KONTZAMANIS ▪ GRAUMANN ▪ SMITH ▪ MACMILLAN INC.
CONSULTING ENGINEERS & PROJECT MANAGERS

GROUP

December 20, 1993 File No. 93-107-08

The City of Winnipeg
Waterworks, Waste and Disposal Department
1500 Plessis Road
Box 178, Transcona P.O.
Winnipeg, Manitoba
R2C 2Z9

ATTENTION: Mr. Dick Girling, P.Eng.
Engineer of Design

RE: Summer Floodway Operation
Feasibility Study

Dear Dick:

Enclosed are six (6) copies our final report documenting the study findings. We look forward to future involvement with the Department should the City decide to pursue one of the alternatives assocaited with summer flood mitigation.

Please do not hesitate to call if you have any questions regarding the report contents.

Signed by: David B. MacMillan P.Eng

DBM/pc
Enclosure

cc: J. Toye (Manitoba Water Resource Branch)

Dec 94/01/04

STRUCTURAL ▪ GEOTECHNICAL ▪ ENVIRONMENTAL ▪ HYDRAULICS ▪ HYDROGEOLOGY ▪ MUNICIPAL ▪ MECHANICAL ▪ ELECTRICAL
3227 ROBLIN BOULEVARD, WINNIPEG, MANITOBA R3R 0C2 PH: (204) 896-1209 FAX: (204) 896-0754
611 SQUIER STREET, THUNDER BAY, ONTARIO P7B 4A7 PHONE: (807) 345-2233 FAX: (807) 345-3433

THE CITY OF WINNIPEG
WATERWORKS, WASTE AND DISPOSAL DEPARTMENT

SUMMER FLOODWAY OPERATION

FEASIBILITY STUDY

DECEMBER, 1993

KGS GROUP

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Yours very truly,

David B. MacMillan, P.Eng.
Principal

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1.0 INTRODUCTION

High Red River levels, as a result of summer rain storms in August 1993, initiated a review of the summer operation of the floodway. During the high intensity rainfall events, which occurred on July 24, 25 and August 8, 14, basement flooding was a common occurrence throughout the combined sewer system in the City of Winnipeg. The basement flooding occurred primarily as a result of the high rainfall runoff which exceeded the design capacity of the sewers. Although the flooding is primarily rainfall related, during August 1993 it was aggravated by the Red River level at flood stages.

The floodway, which was designed for major spring flood conditions, could be modified for use during summer flood events. This would reduce high Red River water levels in the City of Winnipeg, thereby nominally increasing the combined sewer capacity. Given the potential to increase the combined sewer capacity, the Waterworks, Waste and Disposal Department decided to investigate the costs and feasibility associated with operating the floodway during the summer.

Operation of the floodway for summer flood conditions would involve removal of a portion of the floodway inlet crest "plug". This "plug" prevents flows into the floodway diversion channel at Red River levels below elevation 750 ft (228.6 m). KGS Group were retained by the Department to conduct the following:

1. Review relevant information on the floodway inlet hydraulics and earthworks structure.
2. Survey the channel geometry and conduct soils investigations as required.

3. Develop a conceptual plan and estimate quantities for the removal of the inlet "plug" consistent with the hydraulics of the diversion channel inlet.
4. Discuss the removal concept with contractors and determine appropriate unit prices, equipment availability and the time to modify the floodway inlet.
5. Provide a cost estimate and construction schedule for the removal and rehabilitation of the floodway crest. The crest would be restored following the return of the Red River to normal levels.

Construction management and contract administration responsibilities were to be provided if the project was found to be cost effective. Since construction of the floodway opening was ultimately not pursued, these services were not required. In addition to the above, KGS Group was to prepare a report documenting the findings of the study.

This report describes the results of the study findings. The study approach and data sources are described in Section 2.0. Background information regarding the high water levels which occurred in August 1993 is given in Section 3.0. Operation of the floodway and the diversion inlet hydraulics are described in Section 4.0. The requirements to utilize the floodway for summer floods are described in Section 5.0, while cost estimates and construction logistics associated with summer use are described in Section 6.0. The assessment of benefits and long term considerations associated with the channel modifications are described in Section 7.0 and 8.0 respectively. The summary of the study findings is given in Section 9.0.

2.0 STUDY APPROACH AND DATA SOURCES

Following initial meetings with the Province of Manitoba, Water Resources Branch (WRB) on August 11, 1993, the City of Winnipeg decided to proceed with a feasibility investigation of the summer operation of the floodway. The sequence of events associated with the investigation and sources of information obtained throughout this period are described below.

August 11, 1993

- City of Winnipeg officials met with KGS Group to review the study terms of reference and to authorize KGS Group to conduct the study.
- Following the meeting, KGS Group met with officials from the Water Resources Branch (WRB) to obtain information and discuss background data available. The following information was obtained.
    - Floodway Inlet Geometry - Province of Manitoba, Department of Agriculture and Conservation Red River Floodway Construction Layout, Drawing 11-5-1152A, 1962
    - Miscellaneous soil stratigraphy information in the vicinity of the floodway inlet.
- Concurrent with the (WRB) meeting KGS Group, contacted a number of earth moving contractors to alert them of the potential work and to obtain budget prices. In addition, KGS Group survey crews conducted site surveys of the inlet crest. The inlet geometry was obtained to confirm and extend information that was available from the WRB and to provide accurate data for bidding. The preliminary survey was completed on August 11, 1993.
    - Following receipt of information from the WRB and the field survey data, estimates were made of the quantities to effectively remove the inlet "plug". Following an initial hydraulic assessment, KGS Group met at the WRB with Mr. J. Toye to review the hydraulic assessment and to obtain additional data. The following additional data was obtained.
        - Preliminary stage discharge data for the Red River at James Avenue
        - Preliminary stage discharge data for the floodway channel at St. Mary's Bridge.
        - Floodway channel discharge profiles for different flood events.

KGS Group completed the initial hydraulic/geotechnical assessment and cost estimate of the associated works. Overheads and summaries were prepared for a presentation to the Waterworks Waste and Disposal Department on August 12, 1993.

August 12, 1993

- KGS Group presented the results of the hydraulic assessment and the hydraulic benefits associated with lowering the inlet "plug". Cost estimates and backup data were presented for the geotechnical work. Following the meeting, it was decided the results of the investigation as well as the potential benefits of the floodway modifications should be presented to the Committee on Works and Operations. The Waterworks Waste and Disposal Department prepared information related to the impact of reduced Red River levels on the combined sewer system.

- Information was presented to the Committee on Works and Operations and the merits of proceeding with the work and potential provincial funding were discussed. Following this meeting, it was decided to issue a news release and to present the information to council members for a decision to proceed with the work or not.

- The City of Winnipeg and KGS Group presented the background information, relevant study findings and the cost estimates to the council members. It was agreed that final decision to proceed with the work would be postponed until an official response was obtained from the Province with respect to potential cost sharing. KGS Group were instructed to continue with the preparation of drawings and data for bidders for issue of tenders within the next few days.

August 13, 1993

- KGS Group continued with the preparation of drawings for bidders and refinement of calculations associated with the inlet hydraulics. A number of test pits were excavated and soil samples were taken at the floodway inlet to confirm subsurface conditions (See Appendix A). Later on the 13th, the Provincial Department of Natural Resources granted the City of Winnipeg permission to modify the floodway inlet. Costs associated with removal and restoration work would, however, not be cost shared by the Province. At that time the project was abandoned and KGS Group were advised to stop all work associated with the preparation of tender documents. Preparation of a final report documenting the work and study findings would be prepared.

3.0 BACKGROUND INFORMATION

As a result of extremely high rainfalls in the Red River basin in late July and August 1993, Red River discharges and stages within the City of Winnipeg were well above summer normals. Precipitation records for July and August at the Winnipeg Airport are shown on Table 1. Recorded water levels for the Red River at the floodway inlet and at James Avenue are shown on Table 2 for the period July 1 to August 31, 1993. In addition to the water levels and discharges at these locations, the discharge on Assiniboine River at Headingly and the LaSalle River are given as they contribute to the total Red River flow at James Avenue.

Levels and discharges on the Red River in July and August, 1993 were significantly higher than normal. Peak Red River discharges and levels experienced at James Avenue during August, 1993 are the highest summer levels (June, July, August) on record (1915 to 1992). The peak discharge 46,000 cfs (1,300 m^3/s) and stage 16.6 ft (5.1 m) which occurred on August 15 exceeds the previous 1975 peak of 15.4 ft (4.7 m) and 40,600 cfs (1,150 m^3/s). (Pers. Comm. - A. Warkentin, Manitoba Water Resources Branch).

The floodway channel elevation near the floodway inlet is approximately 743.4 ft (226.6 m). Between the channel and the Red River an earth "plug", with a crest elevation of 750 ft (228.6 m), prevents river flows from entering the diversion channel at Red River levels, at the inlet, below el 750 ft (228. 6 m). The primary function of the crest is to keep the floodway ice free in the spring to minimize the potential for ice jams in the channel. If the "plug" was removed, the floodway could be used under summer flood conditions to nominally reduce water levels in Winnipeg.

Following meetings between the City of Winnipeg and the Manitoba Water Resources Branch on August 11, 1993, the Province stated that the the earth "plug" could be removed under the condition that the City replace it prior to the next spring. Initial discussions with the Province indicated that modifications to the floodway inlet would allow a diversion of about 3,000 cfs (85 m^3/s) into the floodway under conditions which prevailed on August 10, 1993. As can be seen from the data on Table 2, this would reduce the Red River discharge at James Avenue from 42,000 cfs to approximately 39,000 cfs. At this time, it was estimated that the corresponding drop in water level at James Avenue would be 0.6 to 0.8 feet (0.2 to 0.25 m). With this information, The City of Winnipeg reviewed the potential increase in combined sewer system capacity and concluded the following.

