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PROVINCE OF MANITOBA

DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT

WATER RESOURCES BRANCH

RED RIVER FLOODWAY

OUTLET STRUCTURE

1974 EROSION INVESTIGATION

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FROM FILE.

Winnipeg, Manitoba.

December 1974.

Prepared by:

Planning Division

PROVINCE OF MANITOBA

DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT

WATER RESOURCES BRANCH

RED RIVER FLOODWAY

OUTLET STRUCTURE

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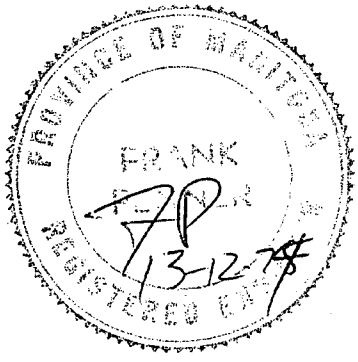

Winnipeg, Manitoba.

December 1974.

Prepared By:

F. Penner, P. Eng.

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4 Letter Mr. R. Bryer to Mr. W. A. Cook November 4, 1974.

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INTRODUCTION

In May 1974 several citizens complained that their property was being threatened by slumping of the west bank of the Red River opposite the Floodway Outlet Structure on the east bank. Copies of the letters of complaint together with letters of reply are included as items 1 to 3 of the Appendix. The slumping of the bank was attributed by the citizens to the operation of the Floodway. Specifically it was alleged that waves generated at the Outlet Structure travelled across the river and eroded the west bank.

A preliminary site inspection on May 24, 1974 indicated that waves were indeed being generated at the Outlet Structure, were travelling across the River and were eroding the west bank. The erosion was judged to contribute to slumping of the bank. One puzzling aspect of the case was that similar wave action and erosion was not observed when the Floodway was operated in 1969, 1970 and 1971. A final assessment of responsibility for damage and the design of remedial works was delayed until further studies could be made.

OBJECTIVES

This study had three objectives:

1. An assessment of the degree to which the operation of the Floodway contributes to erosion of the west bank and the associated bank slumping.
2. An assessment of the need for remedial works.
3. The design of suitable remedial works if such were required.

METHODOLOGY

The degree to which the operation of the Floodway contributed to the erosion and associated bank slumping was evaluated by firstly assessing the relationship between the operation of the Floodway and erosion and

secondly by assessing the relationship between the erosion and the bank slumping.

The need for remedial measures was assessed by considering the frequency of damage and the accumulated effect of the damage.

The design of remedial works was based on the cost-effectiveness of several options. The level of protection proposed was based on a consideration of the frequency of various levels of damage.

The study was based on a review of available data supplemented by field topographic and soil surveys.

DATA

A plan of the study area showing the land ownership was prepared from available legal survey plans and land title certificates. The land between the road and the River is privately held. A special field survey to relate property lines on the east side of the Red River to property lines on the West side of the Red River was made by the Surveys, Mapping and Lands Branch. The location of the Floodway, the Outlet Control structure and a transit line used for a topographic survey were also shown on this plan which is included as Figure 1.

Topographic cross-sections of the west bank of the Red River in the study area were obtained at 100 foot intervals and used to prepare contour plans which are included as Figures 2-1 and 2-2. Also shown are the erosion scarps and slumps formed during the 1974 period of operation of the Floodway.

The soil stratigraphy of the west bank of the Red River in the study area was determined by drilling 11 test holes, by reviewing logs of 6 diamond drill test holes drilled as part of earlier Floodway investigations, and by mapping soil exposures in the field. The locations of 11 of the test holes are shown on Figure 1. The logs of 5 auger test holes are included as Figures 3-1 to 3-5 and the logs of the 6 diamond drill holes

are Figures 3-6 to 3-11. The additional 6 auger test hole locations are shown on Figure 2-2/ Three stratigraphic sections through the west bank of the Red River are included as Figures 4-1 to 4-3. A stratigraphic section along the west bank of the river is included as Figure 5.

Red River and Floodway water level and flow data were provided by the Hydraulic Section for each year that the Floodway was operated and are included as Figures 6-1 to 6-4. Maximum water level and flow data for various frequencies of occurrence are shown on Figures 7-1 and 7-2.

A memo from the Hydraulic Section containing the data from which these Figures were derived is included in the Appendix as item 4.

OBSERVATIONS AND CONCLUSIONS

Relationship Between Floodway Operation & Bank Erosion

Detailed mapping of the erosion scarps on the west bank (shown in Figures 2-1 and 2-2) indicates that they are limited to the area of the west bank opposite and immediately upstream and downstream of the Outlet Structure, decreasing in severity further from the Structure. Similar erosion scarps have not been observed elsewhere in Winnipeg except on a short reach of river immediately downstream of the Inlet Structure where a much smaller scarp has been observed. The elevation of the base of the scarp (728-730) correlates closely with the river level (730-731) at the time of maximum flows in 1974. It is normal for erosion associated with wave action to extend to some depth below water level.

As was mentioned earlier, no appreciable wave action had been observed at the Outlet Structure prior to 1974. Engineers from the Branch made three estimates of wave heights at various times of Floodway operation. On May 8, 1969 waves were estimated to be less than 0.2 feet high. Waves

no higher than 1.0 foot were seen on April 24, 1974. The observed wave height on May 24, 1974 was estimated to be somewhat less than 0.5 feet. In an attempt to determine how wave heights varied with Floodway operation the procedure outlined below was followed.

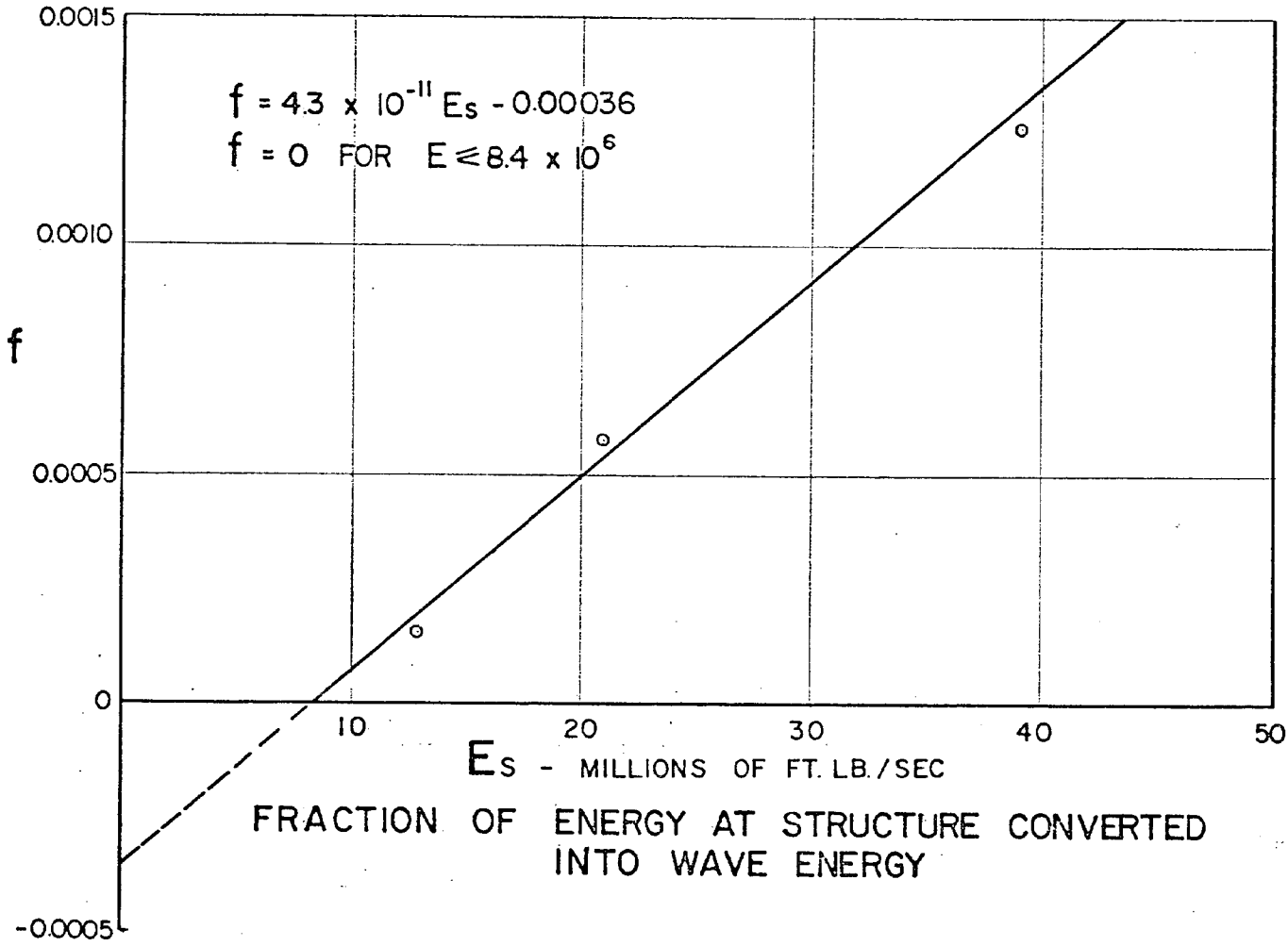
A measure of the energy dissipated at the Outlet Structure was obtained with the formula $E_s = Q.H.\gamma_w$, where Q is the Floodway discharge in cfs, H is the difference in feet in water surface elevations above and below the structure, and γ_w is the density of water in lb./ft.^{3} This formula gives energy in ft. - lb./sec. The formula $E_w = 20h^2TD$ gives a measure of the energy waves expend over a certain distance of shoreline in ft.-lbs./sec. The wave height in feet is h, T is the wave period in seconds and D is the distance in feet of shoreline over which the waves act. The two formulae can be combined thus:

$$20h^2TD = fQH\gamma_w$$

or

$$f = \frac{20h^2TD}{QH\gamma_w}$$

where f is the fraction of the energy at the outlet structure that is converted into wave energy. It is assumed that the waves have a period, T, of two seconds and act over a shoreline distance, D, of 1200 feet (the length of shoreline most severely eroded). By calculating the energy dissipated at the structure on the three dates that wave heights were estimated and using this formula the graph on page 7 was constructed to determine the relationship between f and E_s



FRACTION OF ENERGY AT STRUCTURE CONVERTED INTO WAVE ENERGY

PROVINCE OF MANITOBA

DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT

WATER RESOURCES BRANCH

PREPARED	DRAWN	SUBMITTED	APPROVED				
	CHECKED	DATE	DATE	SCALE	DATE	SHEET OF	FILE NO.

As can be seen a linear relationship is an adequate approximation. It should be noted, however, that the approximation is not adequate where it gives negative values for f. Now, rearranging the $E_w = fE_s$ equation to

$$h = \sqrt{\frac{fQ\ H\gamma_w}{2OTD}}$$

wave heights for various values of E_s and thus various frequencies of occurrence can be calculated. Figure 8 shows the result. It should be pointed out that the values obtained are approximations only, especially beyond the range of observation, and by no means should be considered precise. As Figure 8 shows maximum wave heights were substantially greater in 1974 than in previous years due mainly to increased Floodway discharge.

In summary it is concluded that the observed erosion is associated with the operation of the Floodway and generally speaking becomes worse as the energy at the Outlet Structure increases. This energy increases with increased differences between water surface levels above and below the structure, and with increased Floodway flows. Which of these two factors is most significant in generating waves is unknown but it is primarily wave action that caused the formation of erosion scarps.

Relationship Between Erosion & Bank Slumping

Figure 5 shows a stratigraphic section of the west bank along the reach opposite the Outlet Structure. The till is normally stable. However, there is a surface layer of softer weathered clay roughly 5 feet thick draped over the till. This layer is normally marginally stable. Numerous scars of recent and ancient slumps are evident on both sides of the river

on reaches well beyond the influence of the Floodway. The slumps move slowly and infrequently and are normally well-vegetated. Formation of an erosion scarp in the weathered material reduces its support and causes it to slump. The effect of the erosion may best be described as making an unstable situation worse. The erosion does not cause a stable situation to become unstable. The slumping of the bank opposite the Floodway Outlet Structure is thus partly attributable to the operation of the Floodway.

As noted earlier the relationship between Floodway operation and waves generated at the Outlet Structure as shown in Figure 8 is largely conjecture beyond the range of observation. However, for the purpose of assessing the need for remedial measures it would be reasonable to assume that erosion at least as severe as that experienced in 1974 (say a 10 to 15 foot recession of the bank) would be expected each year that flows equalled or exceeded those of 1974. As can be seen from Figures 7-1 and 7-2 a flood of 1974 magnitude has a probable frequency of once in about 45 years which may be termed "infrequent".

Natural Erosion At Normal Summer Water Level And Associated Bank Recession

It is possible to roughly estimate the natural recession of the bank due to erosion at the normal summer water level. On Figure 1, the 1974 shoreline corresponding to a water level of about elevation 718 is roughly 40 feet landward of the 1918 shoreline corresponding to a water level of about elevation 714. The horizontal distance between the 714 and 718 contours is roughly 20 feet and thus accounts for one half of the 40 feet. The remaining 20 feet may be taken as a rough measure of the natural erosion over a period of 56 years. This estimate of erosion is supported by the observation that the bank in question is on the outside of a curve (rivers normally erode at the outside of curves) and does not support any large old trees on the sloping bank.

Over the long term the bank would maintain its profile shape and any recession at the water line would cause an equal recession over the full height of the bank. Thus the long term average rate of recession of the top of the bank under natural conditions is estimated to be roughly 1/3 of a foot per year.

Assessment of Responsibility for Bank Recession

It is not possible to give a precise estimate of the rate of natural recession of the bank or of the Floodway erosion induced recession of the bank. Nor is it entirely clear how the two effects might be combined. Suffice it to say that the bank appears to be receeding under natural conditions and that the loss of land is not entirely due to the operation of the Floodway.

It is not possible to determine precisely what portion of the bank slumping and recession is attributable to Floodway induced erosion.

To the extent that the R.M. of Saint Andrews is committed to maintain the road in a serviceable condition the question of cause is relevant in determining the apportionment of cost of the remedial works. The question of cause would also affect any compesation granted to owners of property on the river side of the road.

Assessment of Need for Remedial Works

The fact of the matter is that loss of land threatens the River Road and, in fact, the condition of the road is now unsatisfactory as a result of bank erosion. Therefore some form of remedial work is required to protect the road or the road should be relocated. The property between the River Road and the river is privately held and the owners would likely have to be compensated for damage attributable to the operation of the Floodway or the property would have to be purchased.

In summary, while erosion of the magnitude experienced in 1974 would be expected only infrequently, and only a portion of the recession of the top of the bank is attributable to the operation of the Floodway, remedial work is required to protect the Road. Some form of compensation to the owners of the affected property may also be necessary.

DESIGN OF REMEDIAL WORKS

Three forms of remedial works were considered:

1. Stabilization and protection of bank by placement of rock fill.
2. Stabilization and protection of bank by an anchored concrete wall.
3. Relocation of the River Road.

Stabilization and Protection of Bank by Placement of Rock Fill

The length of the river bank to be protected was determined by consideration of the following factors:

1. Length and severity of erosion scarps observed after the 1974 flood
2. Condition of the roadway at the top of the bank
3. Property lines

It was determined on this basis that the length of bank to be protected should extend from Sta. 14 + 00 to Sta. 23 + 00.

The elevations between which the bank should be protected from wave action was determined by considering the elevation at which erosion became serious and the elevation corresponding to the 100 year flood level. It was decided that the bank should be protected from elevation 728 (one foot below serious erosion) to elevation 736 (one foot above the 100 year flood level). At the present rate of erosion below elevation 728 any structure placed at this level would last about 50 years. This life could be extended by placing

additional rock fill at a lower level at a later date if experience shows this to be necessary. Figures 9-1 and 9-2 show plan views of the rock fill in place and Figures 10-1 through 10-4 show cross-sections of the various forms the remedial works would take at different locations along the bank. The rock fill shown above elevation 736 is to protect the clay from sheet erosion and gullying. The rock fill between elevation 728 and 736 would be limestone shot rock with sizes ranging up to three feet in diameter. The dimensions of the rock structure were largely determined by assessing the space requirements of the heavy equipment which would be used to place the rock. The rock fill above elevation 736 would also be limestone shot rock but of a somewhat smaller maximum size.

Included here is a cost breakdown prepared by the Operations Division for this type of remedial work:

Excavation of Material	7000 Cu. Yds. at $1.00	$ 7,000.00
Purchasing and Hauling of Rock Fill	7100 Yds. at $7.00	$49,700.00
Placing of Rock Fill		$10,000.00
	TOTAL	$66,700.00

Included in the Appendix as item 5 are stability analysis done to determine how effective the rock fill would be in stabilizing the bank.

The results may be summarized as follows:

Condition	Required Shear Strength	Safety Factor
Existing bank before 1974 erosion	185 p.s.f.	1.0
Existing bank after 1974 erosion	230	0.8
Bank with rockfill	154	1.2

The increase in stability is modest but is the maximum that can be obtained at reasonable cost.

Stabilization and Protection of Bank By An Anchored Concrete Wall

Another option considered was a reinforced concrete buttress anchored to the bank. It was estimated that such a structure would require one cubic yard of reinforced concrete per lineal foot in place at a cost of $200.00. Total cost would be $200 x 1200 = $ 240,000.00.

Relocation of the River Road

A third possible solution is not to protect the bank at all but to relocate the Road, in the area threatened by bank erosion (Sta. 11 + 00 to Sta. 23 + 00). This would involve moving the road to the west at least 50 feet (to allow for future erosion) and purchasing the portions of the privately held lots affected - lots 110, 111, 112, 113, 114 and possibly 115. Also, the residences on lots 110, 111 and 112 would likely have to be relocated or the owners compensated for the reduced value of their property by an amount roughly equal to the cost of relocation. Very roughly, the cost of this proposal may be as follows:

Purchase portions of lots 110, 111, 112, 113, 114, 115 6 x 5000	30,000
Relocate residences on lots 110, 111, 112 3 x 20,000	60,000
Reconstruct road	20,000
	$ 110,000

These costs should be verified by a qualified appraiser before this proposal is seriously considered.

Purchase of Property Between River and Road

Acquisition of this property or compensation for damages to this property would be common to all options. The cost of purchase of approximately 2 acres may be roughly $ 4,000.00.

Minnow Shack Owned By Mr. Tesch

Mr. W. Tesch operates a fishing bait sale enterprise from a shack located on the bank east of the road. Arrangements could be made to leave the shack and stairway in essentially their existing location under a lease arrangement if his property is purchased.

RECOMMENDATIONS

It is recommended that remedial measures in the form of the rock fill proposal (as shown on Figures 9-1 and 9-2 and Figures 10-1 through 10-4) be implemented since this appears to be the least cost solution.

However, the R.M. of Saint Andrews which is responsible for the River Road may prefer to relocate the road nearer to the Tesch buildings, or even west of the Tesch buildings for other reasons. The difference in cost between relocating the road and the placing of the rock fill is not great and may be within the limits of the accuracy of the cost estimates given. Hence that Municipality should be consulted as well.

Before this recommendation is accepted the affected land owners should be contacted and made aware of what is planned. Should they have specific objections these should be considered and resolved before any work is undertaken. It may be necessary to purchase all the land affected by these measures.

FIGURES

(Note figures 1, 2-1, 2-2, 9-1 and 9-2 are folded plans in pockets)

APPENDIX

Province of Manitoba

inter-departmental memo

To

Hon. Sidney Green, Q.C.
Minister of Mines, Resources
and Environmental Management
Room 302, Legislative Bldg.

Date May 7, 1974

From Hon. Howard Pawley
Minister of Municipal Affairs

Subject WINNIPEG FLOODWAY OUTLET, LOCKPORT, MANITOBA

I have had representation made to me recently by Mr. Robert Tesch, Box 20, Group 336, R.R. #3, Selkirk, phone: 757-2524, who lives directly across the Red River from the outlet of the Winnipeg Floodway. Mr. Tesch's complaint to me was that the waters coming out of the Floodway during the period of time that the Floodway is in use are creating problems with respect to the erosion of the west side of the bank.

He indicated that he had a boathouse on the shore and the erosion from the water lapping against the shores, resulted in this boathouse tipping over.

Further, he advises that trees lining the shore in the area are being torn out by their roots as well as land along the road area caves in towards the river.

I suspect that this is a subject matter that your Department has been made aware of or, in all probability, has been keeping an eye on, and I would appreciate being advised as to any steps that your Department will be taking in regard to preventing any excessive erosion stemming from the waters running out of the Floodway outlet.

Your advice and co-operation is appreciated. Thank you.

Howard Pawley

/ab

MINES, RESOURCES & ENVIRONMENTAL MANAGEMENT
MINISTER'S OFFICE
MAY 13 1974
WC - Red

May 29, 1974

N. Mudry, P. Eng.
Director, Planning Division

F. Penner, P. Eng.
Head, Geotechnical Section

File: 10.5.5

Red River Flooding Outlet - Complaint by R. Tesch

This refers to the attached letter from the Hon. H. Pawley to the Hon. S. Green.

I inspected this property on May 24, 1974. The Floodway Outlet Control Structure was observed to generate waves which travelled across the River and eroded a bench or scarp on the west bank. The waves and scarp were noted only opposite the Outlet Control Structure. They were absent upstream and downstream of this section of the river bank. The phenomenon is similar to that observed on the west bank of the Red River downstream of the Floodway Inlet Control Structure; it is not erosion due to the water currents. It may be noted that we did not observe this effect at the Outlet Structure in 1969. It may be that it only occurs at higher Floodway flows.

The scarp eroded by the waves has accentuated the instability of the bank and widespread slumping of the river bank has occurred. The banks along this reach of river show clear signs of previous slumping. Slumping of river banks in Winnipeg is unusually widespread this spring. However, there is little doubt that the slumping opposite the property in question has been substantially accentuated - perhaps initiated - by the erosion induced by the Floodway Outlet Control Structure.

A check on land ownership indicates that Mr. Tesch holds title to land to the waters edge except for a public road at the top of the bank. This applies generally along the affected river bank.

Remedial measures would likely consist of placing quarried rock fill along the bank at the waters edge and some reshaping of the bank. The cost of this work may be estimated very roughly as follows:

2100 feet of bank affected - place 2 cu. yds. of rock per line. ft. - cost of rock @ $5.00/cu. yd. = 2100 x 2 x 5.00 =	$21,000
- Cost of reshaping bank =	+10,000
	$31,000

The cost of this work could be substantially higher or lower, depending on results of further investigation.

In conclusion, it is recommended that:

1. The attached draft of a letter be sent to Mr. Tesch,

2. We investigate this matter further to determine the necessary remedial measures.

for F. Penner

FP/mc

ITEM 2

J. R. OAKES,
SECRETARY-TREASURER

PHONE PETERSFIELD 799-2264

JOHN ZELYCK,
REEVE

OFFICE OF SEC'Y-TREAS
CLANDEBOYE
MANITOBA

May 21, 1974

Hoourable Howard Pawley,
MLA., Selkirk Constituency,
97 Dorchester Avenue,
Selkirk, Manitoba.

