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MACKENZIE HIGHWAY
Canyon Creek Bridge
Phase 1 (A)
REPORT

Prepared by

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August 1974

AESL
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August 26, 1974
File: 3721-X002

Government of Canada
Department of Public Works
Western Region
10th Floor, One Thorton Court
P.O. Box 488
Edmonton, Alberta

Attention: Mr. N.A. Huculak
Regional Highways Engineer

Dear Sir:

Re: Mackenzie Highway
Canyon Creek Bridge - Mile 620

Enclosed is our Phase 1(A) report for the conceptual design of the Canyon Creek Bridge, Mile 620, on the Mackenzie Highway.

Yours truly,

ASSOCIATED ENGINEERING SERVICES LTD.

D. Charleson, P.Eng.

DC:mm
Enc.

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COMMISSION

The commission to undertake the investigation, design and supervision of construction of Canyon Creek Bridge was given in a letter from Mr. J. A. Brown, Regional Director, Western Region, Department of Public Works, and dated November 15, 1972, addressed to Associated Engineering Services Ltd.

TERMS OF REFERENCE

Instructions for preparing this report have been forthcoming from the Department of Public Works in the form of meetings and letters. The letter dated 4th April 1974 from Mr. N. A. Hucalak, Regional Highways Engineer, calls for completion of Phase 1A "by September 1974", this has been taken to mean by 1st September.

This Phase 1A report is to make recommendations on the type of structure, estimated cost, environmental concerns, aesthetics, and fisheries considerations.

The structure is to be designed in accordance with "Bridge Standards for Mackenzie Highway, N.W.T." published by the Department of Public Works, Ottawa, dated October 1972. Concrete decks are to be designed with additional 1/2-inch top cover as a wearing surface and additional 30 psf is to be allowed for future asphalt surfacing.

Other Consultants for this project are:

1.	*Geotechnical:*	*R. M. Hardy & Associates* *10214 - 112 Street* *Edmonton, Alberta*
2.	*Hydraulogy:*	*Bolter Parish & Trimble* *118 - 149 Street* *Edmonton, Alberta*
3.	*Environmental:*	*Lombard North Planning Ltd.* *PH 1135 - 17th Avenue S.W.* *Calgary, Alberta*

INVESTIGATIONS

The bridge site is situated some ten miles southeast of Norman Wells, and is approximately 1-1/2 miles upstream on the Canyon River from its confluence with the Mackenzie River. The Canyon River rises in the Norman Range roughly ten miles northwest at an altitude of roughly 2500 ft, the outfall being just under 200 ft.

Mr. L. F. Yasinko, P. Eng. of this firm visited the site on 17th May 1974 to make a general inspection and take photographs (A selection of which are shown in Appendix 1). The northern bank of the river rises quite sharply at about one in three slope to about 50 ft while the southern bank is flat for about 300 ft before starting a gentle slope. It was felt that the appoach across this flat area could be by embankment restricting the bridge opening to the existing channel and keeping the bridge as short as possible. This opinion has been confirmed by the Hydraulic Consultant's Report.

Trees generally are spruce with occasional birch and up to 30 ft high with 4-inch to 8-inch butts. There was no apparent ice damage to trees on shore indicating high waters and ice floes together are infrequent. Ice at the time was about 1'-0" thick with water flowing over and under. Water velocity was estimated to be about 10 to 15 fps. Site clearance on the banks has removed moss cover and degradation of permafrost was taking place.

The horizontal road alignment crosses the river at about zero skew and the vertical alignment shows about 3.0% grade across the bridge. The vertical alignment has recently had to be considerably raised on the advice of the Hydraulics Consultant owing to the severe icing conditions observed recently. Canyon Creek appears to be one of the worst "icers" on the highway. A maximum depth of 15 ft of ice having been observed.

The bridge opening is derived on the basis of maintaining the toes of the embankment clear of the existing channel. This makes the tops of embankments 240 ft apart. Vertical abutments to retain the embankments and shorten the

span are undesirable as this would further restrict the channel and create foundation problems due to heavy loadings. Also the soils consultant has not recommended such abutments because of permafrost conditions in the river banks.

Scour has been estimated at elevation 268 ft (about 3'-0" below bed level). It is proposed to keep tops of piles about 3"-0" below this level.

MATERIALS

We have checked as far as possible the availability and costs of materials at this time and have arrived at the unit costs shown in Table 1.

Prices include, where necessary, transportation from Edmonton to the site by truck to Hay River and barge to Norman Wells.