- There would be no increase in sewer capacity for those 14 City combined sewer districts which at that point in time were dependent upon flood pumping stations to discharge runoff to the Red River.
- The remaining 19 districts would see a nominal increase in the combined sewer capacity of about 6 to 8%. That is, if a severe rainstorm were to occur during the period of high Red River level, about half the combined sewer system would have an increase in capacity of 6 to 8%.

Since data to determine the actual difference in number of basements which would be flooded under these conditions does not exist, benefits associated with the increased sewer capacity are difficult to quantify. If the system capacity were exceeded again, the nominal increase in sewer capacity may only decrease the depth and duration of basement flooding, rather than the number of flooded basements. As well, the benefits of floodway inlet modifications would only occur during the periods of high river conditions. At lower Red River levels, the discharge capacity of the floodway is significantly reduced.

4.0 FLOODWAY OPERATION

System Description

As shown on Figure 1, the floodway is an excavated channel 29 miles, (46 km) long with an inlet to the channel at elevation 750 ft (228.6 m) near St. Norbert. During floodway operation a gated inlet control structure, on the Red River, diverts water around Winnipeg and back into the Red River at the outlet control structure near Lockport. The floodway control structure and arrangement is shown on Figure 2 and operation of the floodway is described below[1].

> "Under normal fall, summer and winter conditions all the water in the Red River will continue through the City of Winnipeg as in the past, in its natural bed. In the spring when high flows occur, the Inlet Control Structure is operated in such a manner so that flooding in the City of Winnipeg will be reduced as much as possible. The Floodway was designed, constructed and is operated so that it provides protection for the City of Winnipeg but at the same time does not adversely affect interests upstream of the Floodway (ie. South of the Inlet Control Structure). To accomplish this, the rules of operation require that water levels upstream of the Inlet Control Structure shall be maintained at elevations no higher than would have been obtained under natural conditions. Natural conditions are those that would exist, if the Winnipeg Floodway, Portage Diversion and Shellmouth Dam were not in existence.....
>
> In a normal operating year, when the water level attains the Floodway inlet crest elevations of 750.0 ft (228.6 m) it begins flowing into the diversion channel and around the City of Winnipeg. As the natural water level at the Inlet Control structure increases, the gates are raised to maintain the right division of water between the Floodway and the river channel. The operation of the Floodway Inlet Control Structure does not usually begin until the natural water level is 751.0 ft (228.9 m) which results in at least one foot depth of flow over the Floodway Inlet crest into the diversion channel. This minimizes the possibility of erosion of the crest by ice. As the flow in the Red and Assiniboine subsides the gates at the Inlet Control Structure are lowered in accordance with the calculated natural river levels. When the natural river level has subsided to a level of 750 feet (228.6 m) the gates are completely lowered."

---

[1]Province of Manitoba, The Manitoba Water Commission, A review of Provincial Procedures and Plans for Flood Protection and Flood Fighting, 1974.

Inlet Hydraulics

As described above, the floodway channel is protected by the earth "plug" crest at elevation 750 ft (228.6 m). The earth "plug" is about 700 ft (213 m) wide and the crest extends approximately 1000 ft (300 m) downstream at elevation 750 ft and then slopes down to the channel invert at elevation 743 ft (226.4 m). The channel continues downstream at a constant slope of 0.0000868 to the outlet control structure near Lockport.

The earth "plug" at the inlet is intended to minimize floating ice into channel at Red River elevations at the inlet of less than 750 ft (228.6 m). At higher Red River spring flood stages, the ice cover breaks up and flows freely down the Red River with little tendency to be diverted into the diversion channel. In addition to keeping ice flows out of the diversion channel, the earth "plug" restricts discharges into the channel at Red River elevations between 743.37 ft (226.6 m), and 750 ft (228.6 m), thereby limiting the use of the channel to significant spring flood events.

Water elevations and discharges in the channel are controlled by the hydraulic capacity of the channel itself downstream of the inlet. As shown on Figure 3, for a given discharge, the water surface elevation at the inlet is controlled by the channel which slopes at a constant slope from the outlet to the inlet. At diversion channel discharges of greater than approximately 5,000 cfs (142 m^3/s), the inlet channel crest at elevation 750 ft (228.6 m) has a minimal effect on the floodway channel discharge. As shown on Figure 3, at a Red River elevation of 752.5 ft (229.3 m), the discharge into the diversion channel is approximately 5,000 cfs (140 m^3/s). Similarly at a Red River inlet elevation of 754.7 ft (230.0 m), the diversion discharge would be 10,000 (283 m^3/S). At the design flood elevation of 770.25 ft (234.8 m) on the Red River at the inlet, the diversion channel would pass 60,000 cfs (17,000 m^3/S).

The stage discharge relationship for the diversion channel at low discharges is illustrated by the rating curve at St. Mary Road Bridge (Figure 4) which is located approximately 5,000 ft (1,500 m) downstream of the inlet. As shown on the figure, the water elevation at St. Mary's bridge, as dictated by downstream conditions, for 3,000 cfs (85 m^3/s) is elevation 750 ft (228.6 m).

For Red River elevations below 750 ft (226.8 m), the inlet "crest" functions as a "plug" control and prevents the discharge into the diversion channel. To allow discharge into the channel, at Red River elevations lower than elevation 750 ft (228.6 m), all or a portion of the earth "plug" would have to be removed. With the earth "plug" removed and a Red River elevation of 750 ft, the diversion channel discharge would be less than 5,000 cfs (145 m^3/s). Under normal spring flood operations, a diversion discharge of less than 5,000 cfs (145 m^3/s) is not significant in comparison to Red River discharges of 40,000 cfs to 50,000 cfs (1100 to 1400 m^3/s).

5.0 PROPOSED DIVERSION CHANNEL MODIFICATIONS

Inlet Capacity

During the summer flood conditions experienced in 1993, Red River discharges of 42,000 cfs (1,190 m^3/S) at James Avenue (combined Red and Assiniboine River flow) resulted in water levels in the City of Winnipeg which influence the capacity of the combined sewer. Red River elevations at the inlet to the diversion channel, however, would not exceed the inlet crest elevation at 750 ft (228.6 m) until the Red River discharge at James Avenue of approximately 45,000 cfs (1,270 m^3/s) is exceeded. If the crest elevation was lowered, the diversion channel could, however, relieve flows through the City of Winnipeg.

Modifications to the floodway inlet were proposed to provide discharge relief at the summer flood levels. This would involve excavating a channel through the existing plug and breaching the inlet to the Red River at an elevation below 750 ft (228.6 m). For a specified water elevation on the Red River at the inlet, the diversion channel discharge would be governed by one of two hydraulic conditions.

- the weir flow over the inlet "plug" crest
- the elevation at the St. Mary's bridge plus the additional friction losses from the bridge to the channel inlet. The stage discharge relationship at St. Mary's bridge was provided by the Manitoba Water Resources Branch (See Figure 4).

The proposed crest excavation was calculated as the minimum channel excavation which would ensure that the hydraulic control remained in the channel and that additional friction losses within the excavated channel, through the length of the crest, were not significant. As shown on Figure 5, a channel with a width of 400 ft (122 m) with an invert elevation of 746 ft (227.3 m) was calculated as the minimum size which could meet the criteria above. The channel would slope down from the crest of the "plug" to the diversion channel invert 743.37 (226.6 m). The total excavation required to excavate this channel was estimated to be 85,000 yd^3 (65,000 m^3).

The modified inlet rating curve, with the 400 ft (122 m) wide breach channel, is shown on Figure 6. This curve considers the two hydraulic control components described above. Head losses in the downstream channel and through the breach section govern the diversion flow capacity at the inlet. In addition to the inlet rating curve, the change in water level at James Avenue as a function of the floodway channel discharge is also shown on Figure 6. From this relationship it can be seen that at a diversion discharge of 2,500 cfs (70 m^3/s) the corresponding reduction in stage at James Avenue is approximately 0.7 ft. At a Red River elevation of 748 ft (228.0 m) the inlet discharge would be approximately 500 cfs (14 m^3/s) and the reduction in stage at James Avenue would be limited to about 0.2 ft.

The inlet rating curve, Figure 6, was based upon preliminary calculations conducted with data supplied by the Manitoba Water Resources Branch. If the project had proceeded to the final design stage, further refinements in the channel geometry would have been made on the basis of more detailed backwater calculations. These would have considered head losses from the established conditions at the St. Mary's bridge (Figure 4) through to inlet. These calculations would have been conducted for a series of discharges and channel geometry refinements. The channel excavation would have been minimized on the basis of these calculations.

Reduced Water Levels

The estimated reduction in water levels in the City of Winnipeg was based upon a reduction of the total Red River discharge at James Avenue. This is illustrated graphically on Figure 7, which shows the discharge reduction due to the flow diversion, superimposed on the James Avenue rating curve.

As described above, the reduction in stage at James Avenue for various diversion channel discharges is shown on Figure 6. On August 12, 1993 the discharge at James Avenue was 42,000 cfs (1,190 m^3/s) and the corresponding elevation at the floodway channel inlet was 749.8 ft (228.6 m). If the floodway crest were breached at this time, approximately 2,500 cfs (70 m^3/S) would flow down the floodway channel. As illustrated on Figure 7, the corresponding reduction in stage at James Avenue would be 0.7 ft (.21 m). At lower Red River levels at the inlet, the impact on water levels would be less. For example, at an inlet elevation of 749 ft (228.3 m), the diversion channel discharge would be approximately 1,500 cfs (42 m^3/s). The corresponding reduction in stage at James Avenue would be approximately 0.4 ft (.12 m).