The Municipality has been receiving inquiries and complaints regarding the action of water from the flood-way over the west bank of the Red River north of Lockport.

At the time of the flood -way construction, we were assured that there would be no damage and that any complaints would receive consideration.

When the flood-way was opened this spring and before the River had risen, waves from the flood-way were crossing the river and hitting the west bank at least two feet high. This has washed away a considerable amount of soil and bank and exposed the gravel base which will be very vulnerable to any further action of water from the flood-way.

It appeared that once the Red River rose, the wave action subsided somewhat, but the erosion has commenced and will be aggravated each year or as long as the flood-way operates this year.

The area involved is around Lot 114 St. Andrews, approximately in front of the Doctor Robertson residence. This area has never had an erosion problem before and we would appreciate your investigation of this problem.

JRO/ib.

ITEM 3

Province of Manitoba

inter-departmental memo

To: Mr. W. A. Cook, P. Eng.
Head, Hydraulic Section

Date: November 4, 1974

From: R. Bryer
Watershed Engineer

File: 10.5.5

Subject: Hydrometric Data at the Red River Floodway Outlet

As requested by the Geotechnical Section, discharges and water surface elevations for the Red River and the Red River Floodway, near the Floodway outlet, have been tabulated for the periods of Floodway operation in 1969, 1970, 1971 and 1974. A table was also prepared showing the frequency of occurrence of elevations on the Floodway and the Red River and discharges in the floodway.

The Floodway discharges and elevations were taken at the Water Survey of Canada gauge No. 05QJ014, located on the PTH No. 44 bridge. The 1974 elevations and discharges were supplied by Water Survey of Canada. For the preceeding years discharges were taken from Water Survey of Canada's annual Surface Water Data reports, and elevations were taken from a rating curve prepared from the 1974 data.

The discharges on the Red River were taken at the Water Survey of Canada gauge No. 05QJ010, located approximately 2.1 miles downstream of the Lockport Dam. This is approximately 1.5 miles downstream of the Floodway outlet. Discharges were supplied by Water Survey of Canada. Elevations were not available at this location.

Elevations on the Red River were taken at the Public Works gauge located on the downstream gate of the locks at the Lockport Dam. These elevations were supplied by Public Works. They may be up to one foot higher than the elevations at the Floodway outlet depending on the discharges and the backwater effect caused by the Floodway discharging downstream.

The frequency table is based on theoretical data prepared from 1950 relationships. The values are calculated on the assumption that the flood control works at Portage and Shellmouth are operating. The Floodway elevations are at the Water Survey of Canada gauge No. 05QJ014 and the Red River elevations are at the floodway outlet.

The tables (Tables 1 - 9) and a plan showing the locations of the gauges (Figure 1) are attached.

Please note that all the 1974 data is provisional and subject to revision.

R. Bryer

R. Bryer

RB/dh

Atts.

Note.

ITEM 4

PROVINCE OF MANITOBA
WATER RESOURCES BRANCH

PROJECT No. | SCHEME | DATE | SHEET OF
ENGINEER

TABLE NO. 1
DISCHARGES - 1969

DATE	FLOODWAY	RED RIVER
APRIL 14	0	44300
15	3960	51900
16	5680	51300
17	9480	56000
18	11100	61400
19	13100	62500
20	13900	64200
21	14300	65100
22	14600	65800
23	15000	66100
24	15500	68400
25	16300	69800
26	18100	72100
27	19500	74300
28	21300	76300
29	21300	77100
30	22100	77300
MAY 1	22500	77800
2	22500	77200
3	22500	76400
4	22400	75700
5	21300	74400
6	19900	74600
7	19100	73200
8	18400	71100
9	17600	68500

DATE	FLOODWAY	RED RIVER
MAY 10	16500	66100
11	15600	64200
12	13700	61900
13	11500	59800
14	10500	56000
15	9010	54300
16	7800	53100
17	5180	47600
18	2550	45200
19	1050	44500
20	207	38400
21	0	33900

PROVINCE OF MANITOBA
WATER RESOURCES BRANCH

PROJECT No. SCHEME TABLE NO. 2 DATE SHEET OF
ENGINEER ELEVATIONS - 1969

DATE	FLOODWAY	RED RIVER
APRIL 14	727.50	724.8
15	733.80	724.8
16	734.85	725.4
17	736.55	725.9
18	737.20	726.7
19	737.95	727.2
20	738.25	727.5
21	738.40	727.4
22	738.50	727.6
23	738.65	728.1
24	738.85	728.0
25	739.10	728.4
26	739.75	728.9
27	740.20	729.1
28	740.30	729.1
29	740.95	729.4
30	741.15	729.6
MAY 1	741.20	729.7
2	741.20	729.4
3	741.20	729.3
4	741.10	729.2
5	740.95	729.3
6	740.40	728.9
7	740.10	728.8
8	739.85	728.6
9	739.60	728.3

DATE	FLOODWAY	RED RIVER
MAY 10	739.20	727.8
11	738.90	727.5
12	738.20	726.9
13	737.35	726.7
14	736.95	726.3
15	736.35	725.8
16	735.80	725.4
17	734.55	725.1
18	732.75	724.7
19	731.00	724.1
20	728.60	723.4
21	727.50	722.3

PROVINCE OF MANITOBA
WATER RESOURCES BRANCH

PROJECT No. SCHEME TABLE NO. 3 DATE SHEET OF

ENGINEER DISCHARGES - 1970

DATE	FLOODWAY	RED RIVER
APRIL 12	0	3630
13	210	6010
14	502	9960
15	791	14100
16	1180	22000
17	1610	30000
18	2070	37000
19	2410	44000
20	5500	51000
21	8350	59700
22	8820	61200
23	9590	63300
24	10800	65500
25	13700	69900
26	20200	70400
27	22000	69900
28	22500	69500
29	23400	69200
30	23700	69000
MAY 1	24100	71300
2	23800	72000
3	22300	69300
4	21400	67400
5	20000	64900
6	19000	62700
7	16700	61300

DATE	FLOODWAY	RED RIVER
MAY 8	15500	59700
9	14400	58200
10	12600	56800
11	11500	55200
12	10500	53400
13	8930	51600
14	7170	49900
15	5420	48300
16	4950	46900
17	5090	45500
18	4470	44200
19	3610	43200
20	1560	41200
21	633	39300
22	172	37400
23	0	35400

PROVINCE OF MANITOBA
WATER RESOURCES BRANCH

PROJECT No. SCHEME TABLE NO. 4 DATE SHEET OF
ENGINEER ELEVATIONS - 1970

DATE	FLOODWAY	RED RIVER
APRIL 12	727.80	715.5
13	728.70	715.5 ICE
14	729.70	715.5
15	730.45	715.5
16	731.30	720.0
17	731.80	722.0
18	732.30	724.5
19	732.60	727.3
20	734.70	727.0
21	736.10	727.6
22	736.30	727.3
23	736.60	727.4
24	737.10	727.9
25	739.20	728.1
26	740.40	728.3
27	741.00	728.4
28	741.20	728.6
29	741.45	728.7
30	741.55	729.0
MAY 1	741.70	728.8
2	741.60	728.3
3	741.10	727.8
4	740.80	727.6
5	740.40	727.5
6	740.00	726.8
7	739.30	726.7

DATE	FLOODWAY	RED RIVER
MAY 8	738.80	726.7
9	738.40	726.5
10	737.80	726.1
11	737.35	725.8
12	736.95	725.6
13	736.30	725.3
14	735.60	724.7
15	734.70	724.7
16	734.40	724.9
17	734.50	724.8
18	734.10	724.6
19	733.55	724.3
20	731.70	724.3
21	730.00	724.0
22	728.50	723.5
23	727.50	722.8

PROVINCE OF MANITOBA
WATER RESOURCES BRANCH

PROJECT No. | SCHEME | DATE | SHEET OF
ENGINEER

TABLE NO. 5
DISCHARGES - 1971

DATE	FLOODWAY	RED RIVER
APRIL 7	0	9100
8	250	10100
9	1360	10500
10	2940	10900
11	3360	26900
12	4160	36500
13	8520	55700
14	10100	55300
15	9450	53500
16	8450	49100
17	7600	45600
18	6830	45400
19	4730	45300
20	3600	41600
21	3190	38700
22	1610	35600
23	675	30500
24	0	28100

PROVINCE OF MANITOBA
WATER RESOURCES BRANCH

PROJECT No. | SCHEME | DATE | SHEET OF

ENGINEER

TABLE NO. 6
ELEVATIONS - 1971

DATE	FLOODWAY	RED RIVER
APRIL 7	727.50	718.0
8	728.30	719.0
9	731.45	721.0
10	733.10	726.9
11	733.35	727.6
12	733.90	727.8
13	736.10	726.1
14	736.80	725.6
15	736.50	725.0
16	736.10	725.0
17	735.75	724.9
18	735.40	725.0
19	734.30	724.6
20	733.55	724.0
21	733.30	723.2
22	731.80	722.9
23	730.10	721.8
24	727.50	721.2

PROVINCE OF MANITOBA
WATER RESOURCES BRANCH

PROJECT No. SCHEME TABLE NO. 7 DATE SHEET OF
ENGINEER DISCHARGES - 1974

DATE	FLOODWAY DISCHARGE	RED RIVER DISCHARGE
APRIL 18	0	57000
19	11300	67000
20	21300	72000
21	26700	77800
22	32100	82700
23	36500	87400
24	39900	86400
25	39900	85400
26	38600	84400
27	36900	83900
28	35000	82400
29	33400	81400
30	31400	80400
MAY 1	29500	79200
2	27700	77100
3	26100	75100
4	24700	73000
5	23000	71000
6	21000	68900
7	19400	66800
8	17500	64800
9	15900	62700
10	13900	61400
11	12700	60000
12	12700	58700
13	12000	57300

DATE	FLOODWAY DISCHARGE	RED RIVER DISCHARGE
MAY 14	10600	56000
15	8750	54600
16	6270	53300
17	3940	51900
18	2660	52300
19	1480	52700
20	1570	53100
21	8270	53500
22	19500	53900
23	24700	54300
24	25600	54800
25	21200	55200
26	17300	55600
27	14100	56000
28	11900	56400
29	9160	56800
30	6550	55800
31	3740	54400
JUNE 1	0	41500

PROVINCE OF MANITOBA
WATER RESOURCES BRANCH

PROJECT No. SCHEME TABLE NO. 8 DATE SHEET OF
ENGINEER ELEVATIONS - 1974

DATE	FLOODWAY ELEV	RED RIVER ELEV
APRIL 18	727.50	726.1
19	732.46	727.6
20	740.77	728.7
21	742.47	729.9
22	744.07	730.1
23	745.84	730.5
24	746.31	730.7
25	746.31	731.2
26	745.94	731.2
27	745.45	731.0
28	744.90	730.9
29	744.44	730.6
30	743.87	730.2
MAY 1	743.32	730.0
2	742.78	729.7
3	742.28	729.5
4	741.84	729.2
5	741.31	729.0
6	740.67	728.6
7	740.13	728.1
8	739.50	727.8
9	738.96	727.6
10	738.25	727.3
11	737.81	727.2
12	737.81	727.0
13	737.54	727.0

DATE	FLOODWAY ELEV	RED RIVER ELEV
MAY 14	737.00	727.0
15	736.24	726.2
16	735.13	725.8
17	733.83	725.6
18	732.88	725.6
19	731.67	726.0
20	731.79	726.9
21	736.03	727.8
22	740.17	729.0
23	741.34	729.4
24	742.12	729.1
25	740.73	728.6
26	739.43	728.2
27	738.32	727.6
28	737.50	726.6
29	736.41	726.3
30	735.26	726.1
31	733.70	726.1
JUNE 1	727.50	725.0

PROVINCE OF MANITOBA
WATER RESOURCES BRANCH

PROJECT No. SCHEME TABLE NO. 9 DATE SHEET OF
ENGINEER FREQUENCIES

FREQUENCY	RED RIVER ELEVATION	FLOODWAY DISCHARGE	FLOODWAY ELEVATION
100.00%	–	0	727.5
75.76	–	0	727.5
62.50	–	0	727.5
37.59	720.23	0	727.5
20.41	722.51	4500	734.2
12.34	724.33	11000	737.3
8.06	725.90	17700	739.6
5.56	727.30	24000	741.6
4.00	728.62	30800	743.7
2.98	729.83	37800	745.7
2.31	731.00	43700	747.3
1.82	732.10	47600	748.4
1.43	733.16	50900	749.3
1.15	734.18	53400	750.1
0.91	735.33	55900	750.7
0.74	736.70	58200	751.2
0.62	737.96	60000	751.7
0.60	738.11	60100	751.8
0.50	739.71	62200	752.3
0.41	741.36	64100	752.8
0.34	742.87	66000	753.3
0.28	744.45	68000	753.9
0.24	745.90	70200	754.3
0.20	747.30	72300	754.9
0.17	748.74	74300	755.4
0.14	750.10	76300	755.9
0.12	751.41	78300	756.6

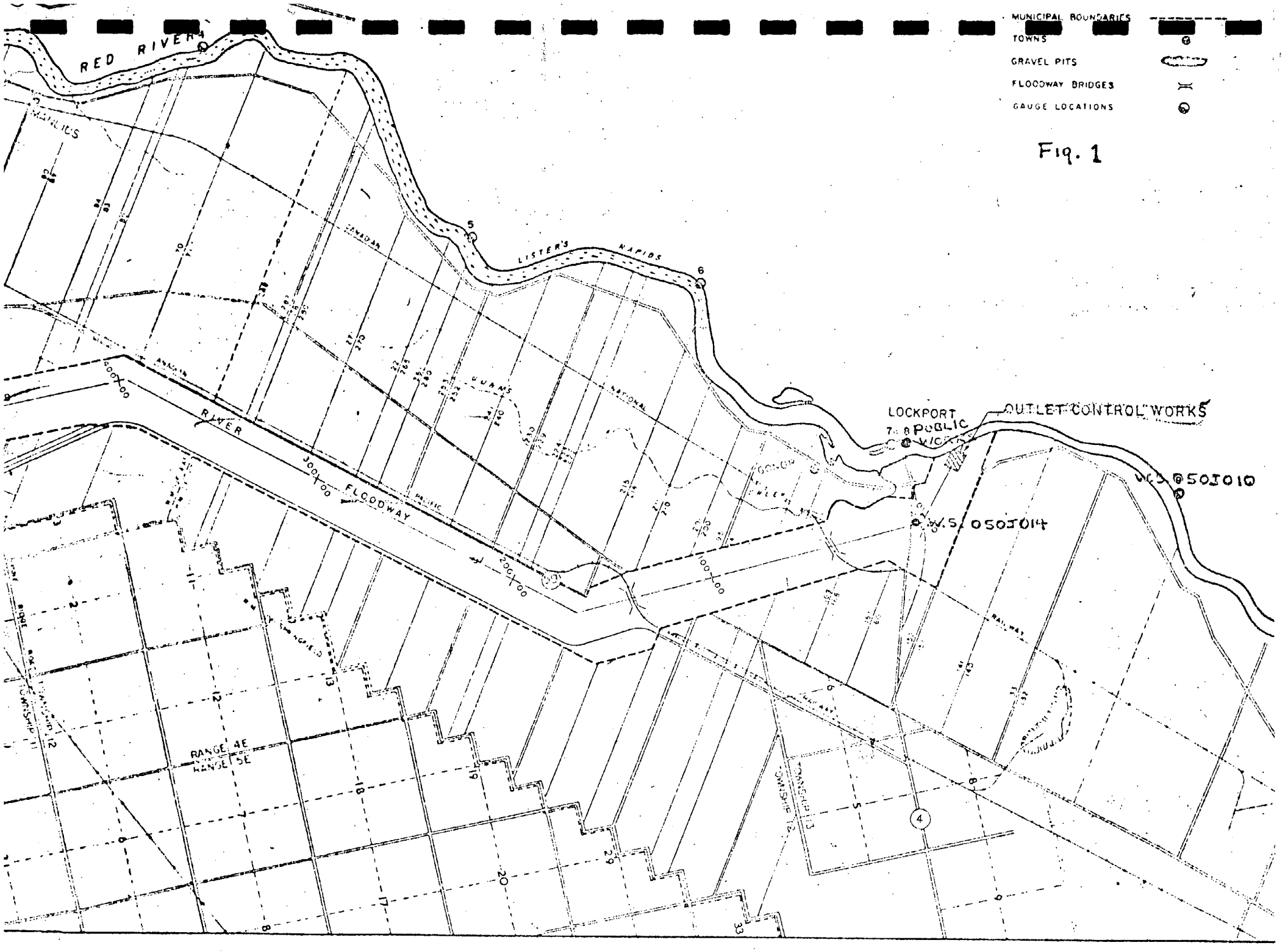
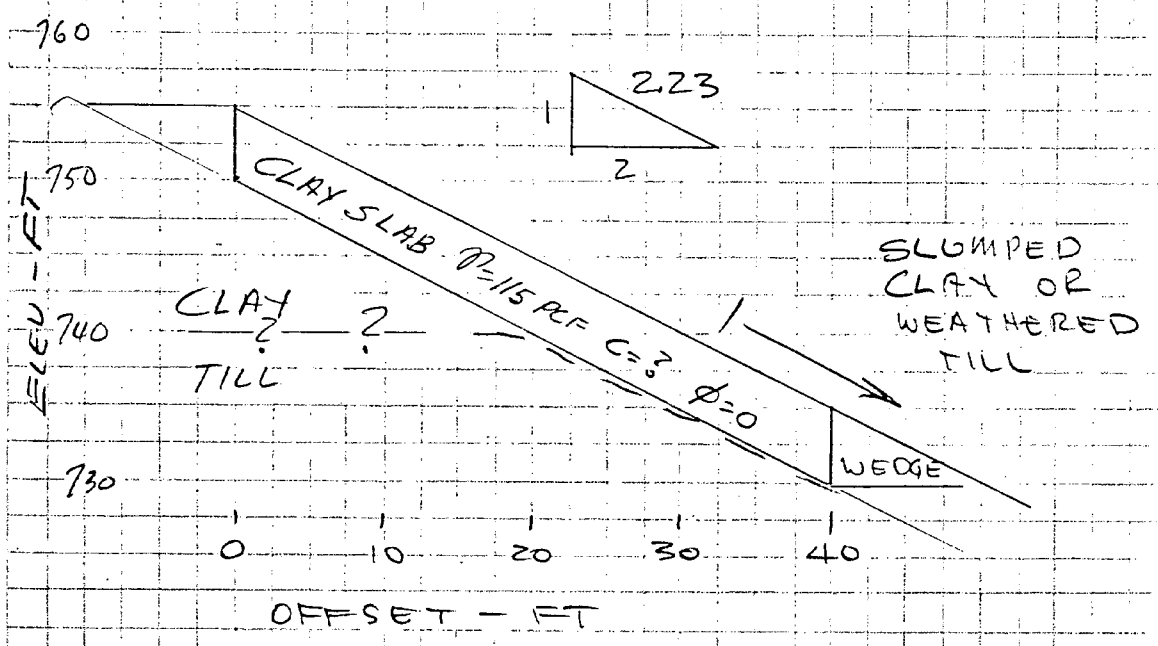

MUNICIPAL BOUNDARIES
TOWNS
GRAVEL PITS
FLOODWAY BRIDGES
GAUGE LOCATIONS
RED RIVER
LISTER'S RAPIDS
CANADIAN NATIONAL
RIVER
FLOODWAY
LOCKPORT
PUBLIC
OUTLET CONTROL WORKS
W.S. 05OJ010
W.S. 05OJ014
RANGE 4E
RANGE 5E
TOWNSHIP 12
TOWNSHIP 13
RAILWAY

Fig. 1

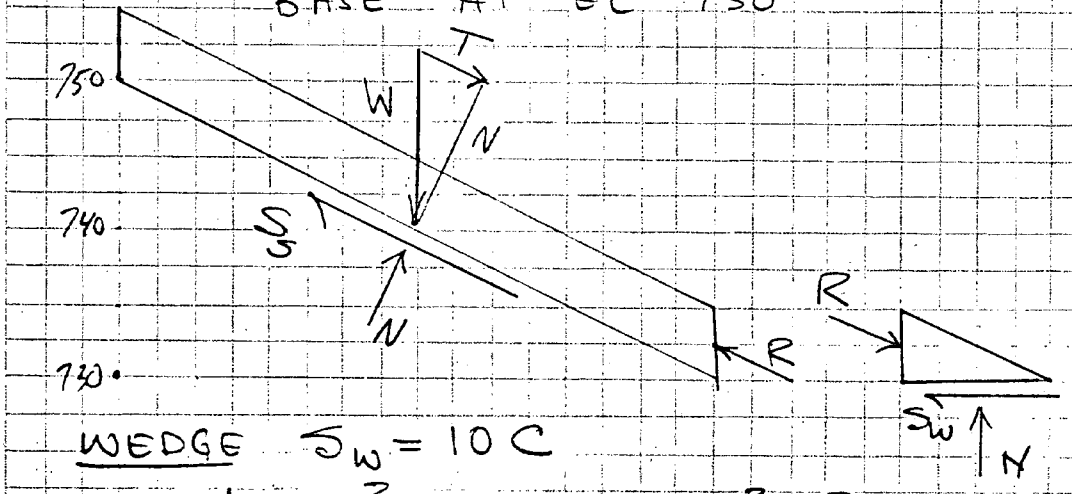
PROVINCE OF MANITOBA
WATER RESOURCES BRANCH

PROJECT No. | SCHEME RED RIVER FLOODWAY | DATE | SHEET OF
ENGINEER F.P. | OUTLET STRUCTURE EROSION

FIELD INSPECTION INDICATES SLOPE FAILURE MAY BE REPRESENTED BY A 5 FOOT THICK SLAB OF CLAY OR WEATHERED TILL SLIDING DOWN A 2:1 SLOPE AS SHOWN BELOW.



CASE 1 EXISTING BANK BEFORE 1974 EROSION. SLAB FROM EL 730 TO 750, CLAY WEDGE WITH BASE AT EL 730



WEDGE $S_W = 10C$

$$\Sigma H = \frac{2}{2.23} R - S_W = \frac{2}{2.23} R - 10C = 0$$

$$R = \frac{2.23}{2} \times 10C = 11.1C$$

MNR-pl-17

ITEM 5

PROVINCE OF MANITOBA
WATER RESOURCES BRANCH

PROJECT No. | SCHEME | DATE | SHEET 2 OF
ENGINEER

SLAB $W = 40 \times 5 \times 115 = 23{,}000$ LB

$T = \frac{1}{2.23} W = \frac{1}{2.23} \times 23{,}000 = 10{,}300$ LB

$S_s = \frac{2.23}{2} \times 40C = 44.6\,C$

Σ SLOPE $= T - S_s - R = 10{,}300 - 44.6C - 11.1C = 0$

$C = \frac{10{,}300}{55.7} = 185$ PSF

EXISTING BANK IS MARGINALLY STABLE.
HENCE CONSIDER SF = 1.0

CASE 2 EXISTING BANK AFTER 1974 EROSION
THIS IS SAME AS CASE 1 EXCEPT
WEDGE HAS BEEN REMOVED.

