ISSUE #19

21

MACKENZIE HIGHWAY

WILLOWLAKE RIVER BRIDGE

PHASE 1 (A)

REPORT

T. LAMB, McMANUS & ASSOCIATES LTD.

Consulting Engineers

10214 - 112 Street
Edmonton, Alberta

Telephone: 482-5806

T. Lamb, McManus and Associates Ltd.
Consulting Engineers

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10214 - 112 Street,
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T5K 1M5

December 1, 1972.

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

Attention: Mr. A. L. Perley
O.I.C. Civil

Dear Sirs:

Re: Willowlake River Bridge

Enclosed please find the report on our preliminary investigation covering Phase 1 (A) of our commission in connection with the Willowlake River Bridge, Mile 395, Mackenzie Highway.

In view of the fact that the geotechnical investigations have not been carried out, many basic assumptions have been necessary.

The recommended spans, type of construction, and estimates of cost reflect these assumptions which we hope will be confirmed when all the factors affecting the design are known.

Yours very truly,

T. LAMB, McMANUS AND ASSOCIATES LTD.

R. N. McManus, P. Eng.

RNM:nn
Enc.

MACKENZIE HIGHWAY

WILLOWLAKE RIVER BRIDGE

INDEX

COMMISSION

The commission to undertake the investigation, design and supervision of construction of the Willowlake River Bridge was outlined in a letter from Mr. J.A. Brown, P. Eng., Regional Director, Western Region, Department of Public Works, dated August 28, 1972, and addressed to T. Lamb, McManus and Associates Ltd. A copy of this letter is attached as Appendix I of this report.

TERMS OF REFERENCE

The instructions for carrying out the investigation have been forthcoming from Department of Public Works personnel in the form of meetings, letters and directives.

The Environmental Consultant (F.F. Slaney & Co.) has furnished us with the broad requirements of the Federal Department of Environment (Fisheries) but very little in the way of unique requirements regarding Willowlake River.

Our own discussions with Mr. R. Porter of the Department of the Environment, Fisheries Service and review of the documents "Fish Resources of the Mackenzie River Valley, Interim Report 1, Vol. 1 and 2" lead us to the conclusion that steel cofferdams should be used for river pier construction to minimize silt deposits in the main river channel.

The Hydrology Consultant (Bolter, Parish and Trimble) has furnished preliminary estimates of the required river channel, clearances for high water, debris and ice and the depth of scour. The estimate of scour depth might change when more detailed geotechnical information becomes available. The river is not fast moving in this region, however, so increase in anticipated scour depth is unlikely.

The requirements governing the design of the structure are that we follow the recommendations of the R.T.A.C. regarding width of roadway and structural geometry. The bridge is to be two lane, HS-25 designed for 60 m.p.h. An overload provision covering HS-40 (Alberta) loading on one centre lane only at 125% of basic stresses is to be considered. The additional cost of this overload is to be assessed by the consultant and a decision made by the Department of Public Works. Through trusses are to provide a minimum overhead clearance of 20 feet above the roadway.

The most recent editions of the Canadian Standards Association Standard S6 "Design of Highway Bridges" and the American Association of State Highway Officials "Standard Specifications for Highway Bridges" are to govern the design.

Concrete slab decks are to be designed with 1/2" additional cover on top bars as an exposed wearing surface. A design allowance of 30 p.s.f. is to be provided to allow for a future asphalt wearing surface.

INVESTIGATIONS AND CONCLUSIONS

Mr. R. M. Morison, P. Eng., visited the site, took numerous pictures and observed the general characteristics of the river and the approaches to it.

The selected crossing location is on a relatively straight section of river channel. The approach road on the south side will cross a fairly flat bench which extends back from the river channel for approximately 3000 feet. The bench elevation is approximately 35 to 40 feet above low water level and terminates in a fairly steep rise of some 120 feet at its southern extremity.

On the south edge of the river channel, there is a fairly broad active flood plain with the tree line being some 360 feet back from the edge of water at low stream level. The upper 175 feet of this flood plain is covered by a thick growth of willows, while the lower section consists of exposed sands, gravel and boulders. A considerable number of boulders up to 2 feet in diameter, embedded into the surface of the channel, are evident both upstream and downstream of the channel.

On the north side, the bank rises quite sharply from river level for approximately 28 feet to elevation 284. Beyond this point the ground surface along the proposed alignment slopes up gently for over a mile with a fairly substantial growth of black spruce.

Subsequent meetings with the Environmental Consultant together with a representative of the Federal Department of Environment (Fisheries) indicate that they will not allow material to be borrowed from the river bed. They have reviewed and approved the extent of the fills at either end of the structure. So far as the requirements for stream flow are concerned, it seems likely that the crossing could be shortened even more. However, the environmentalists are not prepared, at this time, to accept further encroachment on the river channel.

The Hydrology Consultant has reported the results of preliminary investigations on maximum flow, high water, ice and scour.

A maximum rise in river elevation of 42 feet above low water due to ice jams in the Mackenzie River is possible and a bridge alignment on zero skew is recommended.

The river channel is set on the basis of maintaining the toe of fill at a fixed position on either side. The location selected leaves 800 feet between the toe of fill on the south side and the bank on the north side.

We are in general agreement with the location selected and the recommendations on alignment, channel and clearances.

The approach fills and structure would be built on a small vertical curve. This minimizes the height of approach fills while maintaining channel clearances at mid-span and is desirable aesthetically on this length of structure. There would be about 800 feet of approach fill with maximum height of 26 feet on the north end and about 1000 feet of approach fill with maximum height of 46 feet on the south end.

The maximum depth of scour expected by the Hydrology Consultant is about 7 feet below the deepest point in the river bed. We would propose to keep the bases of the river piers about 4 feet below the projected depth of maximum scour.

The Geotechnical Consultant (Acres Western) was unable to get equipment to the site prior to 1973. They do not expect to have information regarding Willowlake River crossing until the end of February, 1973.

This means that our observations of the river banks and bed form the only basis for preliminary designs. The lack of geotechnical information is not of such great significance at this time, but any delay beyond February in obtaining final recommendations would create serious problems in the preparation of the March 31 complete preliminary design submission, as well as meeting deadlines for final plans and specifications.

MATERIALS - AVAILABILITY AND COSTS

We have checked, as well as possible at this time, on the availability and cost of cement, concrete aggregates, precast concrete, structural steel and steel deck grating.

Mr. Morison brought back samples of gravel available at Wrigley and the Liard River pits. These were tested by R. M. Hardy and Associates for their gradation and suitability for concrete aggregates. Both samples were reported as being suitable for concrete aggregate with the Wrigley sample running somewhat higher in silt content. A copy of this report is attached as Appendix No. 2. Assuming the Wrigley sample to be representative, the ratio of fine to coarse aggregate obtained from a screening and washing process would be close to that required for a concrete mix design.

A local gravel supply firm was requested to estimate the cost of processing concrete aggregate at Wrigley. They have informed us that washed, screened and separated aggregate at Wrigley, which is approximately forty miles from the Willowlake River crossing, would cost between five and six dollars per cubic yard on the basis of a total processed volume in the range of 20,000 to 30,000 cubic yards. This volume would apply to more than one bridge.

Barges can operate between Wrigley and the Willowlake River bridge site directly during the higher water months of June and July. Northern Transportation Co. has informed us that charter rates for the forty mile haul would range between $7.40 per ton ($11.10 per cubic yard) and $4.75 per ton ($7.10 per cubic yard) depending on the size of equipment available. This would not include loading or unloading which could cost an additional $1.50 per cubic yard.

Concrete aggregate, delivered to the site, could therefore cost as much as $18.50 or as little as $13.60 per cubic yard.

The hauling charges are high and appear to reflect the fact that Northern Transportation Co. is busy with long hauls during the navigation season and not anxious to divert equipment to short haul freight. We would suggest that a tender call early in 1973 for processing of concrete aggregates necessary for all major structures followed by a tender for delivery during the shipping season could result in appreciable savings.

The requirements for the Willowlake River Bridge would be in the order of 10,000 cubic yards of sand and gravel suitable for concrete aggregate.

Cement is currently being delivered to Northern projects in bags. By barge, during the shipping season up to about the middle of September, cement will cost about $90.00 per ton plus precautionary protective packaging. This protective packaging could cost an additional $5.00 to $10.00 per ton.

Cement can also be delivered to the site over the winter toll road, starting in January, for approximately the same cost per ton as by barge.

Since weatherproof storage at the site will be a factor, it would appear that sufficient cement should be shipped by barge prior to September 15 to carry the project until January 15. The remainder of the cement required for the work until the next shipping season should then be trucked in over the winter road.

On the basis of these figures, the materials for job concrete will apparently cost about $50.00 per cubic yard.

Freight on other materials such as structural steel, reinforcing, etc. from Edmonton would appear to run about 5 cents per lb. depending on volume, road tolls and other charges.

So far as structural steel is concerned, a number of different grades are available. The G40.11 Grade B steel satisfies the notch toughness requirements and may be used without painting. This is of considerable interest in the event open grate decking is used since it will be almost impossible to protect the steel structure below from corrosion. The extra cost of this material above normal bridge steels varies with thickness but will amount to about 2½% of the cost of the steel.

The following unit costs have been assumed for the purposes of this preliminary report. They will be followed up and updated for the March 31 report.

Labour (including subsistence)	$15.00 to $18.00 per hour	
Concrete	$70.00 per cu.yd. in the forms	
Forming	$ 2.00 per square ft.	
Excavation and Backfill	$ 5.00 per cu. yd.	
Rip-Rap	$20.00 per sq. yd.	
Steel Piling	$12.00 per ton of load supported	
Reinforcing Steel	$500.00 per ton in place	
Structural Steel: Plate Girders	$1,200.00 per ton in place	
Trusses	$1,300.00 per ton in place	
Open Steel Deck Grating - 5"	$ 9.00 per sq. ft. in place	
- 6½"	$10.50 per sq. ft. in place	
Single Use Cofferdams	$25,000.00	- sheet piling
	$10,000.00	- bracing
	$10,000.00	- instal
	$45,000.00	
with three uses add	$30,000.00	
	$75,000.00	$25,000.00/each

Structural steel in trusses is estimated to cost more than plate girders primarily because of the extra man hours per ton during erection. This involves on-site labour which will cost more than double the corresponding plant rate.

Box girders are also more expensive to fabricate and erect than plate girders. The unit price of a box girder in place, particularly with a curved soffit, will be at least as high as for a truss.

CHOICE OF SPANS

The preliminary conclusions with regard to maximum flow, debris and ice would indicate that spans as short as 160 feet in the river would be adequate. Economy, fisheries requirements, and aesthetics would be the only reasons for increasing the main spans beyond this length.

The Hydrology Consultant has indicated scour potential to elevation 240 and high water due to ice jams to elevation 298. With the base of pier four feet below scour, the pier shafts will be more than 50 feet high. A river pier will cost very nearly the same for a shorter span as a longer one so the net economy of removing a pier is directly related to the additional cost of the longer spans. Our estimates indicate a river pier will cost approximately $165,000 at this site. On this basis the balance point will come when the superstructure costs are increased approximately $6.00 per square foot by the removal of one pier. The figure would be approximately $11.00 per square foot if two piers are removed since the cost of the remaining piers would be increased by additional piling and perhaps fewer re-uses of cofferdams.

We have, therefore, investigated the crossing on the basis of minimum river spans of 160 feet and maximum of 250 feet.

The only reason for considering spans in excess of 250 feet would be if subsequent geotechnical investigations disclosed foundation conditions to be much worse than we have assumed.

TYPES OF STRUCTURES INVESTIGATED

The deck type structure with unlimited overhead clearance has much to recommend it. This is particularly true in remote areas where overhead bracing and the main truss elements could be damaged by vehicular impact.

The through truss will also require more on-site labour to erect than a plate girder. The girder can be mostly fabricated in the shop, shipped to the site and erected with minimum site time and labour.

In our opinion, the continuous girder structure is more pleasing than the truss from the aesthetic point of view. We have, therefore, given more consideration to various girder spans than trusses although we have included one truss structure for comparison purposes. A total of ten combinations of spans, spacing and materials have been considered.

The following is a resume of the alternatives investigated:

1) A five span continuous plate girder steel structure with spans of 150-200-200-200-150 feet, 2 girders 19 feet apart, stringers and floor beams spaced to use 5 inch metal grating deck.