6.0 COST ESTIMATE AND SCHEDULE

Estimated Costs

Estimated costs were prepared for removal and rehabilitation of the earth "plug" at the inlet. Since the earth "plug" functions to keep the diversion channel ice free at Red River elevations at the inlet below 750 ft. (228.6 m), permission from the Province to remove the plug for summer operation was conditional upon the crest being reinstated prior to the spring of 1994.

Quantities to reinstate "plug" were calculated on the basis that the crest would be restored to its original configuration. It is likely, however, that the channel could have been restored with a properly designed dike which would have less volume and provide the same function as the existing crest. Examination of the dike alternative would, however, require development of design criteria in conjunction with the Province. In the short time period in which the estimate was prepared, this option was not pursued.

The quantity of material to be excavated was estimated to be 85,000 yd^3 (65,000 m^3). In addition to the earth removal and replacement, an allowance for erosion control at the breach section was provided. It was estimated 2,500 yd^3 (1,900 m^3) of limestone riprap would be placed over a filter cloth at this section.

Costs for removal and replacement were based upon discussions with a number of local contractors and KGS Group recent experience with similar work. The following assumptions were made:

- Material removed was to be excavated using scrapers, loaded and hauled to the construction borrow area approximately 2,500 ft (760 m) northeast of the crest.
- Material would be maintained for the period of the flood duration in this borrow area and hauled back to the plug area in the fall.
- All material would be removed in the dry using conventional methods in relatively dry conditions, with the exception of the final breech section, which would require a dragline.
- Replacement and rehabilitation would be conducted with controlled compaction methods.

Total estimated costs for removal and excavation are as follows:

ITEM	QUANTITY	UNIT COST	TOTAL
• "Plug" Excavation	85,000 yd^3	$3.00	$255,000.00
• "Plug" Replacement	85,000 yd^3	4.00	340,000.00
• Rock Riprap & Geotextile	2,500 yd^3	20.00	50,000.00
• Engineering (final design, construction management)			25,000.00
TOTAL			$670,000.00

Schedule

The period in which the combined sewer system was vulnerable to high Red Water levels depends upon the summer flood hydrograph. At the time the assessment was conducted, August 12, 1993, it was forecasted that the flood hydrograph would begin to subside by August 25, 1993. As such, the time to complete the specified excavation and breech the dike was critical to the work being effective. In view of these considerations, the estimated time to complete the excavation was based upon mobilizing the most equipment which could be practically be utilized

in the work site and effectively use the access ramp to the disposal site. Based upon previous related experience and discussions with contractors, it was assumed that 12 scrapers would be operated 24 hours a day to complete the work. On this basis, and assuming relatively dry conditions, it was estimated that the 85,000 yd^3 could be excavated in 4 days. Equipment availability, logistics and scheduling would have been reviewed with contractors at the bid stage to determine if the time to complete the excavation could be reduced.

7.0 ASSESSMENT OF BENEFITS

Following a review of the benefits and costs associated with removing the floodway inlet plug, City officials decided not to proceed with the proposed works. Primary considerations associated with the decision are as follows:

- the cost to remove the plug, $670,000, was higher than originally anticipated.
- benefits at the relatively low Red River flood levels were not substantial. It was estimated that a 6 to 8% increase in sewer capacity would be achieved for approximately 50% of the combined sewer districts.
- the probability of the works being effective was relatively low. At the time of the decision, August 13, 1993, Red River levels were projected to remain high for another 10 days. Benefits associated with the excavation would be reduced with receding Red River flood levels. Given that it would take 4 to 5 days to implement the inlet excavation, the "window" of potential benefit would be reduced to 5 to 6 days.

  To provide benefits of reduced storm sewer flooding would require that the Red River levels remain high [approximately el 742 (15 ft) at James Avenue] coincident with an intense rain storm (1.5 in (38 mm)) in the City of Winnipeg.

The majority of these considerations were associated with the limited short term benefits of conducting the works under emergency conditions. Following an initial review of the project, long term benefits associated with permanent modifications to the floodway inlet were discussed. These considerations are discussed in Section 8.0.

As shown on Figure 8, in the ten (10) days following the decision not to proceed with floodway modifications, Red River levels at the inlet peaked at 751.15 ft on August 16 and dropped to 748.46 ft by August 23 (See Table 2). If floodway modifications had been completed, the "window" of potential benefit would have been from August 18 to August 23. Beyond August 23, Red River

levels at the inlet were too low to provide any relief to Red River discharges. Since there was no significant rainfall in the City of Winnipeg between August 18 and August 25 (Figure 8), breaching the floodway at this time in retrospect, would have had no benefit. That is, it would have been too late to provide relief to the high rainfall events in the City of Winnipeg. From Figure 8, it is evident that periods in which benefits could have been realized (ie. high Red River with rainfall in excess of 1.5 in [35 mm]) are as follows:

August 8; Red River elevation at inlet 748.72 ft, rainfall 3 in (72.2 mm)

August 14; Red River elevation at inlet 749.6 ft, rainfall 2 1/2 in (59 mm)

Although precipitation in excess of 3 inches occurred in July, the Red River level was still below 742 ft (226.2 m) and diversion of flows would not have been possible.

8.0 LONG TERM CONSIDERATIONS

The study completed, in August 1993 addressed the emergency relief of Red River discharges through the City of Winnipeg, by temporarily removing the floodway inlet plug. Although not viable under these conditions, the possibility of the long term utilization of the floodway during summer months was discussed. Factors associated with long term use would include an investigation of the following:

- combined probability of summer flooding in conjunction with severe rainstorms in the City of Winnipeg
- hydraulic/geotechnical considerations associated with channel improvements downstream of the inlet to enhance the low level capacity of the floodway. Consideration would be given to potential impacts on existing structures, within the floodway (ie. hydraulic, geotechnical and structural).
- feasibility of a permanent control structure at the inlet. This could be a gated structure or an overflow dike structure
- re-assessment of sewer capacities affected by the high Red River stages.
- evaluation of flood damages associated with summer flooding and incremental damages attributable to high Red River levels.
- cost benefit analysis of floodway works to relieve summer flood discharges through the City of Winnipeg.

9.0 SUMMARY

The results of the summer floodway operation feasibility study are summarized below:

- 1993 summer flood conditions on the Red River, in combination with intense summer rainstorms in the City of Winnipeg, initiated a review of the summer operation of the floodway.
- Requirements to breach the existing floodway inlet "plug", the associated costs and hydraulic benefits were defined. For conditions which existed on August 12, 1993 these are as follows:
    - approximately 2,500 cfs (70 m^3/s) could be passed down the diversion channel which would relieve flood levels at James Avenue by approximately 0.7 ft (0.2 m).
    - a decrease in stage at James Avenue would increase the capacity of the effected combined storm by 6 to 8%.
    - the cost to complete the work was estimated to be $670,000.
    - benefits associated with breaching the floodway inlet "plug" were short term (for the duration of high Red River levels) and would only occur if high Red River levels were coincident with an intense summer rain storm (approximately 1.5 in (38 mm in) 24 hours). Following an assessment of benefits and associated costs it was decided to abandon plans to breach the floodway to relieve the 1993 flood conditions.
- A review of the hydrologic conditions following the decision (August 13, 1993) not to proceed with floodway modifications was conducted. Based upon actual rainfall and Red River data, it was concluded that no benefits would have been realized from the inlet modifications.
- Recommendations with respect to further study, associated with long term operation of the floodway during summer flooding, are presented.

TABLES

TABLE 1

THE CITY OF WINNIPEG
PRECIPITATION RECORDS (WINNIPEG INTERNATIONAL AIRPORT)
JUNE, JULY, AUGUST, 1993

DATE	RAINFALL (mm)		
	JUNE	JULY	AUG
1		6.0	1.6
2			6.0
3		3.6	.2
4		.8	6.0
5	.2	6.4	
6	.0	4.8	
7	4.2	.0	
8	15.4		72.2
9	.4	6.0	
10	.0		
11	.0	.0	10.6
12	15.8	.4	4.2
13	4.2	.2	
14	1.8		59.0
15		2.2	
16	6.2	11.2	
17		7.6	2.8
18		6.4	1.0
19		2.0	2.6
20	6.8		
21	.6	.2	
22	8.8	6.6	.2
23	3.8	1.2	.0
24	.8	24.2	
25	2.0	83.6	3.8
26	.4	6.8	.8
27	.0	12.4	8.2
28		.8	5.0
29	.0		2.4
30	7.4		2.2
31			2.0
TOTAL MONTHLY	76.8	193.4	190.8
Normal Monthly	83.8	72.0	75.3
Extreme Monthly	255.5	197.4	218.0
Season Total	137.8	331.2	522.0
Season Normal	179.5	251.4	326.8
% Normal	76.8	131.7	159.7