Σ SLOPE $= T - S_s = 10{,}300 - 44.6C = 0$

$C = \frac{10{,}300}{44.6} = 230$ PSF

$SF = \frac{185}{230} = 0.8$

CASE 3 ROCK FILL PLACED AGAINST
INTACT TILL REDUCES LENGTH
OF SLAB TO THAT CORRESPONDING
TO 10 FT HIGH CLAY BANK.
CASE 3 IS SIMILAR TO CASE 1 WITH
BASE OF WEDGE AT ELEV 740

$R = 11.1C$

$S_s = \frac{1}{2} \times 44.6C = 22.3\,C$

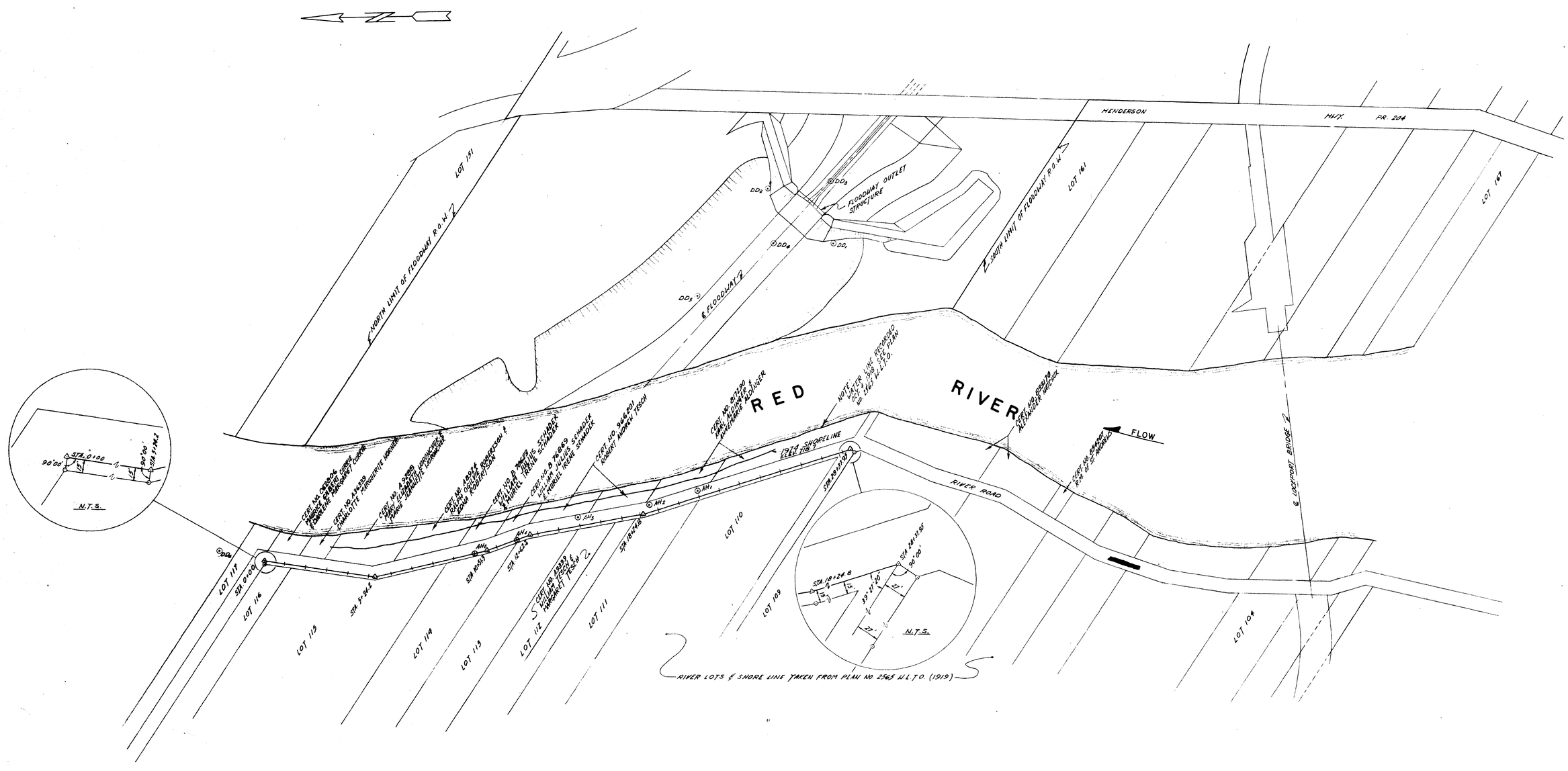
$T = \frac{1}{2} \times 10{,}300 = 5{,}150$ LB

Σ SLOPE $= T - S_s - R = 5{,}150 - 22.3C - 11.1C = 0$

$C = \frac{5{,}150}{33.4C} = 154$ PSF

$SF = \frac{185}{154} = 1.2$

MNR-pl-17



LEGEND

- ⊙ DRILL HOLE
- ⊙ IRON SURVEY PIN LOCATED BY W.R.B.
- △ IRON PIN PLACED BY W.R.B.

0 200 400
SCALE IN FEET

DATUM: GEODETIC

FIELD BOOK	FILE NO. W.C.C. 6068						
SURVEY BRANCH FIELD BOOK	FILE NO. 2257						
EXISTING EROSION	FILE NO. 11-1-1522						
REMEDIAL WORK	FILE NO. 11-1-1523	DATE	REMARKS	NAME			
CROSS REFERENCES		REVISIONS			APPROVED AS TO:		

DRAWN: T.L. MILLAR
SURVEYED: JULY/74 ALLEN VERNON
DESIGNED:
CHECKED:
REVIEWED: FOR OPERATIONS
RECOMMENDED: DIRECTOR OF OPERATIONS

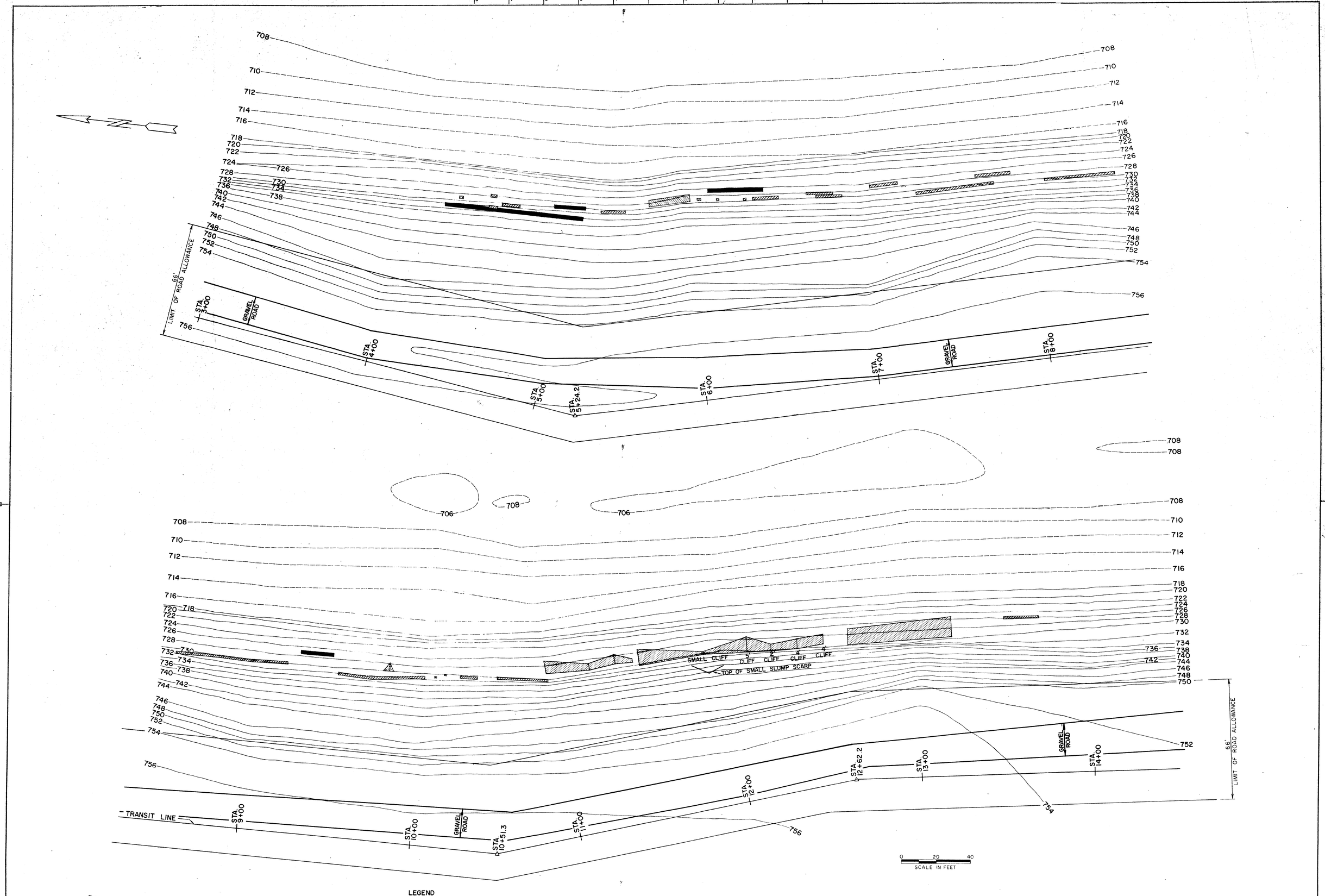
PROVINCE OF MANITOBA
DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT
WATER RESOURCES BRANCH

SUBMITTED: 6 Dec 74
APPROVED: DIRECTOR OF PLANNING

R.M. OF ST. ANDREWS
SITE PLAN
1974
RED RIVER FLOODWAY OUTLET CONTROL STRUCTURE
EROSION INVESTIGATION
IN
PARISH OF ST. ANDREWS
RIVER LOTS 110 TO 116

SCALE:	DATE:	SHEET:	FILE NO.
AS SHOWN	OCT./74	1 OF 1	11-1-1521

FIG. NO. 1



LEGEND

- EROSION SCARPS ≥ 3' WIDE
- EROSION SCARPS < 3' WIDE
- LAG DEPOSITS NO SIGN OF SCARPS
- SURFACE CONTOURS
- UNDERWATER CONTOURS

FIELD BOOK	FILE NO. W.C.C. 6068					
SURVEY BRANCH FIELD BOOK	FILE NO. 2257					
SITE PLAN	FILE NO. 11-1-1521					
REMEDIAL WORK	FILE NO. 11-1-1523	DATE	REMARKS	NAME		
CROSS REFERENCES		REVISIONS			APPROVED AS TO:	

DRAWN: W.K. WARNOCK
SURVEYED: JULY/74 ALLEN VERNON
DESIGNED:
CHECKED:
REVIEWED: FOR OPERATIONS
RECOMMENDED: DIRECTOR OF OPERATIONS

PROVINCE OF MANITOBA
DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT
WATER RESOURCES BRANCH

SUBMITTED: F. Bernard 6 Dec 74
APPROVED: G. Lindsay DIRECTOR OF PLANNING

DATUM: GEODETIC

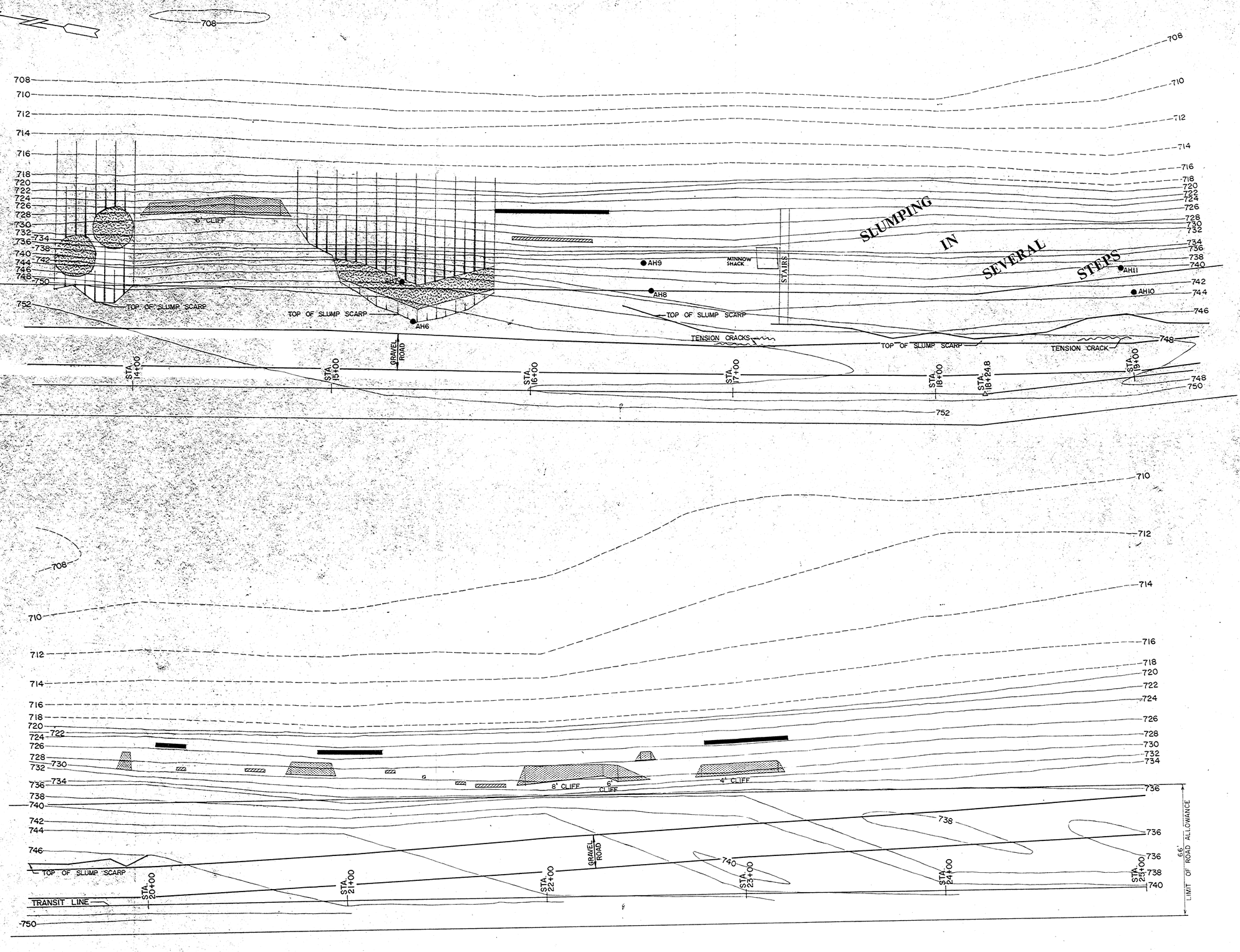
R.M. OF ST. ANDREWS

EXISTING EROSION

1974
RED RIVER FLOODWAY OUTLET CONTROL STRUCTURE
EROSION INVESTIGATION
IN
PARISH OF ST. ANDREWS
RIVER LOTS 113 TO 116

SCALE:	DATE:	SHEET:	FILE NO.
AS SHOWN	NOV. /74	1 OF 2	11-1-1522

FIG. NO. 2-1



LEGEND

- SURFACE CONTOURS
- UNDERWATER CONTOURS
- EROSION SCARPS ≥ 3' WIDE
- EROSION SCARPS < 3' WIDE
- LAG DEPOSITS NO SIGN OF SCARPS
- SLUMPED MASSES
- ● AH7 AUGER HOLE

0 20 40
SCALE IN FEET

DATUM: GEODETIC

FIELD BOOK	FILE NO. W.C.C. 6068					DRAWN: W.K. WARNOCK	SURVEYED: JULY/74 ALLEN VERNON	
SURVEY BRANCH FIELD BOOK	FILE NO. 2257					DESIGNED:		
SITE PLAN	FILE NO. 11-1-1521					APPROVED:		
REMEDIAL WORK	FILE NO. 11-1-1523	DATE	REMARKS	NAME		REVIEWED: FOR OPERATIONS		
CROSS REFERENCES		REVISIONS			APPROVED AS TO.	RECOMMENDED: DIRECTOR OF OPERATIONS		

PROVINCE OF MANITOBA
DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT
WATER RESOURCES BRANCH

SUBMITTED: 6 Aug 74
APPROVED: DIRECTOR OF PLANNING

R.M. OF ST. ANDREWS

EXISTING EROSION

1974
RED RIVER FLOODWAY OUTLET CONTROL STRUCTURE
EROSION INVESTIGATION
IN
PARISH OF ST. ANDREWS
RIVER LOTS 110 TO 113

SCALE:	DATE:	SHEET:	FILE NO:
AS SHOWN	NOV. /74	2 OF 2	11-1-1522

FIG. NO. 2-2

PROVINCE OF MANITOBA
DEPARTMENT OF MINES AND NATURAL RESOURCES

WATER CONTROL & CONSERVATION BRANCH
PLANNING DIVISION

SOIL TEST HOLE LOG

PROPOSED PROJECT: RED RIVER FLOODWAY OUTLET EROSION

TEST HOLE NO. AH1
PROJECT NO. SG 554
WATERSHED NO. WS ∝

ENTERED: D.K.
CHECKED:
APPROVED:
RECORDING TECHNICIAN: T. BUCK
FIELD BOOK: S.M. 725
LAB ORDER: S.M. 1010
DATE OF BORING: AUG. 7, 1974
LOCATION: WEST BANK 25' E. OF STA. 21+00 ON RIVER SHOULDER

SAMPLE IDENTIFICATION — SAMPLING METHOD: 2" DIA. SPLIT TUBE ☑; SHELBY TUBE ■; BAG SAMPLE {

GROUND WATER OBSERVATIONS & NOTES: HOLE DRY UPON COMPLETION

TYPE OF EQUIPMENT USED: FILE FOUNDATION 12"ϕ & 16"ϕ AUGERS.

STANDARD PENETRATION (ASTM D1586) N ● — ● BLOWS/FT.
CL-700 POCKET PENETROMETER q_u ○ — ○ K.S.F
UNCONFINED COMPRESSIVE STRENGTH q_u ⊕ - - - - ⊕ K.S.F

CONSISTENCY: NATURAL MOISTURE CONTENT —○—; WET DENSITY —●—; PLASTIC LIMIT ├──┤ LIQUID LIMIT

LAB. NO.	FIELD NO.	TYPE	PERMEABILITY (K, FT./MIN)	ORGANIC CONTENT (%)	SULFATE CONTENT (SO_4, %)	SWELLING PRESSURE (P_s, K.S.F)	COMPRESSION INDEX (C_c)	MAXIMUM PRECONSOLIDATION LOAD (P_o', K.S.F)	TOTAL LATERAL STRESS (σ_3, P.S.I)	TYPE OF TEST	ANGLE OF INT. FRICTION (ϕ, DEG)	COHESION (c, K.S.F)	DEVIATOR STRESS ($\sigma_1-\sigma_3$, P.S.I)	STRENGTH AS RECEIVED (qu, K.S.F)	REMOLDED STRENGTH (qu', K.S.F)	STRAIN AT FAILURE (%)	WET DENSITY (γ, LBS./FT.³)	SPECIFIC GRAVITY (Gs)	VOID RATIO (e)	DEGREE OF SATURATION (Sr, %)	CLAY (<.002 MM, %)	SILT (.002 MM TO NO.200, %)	SAND (NO.200 TO NO.4, %)	GRAVEL (NO.4 TO 3", %)	UNIFORMITY COEFFICIENT ($C_u = D_{60}/D_{10}$)	EFFECTIVE GRAIN SIZE (D_{10}, MM)	LIQUID LIMIT (ω_L, %)	PLASTIC LIMIT (ω_p, %)	PLASTICITY INDEX (I_p, %)	NATURAL MOISTURE CONTENT (ω, %)	SOIL DESCRIPTION & NOTES	UNIFIED SYMBOLS	ELEV. (FT.)	DEPTH (FT.)
5100	T1	■																									58	24	34	23	CLAY; HIGH PLASTIC; BROWN; VERY STIFF; NUM. SILT POCKETS & LENSES; TRACE ORGANIC AND PEBBLES.	CH		0
5101	T2	■																			35		25	40						5	CLAY; SILTY; SANDY; GRAVELLY (MAX. 1½"ϕ); LOW PLASTIC; BROWN; HARD; DRY; NUM. COBBLES AND BOULDERS (TILL MATERIAL)	GM-GC		5, 9', 10
5102	S3	▨																			60		31	9			17	12	5	7		CL-ML		15, 19', 20

NOTE:
1. REFUSAL TO 12"ϕ AUGER @ D=19' DUE TO BOULDERS.
2. MOVED 10' NORTH AND REDRILLED, REFUSAL AT D=11'

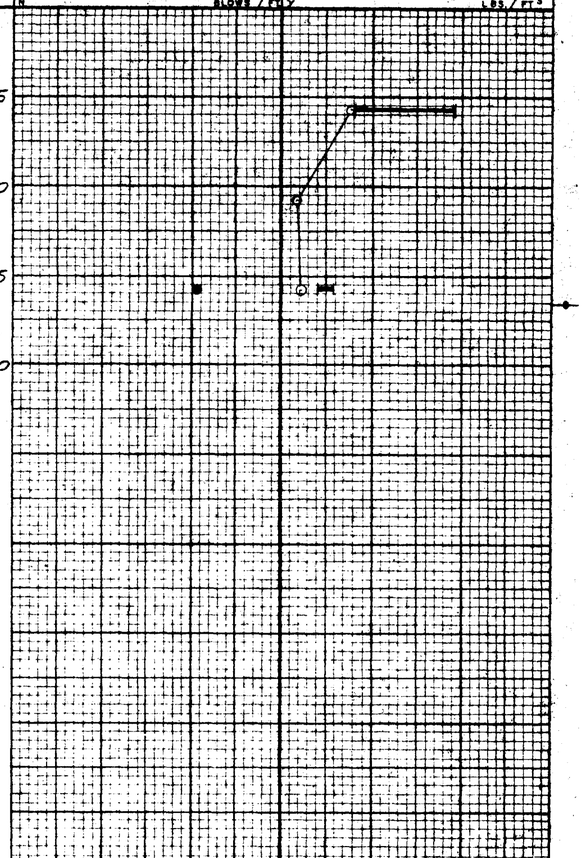


FIG. 3-1 M.283

PROVINCE OF MANITOBA
DEPARTMENT OF MINES AND NATURAL RESOURCES

SOIL TEST HOLE LOG

PROPOSED PROJECT: RED RIVER FLOODWAY OUTLET EROSION

TEST HOLE NO. AH 2
PROJECT NO. SG-554
WATERSHED NO. WS-α

WATER CONTROL & CONSERVATION BRANCH
PLANNING DIVISION

ENTERED: D.K.
CHECKED:
APPROVED:
RECORDING TECHNICIAN: T. BUCK
FIELD BOOK S.M. 725
LAB ORDER S.M. 1010
DATE OF BORING: AUG. 7, 1974
LOCATION: WEST BANK 30' E. OF STA. 13+70 ON RIVER SHOULDER

GROUND WATER OBSERVATIONS & NOTES: HOLE DRY UPON COMPLETION.
TYPE OF EQUIPMENT USED: PILE FOUNDATION 12"φ & 16"φ AUGERS

SAMPLE IDENTIFICATION — SAMPLING METHOD: 2" DIA SPLIT TUBE; SHELBY TUBE; BAG SAMPLE

LAB. NO	FIELD NO.	TYPE	PERMEABILITY (K) FT./MIN	ORGANIC CONTENT %	SULFATE CONTENT (SO4) %	SWELLING PRESSURE (Ps) K.S.F	COMPRESSION INDEX (Cc)	MAXIMUM PRECONSOLIDATION LOAD (Po') K.S.F	TOTAL LATERAL STRESS (σ3) P.S.I	TYPE OF TEST	ANGLE OF INT. FRICTION (φ) DEG	COHESION (c) K.S.F	DEVIATOR STRESS (σ1-σ3) P.S.I	STRENGTH AS RECEIVED (qu) K.S.F	REMOLDED STRENGTH (qu') K.S.F	STRAIN AT FAILURE %	WET DENSITY (γ) LBS./FT.³	SPECIFIC GRAVITY (Gs)	VOID RATIO (e)	DEGREE OF SATURATION (Sr) %	CLAY <.002MM %	SILT .002MM TO NO.200 %	SAND NO.200 TO NO.4 %	GRAVEL NO.4 TO 3" %	UNIFORMITY COEFFICIENT (Cu=D60/D10)	EFFECTIVE GRAIN SIZE (D10) mm	LIQUID LIMIT (ωL) %	PLASTIC LIMIT (ωp) %	PLASTICITY INDEX (Ip) %	NATURAL MOISTURE CONTENT (ω) %	SOIL DESCRIPTION & NOTES	UNIFIED SYMBOLS	ELEV FT.	DEPTH FT.
5103	T1													1.57			116.2														36	CLAY; HIGH PLASTIC; BROWN; STIFF; NUM. SILT POCKETS AND LENSES. TRACE OF OXIDES. SAND AND GRAVEL.	CH		0
5104	T2																					58		26	16			20	14	6	9		CL-ML		9½'
5105	S3																														7	CLAY; SILTY; SANDY; GRAVELLY (MAX. 12"φ); LOW PLASTIC; BROWN; HARD; DRY; NUM. COBBLES + BOULDERS (TILL MATERIAL)			
5106	S4																					56		30	14			16	12	4	8		CL-ML		
5107	S5																														6				27'

NOTE: REFUSAL TO 12"φ AUGER @ D=27' DUE TO BOULDERS.