2) A five span continuous plate girder steel structure with spans of 150-200-200-200-150 feet, 2 girders 21 feet apart, stringers and floor beams spaced to use 6½ inch metal grating deck.

3) A five span continuous plate girder steel structure with spans of 150-200-200-200-150 feet, 2 girders 29 feet apart, stringers and floor beams spaced to use 6½ inch metal grating deck.

4) A five span continuous plate girder steel structure with spans of 150-200-200-200-150 feet, 4 girders spaced at 9'-8", stringers and floor beams spaced to use 5 inch metal grating deck.

5) A five span continuous plate girder steel structure with spans of 160-200-200-200-160 feet (the extra length is required because deeper girders required for the concrete deck extend the height of fill), 2 girders 19 feet apart, composite action 11 inch reinforced concrete deck - no floor beams or stringers.

6) A six span continuous plate girder steel structure with spans of 130-160-160-160-160-130 feet, 2 girders 19 feet apart, composite action 11 inch reinforced concrete deck - no floor beams or stringers.

7) A four span continuous through truss steel structure with spans of 200-250-250-200 feet, 2 trusses, floor beams, stringers and 7 inch concrete deck.

8) A four span continuous box girder steel structure with spans of 200-250-250-200 feet, 2 box girders 19 feet apart, composite action 10½ inch reinforced concrete deck - no floor beams or stringers.

9) A four span continuous box girder steel structure with spans of 200-250-250-200 feet, 2 box girders 27½ feet apart, stringers and floor beams spaced to use 6½ inch metal grating deck.

10) A four span continuous segmental precast concrete box girder structure with spans of 210-250-250-210 feet, one box section including deck.

ESTIMATES OF COST

The unit price upon which these estimates of cost are based have been dealt with under the "Materials" section of this report.

The estimated costs shown in Table I apply to the variables only. Although fill quantities and length of guardrail vary slightly, we have considered them as constants in comparing the cost of various alternates.

The HS-25 design loading is such that no increase in materials is necessary to accommodate a single HS-40 truck with dual axles, spaced not less than 4 feet apart and with 24 feet between front and rear axles. Design stress would be 125% of basic unit values and the truck would be restricted to the centre 12 feet of deck.

Some of the alternates investigated were recognized as being better arrangements than others, but the comparisons were worked out anyway. The two girder systems with cantilever floor beams appear to be the most economical with a slight advantage overall to the reinforced concrete deck alternates.

Although the six span structure appears to have a slight advantage over the comparable five span, foundation conditions, unknown at this time, could easily change this. In the event that piling is not required, the substructure costs will decrease appreciably (about $150,000 with concrete deck and $140,000 with steel deck.)

The estimated cost of the structure, using alternative No. 5 as a basis, would be:

Variables (from Table I)	$1,646,000
Railing	55,000
Fill	330,000
Rip-Rap	60,000
	$2,091,000

The structure itself neglecting fill and rip-rap would be $1,701,000 which is approximately $65.00 per square foot of bridge.

WILLOWLAKE RIVER BRIDGE

TABLE I

ESTIMATES OF COST OF VARIABLES
NOT INCLUDING FILL, RIP-RAP OR RAILING

ALTERNATE NO.	DESCRIPTION	SUBSTRUCTURE COST	SUPERSTRUCTURE COST	DECK COST	TOTAL COST
1 5 Span 150-200-200-200-150	2 Steel Plate Girders continuous @ 19' Stringers @ 36" Floor Beams @ 25' 5" Metal Deck	$758,000	$690,000	$235,000	$1,683,000
2 5 Span Drawing No. 1	2 Steel Girders continuous @ 21' Stringers @ 50" Floor Beams @ 25' 6½" metal deck	$758,000	$660,000	$268,000	$1,686,000
3 5 Span	2 Steel Girders continuous @ 29' Stringers @ 48" Floor Beams @ 25' 6½" metal deck	$758,000	$720,000	$268,000	$1,746,000
4 5 Span	4 Steel Girders continuous @ 9'-8" O.C. Stringers @ 36" Floor Beams @ 25' 5" Metal Deck	$758,000	$720,000	$235,000	$1,713,000
5 5 Span 160-200-200-200-160 Drawing No. 2	2 Steel Girders continuous @ 19' Composite Action 11" Concrete Deck - No floor beams or stringers	$766,000	$590,000	$290,000	$1,646,000

TABLE I (cont'd)

ESTIMATES OF COST OF VARIABLES
NOT INCLUDING FILL, RIP-RAP OR RAILING

ALTERNATE NO.	DESCRIPTION	SUBSTRUCTURE COST	SUPERSTRUCTURE COST	DECK COST	TOTAL COST
6 6 Span 130-160-160-160 -160-130 Drawing No. 3	2 Steel Girders continuous @ 19' Composite Action 11" Concrete Deck - No floor beams or stringers	$916,000	$438,000	$288,000	$1,642,000
7 4 Span 200-250-250-200 Drawing No. 4	2 Through Trusses continuous with floor beams @ 25', Stringers @ 4'-2" and a 7" Concrete Deck	$614,000	$935,000	$197,000	$1,746,000
8 4 Span 200-250-250-200 Drawing No. 5	2 Steel Box Girders continuous @ 19' 11" Concrete Deck - No floor beams or stringers	$616,000	$785,000	$300,000	$1,701,000
9 4 Span 200-250-250-200	2 Steel Box Girders continuous @ 27'-6" Floor Beams @ 25' Stringers @ 50" 6½" Metal Deck	$614,000	$848,000	$267,000	$1,729,000
10 4 Span 210-250-250-210 Drawing No. 6	Precast, Prestressed Concrete, segmental continuous	$630,000	$1,350,000	--	$1,980,000

CONSTRUCTION AND SCHEDULING

The construction of this crossing is likely to be most economical if carried out during a single construction season starting in August. The extra cost of work bridges necessary to reach some of the river piers would be more than offset by the extra costs of moving in and out twice. The schedule for this would involve construction of the south abutment and two south river piers during the fall using a work bridge to reach the second river pier. Work on the other two river piers and the north abutment would not start until the ice was strong enough to support construction equipment.

The structural steel would be erected off the ice during the late winter and early spring. The deck, approach fills and final finish would then take place during the following summer. Since the grading contractors will be different on each side of the Willowlake River, there seems to be no requirement for a temporary crossing beyond an ice bridge.

Recent experience with contractors indicates that most of them have a strong preference for continuity on a project. In this case, a single superintendent and crew are able to start and stay with the project until it is complete.

RECOMMENDATIONS AND CONCLUSIONS

The five and six span structures are reasonably close in estimated cost. Since there are more unknowns involved in river piers than any other part of a project such as this, we would recommend the five span structure over the six.

We also favor the reinforced concrete deck over the metal grillage for a number of reasons. Firstly, our estimates indicate the structure with the concrete deck is more economical because it eliminates the floor beams and stringers necessary to support the metal grill. Secondly, the grating structure is much lighter and will tend to vibrate more under live load.

Finally, the open grillage will allow gravel and mud to spill on to the structure and bearings below and would dictate the use of weathering steels.

We recognize the advantages of a grillage from the point of view of snow removal but pipe curbs on a concrete deck could also be effective.

The attached drawings show typical longitudinal and cross sections of alternates: No. 2 (Drawing No. 1), No. 5 (Drawing No. 2), No. 6 (Drawing No. 3), No. 7 (Drawing No. 4), No. 8 (Drawing No. 5) and a cross section of the precast concrete proposal No. 10 (Drawing No. 6).

We would recommend that Alternate No. 5 shown on Drawing No. 2 be considered as the first choice. On this basis, the geotechnical consultant should investigate this site by drilling at the location of each pier and abutment plus necessary holes to determine the design criteria for the approach fills.

Respectfully submitted,

T. LAMB, McMANUS AND ASSOCIATES LTD.

R. N. McManus, P. Eng.

RNM:nn

APPENDIX I

DEPARTMENT OF PUBLIC WORKS | MINISTÈRE DES TRAVAUX PUBLICS

OFFICE OF THE
REGIONAL DIRECTOR

CANADA

BUREAU DU
DIRECTEUR RÉGIONAL

WESTERN REGION
REGION DE L'OUEST

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

August 28, 1972.

T. Lamb, McManus & Associates,
Consulting Engineers,
10214 - 112 Street,
Edmonton, Alberta.

T. LAMB, McMANUS & ASSOCIATES LTD.
RECEIVED
AUG 31 1972

Attention: Mr. R. N. McManus.

Dear Sirs:

Consultant Investigations and Design,
Willow Lake River Bridge, Mile 395,
Mackenzie Highway.

I am pleased to advise that the Department has selected your firm to undertake the investigation, design and supervision of construction of the Willow Lake River Bridge which is located at Mile 395 on the Mackenzie Highway. This work will involve the bridge crossing which is tentatively proposed for HS-25 loading and will also involve approach embankments and excavation leading to the bridge. The work to be carried out by your firm is to be done in conjunction with the highway location and design being performed by Departmental staff; with a hydrology consultant (Bolter, Parish & Trimble); with an environmental consultant (F. F. Slaney & Co.) and the Federal Department of Environment (Fisheries).

I am enclosing a copy of the Departments Standard Agreement for Engineering Services. It will be necessary that the Department and your firm enter into a contract under this format for work involved. A contract will be divided into six phases as follows:

Phase 1 (A) Preliminary Investigation and report by December 1, 1972 recommending type of structures, estimated cost, environmental concerns, asthetics and fisheries considerations.

Phase 1 (B) Required by March 31, 1973 - the complete preliminary design, finalized concepts.

Phase 2 (A) Completion of plans and specifications for tendered sub-structure.

Phase 2 (B) Completion of plans and specifications for tendered super-structure.

. . . 2

Phase 3 (A) Supervision of construction for sub-structure.

Phase 3 (B) Supervision of construction for super-structure.

The commencement of each of the phases listed above to be taken only on the written authorization by the Department. This letter will constitute the authorization to commence Phase 1 (A).

The method of payment for Phases 1 A & B will be based on the following:

1. Principles - per diem rate - $176.00
2. Executives - per diem rate - $173.00
3. Professional & Technical Staff - Payroll times 2.25.
4. Disbursements at cost.

For Phase 2 A & B method of payment will be on an established percentage of construction cost. For Phase 3 A & B the method of payment will be as follows:

1. Professional & Technical Staff - Payroll times 1.70
2. Disbursements at cost.

Would you please review the information provided and be prepared to meet with officials of the Department to discuss schedules, method of operation and budgets. In preparation of the budgets please be advised that the maximum amount of funds available for the fiscal year 1972/73 is $25,000.00 and payment will be made on invoices up to that amount received prior to April 1, 1973. Should you have any questions concerning the information provided please contact Mr. F. E. Kimball, Project Manager N.W.T. Highways, telephone 429-5511.

Yours truly,

J. A. Brown,
Regional Director.

Attach.

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING • GEOTECHNICAL DIVISION

File No. 5080 - 1

October 5, 1972

T. Lamb, McManus & Associates Ltd.,
10214 - 112 Street,
Edmonton, Alberta.

T5K 1M5

Re: Aggregates for Proposed Manufacture of Concrete - Willow River Bridge, Northwest Territories

Dear Sirs:

We enclose the aggregate analysis reports on two samples of pit run aggregate submitted to our laboratory on September 21, 1972, proposed for concrete manufacture on the above noted job. These aggregates may be briefly described as follows:

Wrigley Source - A max 2" pit run containing about 37% sand fraction. The rock fraction is visually sound, well graded and suitable for concrete manufacture. The fine fraction (sand) is coarse, F.M. = 2.90, well graded, No. 3 color test showing the presence of some organics, but having a silt content of 7.2%. ASTM recommends a limit of 5% for concrete in general usage and 3% for concrete subject to abrasion.

Liard River Source - A max 2" pit run containing about 56% sand fraction. The rock fraction is visually sound, well graded and suitable for concrete manufacture. The fine fraction (sand) is coarse, F.M. = 2.93, reasonably well graded, No. 3 color test showing the presence of some organics, and an acceptable silt content of 2.3%.

Since construction of a bridge is the end use of the concrete it is assumed a high quality concrete is required, that will be subjected to abrasion. The best choice of source with the minimum benefication required, would therefore be the Liard River source. The higher than desirable quantity of sand fraction would necessitate separating the rock and sand fractions and recombining in proper proportions during concrete manufacture. If the pit run material is reasonably dry or in a frozen state but not lumpy, this separation can probably be a dry screen vibratory operation. An excess of sand will result.