TABLE 2
1993 SUMMER FLOOD
DISCHARGE AND WATER LEVEL DATA

DATE	RED RIVER					LA SALLE RIVER	ASSINIBOINE
	ABOVE FLOODWAY (1)		JAMES AVENUE			NEAR SANFORD	AT HEADINGLY
JULY	ELEVATION (ft)	DISCHARGE (cfs)	ELEVATION (ft)	STAGE (ft)	DISCHARGE (cfs)	DISCHARGE (cfs)	DISCHARGE (cfs)
1	736.55		733.97	6.44	13,955	37	484
2	737.75		733.98	6.45	13,980	44	544
3	737.17		733.89	6.36	13,745	44	551
4	738.31		733.89	6.36	13,745	42	558
5	738.68		733.87	6.34	13,703	40	565
6	738.94		733.86	6.33	13,669	40	667
7	739.23		733.89	6.36	13,753	40	812
8	739.13		733.87	6.34	13,686	42	879
9	734.89		733.88	6.35	13,719	43	872
10	737.35		734.01	6.48	14,039	42	879
11	735.74		734.03	6.50	14,098	41	858
12	734.18		734.08	6.55	14,233	41	826
13	733.64		734.02	6.49	14,065	43	798
14	736.13		733.94	6.41	13,871	43	756
15	736.66		733.93	6.40	13,837	40	752
16	733.31		733.84	6.31	13,602	37	805
17	735.88		733.82	6.29	13,568	43	953
18	733.51		733.85	6.32	13,635	50	1,059
19	735.77		733.96	6.43	13,921	60	1,169
20	735.33		733.90	6.37	13,778	59	1,236
21	735.95		733.91	6.38	13,795	53	1,254
22	737.56		734.06	6.53	14,174	49	1,240
23	738.52		734.34	6.81	14,898	50	1,109
24	739.59		735.17	7.64	17,027	47	961
25	740.69		736.18	8.65	19,620	112	851
26	741.98		739.13	11.60	28,589	1,006	1,462
27	743.40		740.41	12.88	33,032	1,201	1,254
28	744.98		741.57	14.04	37,086	1,441	1,522
29	749.11	32,000	742.38	14.85	39,902	1,338	1,285
30	749.48	33,800	742.60	15.07	40,681	1,109	1,067
31	749.61	35,500	742.58	15.05	40,612	798	971

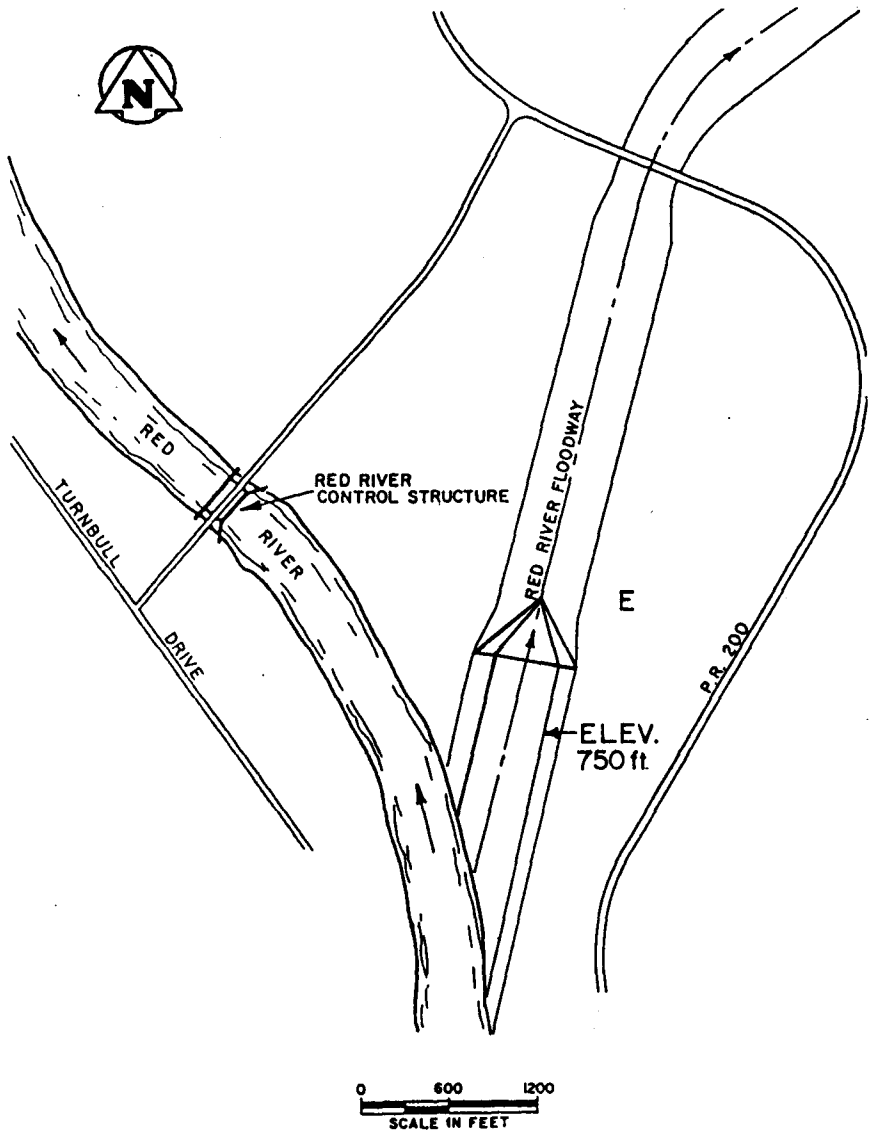
1- WATER LEVELS ABOVE FLOODWAY FOR PERIOD JULY 1 TO 28
CALCULATED FROM WATER LEVELS AT FLOODWAY STRUCTURE

TABLE 2 (Cont'd)
1993 SUMMER FLOOD
DISCHARGE AND WATER LEVEL DATA

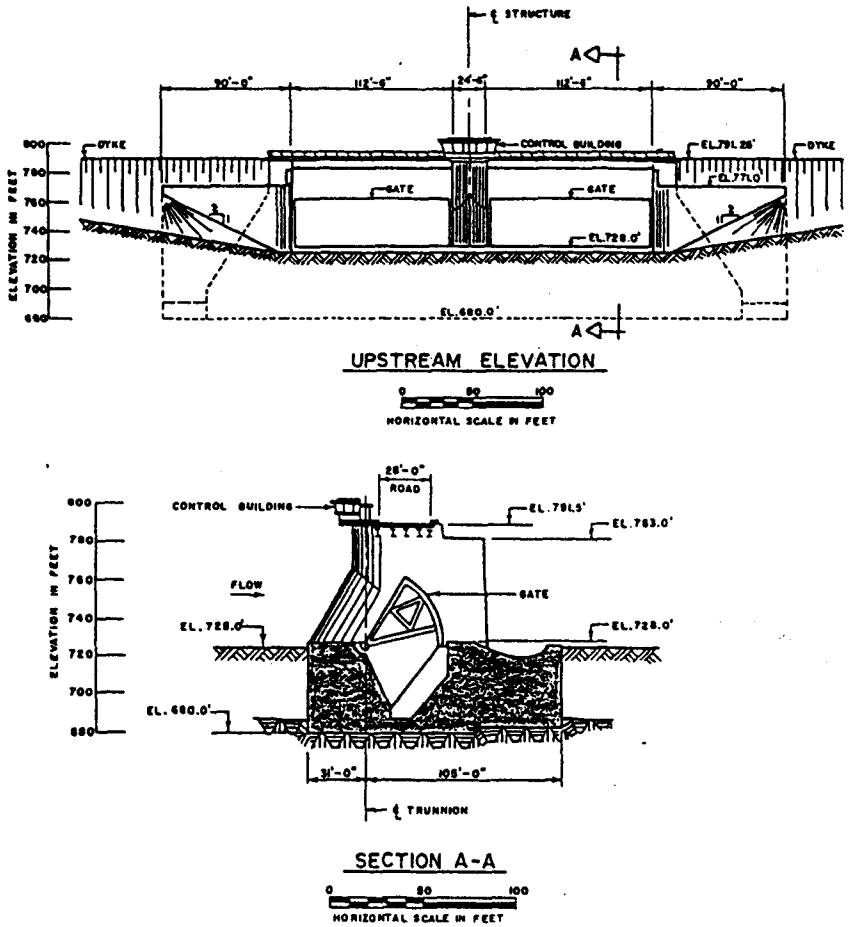
DATE	RED RIVER					LA SALLE RIVER	ASSINIBOINE
	ABOVE FLOODWAY (2)		JAMES AVENUE			NEAR SANFORD	AT HEADINGLY
AUGUST	ELEVATION (ft)	DISCHARGE (cfs)	ELEVATION (ft)	STAGE (ft)	DISCHARGE (cfs)	DISCHARGE (cfs)	DISCHARGE (cfs)
1	749.33		742.37	14.84	39,880	519	946
2	749.02		742.10	14.57	38,929	364	922
3	748.69	34,800	741.80	14.27	37,910	287	911
4	748.40	34,000	741.55	14.02	37,006	213	911
5	748.20	33,400	741.36	13.83	36,353	173	893
6	748.07		741.20	13.67	35,792	145	893
7	747.97		741.07	13.54	35,345	125	840
8	747.92		741.18	13.65	35,735	153	890
9	748.93	32,800	742.59	15.06	40,647	901	2,797
10	749.57	33,800	743.01	15.48	42,124	1,540	2,507
11	749.72	34,700	742.92	15.39	41,792	1,586	1,868
12	749.77	35,100	742.87	15.34	41,643	1,296	1,639
13	749.72		742.70	15.17	41,025	943	1,529
14	750.05		743.22	15.69	42,857	855	1,826
15	751.00	38,900	743.88	16.35	45,147	1,420	2,179
16	751.13	40,000	743.99	16.46	45,626	1,469	1,766
17	750.95	39,600	743.69	16.16	44,483	1,232	1,575
18	750.69	38,800	743.38	15.85	43,418	840	1,494
19	750.32		743.02	15.49	42,147	572	1,158
20	749.87		742.57	15.04	40,590	420	865
21	749.37		742.13	14.60	39,055	315	660
22	748.87		741.69	14.16	37,498	238	586
23	748.35		741.28	13.75	36,067	203	576
24	747.75		740.83	13.30	34,498	174	551
25	747.08		740.37	12.84	32,895	139	537
26	746.43		739.88	12.35	31,189	113	600
27	745.66		739.32	11.79	26,795	96	643
28	744.76		738.69	11.16	24,963	88	675
29	743.91		738.06	10.53	23,151	87	724
30	743.08		737.47	9.94	21,434	90	724
31	742.31		736.87	9.34	19,688	91	710

2- WATER LEVELS ABOVE FLOODWAY FOR PERIOD AUGUST 1 TO 3, 26 TO 31
CALCULATED FROM WATER LEVELS AT FLOODWAY STRUCTURE

FIGURES



LOCATION OF INLET
CONTROL STRUCTURE



INLET CONTROL STRUCTURE

SOURCE:
PROVINCE OF MANITOBA, THE MANITOBA WATER COMMISSION, A REVIEW OF PROVINCIAL PROCEDURES AND PLANS FOR FLOOD PROTECTION AND FLOOD FIGHTING, DECEMBER 1974.