CONSISTENCY: NATURAL MOISTURE CONTENT; WET DENSITY; PLASTIC LIMIT — LIQUID LIMIT

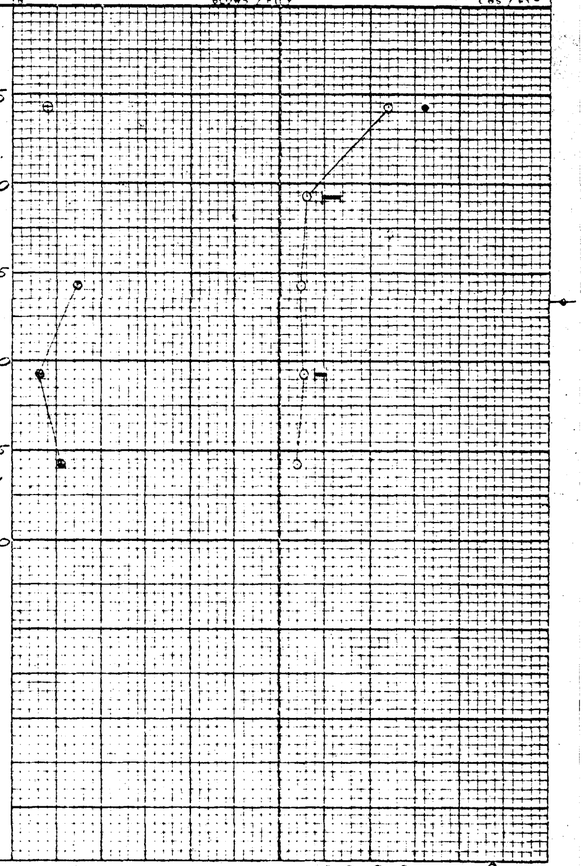


FIG. 3-2 M.283

PROVINCE OF MANITOBA
DEPARTMENT OF MINES AND NATURAL RESOURCES

SOIL TEST HOLE LOG

PROPOSED PROJECT: RED RIVER FLOODWAY OUTLET EROSION

TEST HOLE NO. AH3
PROJECT NO. SG-554
WATERSHED NO. WS α

WATER CONTROL & CONSERVATION BRANCH
PLANNING DIVISION

ENTERED: D.K.
CHECKED:
APPROVED:
RECORDING TECHNICIAN: T. BUCK
FIELD BOOK: S.M.I. 725
LAB ORDER: S.M. 1010
DATE OF BORING: AUG. 1, 1974
LOCATION: WEST BANK 37' E. OF STA. 15+00 ON RIVER SHOULDER

GROUND WATER OBSERVATIONS & NOTES: HOLE DRY UPON COMPLETION

TYPE OF EQUIPMENT USED: FILE FOUDATION 12"φ & 16"φ AUGERS

SAMPLE IDENTIFICATION — SAMPLING METHOD: 2" DIA SPLIT TUBE; SHELBY TUBE; BAG SAMPLE

LAB NO	FIELD NO.	TYPE	MISCELLANEOUS: PERMEABILITY (K, FT/MIN)	ORGANIC CONTENT (%)	SULFATE CONTENT (SO4, %)	CONSOLIDATION: SWELLING PRESSURE (Ps, K.S.F)	COMPRESSION INDEX (Cc)	MAXIMUM PRECONSOLIDATION LOAD (Po', K.S.F)	TRIAXIAL COMPRESSION: TOTAL LATERAL STRESS (σ3, P.S.I)	TYPE OF TEST	ANGLE OF INT. FRICTION (φ, DEG)	COHESION (c, K.S.F)	DEVIATOR STRESS (σ1-σ3, P.S.I)	UNCONFINED COMPRESSIVE STRENGTH: STRENGTH AS RECEIVED (qu, K.S.F)	REMOLDED STRENGTH (qu', K.S.F)	STRAIN AT FAILURE (%)	VOLUMETRIC DATA: WET DENSITY (γ, LBS./FT³)	SPECIFIC GRAVITY (Gs)	VOID RATIO (e)	DEGREE OF SATURATION (Sr, %)	MECHANICAL ANALYSIS: CLAY (<.002MM, %)	SILT (.002MM TO NO.200, %)	SAND (NO.200 TO NO.4, %)	GRAVEL (NO.4 TO 3", %)	UNIFORMITY COEFFICIENT (Cu=D60/D10)	EFFECTIVE GRAIN SIZE (D10, mm)	ATTERBERG LIMITS: LIQUID LIMIT (ωL, %)	PLASTIC LIMIT (ωp, %)	PLASTICITY INDEX (Ip, %)	NATURAL MOISTURE CONTENT (ω, %)	SOIL DESCRIPTION & NOTES	UNIFIED SYMBOLS	ELEV (FT)	DEPTH (FT)
5108	T1													4.44			125.8										56	28	33	24	CLAY; HIGH PLASTIC; BROWN; HARD. NUM. SILT POCKETS & LENSES. TRACE OF TILL. SAND POCKETS AND PEBBLES.	CH		5
5109	T2													4.57			120.0													29				10
5110	T3																					53	32	15			18	12	4	7	CLAY; SILTY; SANDY, GRAVELLY (MAX. 12"φ); LOW PLASTIC; BROWN; DRY; STIFF - HARD; NUM. COBBLES & BOULDERS. (TILL MATERIAL)	CL-ML	12'	15
																															NOTE: REFUSAL TO 16"φ AUGER @ D=19' DUE TO BOULDERS.		19'	20

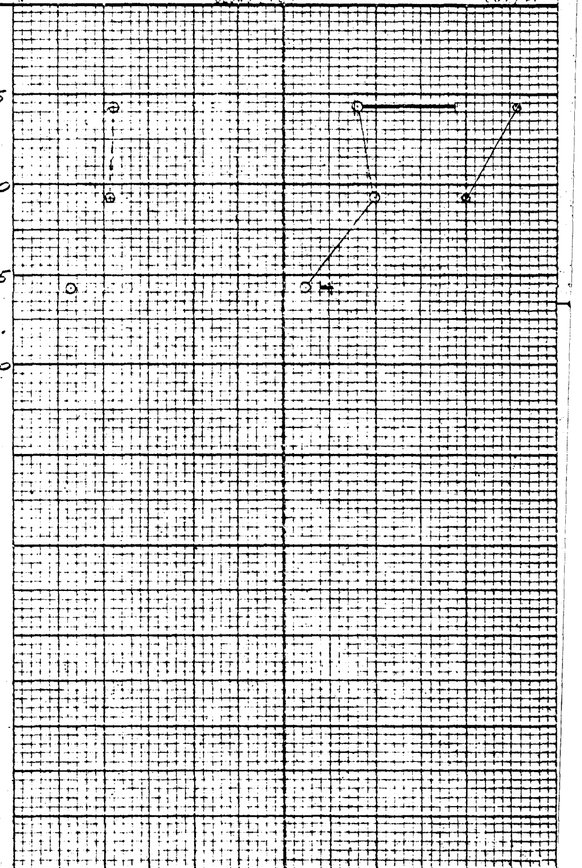


FIG. 3-3 M.283

PROVINCE OF MANITOBA
DEPARTMENT OF MINES AND NATURAL RESOURCES

SOIL TEST HOLE LOG

PROPOSED PROJECT: RED RIVER FLOODWAY OUTLET EROSION

TEST HOLE NO. AH4
PROJECT NO. SG-554
WATERSHED NO. WS-2

WATER CONTROL & CONSERVATION BRANCH
PLANNING DIVISION

ENTERED: D.K
CHECKED:
APPROVED:
RECORDING TECHNICIAN: T. BUCK
FIELD BOOK: S.M.I. 725
LAB ORDER: S.M. 1010
DATE OF BORING: AUG. 7, 1974
LOCATION: WEST BANK AT STA. 12+00

GROUND WATER OBSERVATIONS & NOTES: HOLE DRY UPON COMPLETION

TYPE OF EQUIPMENT USED: PILE FOUNDATION 16"φ AUGERS

STANDARD PENETRATION (ASTM D1586) N — BLOWS/FT.
CL-700 POCKET PENETROMETER q_u — K.S.F
UNCONFINED COMPRESSIVE STRENGTH q_u — K.S.F

CONSISTENCY: NATURAL MOISTURE CONTENT; WET DENSITY; PLASTIC LIMIT — LIQUID LIMIT

LAB NO	FIELD NO.	TYPE	PERMEABILITY (FT./MIN)	ORGANIC CONTENT (%)	SULFATE CONTENT (%)	SWELLING PRESSURE (K.S.F)	COMPRESSION INDEX (Cc)	MAXIMUM PRECONSOLIDATION LOAD (Po' K.S.F)	TOTAL LATERAL STRESS (σ_3 P.S.I)	TYPE OF TEST	ANGLE OF INT. FRICTION (φ DEG)	COHESION (c K.S.F)	DEVIATOR STRESS ($\sigma_1-\sigma_3$ P.S.I)	STRENGTH AS RECEIVED (qu K.S.F)	REMOLDED STRENGTH (qu' K.S.F)	STRAIN AT FAILURE (%)	WET DENSITY (γ LBS./FT.³)	SPECIFIC GRAVITY (Gs)	VOID RATIO (e)	DEGREE OF SATURATION (Sr %)	CLAY (.002MM %)	SILT (.002MM TO NO.200 %)	SAND (NO.200 TO NO.4 %)	GRAVEL (NO.4 TO 3" %)	UNIFORMITY COEFFICIENT (C_u D60/D10)	EFFECTIVE GRAIN SIZE (D10 mm)	LIQUID LIMIT (ω_L %)	PLASTIC LIMIT (ω_p %)	PLASTICITY INDEX (I_p %)	NATURAL MOISTURE CONTENT (ω %)
5111	T1																														13
5112	T2																				80	10	2				70	26	44	31
5113	T3																				60	27	13				38	17	21	24
5114	S4																				50	31	19				17	12	5	7

SOIL DESCRIPTION & NOTES:

UNIFIED SYMBOLS	ELEV (FT)	DEPTH (FT)	SOIL DESCRIPTION & NOTES
CH		0–12½	CLAY; HIGH PLASTIC; BROWN; STIFF TO HARD; NUM. SILT POCKETS + LENSES; TRACE OF SLICKS AND OXIDES; TRACE SAND AND GRAVEL.
CI		12½–17	CLAY; SILTY; SANDY; GRAVEL MAX 1½"φ; MED. PLASTIC; GREY; STIFF; NUM. SILT LENSES.
CL ML		17–22	CLAY; SILTY; SANDY; GRAVELLY (MAX. 2½"φ); LOW PLASTIC; BROWN; HARD; DRY; NUM. COBBLES AND BOULDERS. (TILL MATERIAL)

NOTE:
REFUSAL TO S.P.T. @ D=21.3'.
REFUSAL TO 16"φ AUGER @ D=22'.

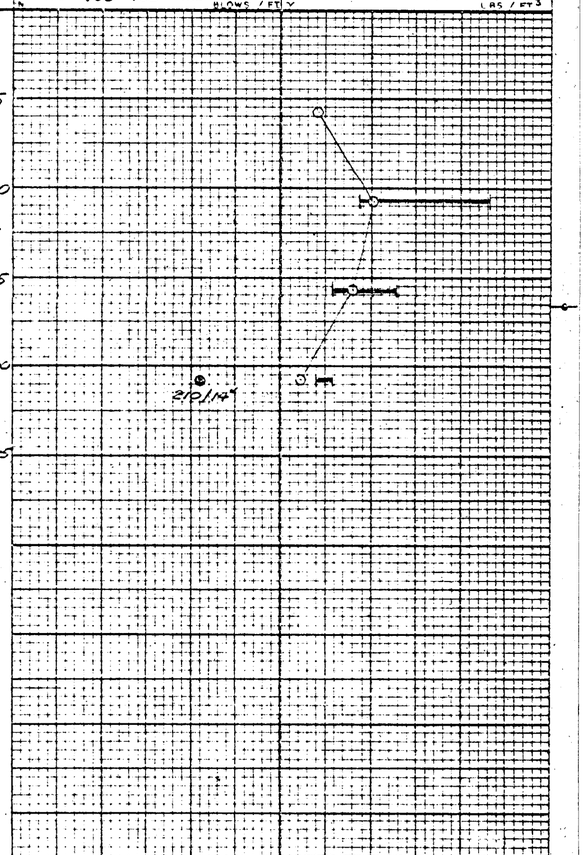


FIG. 3-4 M.283

PROVINCE OF MANITOBA
DEPARTMENT OF MINES AND NATURAL RESOURCES

WATER CONTROL & CONSERVATION BRANCH
PLANNING DIVISION

SOIL TEST HOLE LOG

PROPOSED PROJECT: RED RIVER FLOODWAY OUTLET EROSION

TEST HOLE NO. AH5
PROJECT NO. SG-554
WATERSHED NO. WS-α

ENTERED: D.K.
CHECKED:
APPROVED:
RECORDING TECHNICIAN: T. BUCK
FIELD BOOK: S.M.I. 725
LAB ORDER: S.M. 1010
DATE OF BORING: AUG. 7, 1974
LOCATION: WEST BANK AT STA 10+00

GROUND WATER OBSERVATIONS & NOTES: HOLE DRY UPON COMPLETION.

TYPE OF EQUIPMENT USED: PILE FOUNDATION 16"φ AUGER

STANDARD PENETRATION (ASTM D1586) N ● — ● BLOWS/FT.
CL-700 POCKET PENETROMETER % ○ — ○ K.S.F
UNCONFINED COMPRESSIVE STRENGTH % ⊕ - - - - - ⊕ K.S.F

CONSISTENCY: NATURAL MOISTURE CONTENT —○— ; WET DENSITY —●— ; PLASTIC LIMIT ├──┤ LIQUID LIMIT

SAMPLE IDENTIFICATION: LAB NO	FIELD NO.	TYPE (SAMPLING METHOD: 2" DIA. SPLIT TUBE, SHELBY TUBE, BAG SAMPLE)	MISCELLANEOUS: PERMEABILITY (K) FT./MIN	ORGANIC CONTENT %	SULFATE CONTENT (SO4) %	CONSOLIDATION: SWELLING PRESSURE (Ps) K.S.F	COMPRESSION INDEX (Cc)	MAXIMUM PRECONSOLIDATION LOAD (Po') K.S.F	TRIAXIAL COMPRESSION: TOTAL LATERAL STRESS (σ3) P.S.I	TYPE OF TEST	ANGLE OF INT. FRICTION (φ) DEG	COHESION (c) K.S.F	DEVIATOR STRESS (σ1-σ3) P.S.I	UNCONFINED COMPRESSIVE STRENGTH: STRENGTH AS RECEIVED (qu) K.S.F	REMOLDED STRENGTH (qu') K.S.F	STRAIN AT FAILURE %	VOLUMETRIC DATA: WET DENSITY (γ) LBS./FT.³	SPECIFIC GRAVITY (Gs)	VOID RATIO (e)	DEGREE OF SATURATION (Sr) %	MECHANICAL ANALYSIS: CLAY .002MM %	SILT .002MM TO NO.200 %	SAND NO.200 TO NO.4 %	GRAVEL NO.4 TO 3" %	UNIFORMITY COEFFICIENT (Cu = D60/D10)	EFFECTIVE GRAIN SIZE (D10) mm	ATTERBERG LIMITS: LIQUID LIMIT (ωL) %	PLASTIC LIMIT (ωp) %	PLASTICITY INDEX (Ip) %	NATURAL MOISTURE CONTENT (ω) %	SOIL DESCRIPTION & NOTES	UNIFIED SYMBOLS	ELEV FT.	DEPTH FT.
5115	T1													9.56			126.3															22	CLAY; HIGH PLASTIC; BROWN; HARD TO STIFF; NUM. SILT POCKETS AND LENSES; TRACE SAND. GRAVEL AND TILL POCKETS.	CH		0
5116	T2													6.52			127.5				34	10	6				66	24	42	22					5
5117	T3													4.05 5.94			116.5 112.2													35 40					10
5118	T4																				41	26	33				20	12	8	8	GRAVEL MAX. 3"φ; SANDY; SILTY; CLAYEY; LOW PLASTIC FINES; BROWN; DENSE; DRY; NUM. COBBLES AND BOULDERS. (TILL MATERIAL)	GC		15 18
5118A	S5																													7					20 25 27

NOTE: REFUSAL TO 16"φ AUGER @ D=24'; MOVED 15' N. & RE-DRILLED. REFUSAL @ D=27'.

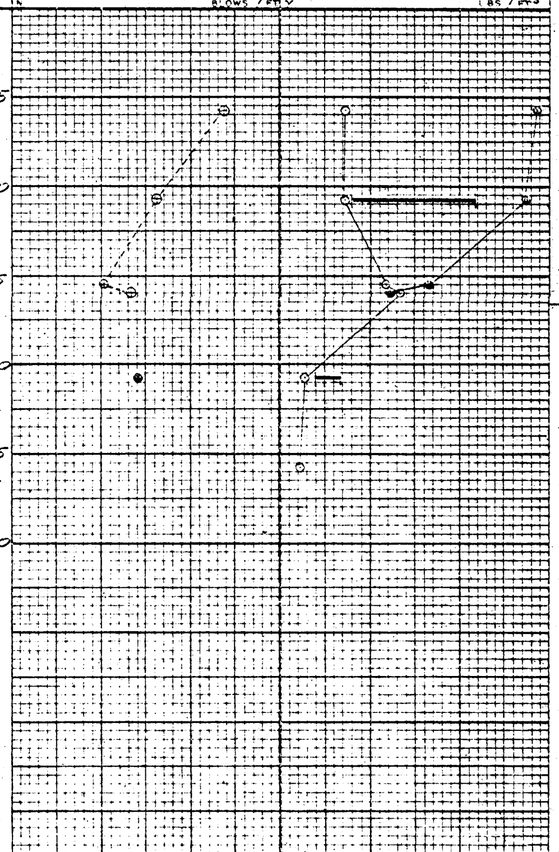


FIG. 3-5 M.283

H. G. ACRES & COMPANY LIMITED — CONSULTING ENGINEERS
NIAGARA FALLS, CANADA

DRILLING REPORT

CLIENT: Province of Manitoba
Department of Agriculture Conservation Branch — JOB No. 940

PROJECT: Red River Floodway — HOLE No. DD01

SITE: Outlet Works — SHEET No. 1 OF 2

CONTRACTOR: Midwest Diamond Drilling Limited — STARTED 2:30 P.M. November 20, 1961 — FINISHED 1:00 .M. November 23, 1961

METHOD OF DRILLING: SOIL 4" flite auger - 42' — CASING DIAM. NX -46'
ROCK Diamond Drilling - 54' — CORE DIAM. NX 46 - 54

LOCATION: LATITUDE *
DEPARTURE
BEARING
INITIAL DIP 90°
OTHER DIPS

ELEVATIONS: DATUM G.S.C.
DRILL PLATFORM --
GROUND SURFACE 753.8
ROCK SURFACE 707.8
BOTTOM OF HOLE 699.8
WATER TABLE 724±

* See Acres' drawing SK 940-C-7

DEPTH	SOIL TYPE	DESCRIPTION, COLOUR, CONSISTENCY, STRUCTURE, WATER CONTENT, PLASTICITY, COMPACTNESS, WATER LOSS OR GAIN, ETC.	SAMPLE NO	TYPE *	SIZE	DEPTH	RET'D	PENETRATION TEST
					inches	feet	in.	
0.0	Humus							
		Black topsoil in cultivated field, very dry and crumbly						
2.0	Silty Clay							
		Greyish brown silty clay mottled with small light and dark silt pockets, weathered, very stiff, only slightly moist in top portion. slight increase in moisture and decrease in weathering with depth. unable to turn the vane in this material	1	BO	2	5.0 6.5	16	pushed 10,000 lb.
			2	BO	2	10.0 11.5	15	pushed 10,000 lb.
14.5	Sandy silt Till		3	BO	2	15.0	nil	unable to push 12,000 lb.