The concrete costs have been arrived at assuming that aggregates are available within 20 miles of the site. This assumption is based on the study of the Government of Canada's Granular Materials Inventory carried out by Pemcan Services in January 1973, which indicates that good limestone aggregates are available from an active quarry near Norman Wells marked (NW4 on the inventory). This quarry should also provide a good source of rock for rip-rap. Concreting sand is also available from an esker marked NW19 further north.

Delivery of structural steel and reinforcing bar at present is at least six months, and this should be borne in mind when planning construction. Providing this is done, this should not cause much difficulty.

Open steel grid decking is not easily obtainable at present. Some manufacturer's having stopped production as a result of the present steel situation. Prices have nevertheless been included for comparison purposes.

Quotations were obtained from specialist contractors for prestressed concrete units and laminated timber beams and deck. These prices were used in arriving at the relative alternatives in Table 2.

TABLE 1

UNIT COSTS (in place)

Rip-rap	*$ 40.00*	*sq yd*
Excavation (wet)	*15.00*	*cu yd*
Cofferdams - Sheet piling	*10.00*	*sq ft*
Piling - Steel H - Sections	*1000.00*	*ton*
Backfill	*8.00*	*cu yd*
Concrete - 3000 psi in foundation	*90.00*	*cu yd*
- 4500 psi in deck	*100.00*	*cu yd*
Reinforcement	*900.00*	*ton*
Structural Steel - Girders G40 - 12	*2100.00*	*ton*
Trusses	*2,500.00*	*ton*
Weathering Steel	*200.00*	*ton extra*
Steel Grid Decking - 5-inch	*15.00*	*psf*
6-1/2-inch	*17.00*	*psf*
Formwork	*4.00*	*psf*
Guardrail	*40.00*	*per foot*
Bridge Bearings	*500.00*	*each*
Expansion Joints	*4000.00*	*each*

TYPES OF STRUCTURE

The opening between tops of embankments shown on the Hydraulogy Consultants drawing is 240 ft. This can be reduced to 220 ft when the width and position of abutments is subtracted.

There is also a restriction on construction depth below grade level of approximately 5 ft so to span this opening with one span would involve an overhead structure namely a through truss. A single span has much to recommend it, from the point of view of avoiding piers in the river with the consequent icing problems. However, a truss is not an attractive structure easthetically; places a restriction on head room and width; is expensive to construct due to its high site labour content; and is expensive to maintain. We have, therefore, not further considered this form of structure.

A two span continuous structure is an alternative utilizing below grade construction within the construction depth restriction. This however, would mean placing a pier in mid-stream of the high water level. We do not consider it desirable to place a pier in the stream where its velocity will be highest. The risk of debris blockage will also be heightened with this arrangement.

The more desirable arrangement of spans seems to be a three span structure, where the piers can be kept out of the low water channel and giving a good wide channel under the centre span. We have therefore concentrated more on this arrangement of spans.

The position of the southern pier is limited in order to keep it out of the low water channel, the maximum southern span which can be obtained is about 65.0 ft. This more or less determines the spans.

Another concept looked at was extending the centre span and having two cantilever side spans. However, with this arrangement the construction depth of the deck becomes excessive so the scheme was not persued further.

The forms of construction investigated were as follows:

1. *Two span continuous 4 steel girders with concrete deck.*

2. *Three span continuous 5 steel girders with concrete deck.*

3. *Three span continuous 4 steel girders with concrete deck.*

4. *Three span continuous 2 steel girders with concrete deck.*

5. *Three span continuous 4 steel girders with all steel grid deck.*

6. *Three span simply supported prestressed concrete. (channel units)*

7. *Three span timber girders with timber deck.*

8. *Three span timber girders with concrete deck.*

Substructures are all based on the same form of construction, namely reinforced concrete piers and abutments with steel H piles. This being considered the only suitable construction for this site and conditions.

Drawing Number 02-00-60-S1 in Appendix 2 shows elevation of the 2 and 3 span structures.

ESTIMATE OF COST

The estimates of cost shown in Table 2, do not include for any earthworks for road embankments, as we understand this will be included in the roadworks program, and completed before bridgeworks commence.

The Hydraulics Consultant has recommended quite extensive river works at this site consisting of embankments on the upstream side with rip-rap facing (See Bolter Parish and Trimble drawing No. 115-3-220, Rev: 2, August 12, 1974). We have not included the earthworks involved in forming these embankments as we feel that they could be more economically constructed as part of the roadworks program which will probably be carried out under a separate contract. Our estimate of the cost of rip-rap has been added on as a separate item under "Recommendations and Conclusions".

