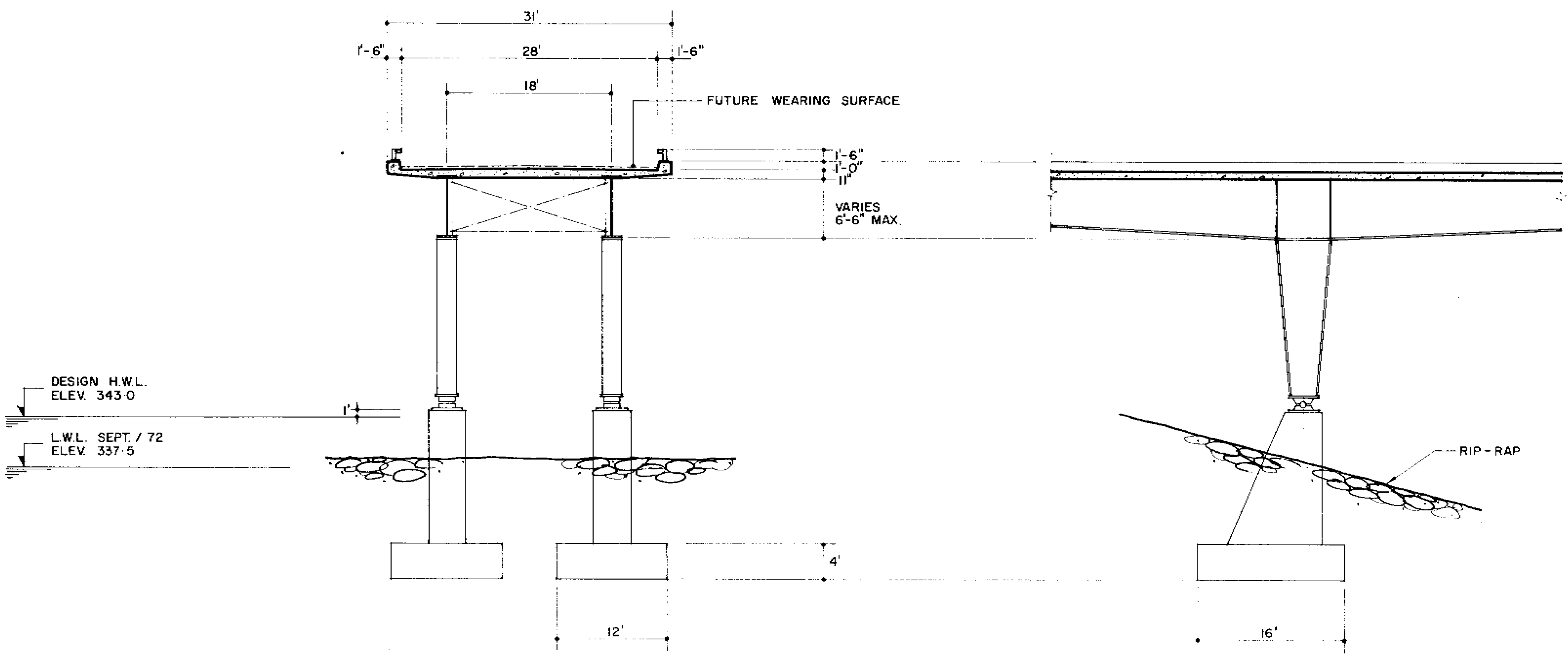

PIER

0 8' 16'

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SHALE CREEK BRIDGE
Mile 331.0

DETAILS

designed by conçu par
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Tender Soumission
D.P.W. Project Manager Administrateur de projets M.T.P.
project number no. du projet
85024
drawing no. dessin no.
9554–P202