SAMPLING METHOD
* A – SPLIT TUBE
B – THIN WALL TUBE
C – PISTON SAMPLER
D – CORE BARREL
E – AUGER
F – WASH

SHIPPING CONTAINER
N – INSERT
O – TUBE
P – WATER CONTENT TIN
Q – GLASS JAR
R – CLOTH BAG
S – PLIOFILM BAG
Z – DISCARDED

INSPECTOR H.W. Ryder
LOGGED BY H.W. Ryder
APPROVED PRELIMINARY
DATE

FIG. 3-6

H. G. AC S & COMPANY LIMITED – CONSI NG ENGINEERS
NIAGARA FALLS, CANADA

DRILLING REPORT

CLIENT: Province of Manitoba
Department of Agriculture Conservation Branch — JOB No. 940

PROJECT: Red River Floodway — HOLE No. DD01

SITE: Outlet Works — SHEET No. 2 OF 2

DEPTH	SOIL TYPE	DESCRIPTION, COLOUR, CONSISTENCY, STRUCTURE, WATER CONTENT, PLASTICITY, COMPACTNESS, WATER LOSS OR GAIN, ETC	SAMPLE NO	TYPE	SIZE	DEPTH	PEL	PENETRATION TEST blow/6"
					inches	feet	in.	
14.5			4	AS	2	20		
						20.5		36
						21.0	12	100
			5	AS	2	25.0		
						25.5		75
	Sandy silt (Till)	Light brown (yellowish) silty till containing many limestone and some granite boulders very dry and dense with several somewhat more moist and softer seams @ 31' and 35' noted, could be lack of larger stones encountered. Struck a water seam at 36'. In 36 hours water rose to 28.7'				26.0		100
						26.5		115
			6	AS	2	30		
						30.5		Disturbed
						31.0		
						31.5	10	70/10"
			7	AS	2	35		
						35.5		10
						35.5	6	200
			8		2	40	0	100/0"
		Impossible to auger beyond 42'						
46.0		Setup BBS-2 put down NX casing to 42' drilled till to 46'						
	Rock	Nodular dolomitic limestone or limestone. pale grey with moderate brown to limonite yellow nodules. finegrained - Hardness - 3.0 - 3.5 in nodules, 3.5 - 4.0 in pale grey component some irregular soft chalking inclusions and few hard siliceous inclusions in the grey component						
54.0		Water Table constant at El. 724± upon completion of hole						

PRELIMINARY

FIG. 3-6

H. G. ACRES & COMPANY LIMITED — CONSULTING ENGINEERS
NIAGARA FALLS, CANADA

DRILLING REPORT

CLIENT: Province of Manitoba, Department of Agriculture Conservation Branch — JOB No. 940

PROJECT: Red River Floodway — HOLE No. DD02

SITE: Outlet Works — SHEET No. 1 OF 2

CONTRACTOR: Midwest Diamond Drilling Limited — STARTED 2:00 P.M. November 21, 1961 — FINISHED 5:00 P.M. December 1, 1961

METHOD OF DRILLING: SOIL 4" flite augering - 31.5' — CASING DIAM. NX - 44.5

ROCK Diamond Drilling - 62.0' — CORE DIAM. NX - 44.5 - 62.0

LOCATION: LATITUDE *; DEPARTURE; BEARING; INITIAL DIP 90°; OTHER DIPS

ELEVATIONS: DATUM G.S.C.; DRILL PLATFORM; GROUND SURFACE 755.3; ROCK SURFACE 710.8; BOTTOM OF HOLE 693.3; WATER TABLE 724±

* See Acres' drawing BK 940-L-7

DEPTH	SOIL TYPE	DESCRIPTION: COLOUR, CONSISTENCY, STRUCTURE, WATER CONTENT, PLASTICITY, COMPACTNESS, WATER LOSS OR GAIN, ETC.	SAMPLE NO.	TYPE*	SIZE	DEPTH	RET'D	PENETRATION TEST
					inches	feet	in.	
0.0	Humus	Black topsoil, cultivated land, very dry and crumbly						
1.0	Silty clay	Mottled dark brown changing to light grey-brown. Weathered and dry with weathering decreasing with depth. containing dark and light silt pockets and some gravel particles and cobbles (mostly limestone) up to 6"	1	BO	2	5.0 6.5	18	pushed 10,000 lb.
				Vane Test		7.0		
			2	BO	2	10.0 11.5		pushed 10,000 lb.
				Vane Test		12.0		
			3	BO	2	15.0 16.5	16	pushed 10,000 lb.
				Vane Test		17.5		
			4	BO	2	20 21.5	15	pushed 10,000 lb.
21.0	Sandy silt (Till)							

SAMPLING METHOD
* A – SPLIT TUBE
B – THIN WALL TUBE
C – PISTON SAMPLER
D – CORE BARREL
E – AUGER
F – WASH

SHIPPING CONTAINER
N – INSERT
O – TUBE
P – WATER CONTENT TIN
Q – GLASS JAR
R – CLOTH BAG
S – PLIOFILM BAG
Z – DISCARDED

INSPECTOR: H.W. Ryder

LOGGED BY: H.W. Ryder

APPROVED: PRELIMINARY

DATE

FIG. 3-7

H. G. A[illegible]S & COMPANY LIMITED — CONS[illegible]ING ENGINEERS
NIAGARA FALLS, CANADA

DRILLING REPORT

CLIENT: Province of Manitoba
Department of Agriculture Conservation Branch

JOB No. 940

PROJECT: Red River Floodway

HOLE No. DD02

SITE: Outlet Works

SHEET No. 2 OF 2

DEPTH	SOIL TYPE	DESCRIPTION: COLOUR, CONSISTENCY, STRUCTURE, WATER CONTENT, PLASTICITY, COMPACTNESS, WATER LOSS OR GAIN, ETC	SAMPLE NO	TYPE	SIZE inches	DEPTH feet	REC'D in.	PENETRATION TEST blow/6"
21.0	Sandy silt (Till)	Light brown (yellowish)						
		Very dry mainly with some areas more moist. very crumbly and dense, not cohesive unless quite moist	5	RO	2	25.0 26.5	16	
		numerous small and large stones	6	RS	2	30 30.5 30.8	10	22 78
		Unable to auger beyond 31.5'						
42.0		Setup BBS-2 ran NX casing to 42.0 with drill water return. many large cobbles mostly limestone but some granites						
	Gravel	Very porvious open granular material, all drill water lost. when 7 gpm was poured into casing water level could not be raised above elevation 724						
44.5	Rock	Nodular dolometic limestone, or limestond, sound, cove recovery 85% no water loss from 44.5 to 51.0 feet 51.0 feet all water lost and 7 gpm would not raise water level above elevation 724.						
62.0		2" Ø well drive point installed in bedrock with 2" Ø stand pipe to surface.						
		water level elevation 724						

PRELIMINARY

FIG. 3-7 (CONT.)

H. G. RES & COMPANY LIMITED — CON LTING ENGINEERS
NIAGARA FALLS, CANADA

DRILLING REPORT

CLIENT: Province of Manitoba, Department of Agriculture Conservation Branch — JOB No. 940

PROJECT: Red River Floodway — HOLE No. DD03

SITE: Outlet Works — SHEET No. 1 OF 2

CONTRACTOR: Midwest Diamond Drilling Limited — STARTED 1:00 P.M. November 22, 1961 — FINISHED 5:00 P.M. December 10, 1961

METHOD OF DRILLING: SOIL 4" Ø flite auger - 23.0 — CASING DIAM. NX - 41.0'

ROCK Diamond Drilling — CORE DIAM. NX - 410 - 93.5

LOCATION: LATITUDE * — DEPARTURE — BEARING — INITIAL DIP — OTHER DIPS

ELEVATIONS: DATUM G.S.C. — DRILL PLATFORM -- — GROUND SURFACE 753.2 — ROCK SURFACE 712.2 — BOTTOM OF HOLE 659.7 — WATER TABLE 724±

* See Acres' drawing SK 940-C-7

DEPTH	SOIL TYPE	DESCRIPTION: COLOUR, CONSISTENCY, STRUCTURE, WATER CONTENT, PLASTICITY, COMPACTNESS, WATER LOSS OR GAIN, ETC.	SAMPLE NO	TYPE *	SIZE	DEPTH	RET'D	PENETRATION TEST blows/6"
					inches	feet	in.	
0.0	Humus	Black dry and crumbly cultivated land						
2.0	Silty clay	Mottled dark brown very dry and weathered to depth of 7' containing gravel particles and cobbles, and light and dark silt pockets. Below 7' mottled medium brown with increasing water content	1	BO	2	5.0		pushed
						6.5	16	
			2	BS		7.0		
						9.0		
			3	BO	2	10.0		pushed
						11.5	16	
				Vane	Test	13.0		
			4	BO	2	15.0		pushed
						16.5		
				Vane	Test	18.0		
19.0	Sandy silt (Till)	Light brown (yellowish) dry silty till with many gravel particles and cobbles. unable to auger beyond 23.0'	5	BO	2	20	0	unable to push 12,000 lb.
			6	AS	2	20		
						20.5		45
						21.0		35
						21.5		30

SAMPLING METHOD
* A – SPLIT TUBE
B – THIN WALL TUBE
C – PISTON SAMPLER
D – CORE BARREL
E – AUGER
F – WASH

SHIPPING CONTAINER
N – INSERT
O – TUBE
P – WATER CONTENT TIN
Q – GLASS JAR
R – CLOTH BAG
S – PLIOFILM BAG
Z – DISCARDED

INSPECTOR H.W. Ryder

LOGGED BY H.W. Ryder

APPROVED PRELIMINARY

DATE

H. G. ACRES & COMPANY LIMITED — CONSULTING ENGINEERS
NIAGARA FALLS, CANADA

DRILLING REPORT

CLIENT: Province of Manitoba
Department of Agriculture Conservation Branch — JOB No. 940

PROJECT: Red River Floodway — HOLE No. DD03

SITE: Outlet Works — SHEET No. 2 OF 2

DEPTH	SOIL TYPE	DESCRIPTION, COLOUR, CONSISTENCY, STRUCTURE, WATER CONTENT, PLASTICITY, COMPACTNESS, WATER LOSS OR GAIN, ETC.	SAMPLE NO	TYPE	SIZE	DEPTH	RET'D	PENETRATION TEST
		Auger refusal at 23.0' using B48-2 drilled HX casing						
23.0	Boulder							
24.2	Silty sand (Till)	As above						
		Lost drill water at 37'						
		Recovered drill water when casing set in rock						
41.0	Rock							
	Dolomitic limestone or limestone	Nodular, pale grey with moderate brown to limonite yellow nodules, both components fine grain, hardness: 3-3.5 nodules; 3.5-4 pale grey components; in pale grey components there are a few irregular dessimated white and chalky and a few hard siliceous inclusions						
		Evidence of leaching decreasing with depth no leaching near bottom rock grinds easily						
		41.0 - 51.0 lost drill water				Core recovery	% 50	
		51.0 - 61.0						
		61.0 - 71.0					100	
		71.0 - 81.0					80	
		81.5 - 91.5					70	
		91.5 - 93.5					70	
93.5		End of hole						

PRELIMINARY

FIG. B-8 (CONT'D)

H. G. ACRES & COMPANY LIMITED — CONSULTING ENGINEERS
NIAGARA FALLS, CANADA

DRILLING REPORT

CLIENT: Province of Manitoba Department of Agriculture Conservation Branch — JOB No. 940

PROJECT: Red River Floodway — HOLE No. DD04

SITE: Outlet Works — SHEET No. 1 OF 2

CONTRACTOR: Midwest Diamond Drilling Limited — STARTED 4:00 P.M. November 22, 1961 — FINISHED 10:00 A.M. November 23, 1961

METHOD OF DRILLING: SOIL 4" Ø flite augering - 27.0' — CASING DIAM.
ROCK — CORE DIAM.

LOCATION: LATITUDE * — DEPARTURE — BEARING — INITIAL DIP — OTHER DIPS

ELEVATIONS: DATUM G.S.C. — DRILL PLATFORM -- — GROUND SURFACE 756.0 — ROCK SURFACE -- — BOTTOM OF HOLE 729.0 — WATER TABLE --

* See Acres' drawing SK 940-C-7

DEPTH	SOIL TYPE	DESCRIPTION: COLOUR, CONSISTENCY, STRUCTURE, WATER CONTENT, PLASTICITY, COMPACTNESS, WATER LOSS OR GAIN, ETC.	SAMPLE NO.	TYPE *	SIZE (inches)	DEPTH (feet)	PENETRATION (in.)	PENETRATION TEST
0.0	Humus	Black dry and crumbly						
2.0	Silty clay							
			1	BO	2	5.0		pushed
						6.5	18	10,000 lb.
				Vane	Test	7.5		
			2	BS	2	10.0		pushed
		Light brown, dry to moist with light and dark silt pockets				11.5	6	10,000 lb.
				Vane	Test	13.0		
			3	BO	2	15.0		
						15.5		pushed
						16.0		
						16.5	18	
				Vane	Test	17.		
20.0								

SAMPLING METHOD
* A - SPLIT TUBE
B - THIN WALL TUBE
C - PISTON SAMPLER
D - CORE BARREL
E - AUGER
F - WASH

SHIPPING CONTAINER
N - INSERT
O - TUBE
P - WATER CONTENT TIN
Q - GLASS JAR
R - CLOTH BAG
S - PLIOFILM BAG
Z - DISCARDED

INSPECTOR: H.W. Ryder

LOGGED BY: H.W. Ryder

APPROVED: PRELIMINARY

DATE

FIG. 3-9

H. G. ACRES & COMPANY LIMITED – CONSULTING ENGINEERS
NIAGARA FALLS, CANADA

DRILLING REPORT

CLIENT: Province of Manitoba
Department of Agriculture Conservation Branch

JOB No. 940

PROJECT: Red River Floodway

HOLE No. DD 04

SITE: Outlet Works

SHEET No. 2 OF 2

DEPTH	SOIL TYPE	DESCRIPTION: COLOUR, CONSISTENCY, STRUCTURE WATER CONTENT, PLASTICITY, COMPACTNESS, WATER LOSS OR GAIN, ETC	SAMPLE NO	TYPE	SIZE inches	DEPTH feet	REC'D in.	PENETRATION TEST blows/6"
20.0			4 162	BO	2	20 20.5 21.0		pushed
	Sandy silt	Light brownish-yellow, dry, medium dense, containing gravel particles and boulder	5	A	2	25.0 25.5 26.0 26.5		45 60 70
27.0		Could not auger beyond 27.0'						
		End of hole						

PRELIMINARY

FIG. 3-9 (CONT'D)

H. G. AC S & COMPANY LIMITED — CONS ING ENGINEERS
NIAGARA FALLS, CANADA

DRILLING REPORT

CLIENT: Province of Manitoba
Department of Agriculture Conservation Branch — JOB No. 940

PROJECT: Red River Floodway — HOLE No. DD 05

SITE: Outlet Works — SHEET No. 1 OF 3

CONTRACTOR: Midwest Diamond Drilling Limited — STARTED 11:00 A.M. November 23 1961 — FINISHED 5:00 P.M. December 6 1961

METHOD OF DRILLING: SOIL 4" flite augerings - 27.0 — CASING DIAM. NX - 46.5
ROCK Diamond Drilling 27.0-72.5 — CORE DIAM. NX - 46.5 - 72.5

LOCATION: LATITUDE *
DEPARTURE
BEARING
INITIAL DIP
OTHER DIPS

ELEVATIONS: DATUM G.S.C.
DRILL PLATFORM --
GROUND SURFACE 751.5
ROCK SURFACE 705.0
BOTTOM OF HOLE 679.0
WATER TABLE 724.0±

* See Acres' drawing Sk-940-C-7

DEPTH	SOIL TYPE	DESCRIPTION: COLOUR, CONSISTENCY, STRUCTURE, WATER CONTENT, PLASTICITY, COMPACTNESS, WATER LOSS OR GAIN, ETC.	SAMPLE NO.	TYPE *	SIZE	DEPTH	RET'D	PENETRATION TEST
					inches	feet	in.	
0.0	Humus	Black topsoil cultivated land						
2.5	Silty clay	Dark brown dry and stiff lightly weathered, containing light and dark silt pockets	1	BO	2	5.0 6.5	18	pushed
			2	ER		6.0 10.0		
5.0	Silty clay	Mottled light brown, moist and stiff, light and dark silt pockets rust stained throughout, showing effects of weathering	3	EP		7.0		
			4	EP		9.0		
			5	BS	2	10.0 11.5	0	
			6	ER		11.0 15.0		
			7	EP		12.0		
			8	EP		14.0		
16.0	(Till)		9	BO	2	15.0 16.5	18	pushed

SAMPLING METHOD
* A – SPLIT TUBE
B – THIN WALL TUBE
C – PISTON SAMPLER
D – CORE BARREL
E – AUGER
F – WASH

SHIPPING CONTAINER
N – INSERT
O – TUBE
P – WATER CONTENT TIN
Q – GLASS JAR
R – CLOTH BAG
S – PLIOFILM BAG
Z – DISCARDED

INSPECTOR H.W. Ryder

LOGGED BY H.W. Ryder

APPROVED PRELIMINARY

DATE

FIG. 3-10

H. G. ACRE & COMPANY LIMITED — CONSULTING ENGINEERS
NIAGARA FALLS, CANADA

DRILLING REPORT

CLIENT: Province of Manitoba, Department of Agriculture Conservation Branch — JOB No. 940

PROJECT: Red River Floodway — HOLE No. DD 05

SITE: Outlet Works — SHEET No 2 OF 3

DEPTH	SOIL TYPE	DESCRIPTION: COLOUR, CONSISTENCY, STRUCTURE, WATER CONTENT, PLASTICITY, COMPACTNESS, WATER LOSS OR GAIN, ETC	SAMPLE NO	TYPE	SIZE inches	DEPTH feet	SET in.	PENETRATION TEST blows/6"
16.0	Sandy silt (Till)	Light brown (yellow) dry to slightly moist medium dense with many gravel particles and cobbles mostly limestone	10	ER		16.0		
						20.0		
			11	EP		17.0		
			12	EP		19.0		
			13	AS	2	20.0		
						20.5		10
						21.0		11
						21.5		14
			14	ER		20.0		
						20.5		
			15	EP		22.0		
			16	EP		24.0		
		Auger refusal at 27.0' Continued with BBS-2 and NX casing	17	AS	2	25.0		
						25.5		17
						26.0		15
						26.5		80
27.0	Boulder							
28.2	Sandy silt	Till as described above. Lost drill water at 33'. between 33' and 43' recovered 2' of gravel and one 8" piece of core in core barrel						
45	Boulder							
46.5	Rock	See next page						

PRELIMINARY

H. G. ACRES & COMPANY LIMITED — CONSULTING ENGINEERS
NIAGARA FALLS, CANADA

DRILLING REPORT

CLIENT: Province of Manitoba
Department of Agriculture Conservation Branch

JOB No. 940

PROJECT: Red River Floodway

HOLE No. DD05

SITE: Outlet Works

SHEET No. 3 OF 3

DEPTH	ROCK TYPE	DESCRIPTION: COLOUR, TEXTURE, FOLIATION, JOINTING, FRACTURING, FAULTING, ALTERATION, WATER LOSS OR GAIN, CAVING, LOST CORE, CEMENTING, ETC.	% CORE
46.5	Dolomitic limestone or limestone	Pale grey with moderate brown to limonite yellow nodules, fine grained, unsound.	
		hardness: 3.0 - 3.5 nodules	
		3.5 - 4.0 pale grey component	
		few chalky inclusions	
		core breaks average 2 - 3 inches	
		46.5 - 61.5 strongly leached with few 2 - 3%	
		solution cavities and a few interconnecting	
		solution channels 1/4" in diameter	
		46.5 - 49	40
		49 - 53	100
		53 - 63	70
		63 - 72.5	75
72.5		End of hole	

PRELIMINARY

FIG. 3-10 (CONT'D)

H. G. A(.S & COMPANY LIMITED – CONS ING ENGINEERS
NIAGARA FALLS, CANADA

DRILLING REPORT

CLIENT: Province of Manitoba
Department of Agriculture Conservation Branch — JOB No. 940

PROJECT: Red River Floodway — HOLE No. DD 06

SITE: Outlet Works — SHEET No. 1 OF 3

CONTRACTOR: Midwest Diamond Drilling Limited — STARTED 1:00 P.M. November 23 1961 — FINISHED 5:00 P.M. December 14 1961

METHOD OF DRILLING: SOIL 4" flite auger 0 - 30.0' — CASING DIAM. NX - 48.0
ROCK Diamond Drilling 0 - 73.5 — CORE DIAM. NX - 48.0 - 73.5

LOCATION: LATITUDE *
DEPARTURE
BEARING
INITIAL DIP 90°
OTHER DIPS

ELEVATIONS: DATUM G.S.C.
DRILL PLATFORM --
GROUND SURFACE 754.0
ROCK SURFACE 706.0
BOTTOM OF HOLE 680.5
WATER TABLE --

* See Acres' drawing SK-940-C-7

DEPTH	SOIL TYPE	DESCRIPTION, COLOUR CONSISTENCY, STRUCTURE, WATER CONTENT, PLASTICITY, COMPACTNESS, WATER LOSS OR GAIN, ETC.	SAMPLE NO.	TYPE *	SIZE	DEPTH	RECD	PENETRATION TEST blow/6"
					inches	feet	in.	
0.0	Humus							
1.0	Silty clay	Very dark brown dry and stiff, extremely weathered						
3.0	Silty clay	mottled medium greyish-brown, stiff dry to moist, weathered containing light and dark silt pockets and gravel particles	1	BO	2	5.0		pushed
						6.5	16	
				Vane Test		8.0		
			2	BO	2	10.0		pushed
						11.5	16	
				Vane Test		13.0		
			3	ES		12.0-14.0		
			4	BZ	2	15.0		pushed
16.5	Silt	Dry				16.5		hit boulder
17.5	Silty clay	Mottled light brown, stiff, moist, less weathered, containing light and dark silt pockets and gravel particles	5	BO	2	20.0		pushed
						21.5		
				Vane Test		23.0		
24.5								

SAMPLING METHOD
* A – SPLIT TUBE
B – THIN WALL TUBE
C – PISTON SAMPLER
D – CORE BARREL
E – AUGER
F – WASH

SHIPPING CONTAINER
N – INSERT
O – TUBE
P – WATER CONTENT TIN
Q – GLASS JAR
R – CLOTH BAG
S – PLIOFILM BAG
Z – DISCARDED

INSPECTOR H.W. Ryder
LOGGED BY H.W. Ryder
APPROVED
DATE

PRELIMINARY

FIG. 3-11

H. G. ACRE & COMPANY LIMITED — CONSULTING ENGINEERS
NIAGARA FALLS, CANADA

DRILLING REPORT

CLIENT: Province of Manitoba, Department of Agriculture Conservation Branch — JOB No. 940

PROJECT: Red River Floodway — HOLE No. DD 06

SITE: Outlet Works — SHEET No. 2 OF 3

DEPTH	SOIL TYPE	DESCRIPTION COLOUR CONSISTENCY, STRUCTURE, WATER CONTENT, PLASTICITY, COMPACTNESS, WATER LOSS OR GAIN, ETC	SAMPLE NO	SAMPLE TYPE	SAMPLE SIZE inches	SAMPLE DEPTH feet	SAMPLE FEET in.	PENETRATION TEST blows/6"
24.5 to	Silty sand and gravel	Light brown (yellow) dry and dense with many gravel particles.						
25.0	Sand and gravel (Till)	Light brownish (yellow) fine sand with many gravel particles, dry and dense	6	AS	2	25.0 25.5 26.0 26.5		30 60 70
		Auger refusal at 30' Due to misalignment of auger hole, redrilled hole 2' to north utilizing BBS-2 with NX casing — At 25' water began to return from auger hole						
27	Boulders							
33	Sands (?)	Fine-grained deposit with few gravel particles water return via auger hole lost all water at 46'						
48	Rock	See next page						