No extra cost is involved in providing for the Double HS-20 (Alberta) load called for in the specification. This load will be restricted to the centre of the roadway and design stresses of 125% basic used.

The estimate for a prestressed concrete deck is based on the assumption of supplying units to this project only. If other bridges on this section of road utilize the same construction leading to repetition of the same units, the suppliers claim that this cost could be reduced by 5% to 10%.

TABLE 2

CANYON CREEK BRIDGE
Estimates of Cost ($)

No.	Description	Substructure	Superstructure	Total	Super/Str. per sq ft	Total per sq ft
1	2 Span continuous (105'-105') 4 Steel girders @ 8'-4" 9" Concrete deck	334,000	377,000 [27,000]+	671,000	55	97
2	3 Span continuous (60'-100'-60') 5 Steel girders @ 6'-0" 7-1/2" Concrete deck	352,000	310,000 [21,000]+	662,000	45	96
3	3 Span continuous (60'-100'-60') 4 Steel girders @ 8'-4" 9" Concrete deck	352,000	299,000 [19,000]+	651,000	43	94
4	3 Span continuous (60'-100'-60') 2 Steel girders 11" Concrete deck	352,000	252,000 [13,000]+	604,000	37	87
5	3 Span continuous (60'-100'-60') 4 Steel girders @ 8'-4" Floor beams @ 3'-0" 5" Steel gird deck	336,000	423,000 [25,000]+	759,000	61	109
6	3 Span simply supported (65'-90'-65') Precast prestressed deck units	364,000	307,000	671,000	44	97
7	3 Span timber girders (60'-100'-60') Timber deck	352,000	306,000	658,000	44	95
8	3 Span timber girders (60'-100'-60') 9" concrete deck	352,000	317,000	669,000	46	97

+ *Quantities in brackets show additional cost of weathering steel*

PROGRAMMING

We understand that the highway will be graded to the site prior to commencement of construction of this bridge. There will therefore be no problem with transport from Norman Wells to the site.

It is suggested that materials be barged in during the navigation season i.e. prior to September 15, 1975, and construction start in the fall season. Completion of substructures and erection of steel beams can be carried through in a continuous program ready for pouring of the concrete deck the following spring.

RECOMMENDATIONS AND CONCLUSIONS

It can be seen from Table 1 that despite only having one pier, the two span structure in fact works out more expensive than most of the three span alternatives. This is due to the higher steel content of the superstructure, also very little reduction in substructure cost is effected with this construction.

The most expensive structure would be all steel with a grid deck, which reflects the current high cost of steel. In any case we do not consider a steel grid deck desirable because observations indicate high maintenance, higher vibration, and an adverse affect on the directional stability of vehicles.

The most economical construction is that of alternative 4, i.e. a three span continuous structure with two steel girders and a concrete deck. We consider this to be a fairly straightforward construction which should be fairly easy to erect, and have fairly low maintenance costs. This latter can almost be eliminated with the use of weathering steel which would add about $13,000 to this particular structure. We feel that this would be a good investment at this stage as this only represents an additional 2% extra on the cost. We therefore recommend this alternative and the use of weathering steel.

Our estimate of the cost of this bridge using alternative No. 4 would be:

Cost as Table 2	*$604,000*
Extra for Weathering Steel	*13,000*
Cost of Bridge Structure	*617,000*
Rip-rap to Embankments	*355,000*
Subtotal	*972,000*
Add 20% for General Contractor overheads, profit, and contract contingencies	*195,000*
TOTAL	*$1,167,000*

The estimates are based on present prices and have not been projected for increases in cost. It should be borne in mind that the present inflation rate in the construction industry is running at about 10% per annum, so costs will increase accordingly in relation to time. Prices will, of course, be updated at the time of submission of the Phase 1(B) report.

We consider that the structure recommended has a very pleasing appearance and is quite acceptable from the aesthetic point of view.

The environmental consultants have no comments or specific recommendations to make at this stage. We can see no reason why this structure should have any significant permanent effect on the environment or fish life. Some disturbance to the river bed and banks in inevitable during construction but this will be of a temporary nature and can be minimized with strict supervision. We do not envisage that it will be necessary to set up a construction camp here in view of the close proximity to Norman Wells.

Respectfully submitted,

L.F. Yasinko

L.F. Yasinko, P.Eng.

APPENDIX I.