Respectfully submitted,

E. F. Holmgren, P. Eng.

10214 - 112 STREET, EDMONTON, ALBERTA T5K 1M5 PHONE (403) 482-3494
CONSOLIDATING THE SERVICES OF: R. M. HARDY & ASSOCIATES LTD., MATERIALS TESTING LABORATORIES LTD. & NON DESTRUCTIVE INSPECTION LTD.
BURNABY CALGARY DAWSON CREEK EDMONTON LETHBRIDGE PRINCE GEORGE RED DEER WINNIPEG

Materials Testing Laboratories Ltd.

CALGARY
EDMONTON
VANCOUVER

LETHBRIDGE
RED DEER
REGINA
DAWSON CREEK

CONCRETE AGGREGATE REPORT

To: T. Lamb, McManus & Associates Ltd.,
10214 - 112 Street,
EDMONTON, Alberta.

Lab. Order No. 5080-1
Type of Sample Pit Run
Job Willowlake River Bridge
Source Wrigley
Sampled by Client
Date Sampled
Date Received September 21/72
Date Tested September 25/72
Date Reported October 4/72
Laboratory Edmonton
Copies to:

COARSE AGGREGATE			FINE AGGREGATE		
Screen Size	Percent Retained Individual	Percent Retained Cumulative	Screen Size	Percent Retained Individual	Percent Retained Cumulative
3"			No. 4		
2"			No. 8	18.5	18.5
1½"	14.1	14.1	No. 16	13.9	32.4
1"	10.8	24.9	No. 30	29.2	61.6
¾"	18.1	43.0	No. 50	25.4	87.0
½"	20.5	63.5	No. 100	4.1	91.1
⅜"	14.5	78.0	No. 200	1.7	
No. 4	22.0	100.0	Pass No. 200	7.2	
Pan			F.M.	2.90	

Shape Sub-Rounded, Rounded

Percent Crush Pit Run

Soundness (visual inspection) Good

Coal Content

Other Remarks
1 1/2" - #4 Spec Band

F.M. Range
2.2-2.6 Fine Sand
2.6-2.9 Medium Sand
2.9-3.2 Coarse Sand

Percent Sand 36.8

Percent finer than No. 200 7.2

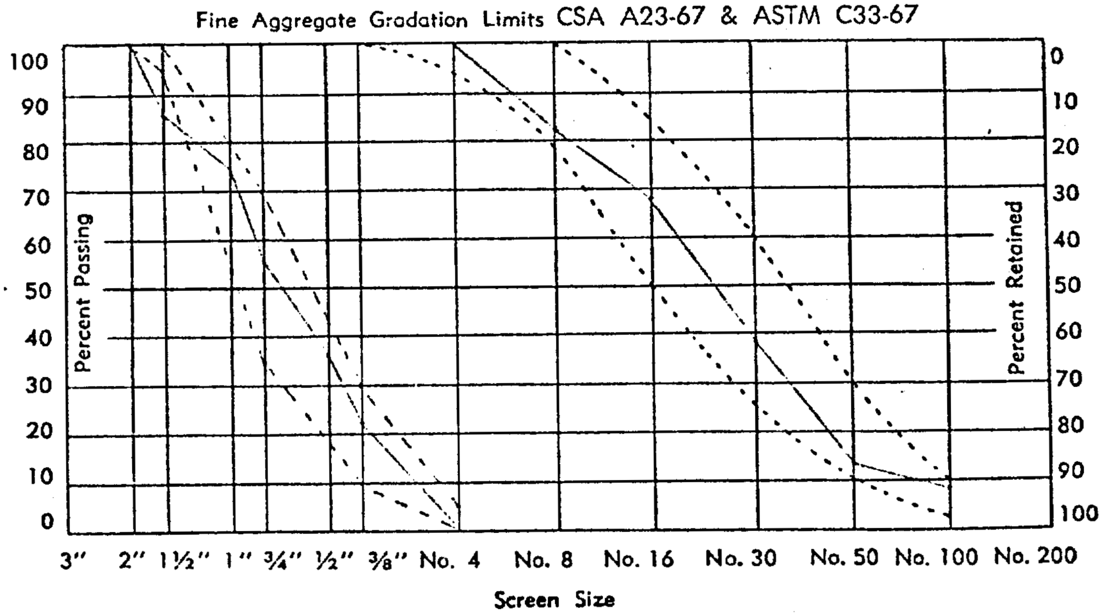
Organic Impurities No. (Color Range 1-5)
(as is) #3
(with coal removed)

Coal Content

Other Remarks

COARSE AGGREGATE GRADATION LIMITS PERCENT RETAINED			
	1½"-4	1"-4	¾"-4
2"	0		
1½"	0-5	0	
1"		0-5	0
¾"	30-65		0-10
½"		40-75	
⅜"	70-90		45-80
4	95-100	90-100	90-100
8		95-100	95-100

Fine Aggregate Gradation Limits CSA A23-67 & ASTM C33-67



Report Certified:

MTL—C10—68

Materials Testing Laboratories Ltd.

CALGARY
EDMONTON
VANCOUVER

LETHBRIDGE
RED DEER
REGINA
DAWSON CREEK

CONCRETE AGGREGATE REPORT

Lab. Order No. 5080-1
Type of Sample Pit Run
Job Willowlake River Bridge
Source Liard River
Sampled by Client
Date Sampled
Date Received September 21/72
Date Tested September 25/72
Date Reported October 4/72
Laboratory Edmonton

To: T. Lamb, McManus & Associates Ltd.,
10214 - 112 Street,
EDMONTON, Alberta.

Copies to:

COARSE AGGREGATE			FINE AGGREGATE		
Screen Size	Percent Retained Individual	Percent Retained Cumulative	Screen Size	Percent Retained Individual	Percent Retained Cumulative
3"			No. 4		
2"			No. 8	20.7	20.7
1½"	6.3	6.3	No. 16	20.2	40.9
1"	24.4	30.7	No. 30	19.7	60.6
¾"	10.1	40.8	No. 50	14.5	75.1
½"	16.4	57.2	No. 100	20.8	95.9
⅜"	11.4	68.6	No. 200	1.8	
No. 4	31.4	100.0	Pass No. 200	2.3	
Pan			F.M.	2.93	

Shape Sub-Rounded, Rounded

Percent Crush Pit Run

Soundness (visual inspection) Good

Coal Content

Other Remarks 1 1/2" - #4 Spec Band.

F.M. Range 2.2-2.6 Fine Sand
2.6-2.9 Medium Sand
2.9-3.2 Coarse Sand

Percent Sand 56.0

Percent finer than No. 200 2.3

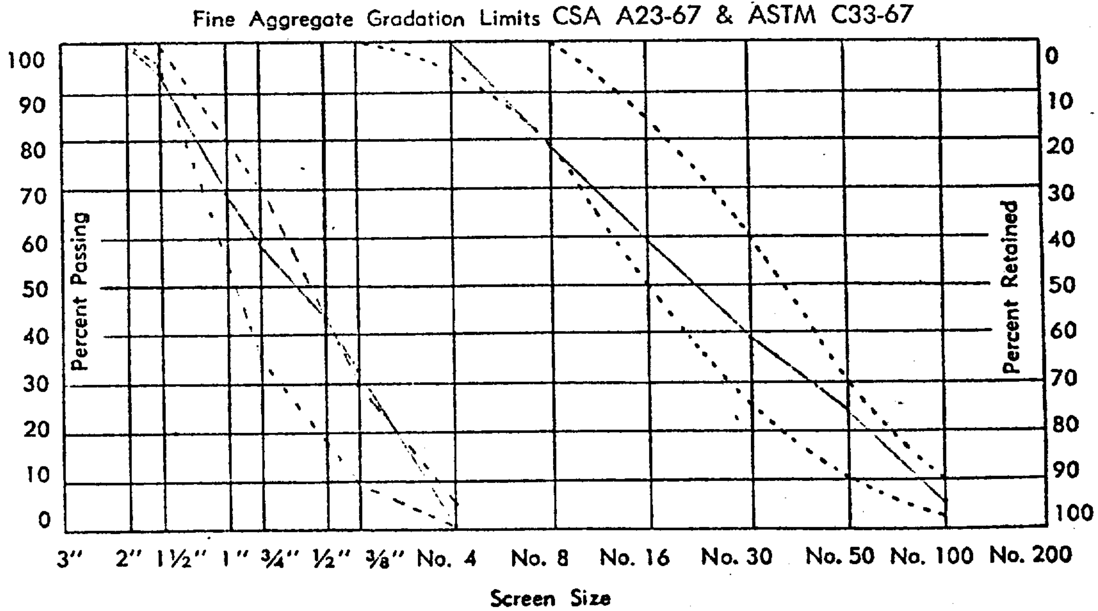
Organic Impurities No. (Color Range 1-5)
(as is) #3
(with coal removed)

Coal Content

Other Remarks

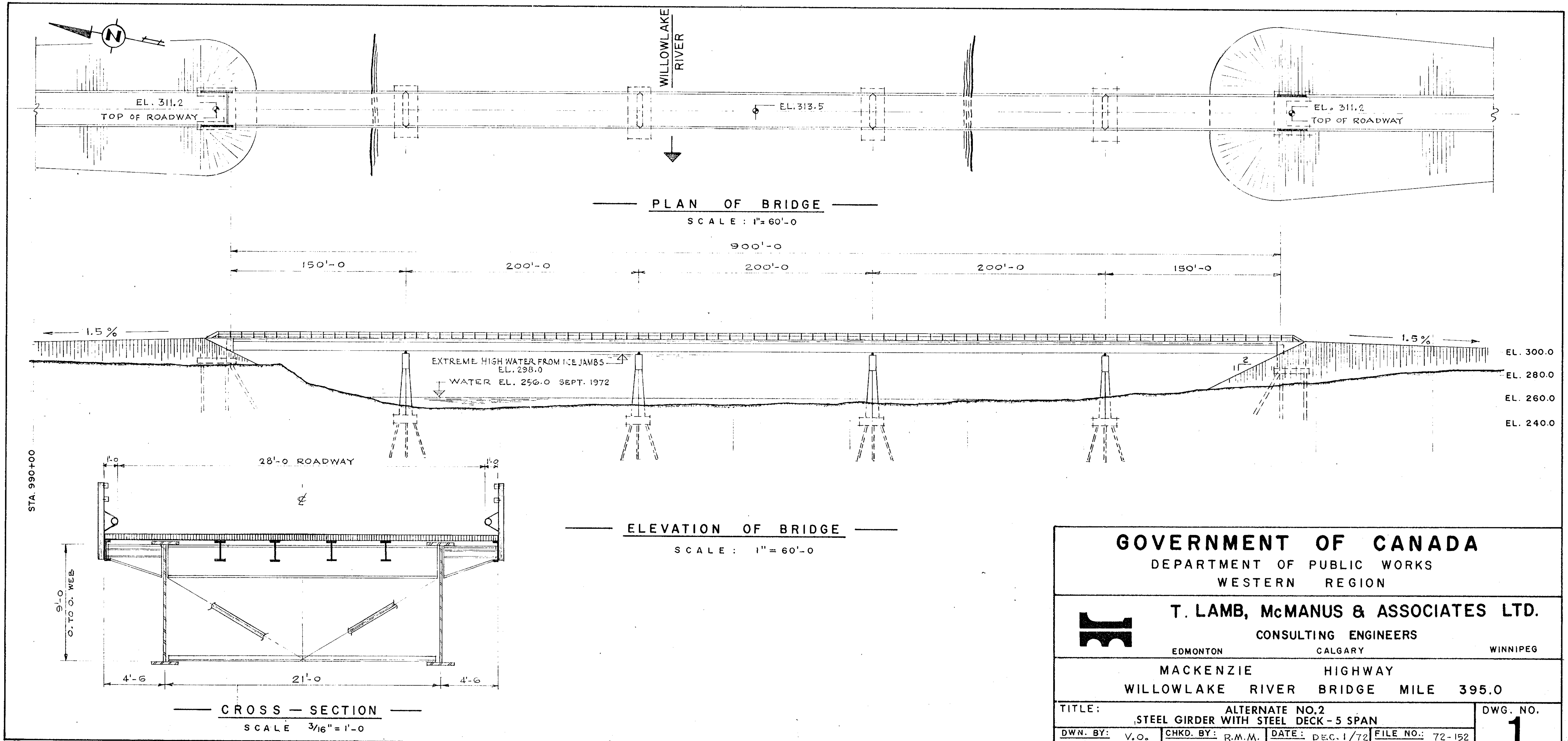
COARSE AGGREGATE GRADATION LIMITS PERCENT RETAINED			
	1½"-4	1"-4	¾"-4
2"	0		
1½"	0-5	0	
1"		0-5	0
¾"	30-65		0-10
½"		40-75	
⅜"	70-90		45-80
4	95-100	90-100	90-100
8		95-100	95-100