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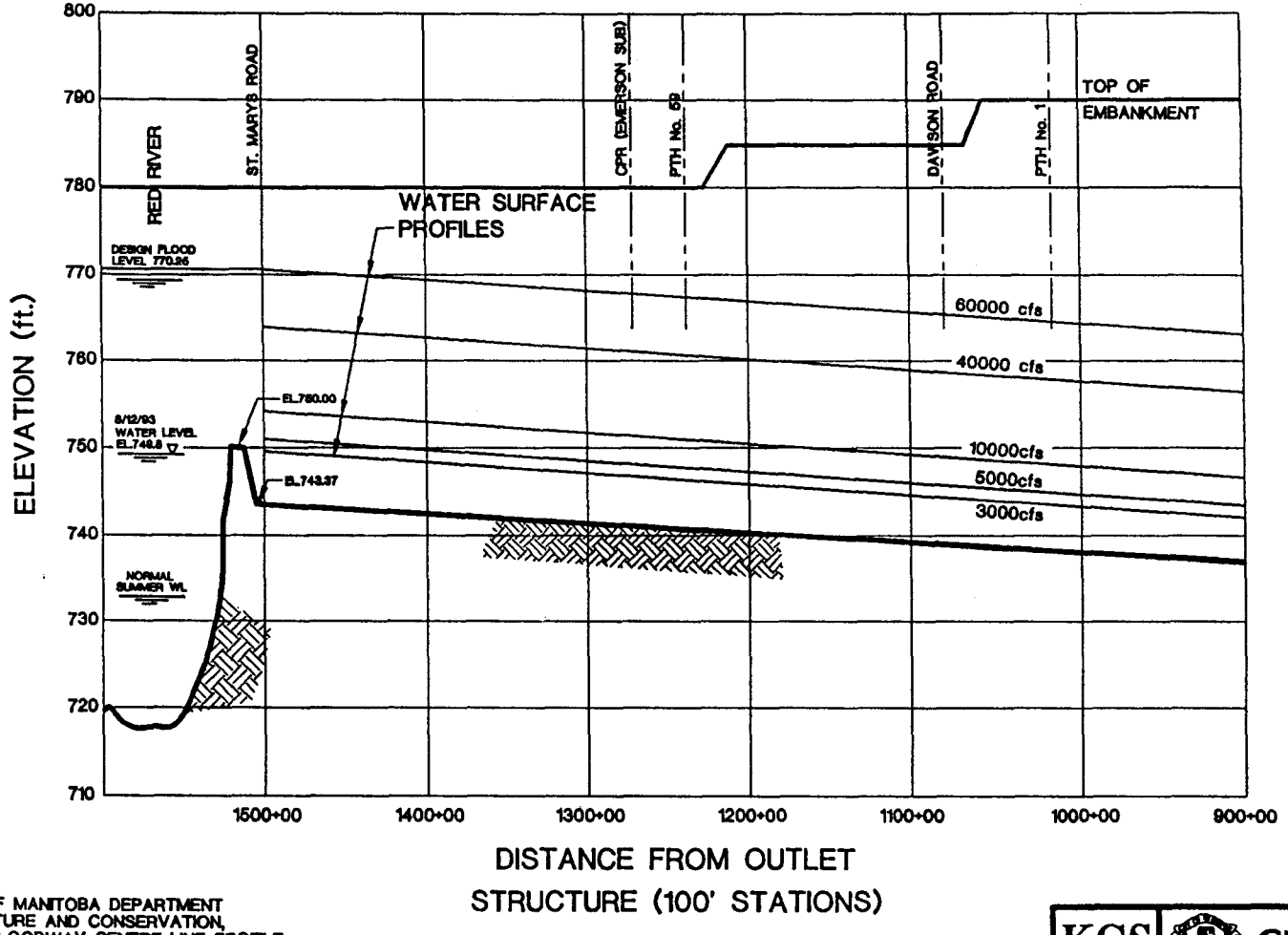
SUMMER FLOODWAY OPERATION STUDY

RED RIVER FLOODWAY
INLET AND CONTROL
STRUCTURE ARRANGEMENT

SEPT. 1993

FIGURE 2



SOURCE:
PROVINCE OF MANITOBA DEPARTMENT OF AGRICULTURE AND CONSERVATION, RED RIVER FLOODWAY CENTRE-LINE PROFILE AND EAST EMBANKMENT, DRAWING 11-5-11153, NOVEMBER 1985.

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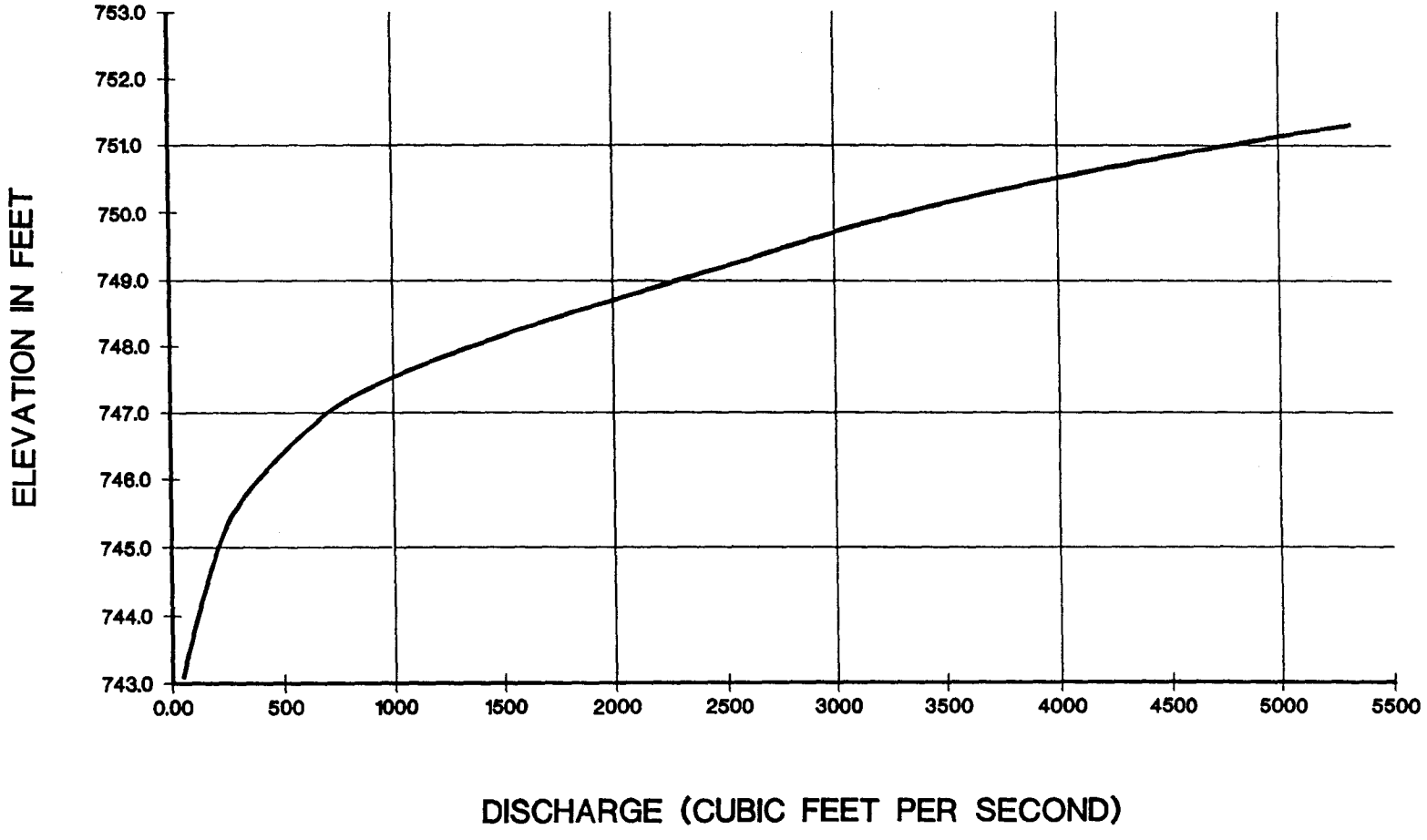
SUMMER FLOODWAY OPERATION STUDY

FLOODWAY CHANNEL
WATER SURFACE PROFILES

SEPT. 1993

FIGURE 3



SOURCE: FROM DATA PROVIDED BY MANITOBA WATER REOURCES BRANCH.