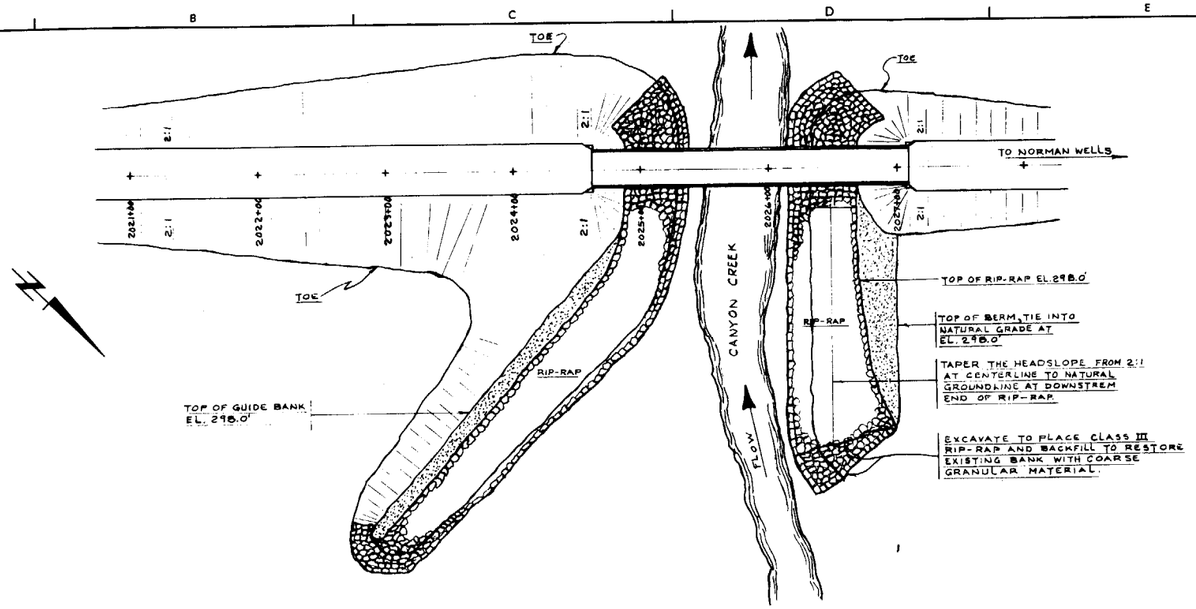
Aerial View of Site looking upstream.

Aerial View of Site looking downstream.

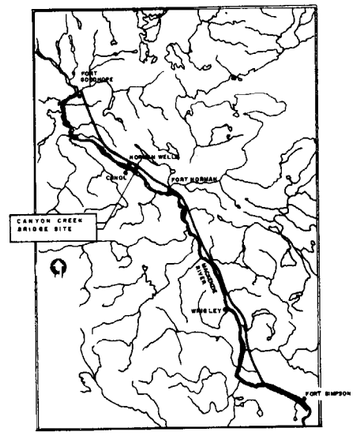
Looking South along road line.

Looking North along road line.

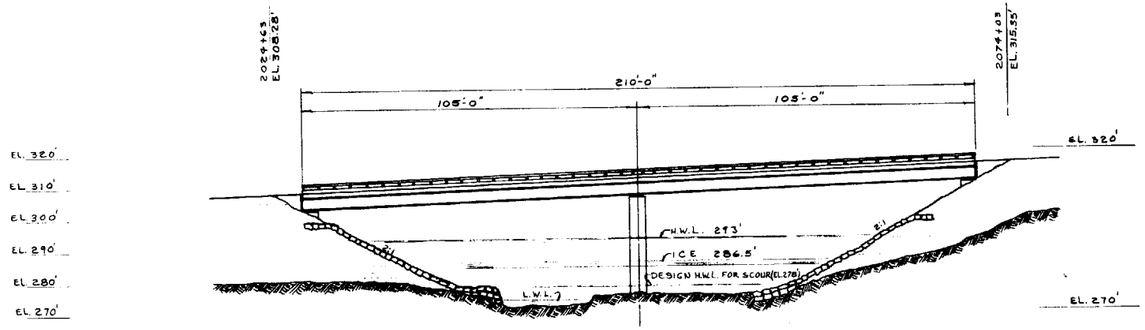
APPENDIX II.