Fine Aggregate Gradation Limits CSA A23-67 & ASTM C33-67

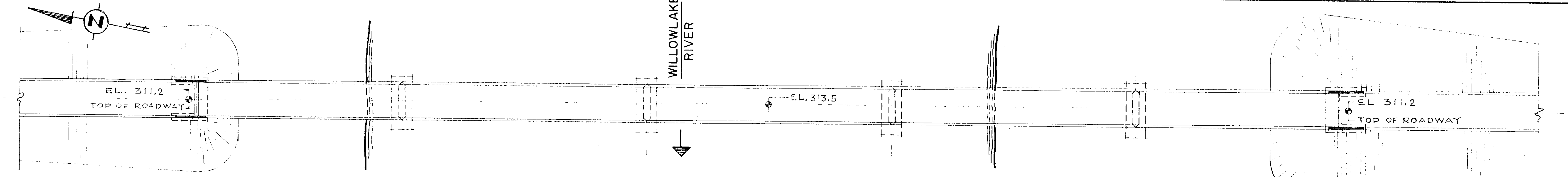


Report Certified:

MTL—C10—68

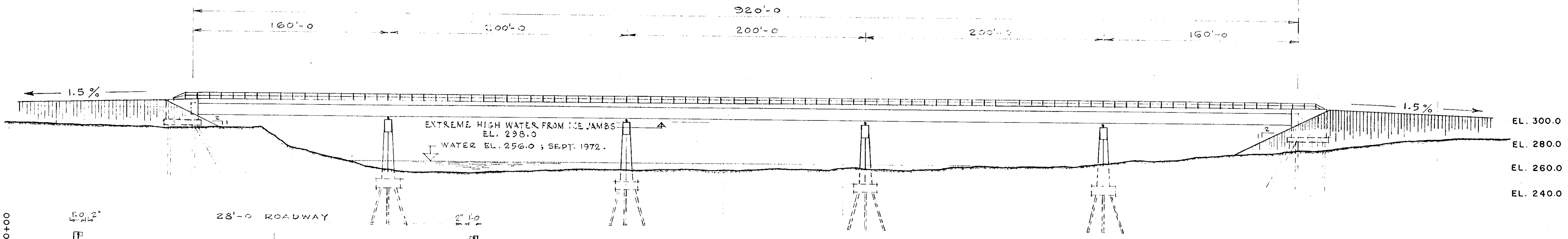


GOVERNMENT OF CANADA DEPARTMENT OF PUBLIC WORKS WESTERN REGION	
T. LAMB, McMANUS & ASSOCIATES LTD. CONSULTING ENGINEERS EDMONTON CALGARY WINNIPEG	
MACKENZIE HIGHWAY WILLOWLAKE RIVER BRIDGE MILE 395.0	
TITLE: ALTERNATE NO.2 STEEL GIRDER WITH STEEL DECK - 5 SPAN	DWG. NO. 1
DWN. BY: V.O. · CHKD. BY: R.M.M. · DATE: DEC. 1/72 · FILE NO.: 72-152	

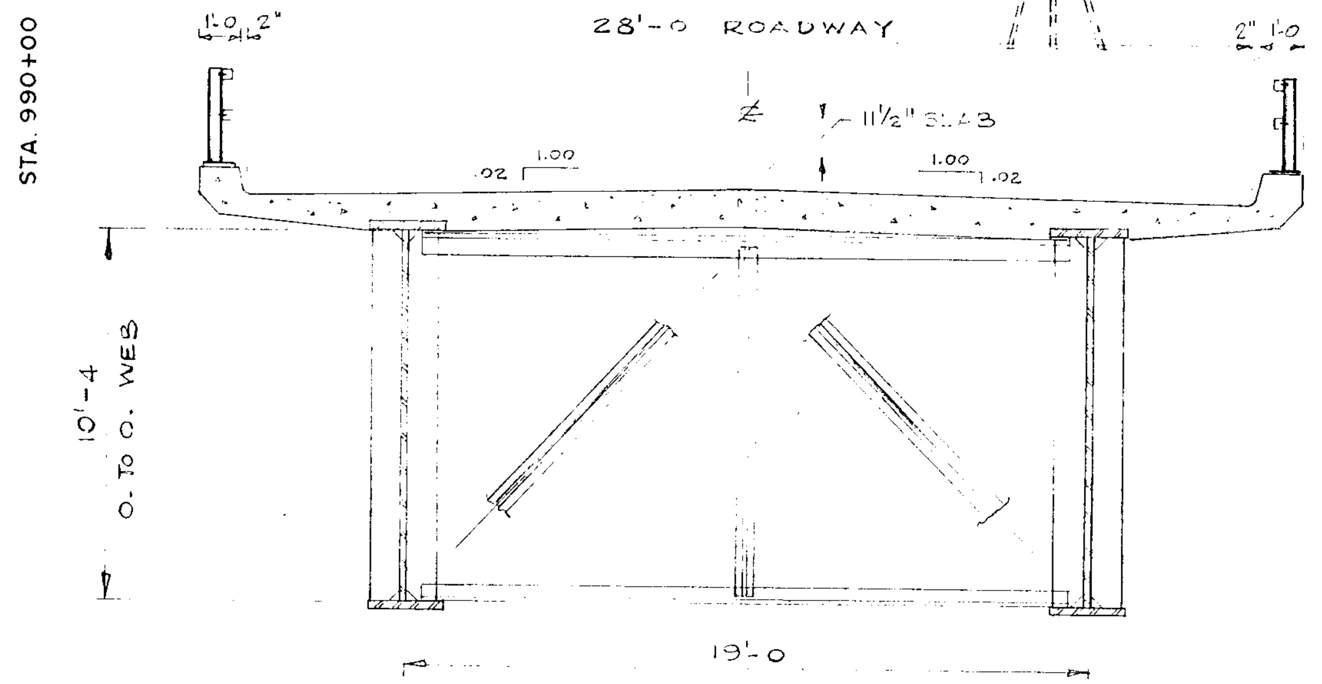


PLAN OF BRIDGE

SCALE : 1" = 60'-0



STA. 990+00



CROSS — SECTION

SCALE 3/16" = 1'-0

ELEVATION OF BRIDGE

SCALE : 1" = 60'-0

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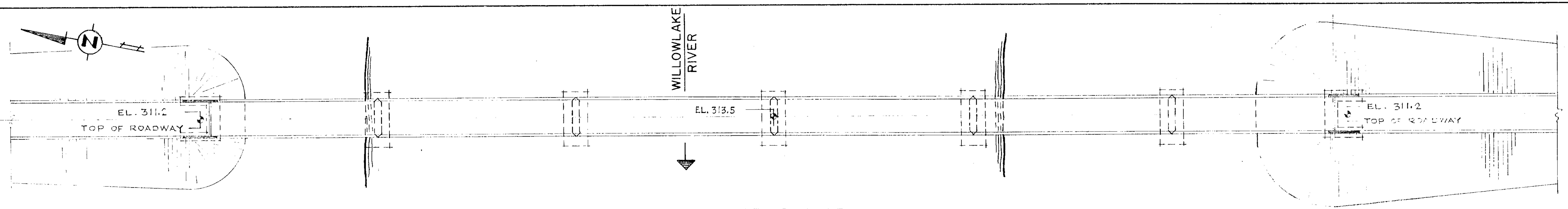
MACKENZIE HIGHWAY

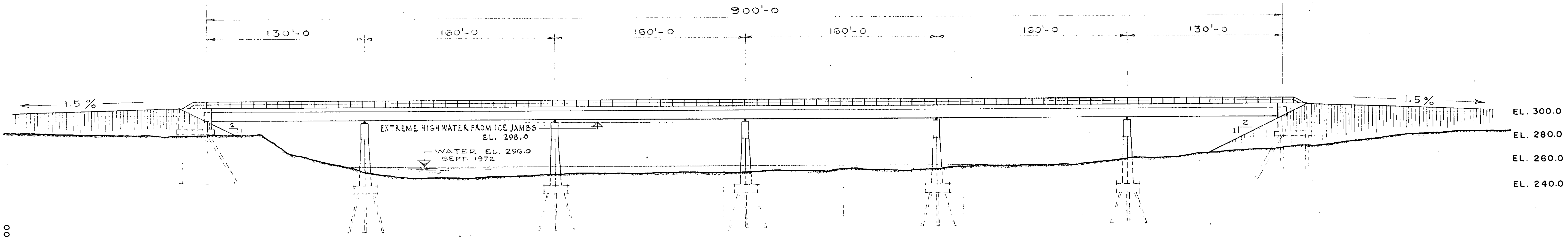
WILLOWLAKE RIVER BRIDGE MILE 395.0

TITLE: ALTERNATE NO. 5 STEEL GIRDER WITH CONCRETE DECK - 5 SPAN				DWG. NO. 2
DWN. BY: V.O.	CHKD. BY: R.M.W.	DATE: DEC. 1/72	FILE NO.: 72-152	



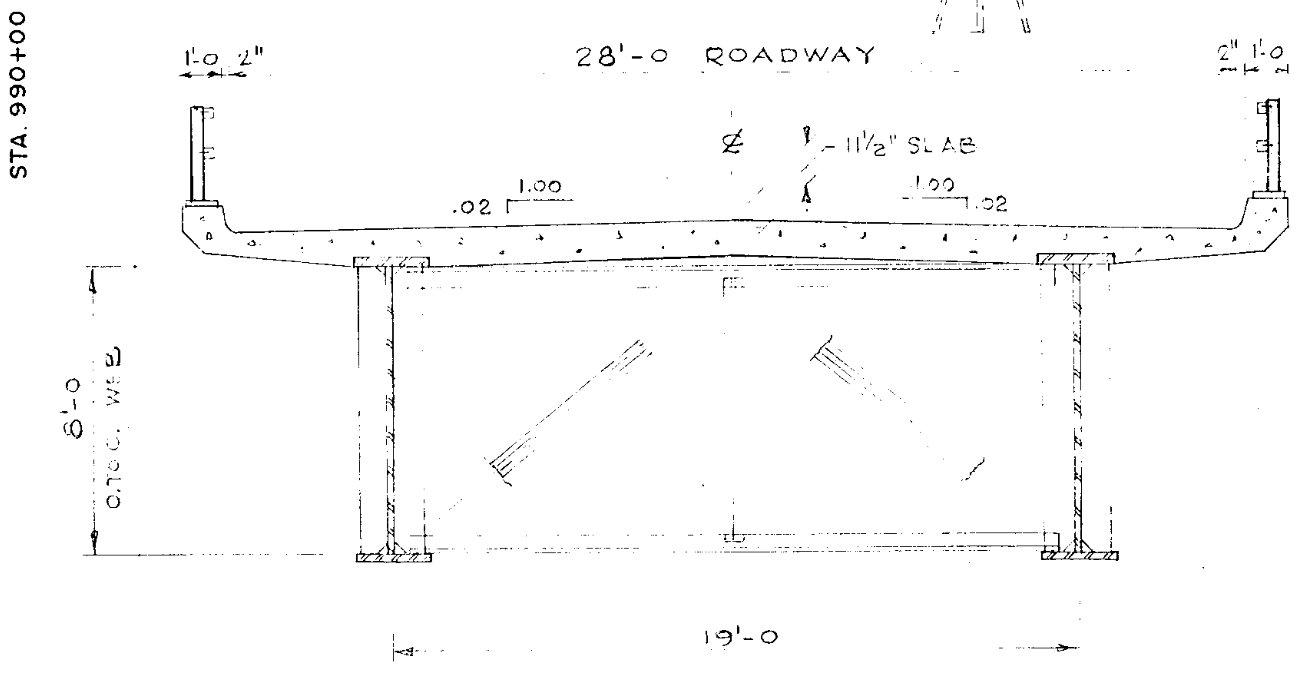
PLAN OF BRIDGE

SCALE : 1" = 60'-0



ELEVATION OF BRIDGE

SCALE : 1" = 60'-0



CROSS — SECTION

SCALE 3/16" = 1'-0

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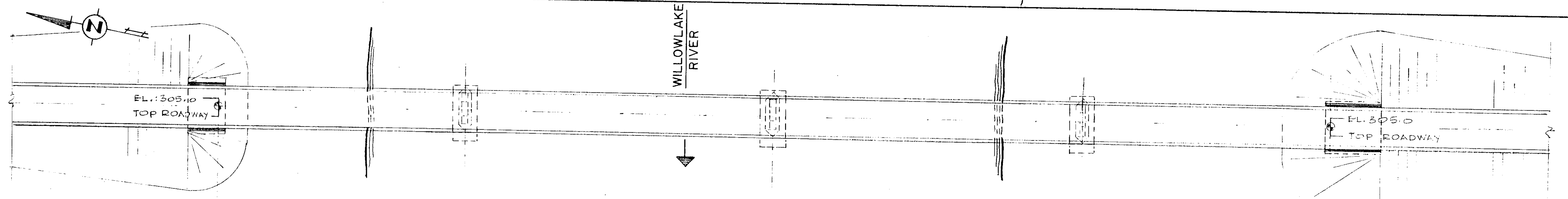
MACKENZIE HIGHWAY