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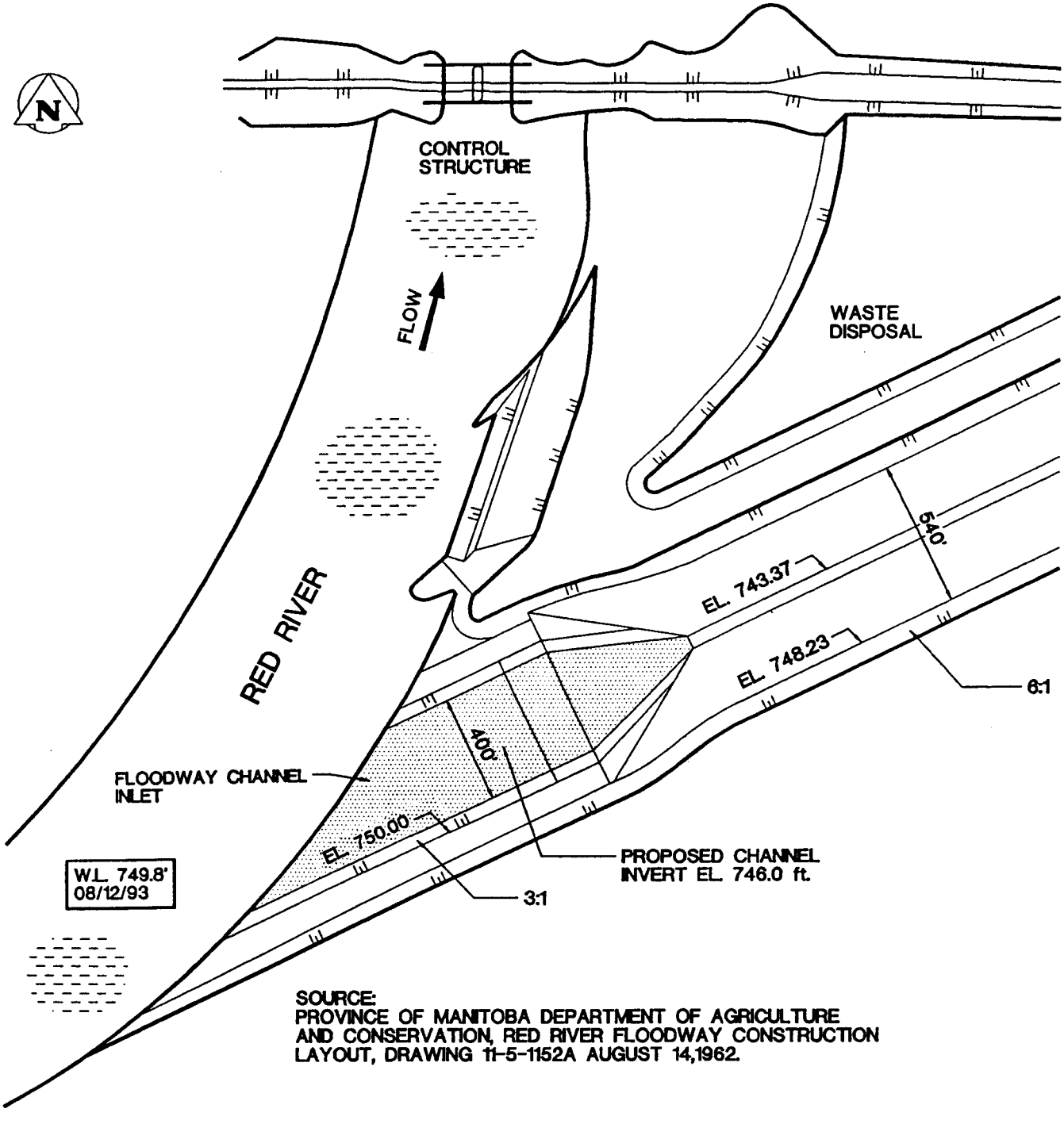
SUMMER FLOODWAY OPERATION STUDY

STAGE DISCHARGE CURVE
RED RIVER FLOODWAY AT ST. MARY'S RD.

SEPT. 1993 | FIGURE 4



SOURCE:
PROVINCE OF MANITOBA DEPARTMENT OF AGRICULTURE AND CONSERVATION, RED RIVER FLOODWAY CONSTRUCTION LAYOUT, DRAWING 11-5-1152A AUGUST 14,1962.

SCALE: FEET

0 500 1000 ft

0 100 200 300m

SCALE: METRES

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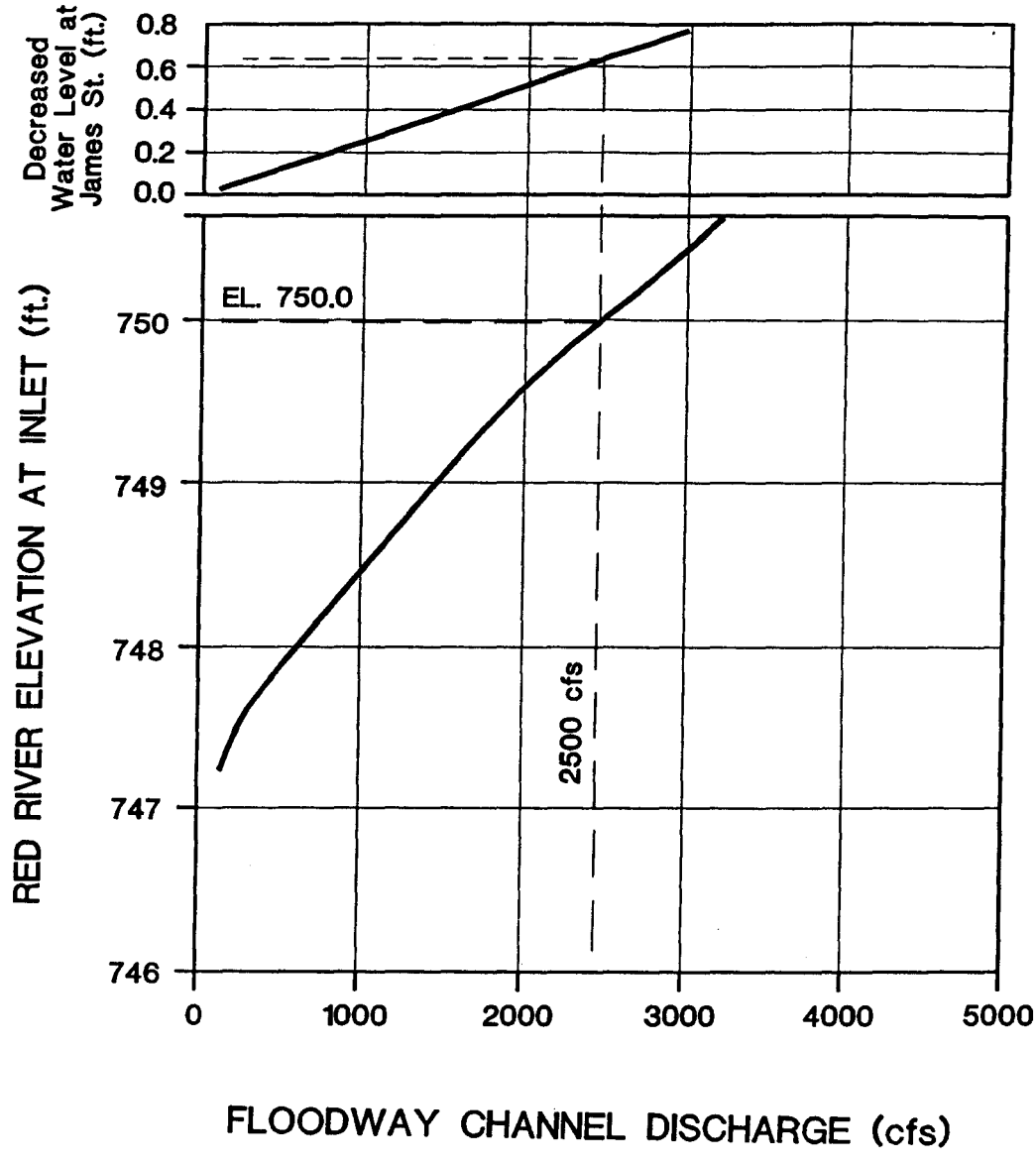
SUMMER FLOODWAY OPERATION STUDY

PROPOSED INLET CHANNEL EXCAVATION

SEPT. 1993 | FIGURE 5



NOTE:

-STAGE DISCHARGE CURVE FOR PROPOSED FLOODWAY CREST CHANNEL 400 ft. WIDE, INVERT EL. 746.0 ft.