PRELIMINARY

FIG. 3-11 (CONT'D)

H. G. ACK[illegible] & COMPANY LIMITED — CONSU[illegible]NG ENGINEERS
NIAGARA FALLS, CANADA

DRILLING REPORT

CLIENT: Province of Manitoba
Department of Agriculture Conservation Branch

JOB No. 940

PROJECT: Red River Floodway

HOLE No. DD 06

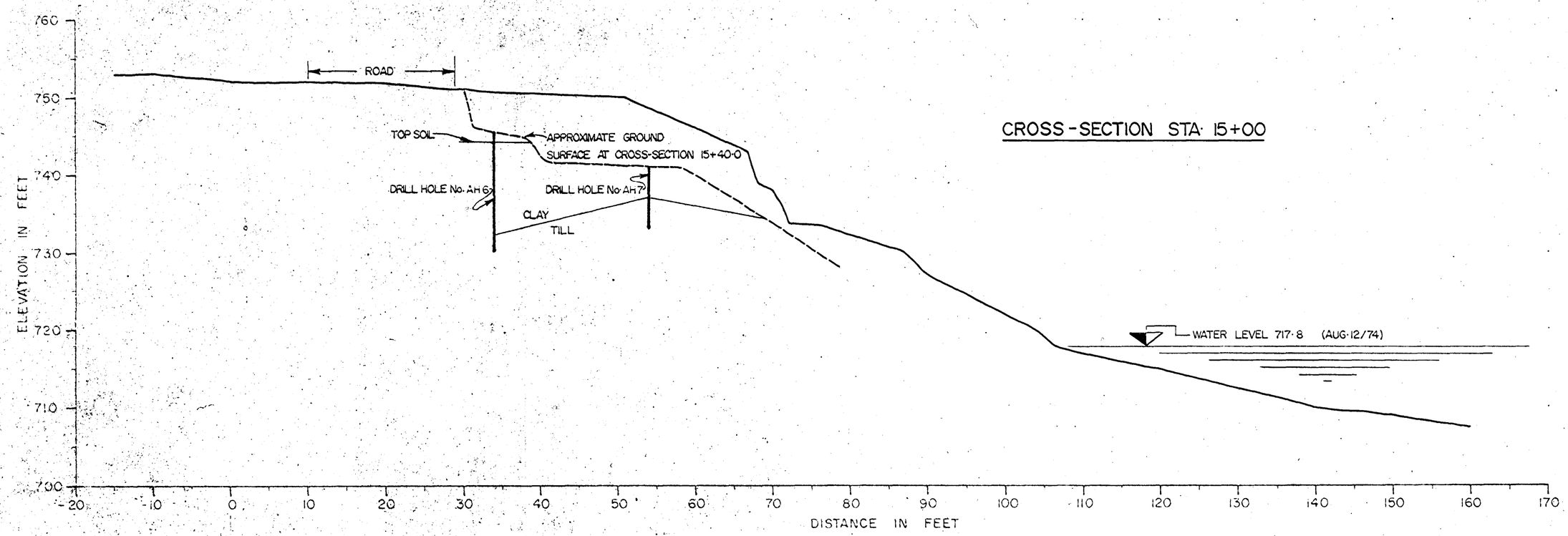
SITE: Outlet Works

SHEET No. 3 OF 3

DEPTH	ROCK TYPE	DESCRIPTION: COLOUR, TEXTURE, FOLIATION, JOINTING, FRACTURING, FAULTING, ALTERATION, WATER LOSS OR GAIN, CAVING, LOST CORE, CEMENTING, ETC	% CORE
48.0	Dolomitic limestone or limestone	Pale grey with moderate brown to limonite yellow nodules, fine grained, hardness: 3.0 - 3.5 nodules 3.5 - 4.0 pale grey component	
		48.0 - 54.0 minor leaching	
		54.0 - core breaks at 1 to 1-1/2 feet sound	
		48 - 52	75
		52 - 73.5	100
73.5		End of hole	

PRELIMINARY

FIG. 3-11 (CONT'D)



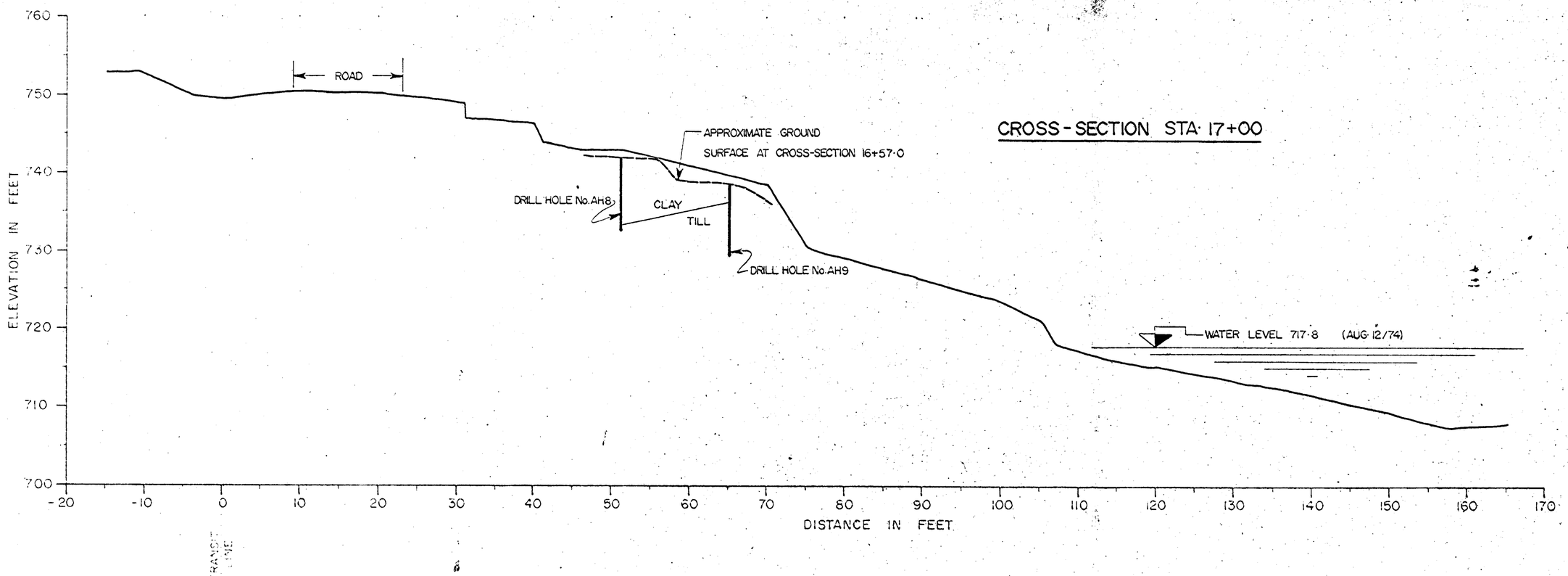
NOTES

1. SEE PLAN NO. 11-1-1521 FOR LOCATION OF CROSS SECTION.
2. CROSS SECTION LOOKING DOWNSTREAM

DATUM GEODETIC

PROVINCE OF MANITOBA DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT WATER RESOURCES BRANCH	RED RIVER FLOODWAY OUTLET STRUCTURE EROSION INVESTIGATION STRATIGRAPHIC PROFILE AT STATION 15+00
PREPARED M. YOUNG DRAWN H.S.R. CHECKED F.P. DATE 6-12-74	SCALE AS SHOWN DATE NOV./1974 SHEET 1 of 1 DRAWING 11-1-1524

FIG. NO. 4-1



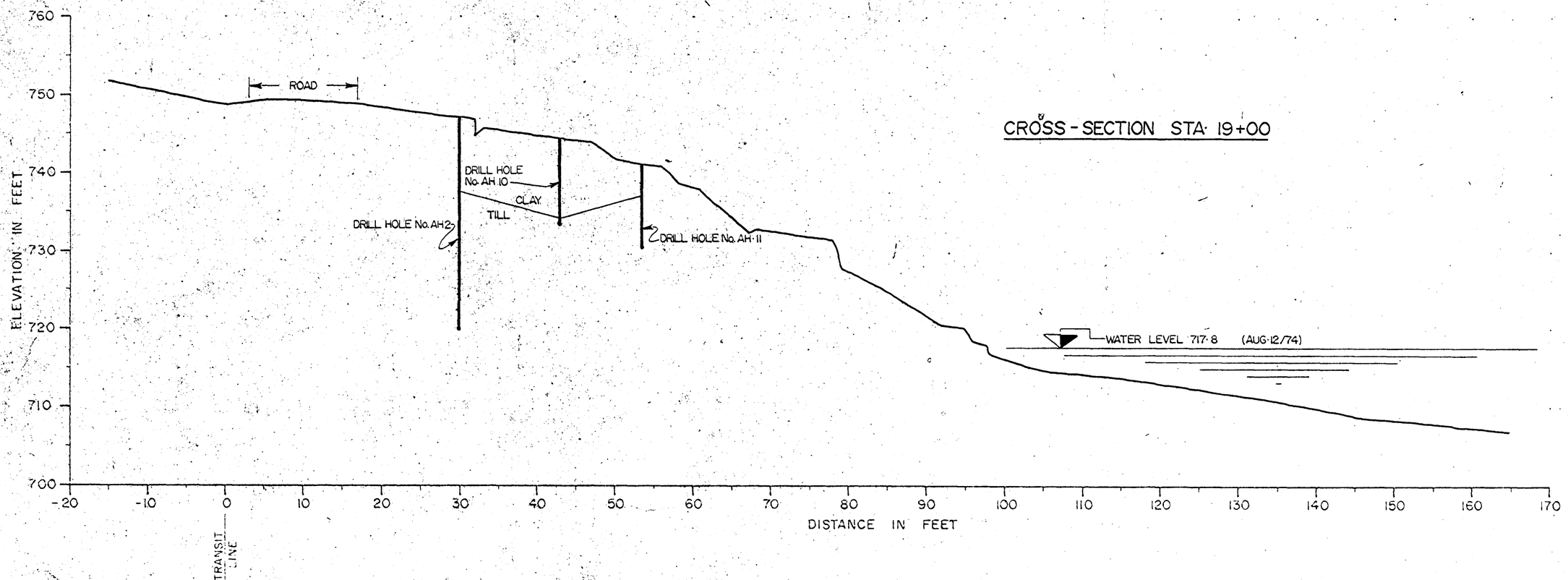
NOTES

1. SEE PLAN NO. 11-1-1521 FOR LOCATION OF CROSS SECTION
2. CROSS SECTION LOOKING DOWNSTREAM

DATUM: GEODETIC

PROVINCE OF MANITOBA DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT WATER RESOURCES BRANCH	RED RIVER FLOODWAY OUTLET STRUCTURE EROSION INVESTIGATION STRATIGRAPHIC PROFILE AT STATION 17+00
PREPARED M. YOUNG · DRAWN H.S.R. · CHECKED F.P. · SUBMITTED · DATE 6-12-74 · DATE	SCALE AS SHOWN · DATE NOV./1974 · SHEET 1 OF 1 · FILE NO. 11-1-1524

FIG. NO. 4-2



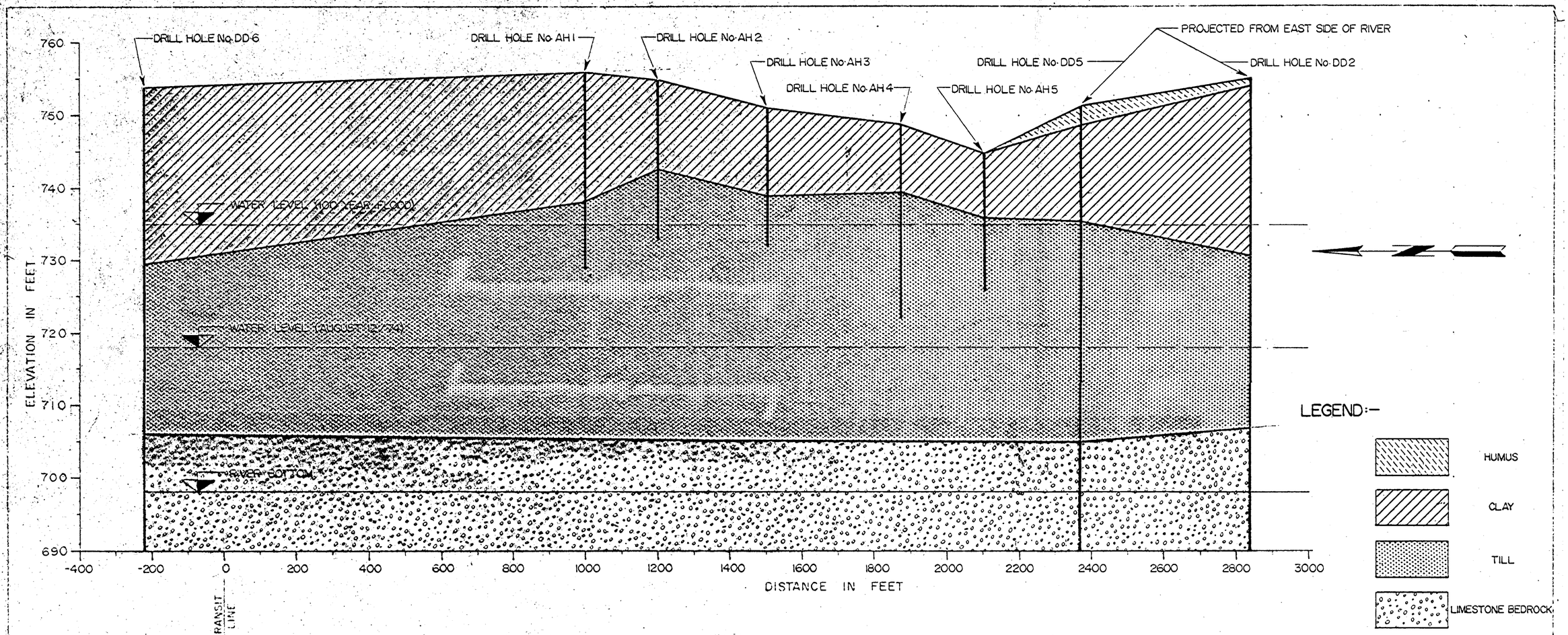
NOTES

1. SEE PLAN NO. U-1-1521 FOR LOCATION OF CROSS SECTION.
2. CROSS SECTION LOOKING DOWNSTREAM

DATUM GEODETIC

PROVINCE OF MANITOBA DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT WATER RESOURCES BRANCH	RED RIVER FLOODWAY OUTLET STRUCTURE EROSION INVESTIGATION STRATIGRAPHIC PROFILE AT STATION 19+00
PREPARED M. YOUNG · DRAWN H.S.R. · CHECKED F.P. · DATE · SUBMITTED · DATE · APPROVED · DATE	SCALE AS SHOWN · DATE NOV/1974 · SHEET 1 OF 1 · DWG. NO. U-1-1524

FIG. NO 4-3



NOTE

1. SEE FIG. NO. 1 FOR LOCATION OF CROSS SECTION.

DATUM GEODETIC

PROVINCE OF MANITOBA DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT WATER RESOURCES BRANCH PREPARED M. YOUNG DRAWN H.S.R. CHECKED F.P. DATE 8-12-74	RED RIVER FLOODWAY OUTLET STRUCTURE EROSION INVESTIGATION STRATIGRAPHIC SECTION OF WEST BANK SCALE AS SHOWN DATE NOV/1974 SHEET 1 OF 1 DWG. NO. 11-1-1525