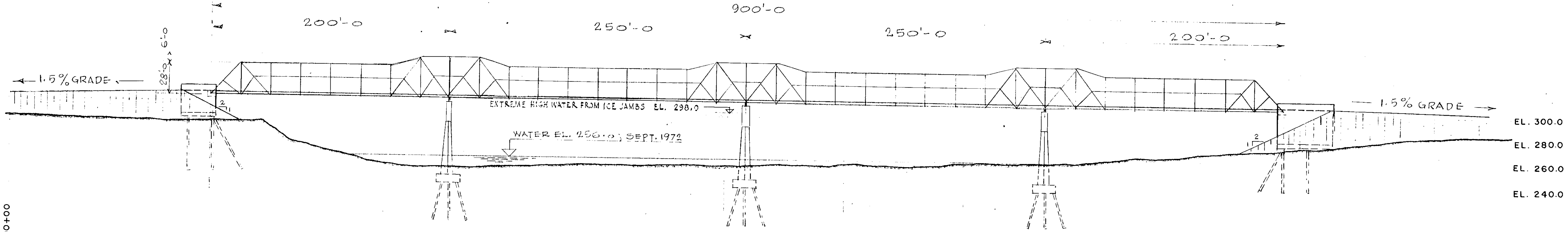
WILLOWLAKE RIVER BRIDGE MILE 395.0

TITLE: ALTERNATE NO.6 STEEL GIRDER WITH CONCRETE DECK-6 SPAN				DWG. NO. 3
DWN. BY: V.O.	CHKD. BY: R.M.M.	DATE: DEC. 1/72	FILE NO.: 72-152	

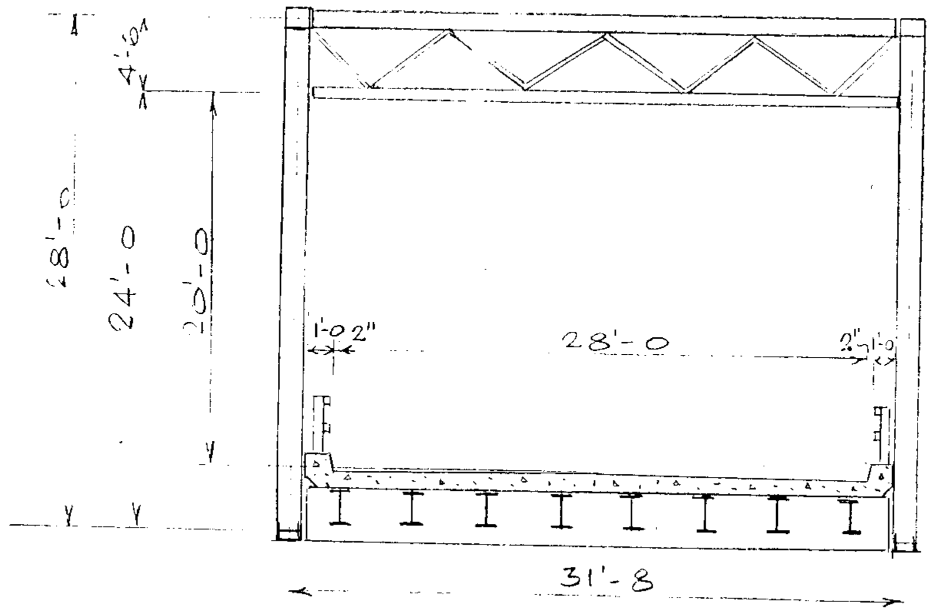


PLAN OF BRIDGE

SCALE: 1" = 60'-0



STA. 990+00



ELEVATION OF BRIDGE

SCALE: 1" = 60'-0

CROSS — SECTION

SCALE: 1" = 10'-0

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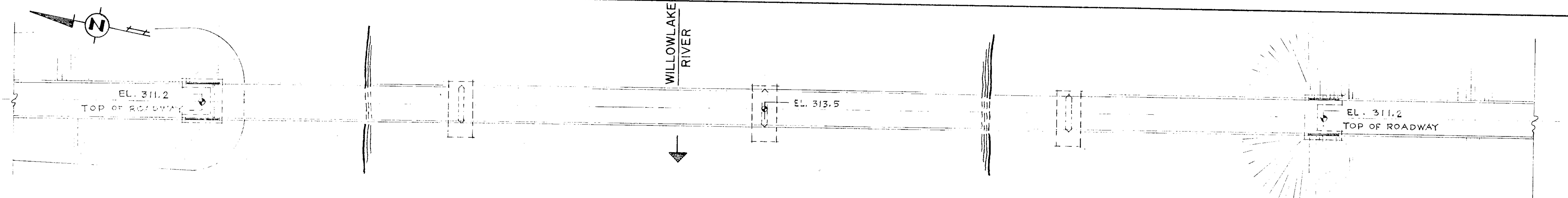
MACKENZIE HIGHWAY

WILLOWLAKE RIVER BRIDGE MILE 395.0

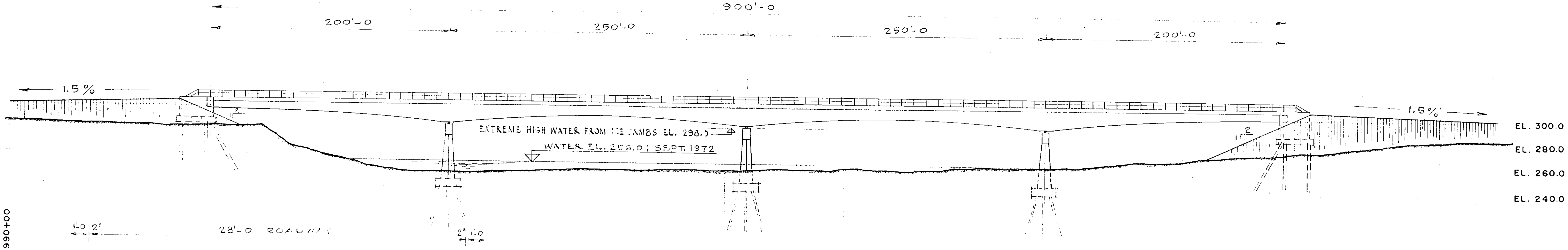
TITLE:	ALTERNATE NO.7 THROUGH TRUSS - 4 SPAN	DWG. NO. 4

DWN. BY: W.L.D.	CHKD. BY: R.W.M.	DATE: DEC. 1/72	FILE NO.: 72-152



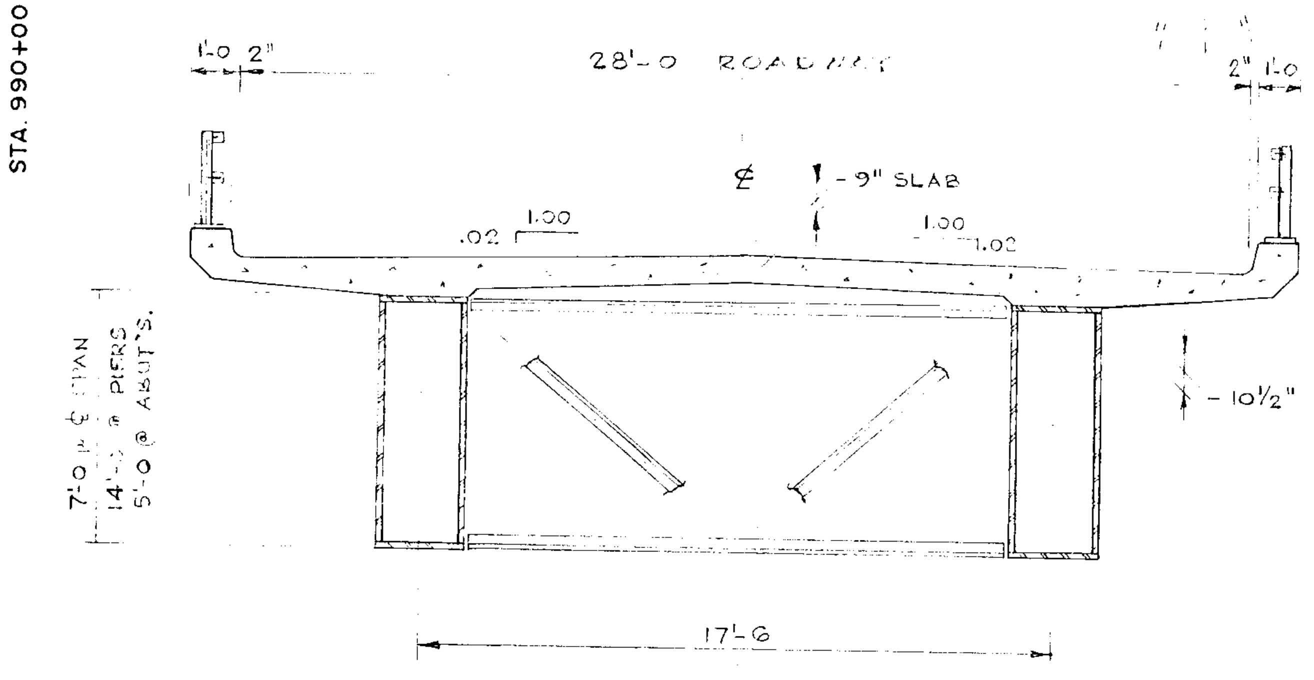
PLAN OF BRIDGE

SCALE : 1" = 60'-0



ELEVATION OF BRIDGE

SCALE : 1" = 60'-0



CROSS – SECTION

SCALE 3/16" = 1'-0

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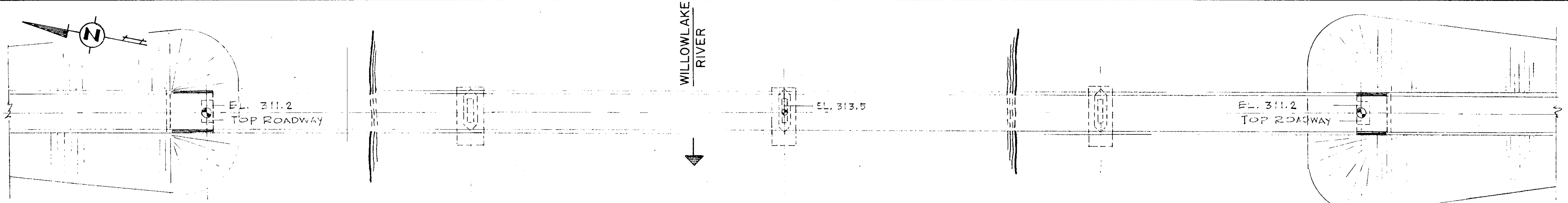
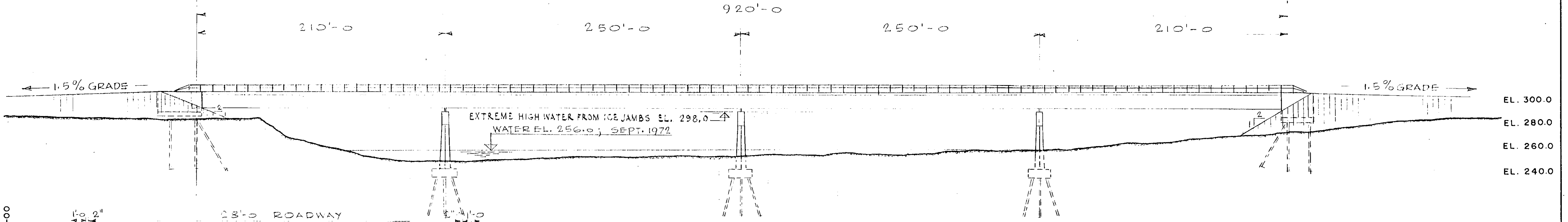
WILLOWLAKE RIVER BRIDGE MILE 395.0