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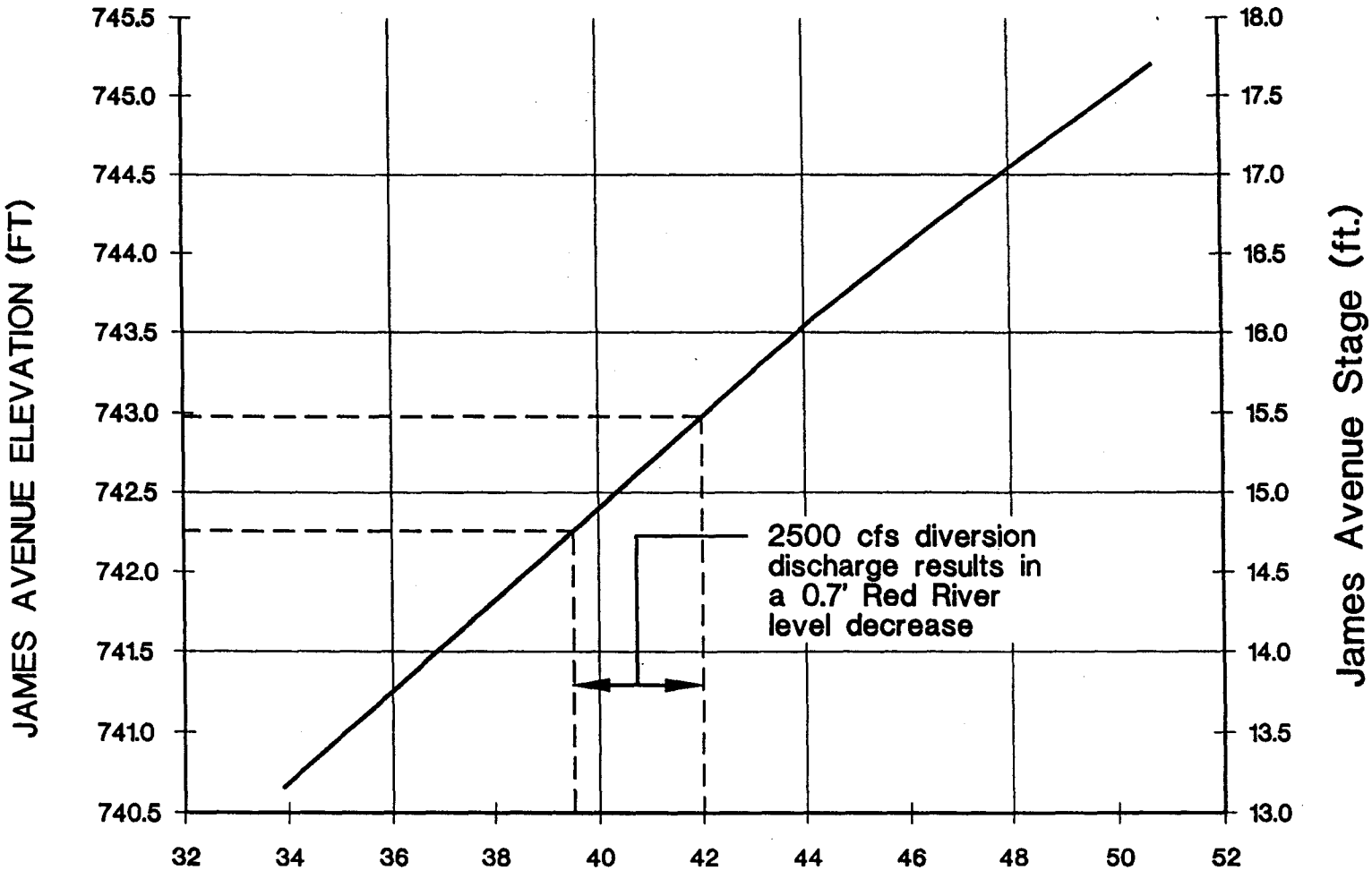
SUMMER FLOODWAY OPERATION STUDY	
STAGE DISCHARGE CURVE RED RIVER AT THE FLOODWAY INLET	
SEPT. 1993	FIGURE 6



SOURCE: FROM DATA PROVIDED BY MANITOBA WATER RESOURCES BRANCH

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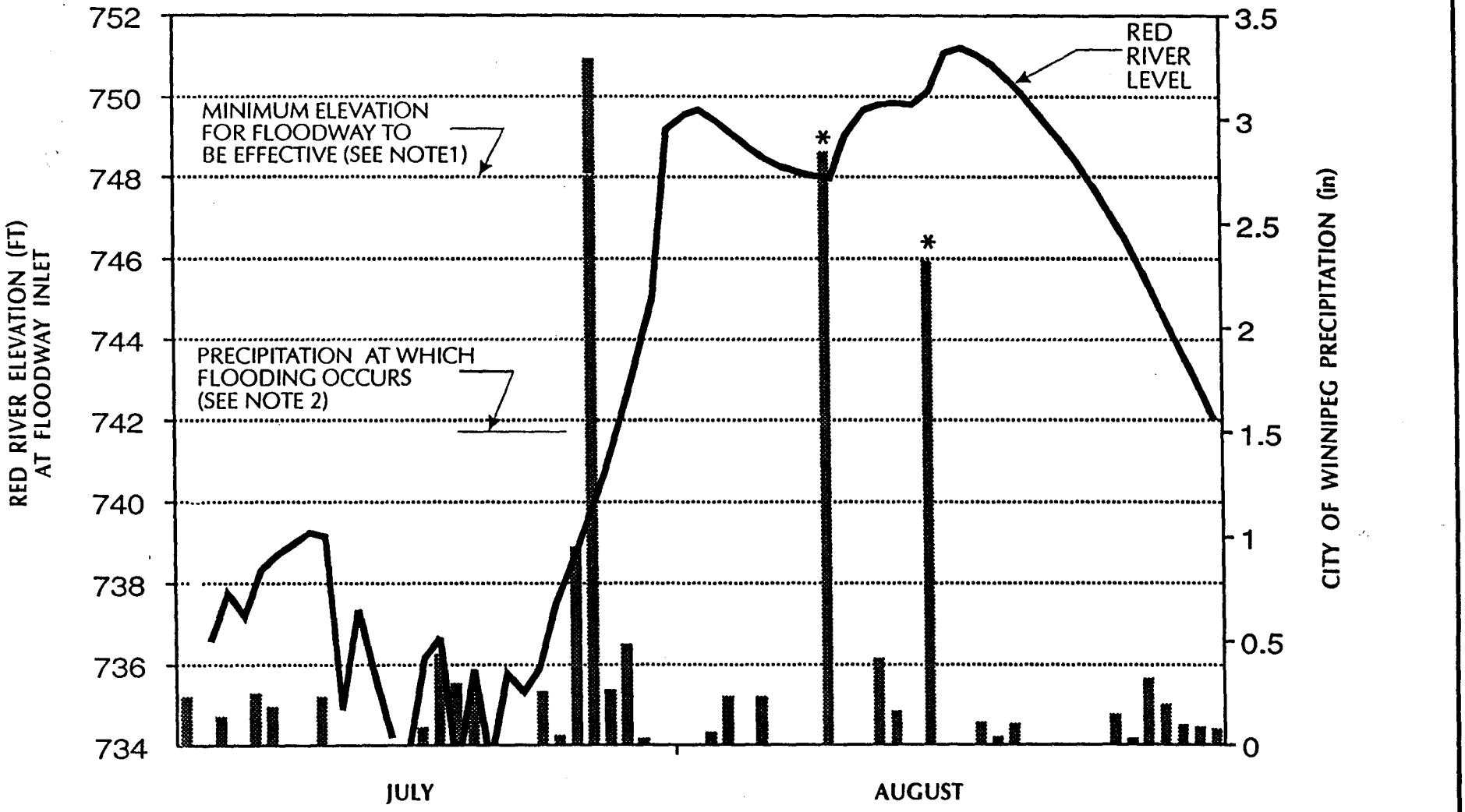
Waterworks, Waste and Disposal Department

SUMMER FLOODWAY OPERATION STUDY

STAGE DISCHARGE CURVE
RED RIVER AT JAMES AVE.

SEPT. 1993

FIGURE 7



NOTES - (1) AT RED RIVER LEVELS BELOW 748 ft THE FLOODWAY DISCHARGE IS INSIGNIFICANT

(2) FOLLOWING SEVERE SUMMER RAINFALL EVENTS (APPROXIMATELY 1.5 in) BASEMENT FLOODING OCCURS IN THE COMBINED SEWER DISTRICTS

* 1993 RAINFALL EVENTS IN WHICH THE FLOODWAY WOULD BE EFFECTIVE.

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SUMMER FLOODWAY OPERATION STUDY

RED RIVER ELEVATION AT INLET AND PRECIPITATION FOR JULY AND AUGUST 1993

SEPT. 1993 | FIGURE 8

APPENDIX A

TEST HOLE DATA

APPENDIX A

FLOODWAY INLET STRATIGRAPHY

The general stratigraphy at the floodway inlet consists of a thin layer of silts, weathered and unweathered clays and till, overlying the carbonate bedrock aquifer, based on the soil profile prepared during investigations for the channel (Reference Drawing 11-5-1137).

Organic Clay/Silts - Upper layer 0.05 to 0.15 m (2 to 5 ft) in thickness, overlying lacustrine clays

Lacustrine Clays - Upper weathered brown to grey clay approximately 15 m (50 ft) in thickness.

Till - Silt till to bedrock

The total overburden thickness is approximately 27 to 30 m in the area of the floodway inlet [Manitoba Water Resources, Winnipeg Area (62-H) Groundwater Availability Map Series, 1980].