FIG. NO. 5

K+E 10 X 10 TO THE INCH • 7 X 10 INCHES KEUFFEL & ESSER CO. MADE IN U.S.A.
46 0703

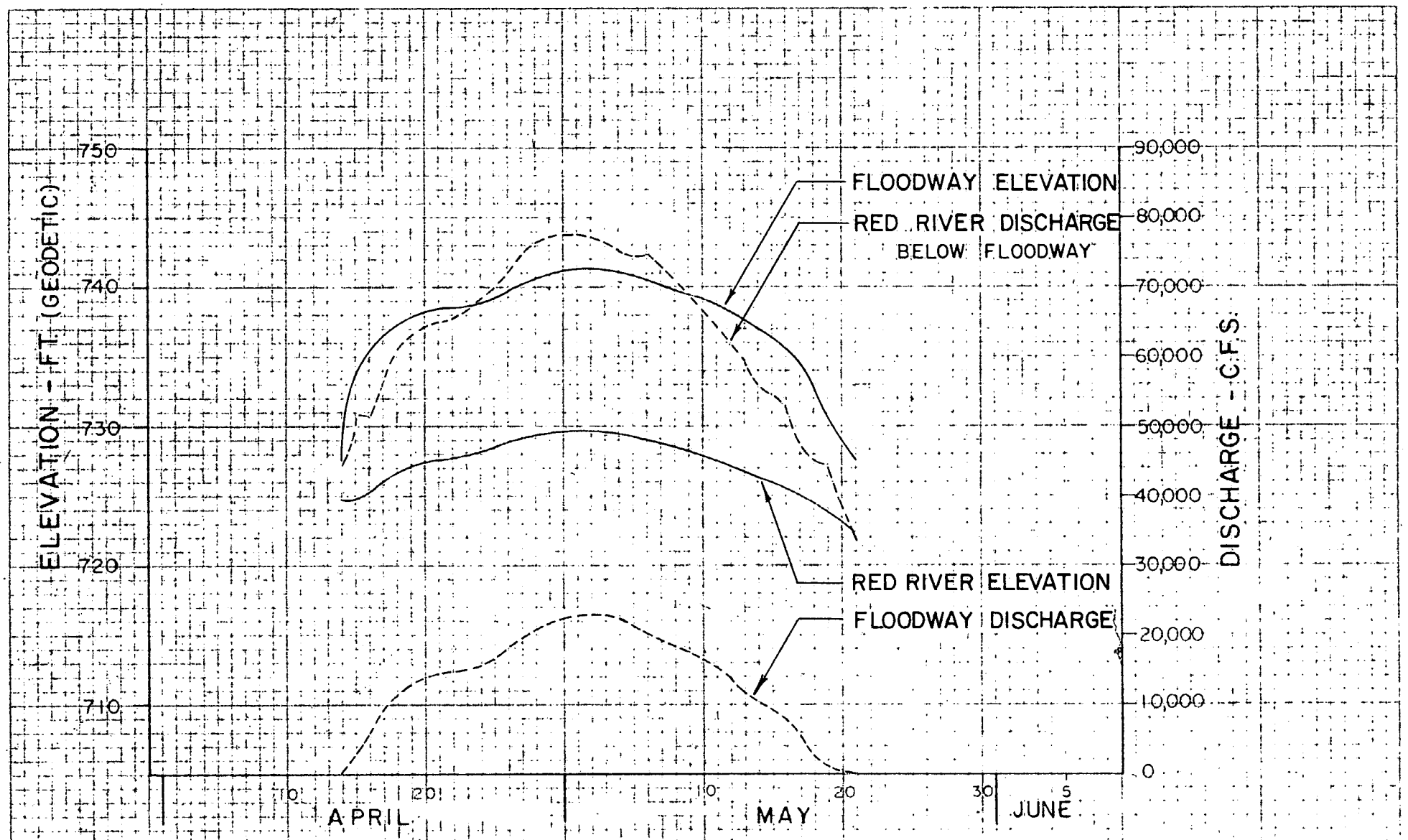


FIG. 6-1 WATER LEVEL AND FLOW DATA FOR YEAR 1969

K+E 10 X 10 TO THE INCH 46 0703

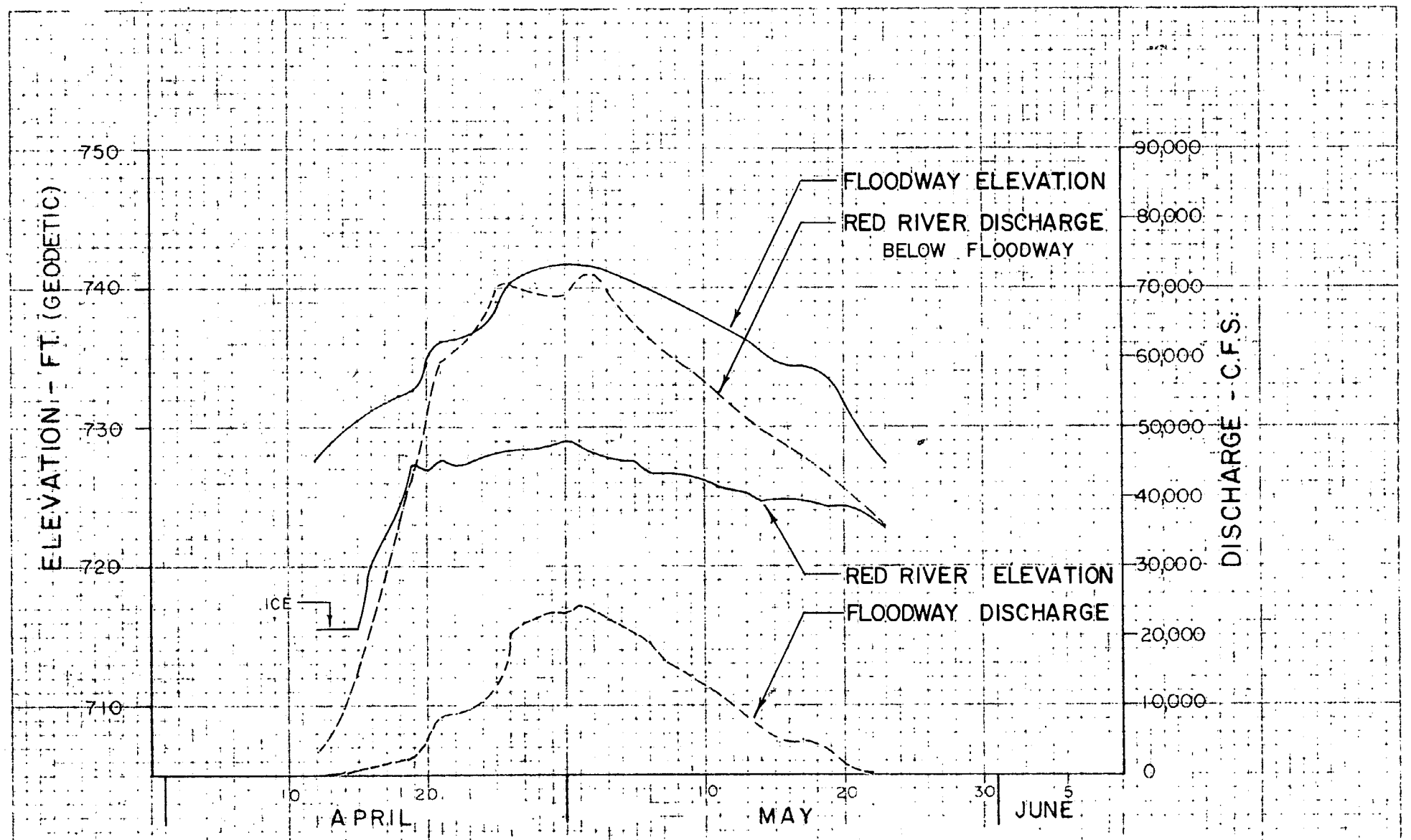


FIG. 6-2 WATER LEVEL AND FLOW DATA FOR YEAR 1970

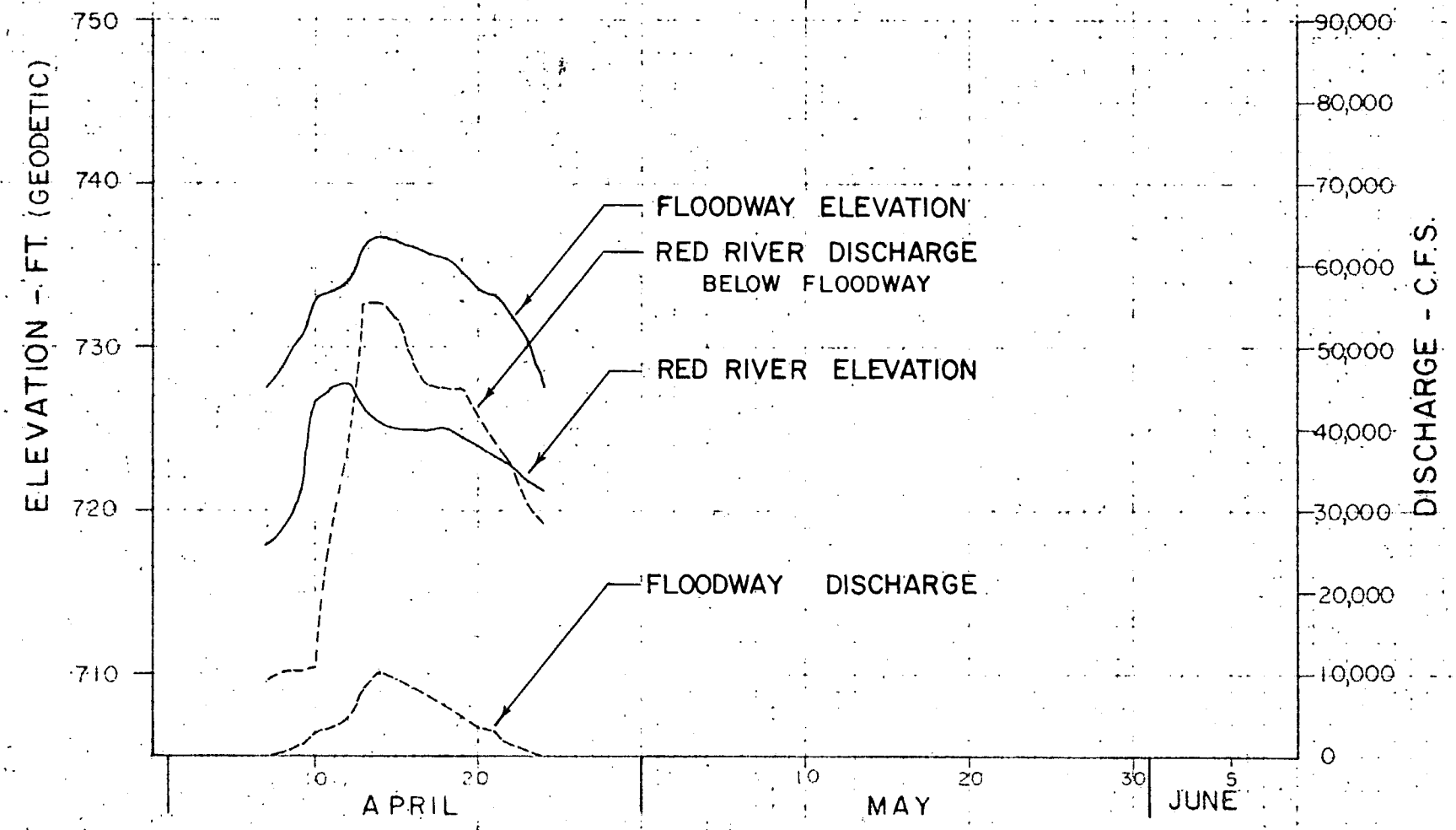


FIG. 6-3 WATER LEVEL AND FLOW DATA FOR YEAR 1971

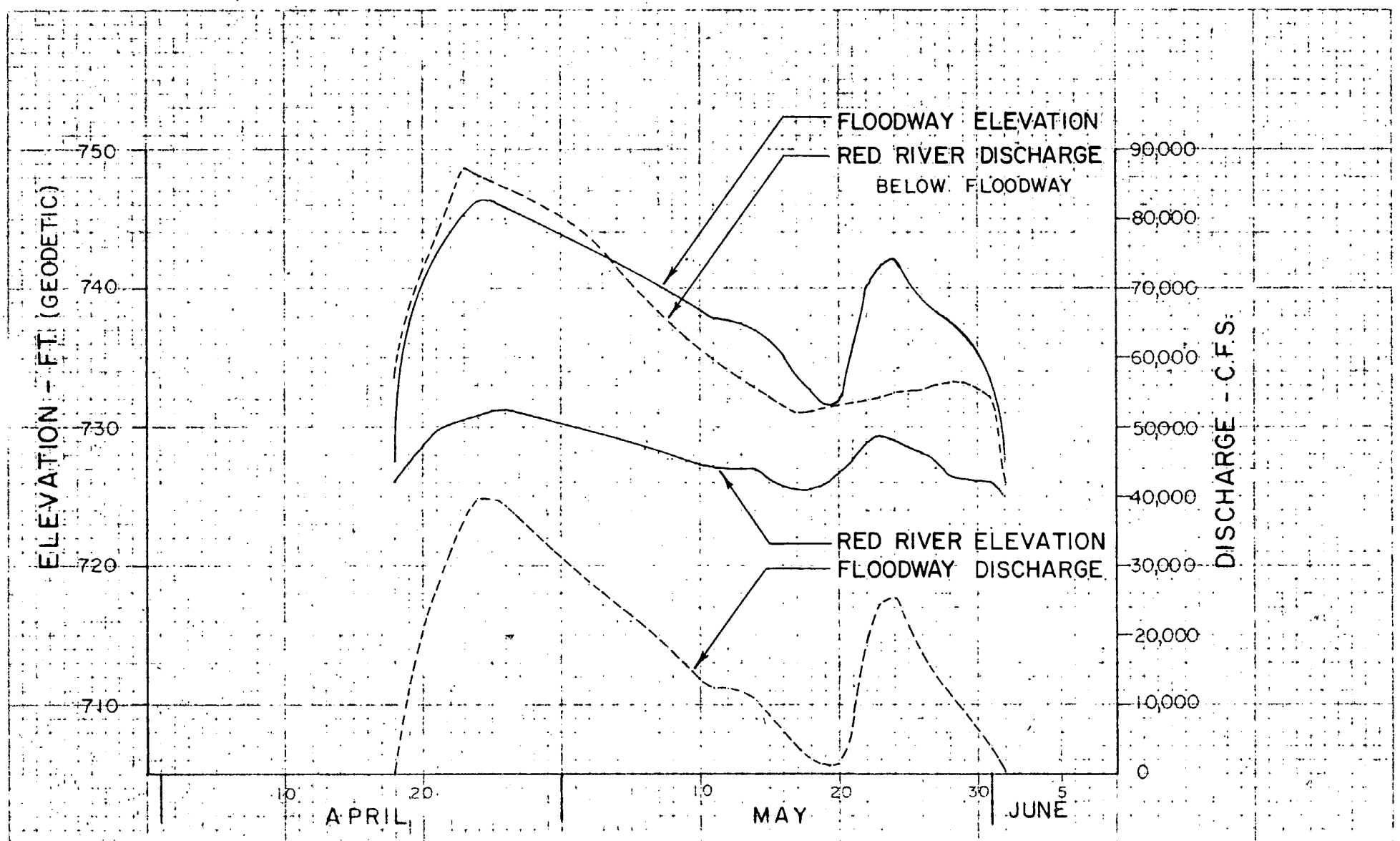
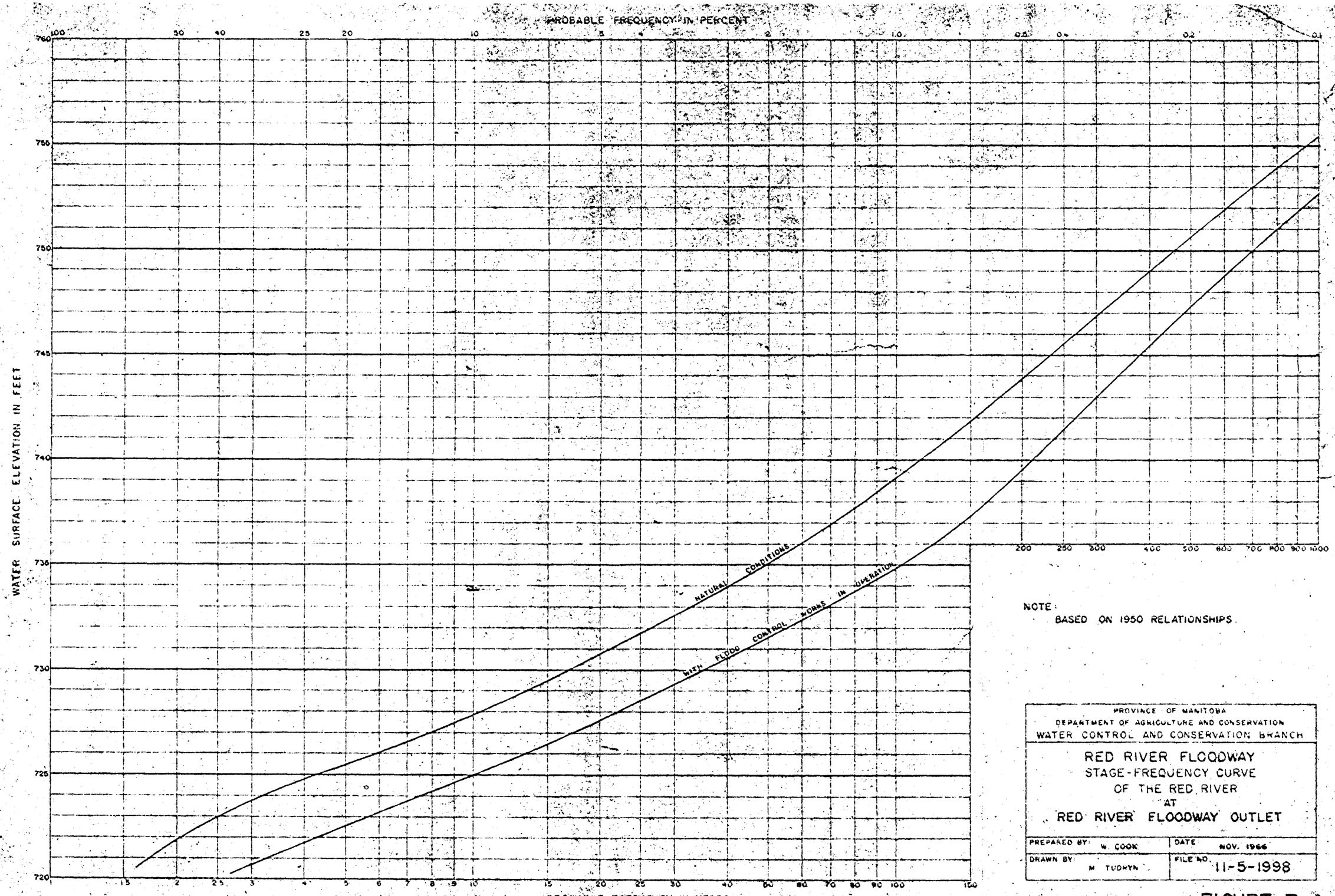


FIG. 6-4 WATER LEVEL AND FLOW DATA FOR YEAR 1974



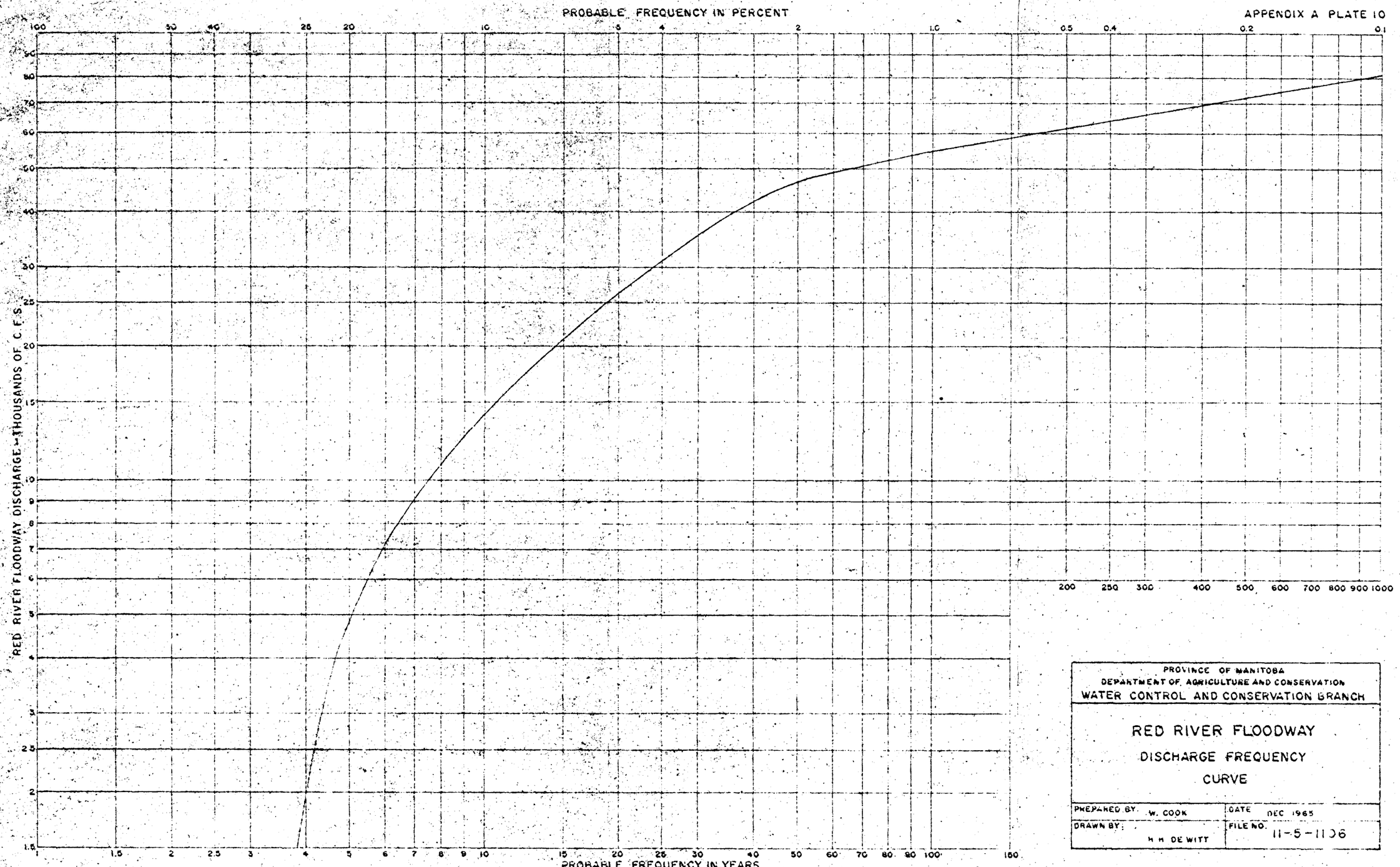
NOTE:
BASED ON 1950 RELATIONSHIPS.

PROVINCE OF MANITOBA
DEPARTMENT OF AGRICULTURE AND CONSERVATION
WATER CONTROL AND CONSERVATION BRANCH

RED RIVER FLOODWAY
STAGE-FREQUENCY CURVE
OF THE RED RIVER
AT
RED RIVER FLOODWAY OUTLET

PREPARED BY: W. COOK	DATE NOV. 1966
DRAWN BY: M. TUDRYN	FILE NO. 11-5-1998

FIGURE 7-1



PROVINCE OF MANITOBA
DEPARTMENT OF AGRICULTURE AND CONSERVATION
WATER CONTROL AND CONSERVATION BRANCH

RED RIVER FLOODWAY
DISCHARGE FREQUENCY
CURVE

PREPARED BY: W. COOK	DATE: DEC 1965
DRAWN BY: H H DE WITT	FILE NO. 11-5-1106

FIGURE 7-2

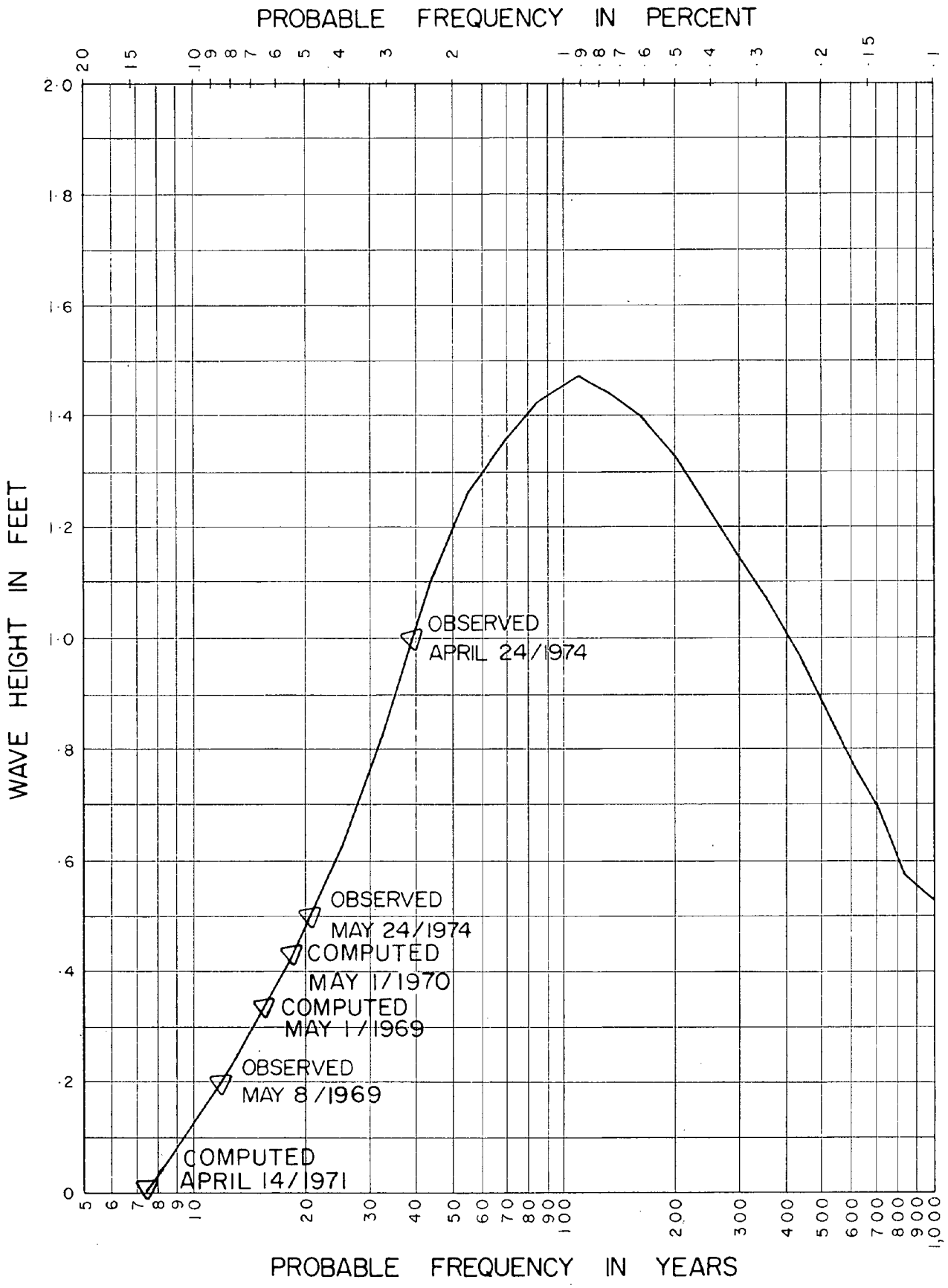


FIG. NO. 8

PROVINCE OF MANITOBA

DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT

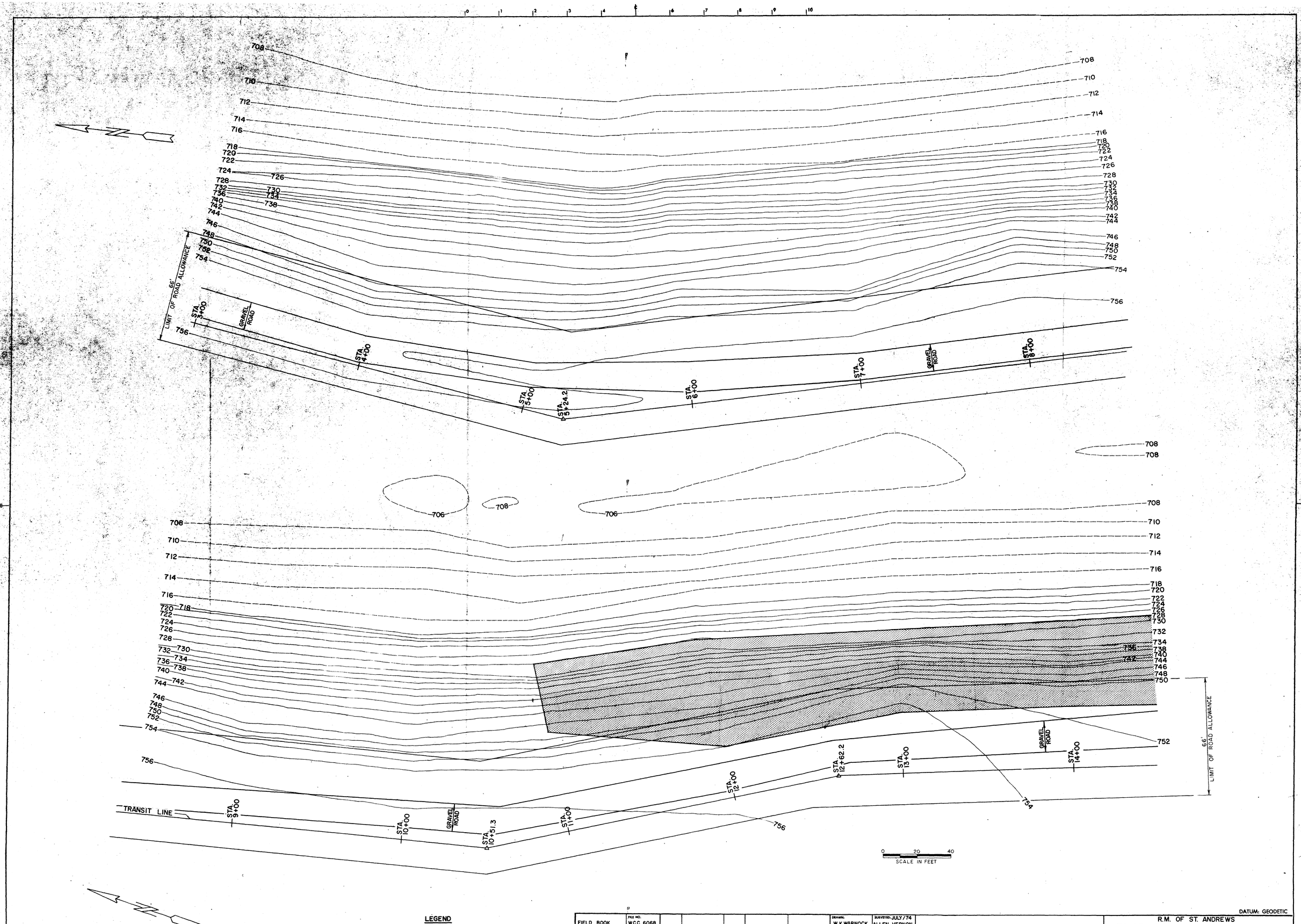
WATER RESOURCES BRANCH

FREQUENCIES OF ESTIMATED WAVE HEIGHTS

AT

FLOODWAY OUTLET

PREPARED	DRAWN	SUBMITTED	APPROVED	SCALE	DATE	SHEET	FILE NO.
M. YOUNG	H. S. R. / CHECKED F. P.	DATE	DATE	AS SHOWN	NOV./1974	1 OF 1	11-1-1526