TITLE:				DWG. NO.
ALTERNATE NO. 8 STEEL BOX GIRDER-4 SPAN				5
DWN. BY: V.O.	CHKD. BY: R.M.M.	DATE: DEC. 1/72	FILE NO.: 72-152	



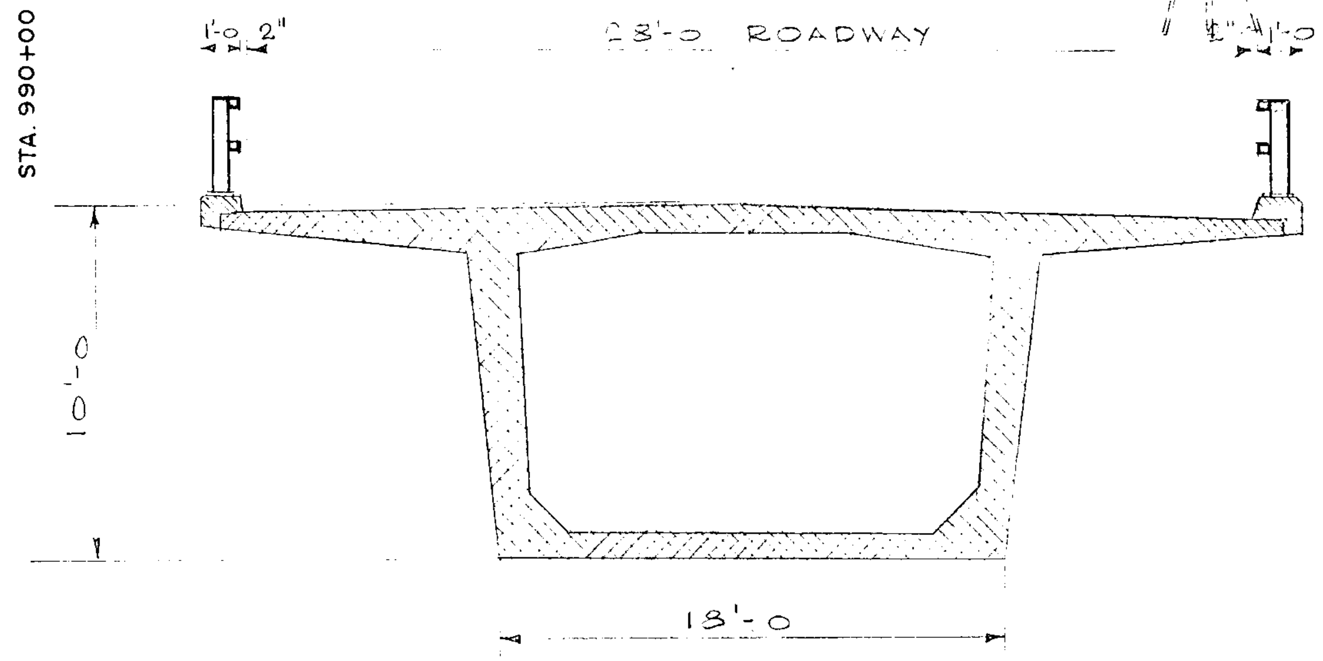
PLAN OF BRIDGE

SCALE : 1" = 60'-0



ELEVATION OF BRIDGE

SCALE : 1" = 60'-0



CROSS — SECTION

SCALE 3/16" = 1'-0

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MACKENZIE HIGHWAY

WILLOWLAKE RIVER BRIDGE MILE 395.0

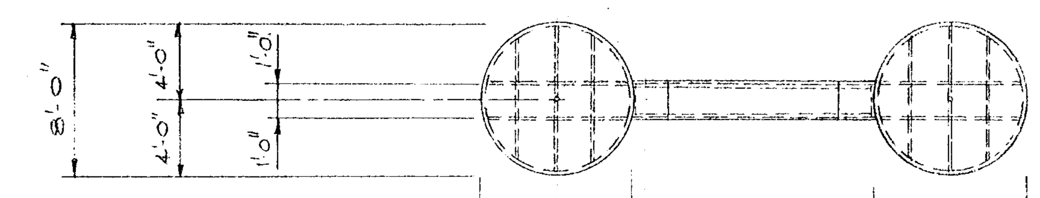
TITLE: ALTERNATE NO.10
SEGMENTAL PRECAST CONCRETE BOX GIRDER-4 SPAN

DWG. NO. 6

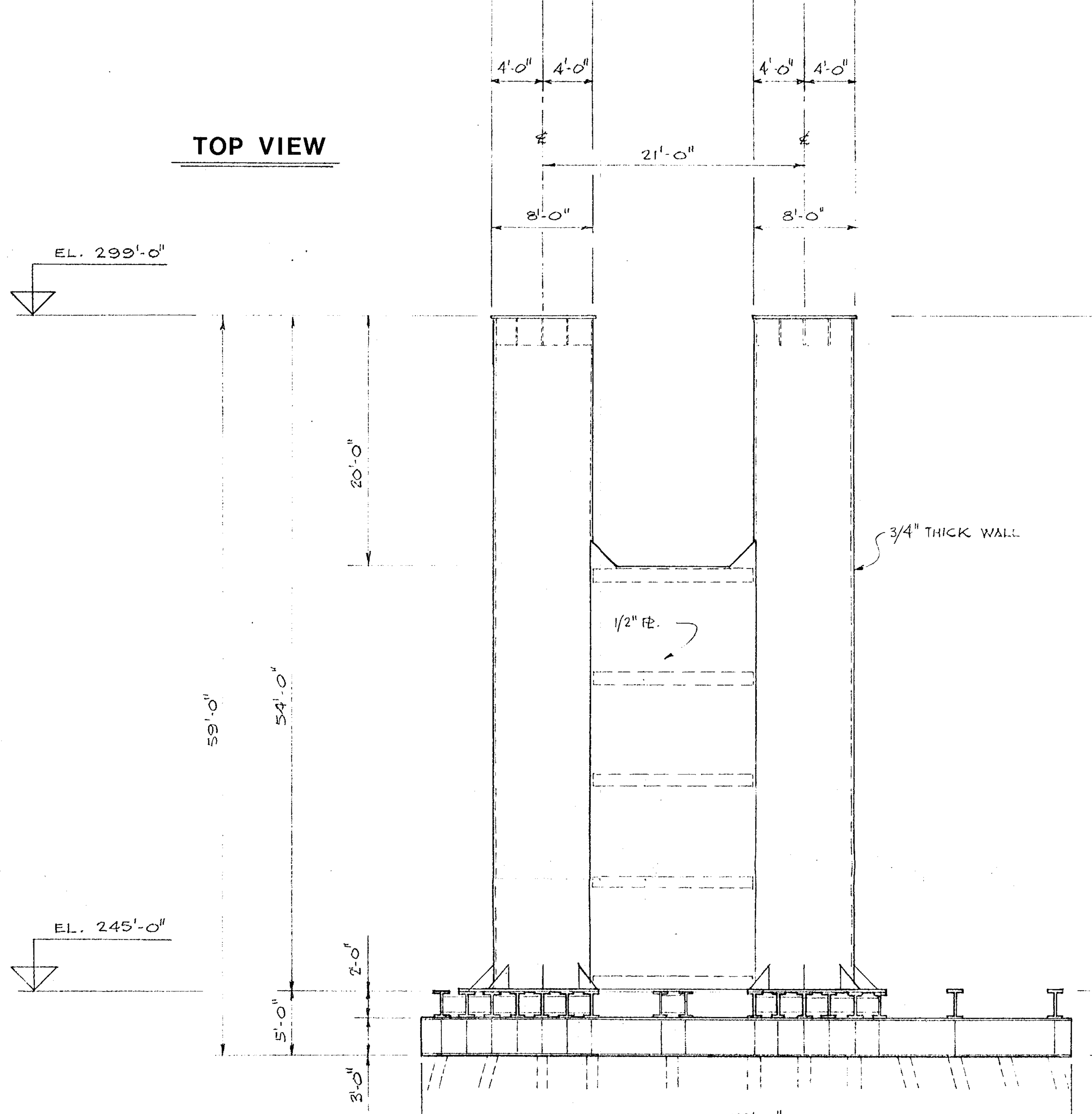
DWN. BY:	CHKD. BY:	DATE:	FILE NO.:
W.L.D.	R.M.M.	DEC. 1/72	72-152

GENERAL NOTES

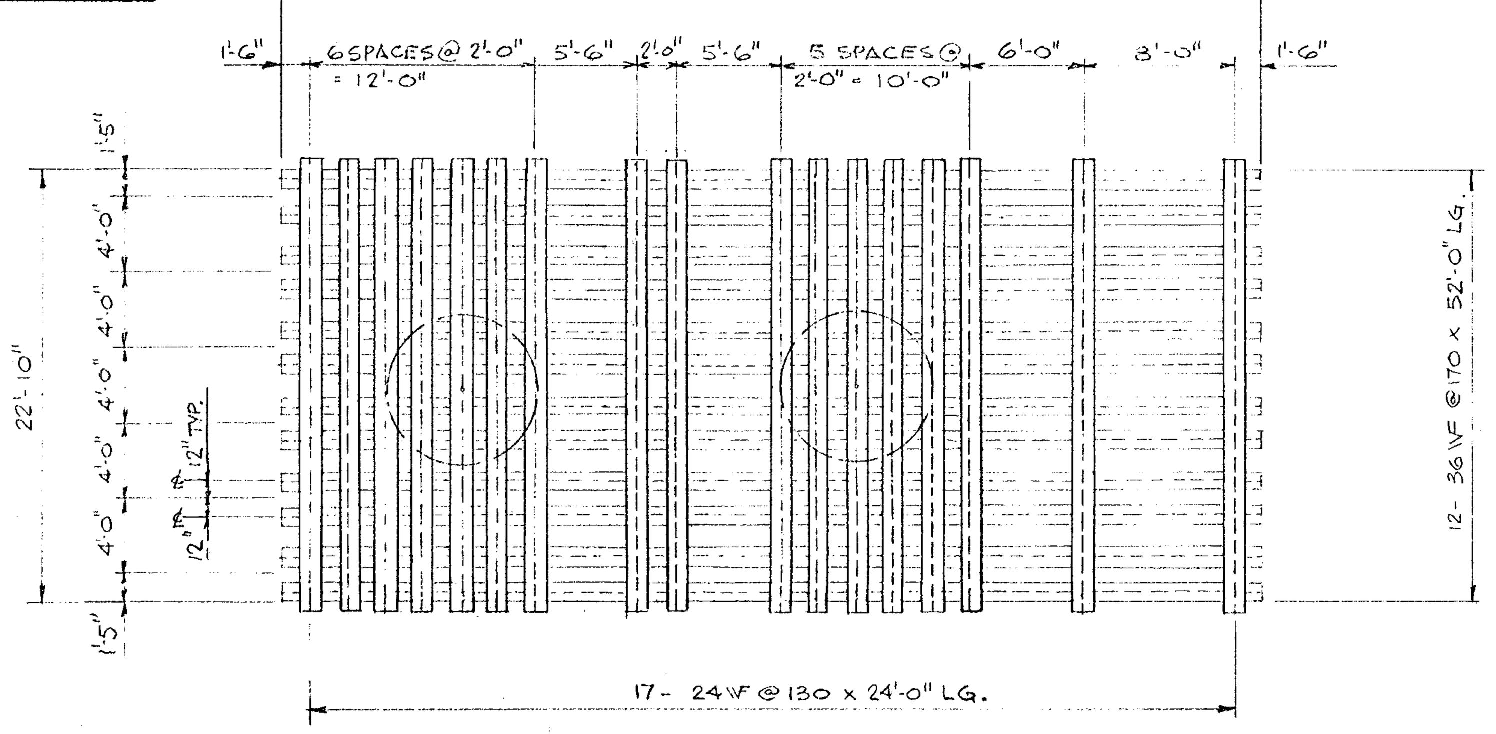
- DESIGN ICE FORCE @ ELEVATION 275' = 1380 KIPS
- DESIGN WIND FORCE @ ELEVATION 307' = 130 KIPS
- DESIGN GOVERNED BY GROUP IX LOADING
- 72 - 10" BP@57 PILES.
- REFER TO DRAWING '1' FOR CORRESPONDING SUPERSTRUCTURE.