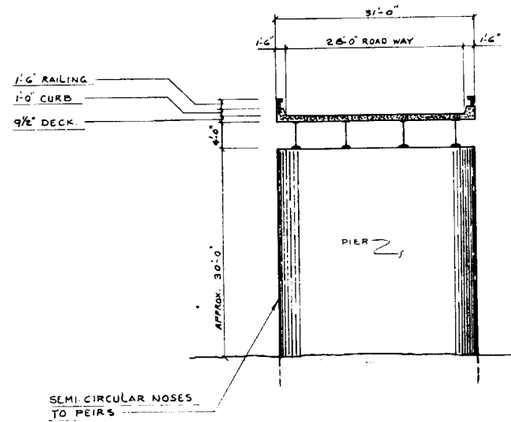
SITE PLAN



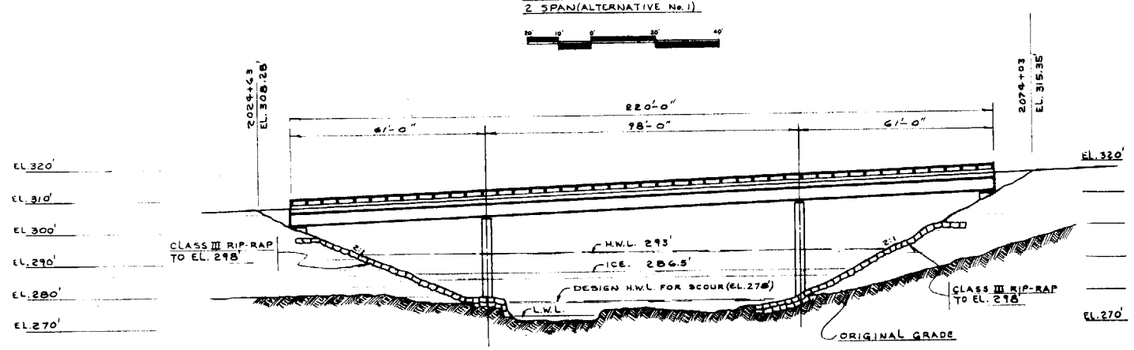
KEY MAP



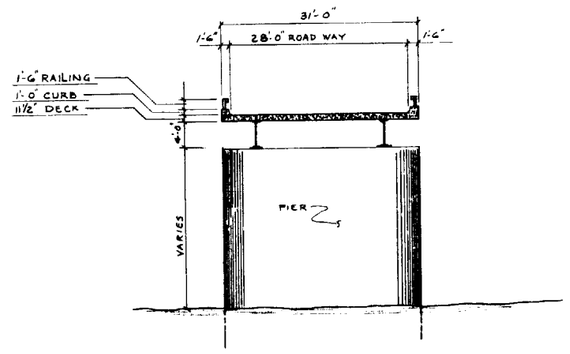
ELEVATION OF BRIDGE
2 SPAN(ALTERNATIVE No. 1)



CROSS SECTION



ELEVATION OF BRIDGE
3 SPAN(ALTERNATIVE Nos. 2, 3, & 4/5)



CROSS SECTION

NOTES

SPECIFICATION - Design in accordance with "Bridge Standards for Mackenzie Highway N.W.T." (dated October 1972) and all relevant specifications refered to therein.

DESIGN LOADS - Live: Normal - Standard HS25 plus impact at normal design stresses.

Overload - Single HS40 Truck in centre of carriageway plus impact at 125% of basic stresses.

- Surfacing - Future asphalt 30 p.s.f. on roadway.

- Ice Loading - Design Ice force of 388 kips acting at elevation 291.0 based on 4.5 ft. ice thickness at crushing strength of 200 p.s.i. Lateral ice force to be 15% of longitudinal force.

AESL
Consulting Engineers

ASSOCIATED ENGINEERING SERVICES LTD.
BRITISH COLUMBIA - ALBERTA - SASKATCHEWAN

NOTES / LEGEND

REVISIONS

REV. No.	DATE	BY	ENG.	GEIO REF.	DESCRIPTION

DATE	DWG. No.	REFERENCE DRAWING

DRAWING REFERENCE

ITEM NUMBER - Detail, Plan, Section Profile, etc.
DRAWING NUMBER - Item Location - Drawing On Which Item is Detailed Or Sectioned
DRAWING NUMBER - Drawing On Which Item Originates

AESL JOB No.	3721-X002
SCALE	AS NOTED
DRAWN BY	E.A.D.
CHECKED BY	
DESIGN BY	
APPROVED BY	

ENGINEER'S STAMP

PERMIT STAMP

CLIENT / LOCATION
PUBLIC WORKS CANADA
MACKENZIE HIGHWAY

PROJECT / SUBJECT
PROPOSED
CANYON CREEK BRIDGE
SITE PLAN, SCHEMATIC, ELEVATIONS SECTIONS

KEY PLAN No. | SHEET No. | TOT. No. OF DWGS. FOR FILING PURPOSE ONLY

DRAWING No. 02-00-60-S1

DATE AUG./1974

REV No.