LEGEND

ROCK FILL

FIELD BOOK	FILE NO. W.C.C. 6068						DRAWN: W.K. WARNOCK	SURVEYED: JULY / 74 ALLEN VERNON
SURVEY BRANCH FIELD BOOK	FILE NO. 2257						DESIGNED:	
SITE PLAN	FILE NO. 11-1-1521						CHECKED:	
EXISTING EROSION	FILE NO. 11-1-1522	DATE	REMARKS	NAME			RECOMMENDED: FOR OPERATIONS	
CROSS REFERENCES		REVISIONS			APPROVED AS TO:		RECOMMENDED: DIRECTOR OF OPERATIONS	

PROVINCE OF MANITOBA
DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT
WATER RESOURCES BRANCH

SUBMITTED: F. Penner 6 Dec 74
APPROVED: D. Shmeny DIRECTOR OF PLANNING

DATUM: GEODETIC

R.M. OF ST. ANDREWS

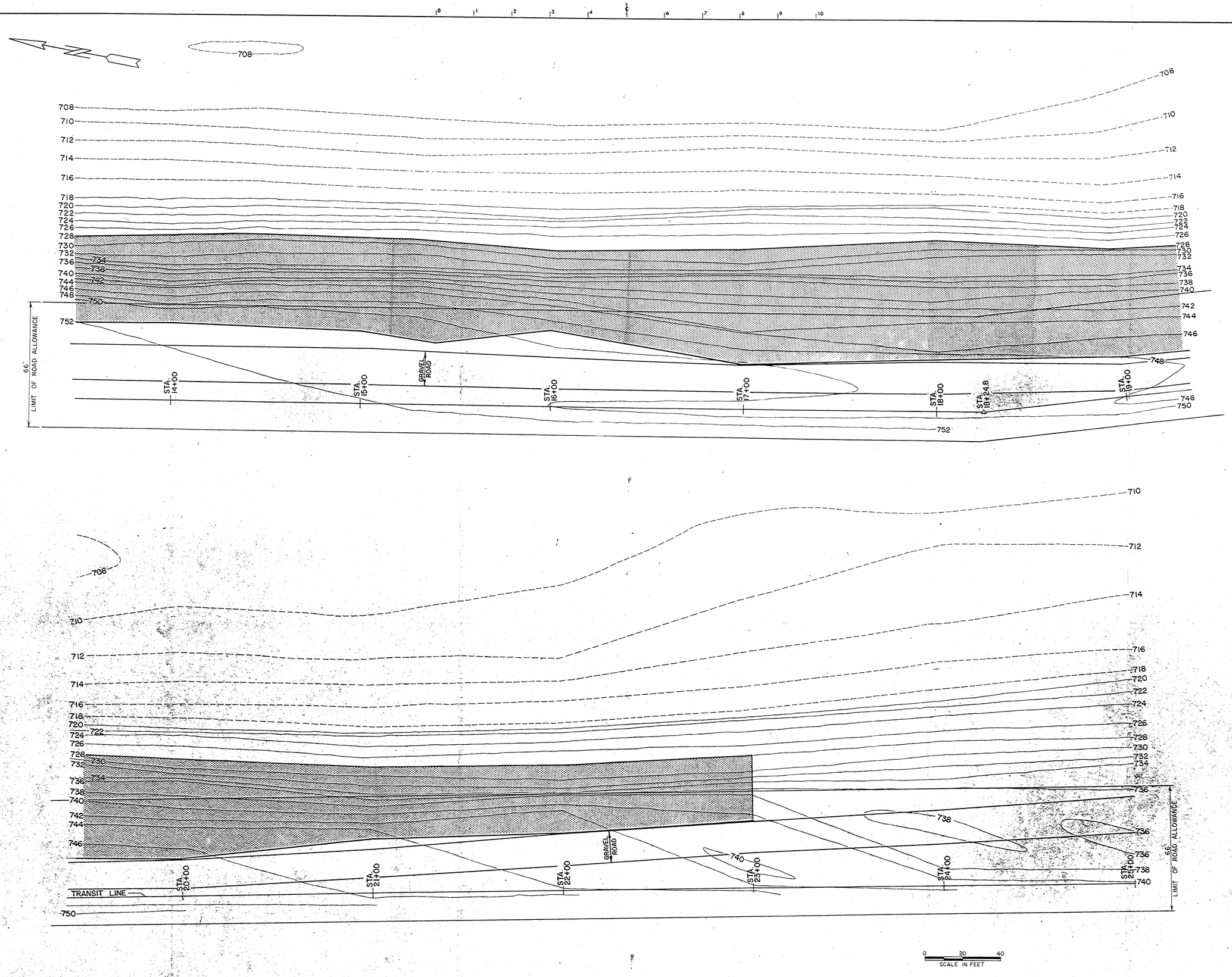
PROPOSED REMEDIAL WORK

1974

RED RIVER FLOODWAY OUTLET CONTROL STRUCTURE
EROSION INVESTIGATION
IN
PARISH OF ST. ANDREWS
RIVER LOTS 113 TO 116

SCALE:	DATE:	SHEET:	FILE NO.
AS SHOWN	NOV. / 74	1 OF 2	11-1-1523

FIG. NO. 9-1



LEGEND

ROCK FILL

DATUM: GEODETIC

FIELD BOOK	FILE NO. W.C.C. 6068					
SURVEY BRANCH FIELD BOOK	FILE NO. 2257					
SITE PLAN	FILE NO. 11-1-1521					
EXISTING EROSION	FILE NO. 11-1-1522	DATE	REMARKS	NAME		
CROSS REFERENCES		REVISIONS			APPROVED AS TO:	

DRAWN: W. K. WARNOCK
SURVEYED: JULY / 74 ALLEN VERNON
DESIGNED:
CHECKED:
REVIEWED: FOR OPERATIONS
RECOMMENDED: DIRECTOR OF OPERATIONS

PROVINCE OF MANITOBA
DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT
WATER RESOURCES BRANCH

SUBMITTED: F. Peterson
APPROVED: J. Lindsay
DIRECTOR OF PLANNING

R.M. OF ST. ANDREWS

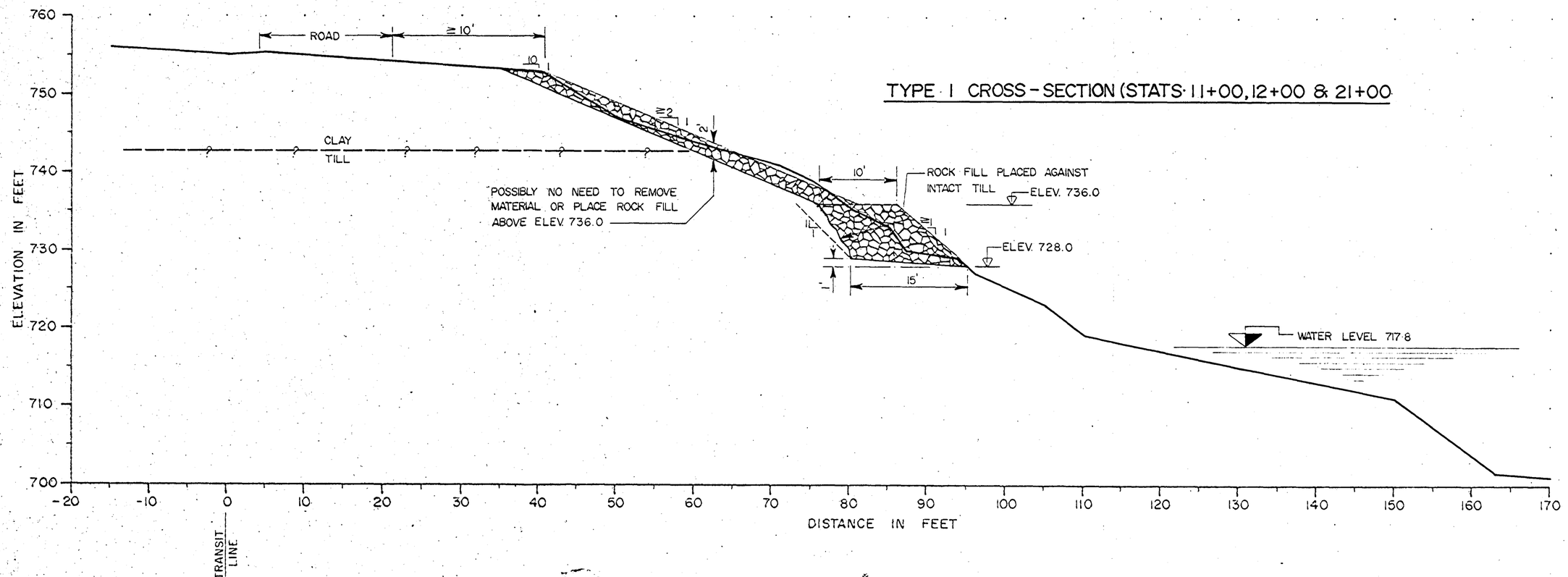
PROPOSED REMEDIAL WORK

1974

RED RIVER FLOODWAY OUTLET CONTROL STRUCTURE
EROSION INVESTIGATION
IN
PARISH OF ST. ANDREWS
RIVER LOTS 110 TO 113

SCALE:	DATE:	SHEET:	FILE NO.
AS SHOWN	NOV. / 74	2 OF 2	11-1-1523

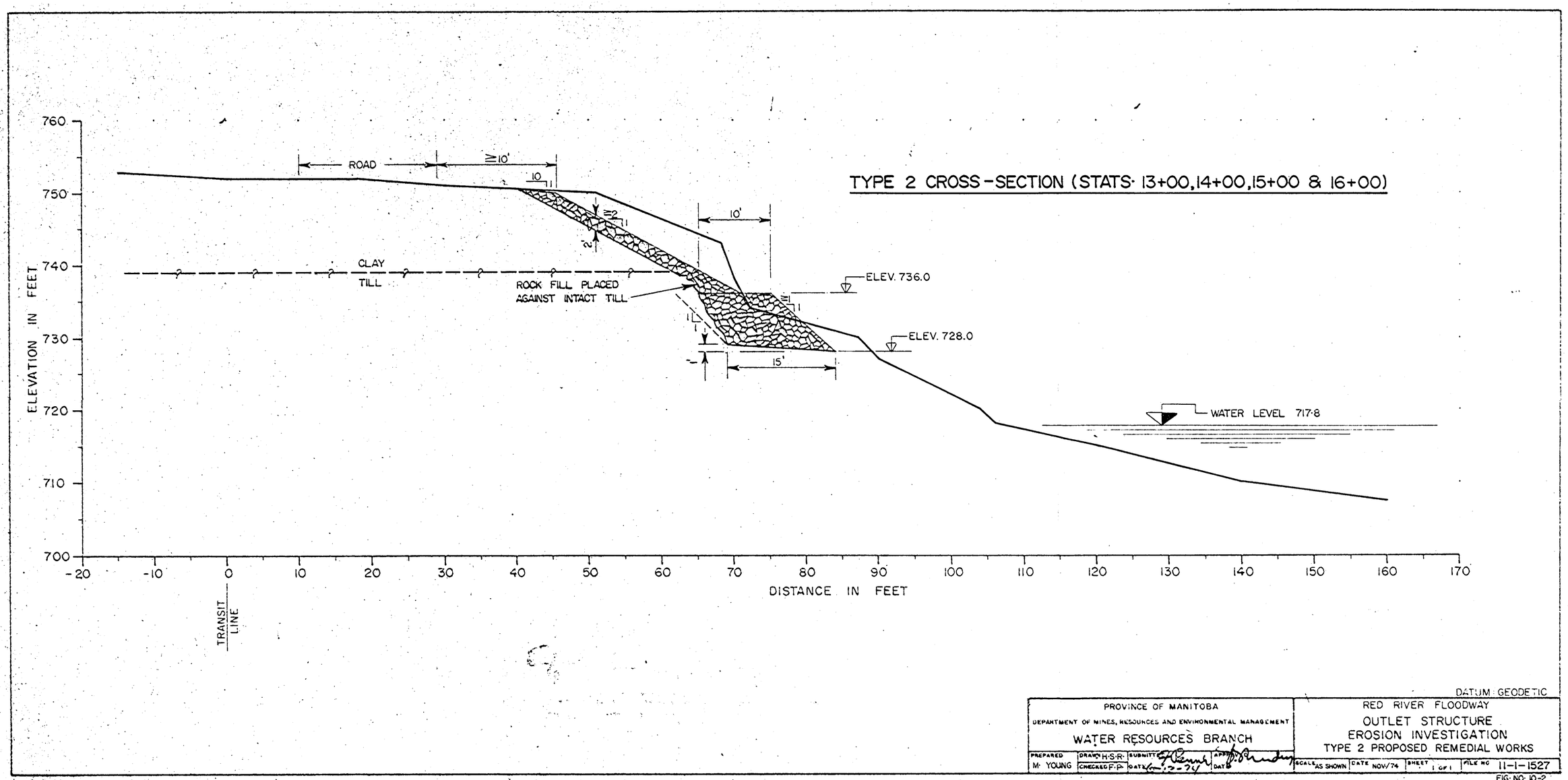
FIG. NO. 9-2



DATUM GEODETIC

PROVINCE OF MANITOBA DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT WATER RESOURCES BRANCH	RED RIVER FLOODWAY OUTLET STRUCTURE EROSION INVESTIGATION TYPE I PROPOSED REMEDIAL WORKS
PREPARED M. YOUNG · DRAWN H.S.R. · CHECKED F.P. · SUBMITTED · DATE · APPD. · DATE	SCALE AS SHOWN · DATE NOV./74 · SHEET 1 OF 1 · FILE NO. 11-1-1527

FIG. NO. 10-1

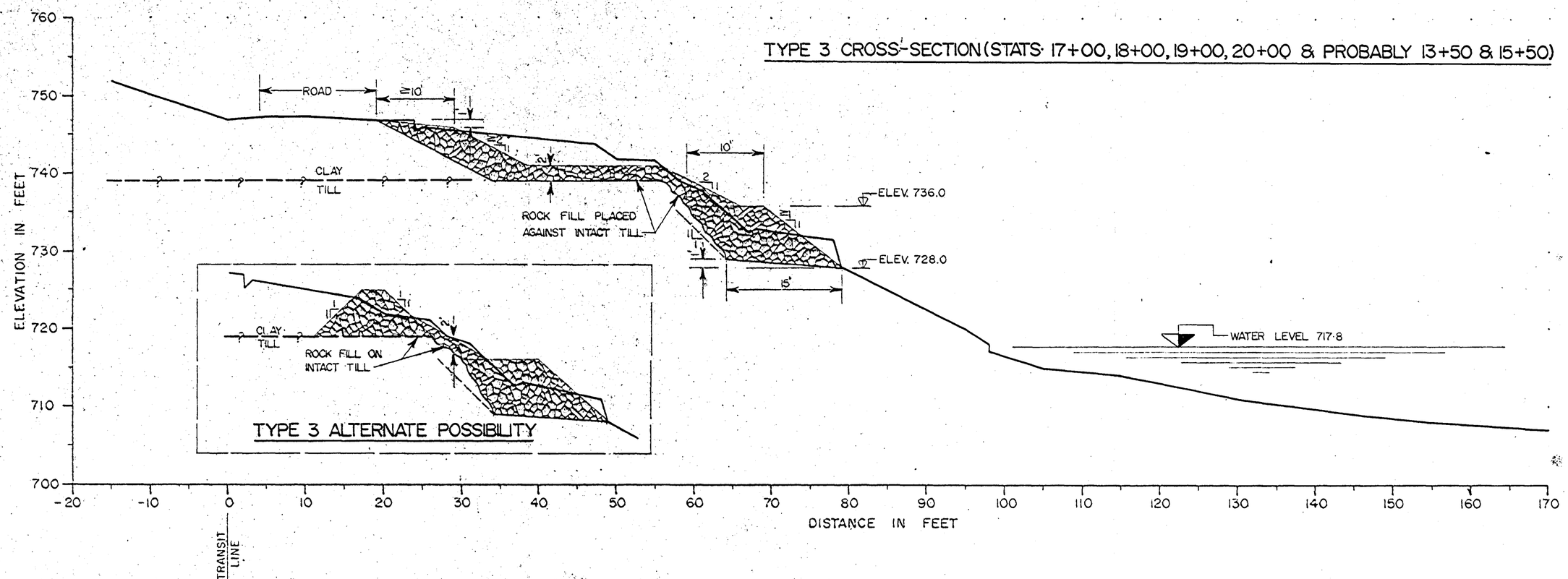


DATUM: GEODETIC

PROVINCE OF MANITOBA DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT WATER RESOURCES BRANCH	RED RIVER FLOODWAY OUTLET STRUCTURE EROSION INVESTIGATION TYPE 2 PROPOSED REMEDIAL WORKS

PREPARED	DRAWN H·S·R·	SUBMITTED	APPROVED	SCALE AS SHOWN	DATE NOV/74	SHEET 1 OF 1	FILE NO 11-1-1527
M· YOUNG	CHECKED F·P·	DATE	DATE				

FIG· NO· 10-2

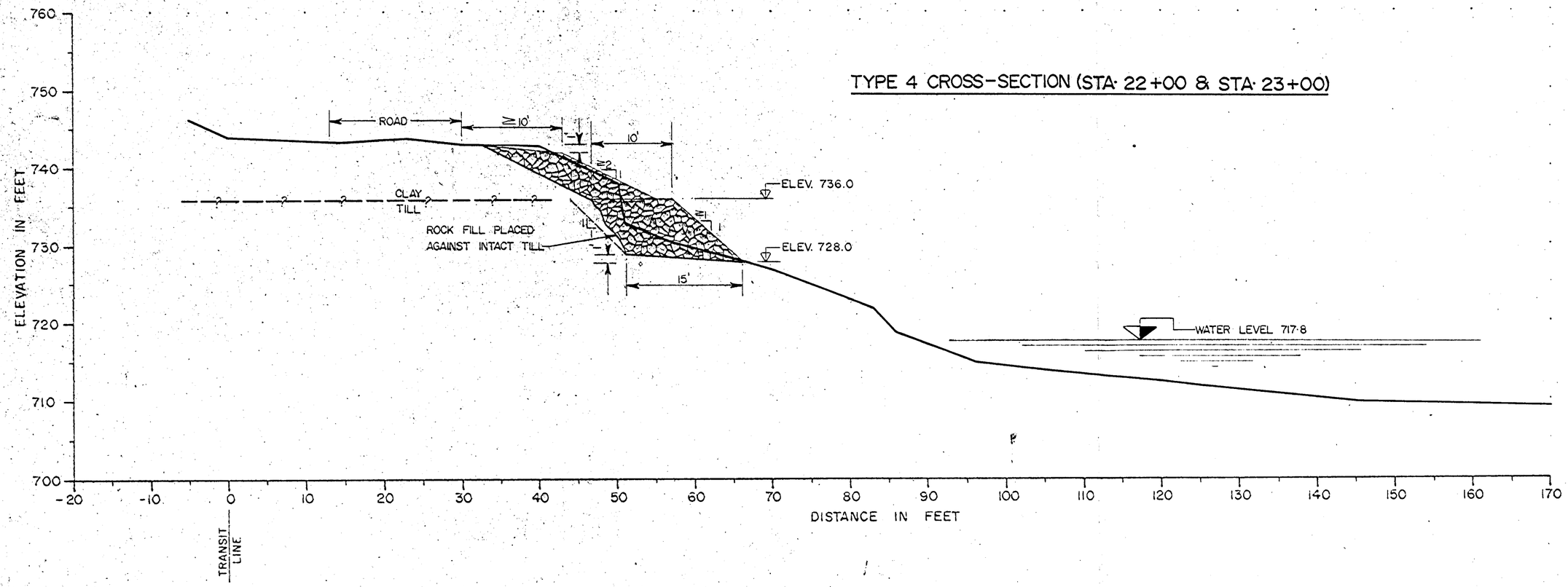


DATUM: GEODETIC

PROVINCE OF MANITOBA DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT WATER RESOURCES BRANCH	RED RIVER FLOODWAY OUTLET STRUCTURE EROSION INVESTIGATION TYPE 3 PROPOSED REMEDIAL WORKS

PREPARED	DRAWN	SUBMITTED	APPROVED	SCALE	DATE	SHEET	FILE NO
M. YOUNG	H.S.R. / CHECKED F.P.	DATE 6-12-74	DATE	AS SHOWN	NOV/74	1 OF 1	11-1-1527

FIG. NO. 10-3



DATUM: GEODETIC

PROVINCE OF MANITOBA DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT WATER RESOURCES BRANCH	RED RIVER FLOODWAY OUTLET STRUCTURE EROSION INVESTIGATION TYPE 4 PROPOSED REMEDIAL WORKS
PREPARED M· YOUNG · DRAWN H·S·R· · CHECKED F.P. · SUBMITTED · DATE 6-12-74 · APPROVED · DATE	SCALE AS SHOWN · DATE NOV/74 · SHEET 1 OF 1 · FILE NO. 11-1-1527

FIG· NO· 10-4