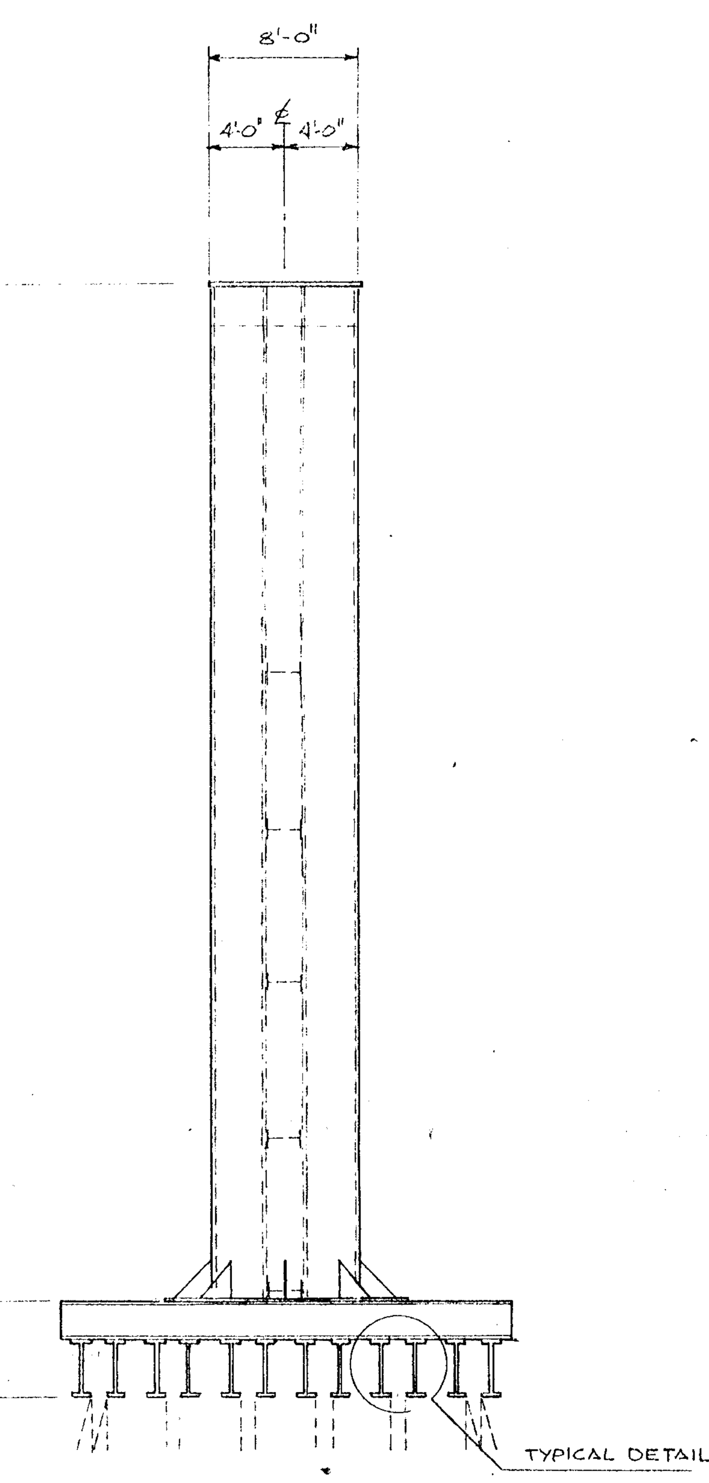
TOP VIEW



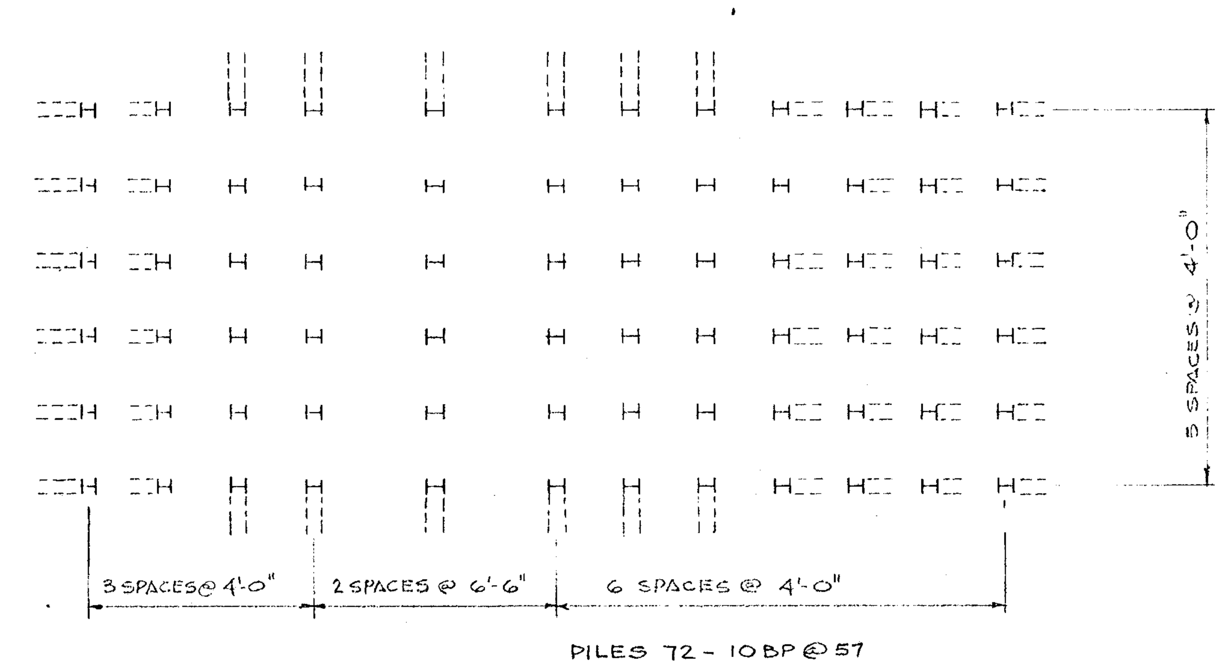
ELEVATION



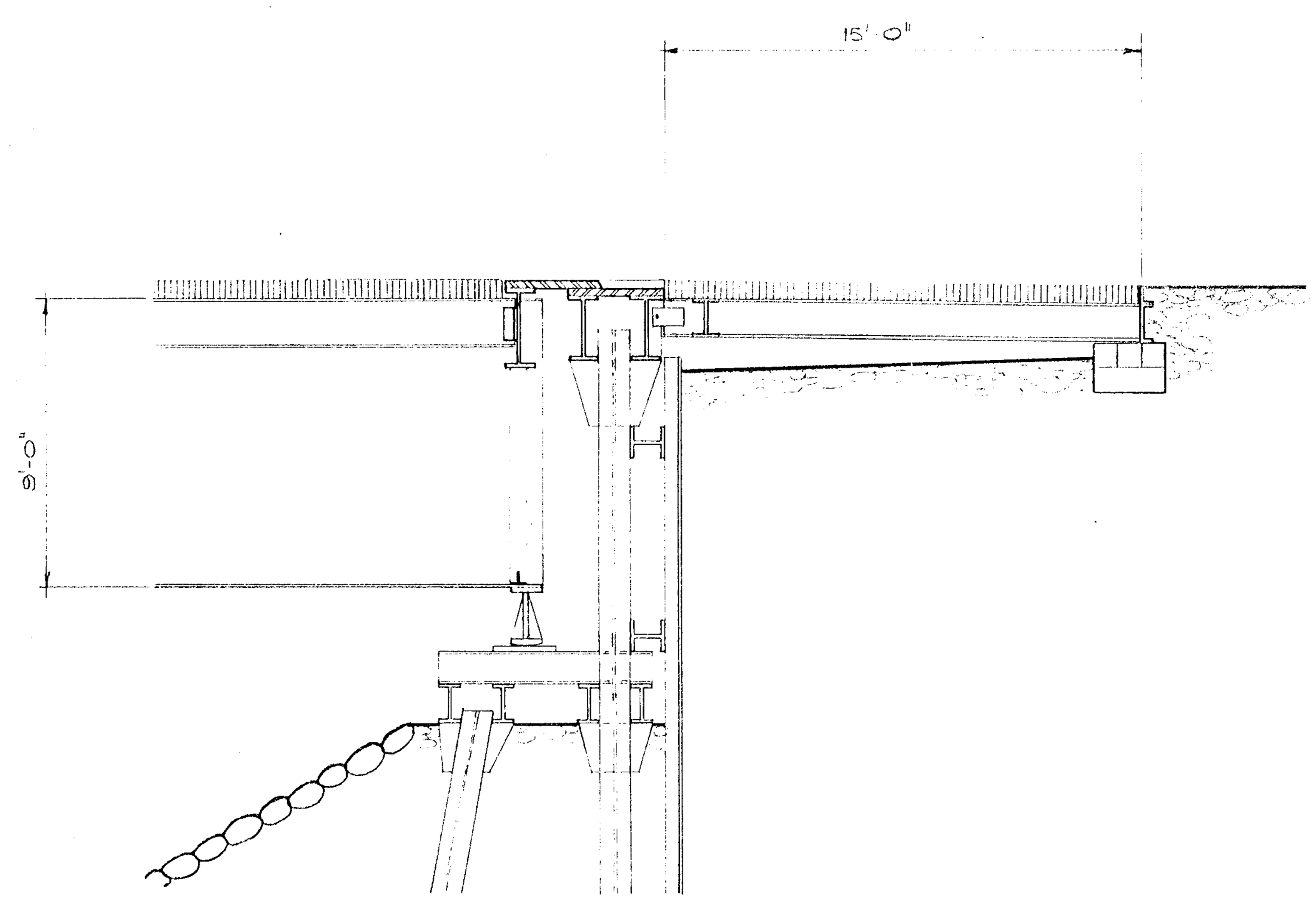
SECTION



SIDE VIEW

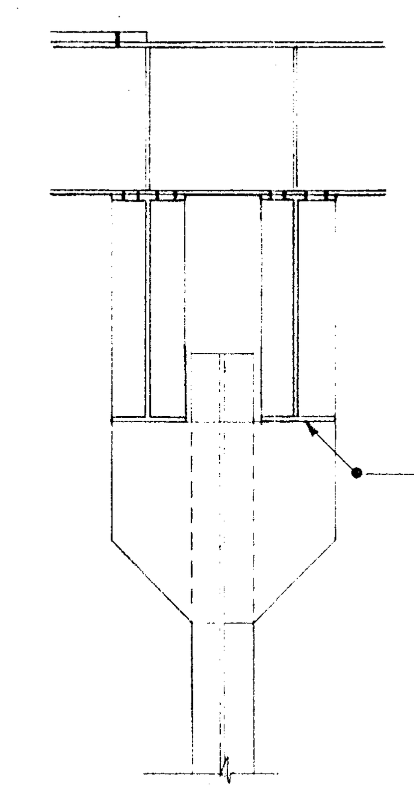


PILE LAYOUT



TYPICAL ABUTMENT SECTION

SCALE : 1/4" = 1'-0"



TYPICAL CONNECTION DETAIL

SCALE : 1/2" = 1'-0"

ISSUED FOR	DATE	DESIGN	CHECKED	DRAWN	CHECKED

MK.	DATE	REVISIONS

FILE 72 - 152
SCALE 1/8" = 1'-0"
DATE JAN. 16, 1973
APPROVED

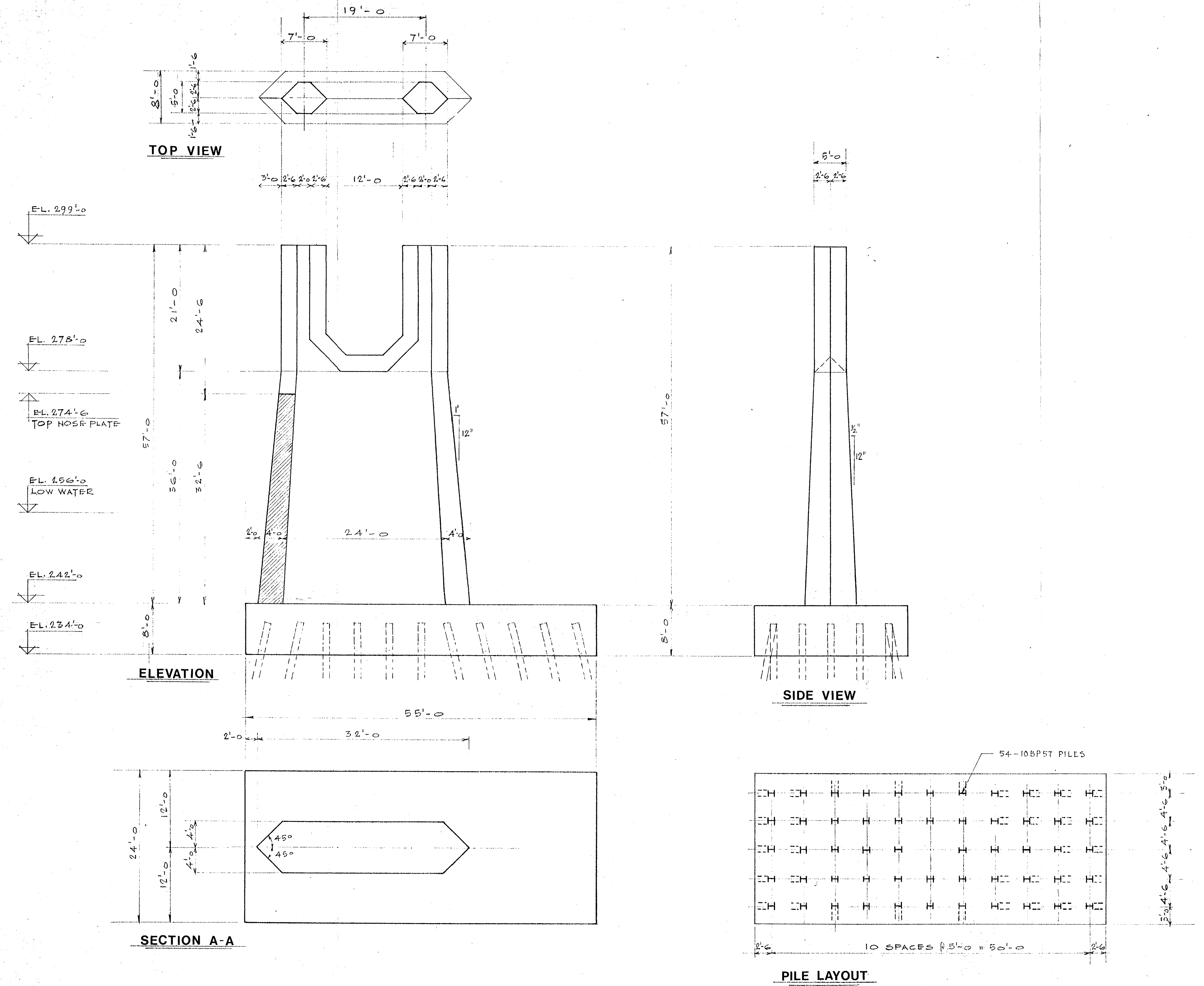
GOVERNMENT OF CANADA
DEPARTMENT OF PUBLIC WORKS
WESTERN REGION

MACKENZIE HIGHWAY
WILLOWLAKE RIVER BRIDGE, MILE 395.0

T. LAMB, McMANUS & ASSOCIATES LTD.
CONSULTING ENGINEERS
EDMONTON CALGARY WINNIPEG

DWG. TITLE
TYPICAL PIER AND ABUTMENT
ALL STEEL BRIDGE CONCEPT

DWG. NO. 7



GENERAL NOTES

DESIGN ICE FORCE AT ELEVATION 275'-0" = 940 KIPS.

DESIGN WIND FORCE AT ELEVATION 307'-0" = 130 KIPS.

DESIGN GOVERNED BY GROUP IX LOADING.

54 – 10 BP57 PILES.

REFER TO DRAWING 2 FOR CORRESPONDING SUPERSTRUCTURE.

ISSUED FOR	DATE	DESIGN	CHECKED	DRAWN	CHE

MK.	DATE	REVISIONS

FILE: 72 - 152
SCALE: 1/8" = 1'-0"
DATE: JAN. 16, 1973
APPROVED

GOVERNMENT OF CANADA
DEPARTMENT OF PUBLIC WORKS
WESTERN REGION

MACKENZIE HIGHWAY
WILLOWLAKE RIVER BRIDGE, MILE 395.0

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DWG. TITLE: TYPICAL CONCRETE PIER

DWG. NO. 8

APPENDIX II

SUPPLEMENTARY REPORT

INVESTIGATION OF AN ALL STEEL BRIDGE CONCEPT

Introduction:

Because of possible problems and excessive costs related to the procurement and supply of suitable concrete aggregates for use in the bridge substructure and deck, the merits of an all steel bridge concept has been investigated. The investigation was carried out on the basis of certain specific assumptions and pier requirements as applicable to the Willowlake River Crossing using Alternative No. 2 (as designated in the main body of the report) for the bridge superstructure. This was chosen rather than Alternative No. 1 because the extra two feet between girders is helpful in resisting overturning. The total cost of Alternative No. 2 is not significantly different from Alternative No. 1.

To facilitate a comparison of costs, a typical concrete pier was designed which would be applicable for the substructure of Alternative No. 5. Both bridge alternatives have the same basic span lengths and pier requirements and differ only in the type of deck system employed.

Assumptions:

1. Ice pressures were calculated on the basis of 300 p.s.i. using 48 inches of thickness at an elevation of approximately 25 feet above stream bed level as suggested by the Hydrology Consultants.

2. Lateral wind forces were calculated for a pressure of 50 p.s.f. acting on the exposed area of the superstructure.

3. Foundation conditions were assumed suitable for the use of drive steel 'H' piles or pipe piles with adequate embedment to develop uplift capacity.

Design Considerations:

One of the basic problems in developing an all steel pier concept is the lack of dead load necessary to resist overturning moments from ice and wind and the lack of an adequate mass to dampen the dynamic effects of such loadings. This is particularly true for the Willowlake River Bridge where pier heights as much as 60 feet above river bed are required.

Two basic concepts of steel pier design have been investigated. In the one case the piles are considered as extending up to the pier cap and resisting all lateral forces as a combination of vertical cantilevers. Their total resistance is equal to the sum of the capacities of the individual vertical members. Since the piles cannot be considered fixed less than 10 feet below river bed, a total design movement of 60,000 foot kips requires an excessive number of piles extending above and below river bed. Large diameter cylinders, driven into the river bed and extending upward as pier shafts would not have sufficient moment or uplift capacity even if they exceeded 8 feet in diameter.

This situation is not relieved by joining the members into a single unit above ground since uplift forces are then brought into play and the total width of the pile group is limited.

A design featuring a combination of batter piles and vertical piles below river bed, spaced to result in optimum resistance to overturning, lateral forces and vertical loads was also considered. A pile cap in the form of a steel grillage was designed and a steel pier carried from the grillage to the underside of the superstructure.

The pier shaft consists of two large diameter steel cylinders, filled with gravel to improve the stability of the structure, and joined by a steel web.

The advantage of this system is that the pier shafts can be located directly below the girders for aesthetic reasons and, being joined by a web, will have sufficient capacity to resist lateral forces.

Below the grillage the piles can be driven with batter and widely spaced to resist overturning.

This design is the one recommended for consideration in the all steel concept. The pier shaft consists of two 8 foot diameter steel cylinders filled with gravel and interconnected by a diaphragm throughout their length. The shaft in turn is connected below river bed level to a steel grillage which acts as a pile cap. Below the grillage battered and vertical piles are driven in a pattern considerably wider than the pier shaft. The proposed design is shown on Drawing No. 7 attached.

Although the pier shaft cylinders can be shop fabricated complete with connecting stiffeners and gusset plates, the pile cap grillage would have to be field welded to the piles after cut off.

Furthermore, the shaft should extend below the scour line so a dewatered cofferdam will be necessary to make the connection of grillage to piles and shaft.

In order to compare costs, a typical mass concrete pier on steel pile foundation has been designed and is shown on Drawing No. 8. The shaft section has been kept to a practical minimum size consistent with the requirements of mass and strength.

Cost Estimates

The following is an estimate of costs for the typical "steel" and concrete piers that are shown on the attached drawings:

Steel Pier

72 'H' piles @ 57#/ft.		*	$ 43,100.
Steel Grillage:-			
12 - 36" WF @ 170# x 52') 17 - 24" WF @ 130# x 24') Gussets, stiffeners & diaphragms)	190,000 lbs @ $0.45		85,500.
Pier Shafts:-			
2 - 8 ft. diameter cylinders) diaphragms, stiffeners) cap plate and base detail)	208,000 lbs @ $0.50		104,000.
Gravel Fill	250 cu. yds. @ $20.00		5,000.
Cofferdam			25,000.
Excavation and Backfill			5,000.
			$267,600.

* Since geotechnical information is still not available, the cost of piling has been estimated at $12.00 per ton of load supported for both the steel and concrete piers.

Concrete Pier

54 'H' piles @ 57#/ft.	$ 32,400
* 660 cu. yds of concrete	66,000
Forming	15,000
Reinforcing	16,500
Nose Plate	5,000
Excavation and Backfill	10,000
Cofferdam	25,000
	$169,900

* Concrete in the form has been taken at $100.00/cu.yd. The figure of $70.00 used in the original report was for a more massive pier and may be slightly low even for that. The amount of concrete in the piers shown on Drawing No. 7 is less than that assumed in the original design but will be more difficult to place. We have, therefore, increased the estimated cost of concrete per cubic yard in place.

Summary and Conclusions

On the basis of these estimated costs summarized in Table No. 2, the all steel bridge structure would cost approximately $450,000 more than a bridge with comparable spans but constructed with composite concrete deck and conventional concrete substructure.

The per cubic yard price for concrete in the forms used in estimating the cost of the concrete substructure was taken at a nominal $100.00 with a total cost including forming and reinforcing of just under $150.00 per cubic yard. If this price for concrete was raised by $50.00 per cubic yard the total price differential would decrease to approximately $300,000.

As pointed out in the main report, if foundation conditions at the site were such that piling was not required a substantial saving in the order of $130,000 to $150,000 would be achieved. This saving would only apply if a conventional concrete type substructure was employed.

Construction of an "all steel bridge" for the Willowlake River crossing is possible where foundation conditions appear to be suitable to the use and de-watering of a sheet pile cofferdam. Construction of a steel substructure of the type indicated in this report at other locations such as the Blackwater River crossing where the river channel is primarily gravel to a considerable depth would not likely be practical or possible. The principal difficulty would be dewatering a cofferdam without seal concrete in order to connect the steel grillage.

COST SUMMARY - TABLE NO. 2

I. <u>All Steel Bridge</u> (Steel Girder & Metal Deck Grating)

Structural Steel in Girders, Floor System and Bracing 570 tons @ $12.00	$ 684,000
25,550 sq. ft. of 6½" steel deck grating @ $10.50	268,000
Handrail and Guard Rail	55,000
4 River Piers @ $267,600	1,070,400
2 Abutments @ $40,000	80,000
Approach Fill	330,000
Rip Rap	60,000
	$2,547,400

II. <u>Steel Girder Bridge</u> - Concrete Deck & Substructure

Structural Steel in Girders & Bracing 491 tons @ $12.00	$ 590,000
11½" Concrete Deck Slab	290,000
Handrail and Guard Rail	55,000
4 Concrete Piers @ $169,900	679,600
2 Abutments @ $43,200	86,400
Approach Fill	330,000
Rip Rap	60,000
	$2,091,000