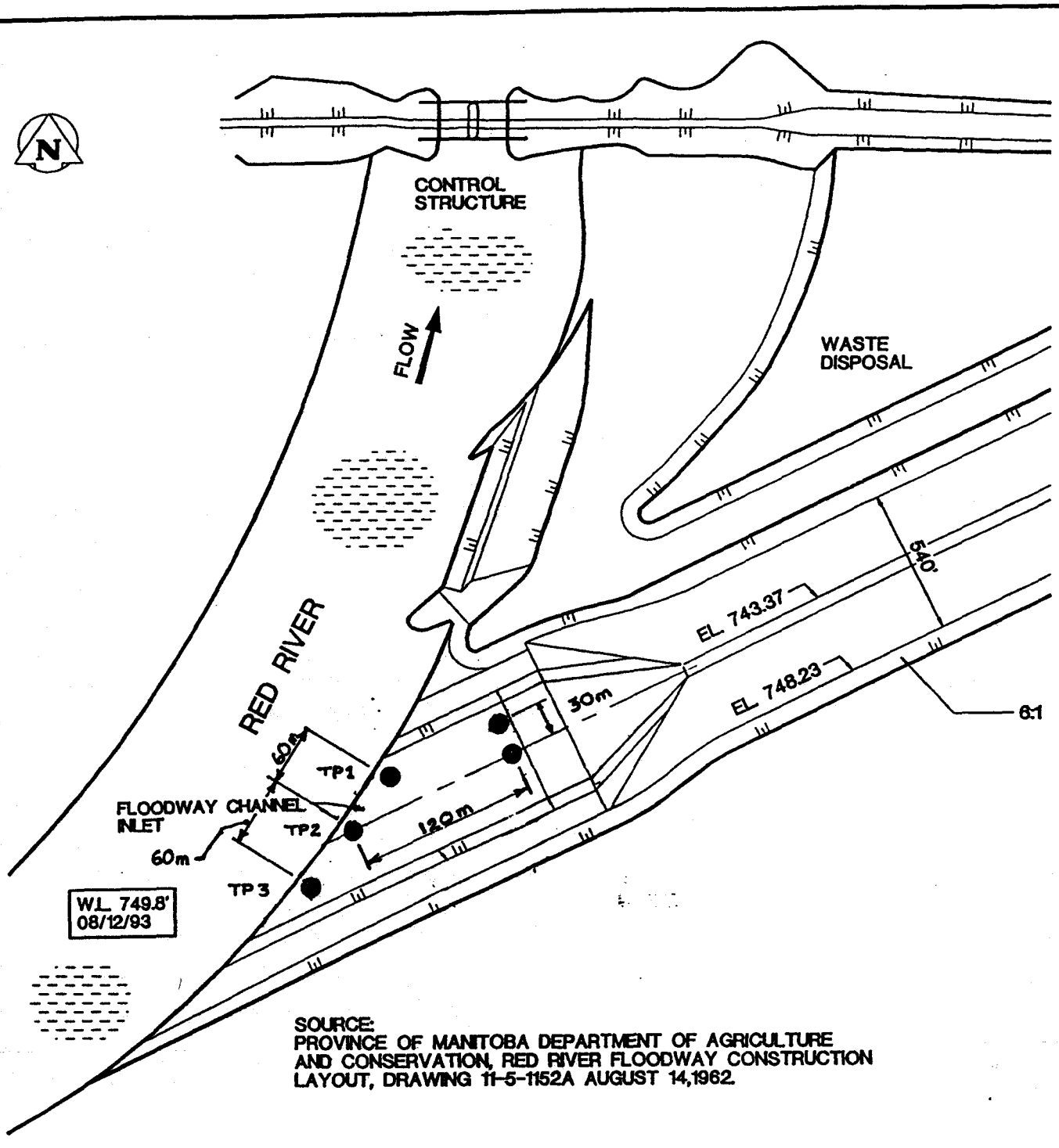
Shallow Site Investigation, August 1993

A total of five test pits were dug on August 13, 1993 at the floodway inlet to check the shallow soil conditions relative to ease of excavation and potential river seepage problems related to the proposed excavation. The logs TP1 to TP5 inclusive summarize the soil conditions encountered. The test pit locations are in the existing channel bottom, as shown on Figure A-1.

The shallow soil profile consisted of:

0 to 0.1 m	- ***Topsoil and Silt*** -	with grass cover and root system.
0.1 to 2.4 m	- ***Lacustrine Silty Clay*** -	brown to grey, firm, high plasticity, fractured and blocky with roots to 0.9 m depth. Moisture content range from 30% to 40%.
	-	Some site pockets, sand lenses and gravel seams from 1.1 to 1.9 m.

At TP2 on channel centreline, near the bank of the Red River, a 7.5 cm gravel seam and numerous sand seams were present below 1.1 m depth. At TP4, 120 m inland the sand seams were not encountered.



SOURCE:
PROVINCE OF MANITOBA DEPARTMENT OF AGRICULTURE AND CONSERVATION, RED RIVER FLOODWAY CONSTRUCTION LAYOUT, DRAWING 11-5-1152A AUGUST 14,1962.

SCALE: FEET

0 500 1000 ft

0 100 200 300m

SCALE: METRES

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SUMMER FLOODWAY OPERATION STUDY

PROPOSED INLET CHANNEL EXCAVATION

LOCATION OF TEST PITS

SEPT. 1993 | FIGURE A-1

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SUMMARY LOG

HOLE NO. TP-1

SHEET 1 of 1

CLIENT: CITY WINNIPEG - STREETS & TRANSPORTATION DEPT.

PROJECT: FLOODWAY INLET STUDY

SITE: RED RIVER FLOODWAY

LOCATION:

DRILLING METHOD: Backhoe

JOB NO. 93-107-08

GROUND ELEV.:

WATER ELEV.:

DATE DRILLED 93/8/13

ELEV. (m)	DEPTH (m)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	PIEZ. LOG	DEPTH (m)	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE RECOVERY	P.L. MC L.L. / Cu TORVANE (kPa) ◇ / % - kPa 20 40 60 80
	0		**TOPSOIL** - Grass cover, black organics, clay, silt, moist, soft.				1		
			SILTY CLAY - Grey, moist, firm, high plasticity, blocky, some root fibers to 0.75 m. -silt content increasing with depth -numerous dry silt pockets at 0.6 m -brown at 0.8 m				2		
	1		-mottled brown and grey at 1.15 m				3		
							4		
							5		
	2		**END OF HOLE at 1.98 m**				6		
	3								
	4								

SAMPLE TYPE ☒ SPLIT SPOON ▤ SHELBY ▮ SPLIT BARREL SAMPLER ◘ AUGER GRAB

CONTRACTOR CAMBRIAN

INSPECTOR G. HARRISON

APPROVED

DATE 93/8/31

KGS GROUP

SUMMARY LOG

HOLE NO. TP-2

SHEET 1 of 1

CLIENT: CITY WINNIPEG - STREETS & TRANSPORTATION DEPT.

PROJECT: FLOODWAY INLET STUDY

SITE: RED RIVER FLOODWAY

LOCATION:

DRILLING METHOD: Backhoe

JOB NO. 93-107-08

GROUND ELEV.:

WATER ELEV.:

DATE DRILLED 93/8/13

ELEV. (m)	DEPTH (m)	GRAPHICS	DESCRIPTION AND CLASSIFICATION
	0		**TOPSOIL** - Grass cover, black organics, clay, silt, moist, soft.
			SILTY CLAY - Dark brown, moist, firm, high plasticity, blocky, some root fibers to 0.9 m. -silt content increasing with depth
			-numerous silt pockets and lenses at 0.75 m
	1		-gravel seam (7.5 cm thick), brown, dry, well graded (<13 mm diam.), dense at 0.95 m -frequent sand seams (5 cm thick), brown, moist, poorly graded, medium dense at 1.1, 1.25, 1.4, 1.5 and 1.9 m
	2		-stiff to very stiff, with frequent silt seams below 2 m
			END OF HOLE at 2.44 m
	3		
	4		

PIEZ. LOG

DEPTH (m)

SAMPLE: TYPE, NUMBER, RECOVERY

P.L. MC L.L.

Cu TORVANE (kPa) ◇

% - kPa

20 40 60 80

SAMPLE TYPE: SPLIT SPOON; SHELBY; SPLIT BARREL SAMPLER; AUGER GRAB

CONTRACTOR: CAMBRIAN

INSPECTOR: G. HARRISON

APPROVED: GH DATE: 93/8/31

KGS GROUP

SUMMARY LOG

HOLE NO. TP-3

SHEET 1 of 1

CLIENT: CITY WINNIPEG - STREETS & TRANSPORTATION DEPT.

PROJECT: FLOODWAY INLET STUDY

SITE: RED RIVER FLOODWAY

LOCATION:

DRILLING METHOD: Backhoe

JOB NO. 93-107-08

GROUND ELEV.:

WATER ELEV.:

DATE DRILLED 93/8/13

ELEV. (m)	DEPTH (m)	GRAPHICS	DESCRIPTION AND CLASSIFICATION
	0		**TOPSOIL** - Grass cover, black organics, clay, silt, moist, firm.
			SILTY CLAY - Grey, moist, firm, high plasticity, blocky, some rootlets and root fibers to 0.9 m.
			-silt content increasing with depth
			-brown at 0.75 m
	1		
			-numerous silt pockets and lenses at 1.2 m
			-grey at 1.4 m
			-mottled brown and grey, frequent silt pockets and lenses at 1.5 m
	2		
			END OF HOLE at 2.13 m
	3		
	4		

PIEZ. LOG

DEPTH (m)

SAMPLE TYPE / NUMBER / RECOVERY

1 2 3 4 5 6 7

P.L. MC L.L.

Cu TORVANE (kPa) ◇

% - kPa

20 40 60 80

SAMPLE TYPE: SPLIT SPOON; SHELBY; SPLIT BARREL SAMPLER; AUGER GRAB

CONTRACTOR: CAMBRIAN

INSPECTOR: G. HARRISON

APPROVED

DATE 93/8/31

KGS GROUP

SUMMARY LOG

HOLE NO. TP-4

SHEET 1 of 1

CLIENT: CITY WINNIPEG - STREETS & TRANSPORTATION DEPT.

PROJECT: FLOODWAY INLET STUDY

SITE: RED RIVER FLOODWAY

LOCATION:

DRILLING METHOD: Backhoe

JOB NO. 93-107-08

GROUND ELEV.:

WATER ELEV.:

DATE DRILLED 93/8/13

ELEV. (m)	DEPTH (m)	GRAPHICS	DESCRIPTION AND CLASSIFICATION
	0		**TOPSOIL** - Grass cover, black organics, clay and silt, moist to wet.
			SILTY CLAY - Brown, moist, firm, high plasticity, blocky, some rootlets and root fibers to 1 m.
			-silt content increasing with depth
	1		
			-mottled brown and grey at 1.4 m
	2		-stiff at 2 m
			END OF HOLE at 2.44 m
	3		
	4		

PIEZ. LOG

DEPTH (m)

SAMPLE: TYPE, NUMBER, RECOVERY

1 2 3 4 5 6 7 8

P.L. MC L.L.

Cu TORVANE (kPa) ◇

% - kPa

20 40 60 80

SAMPLE TYPE: SPLIT SPOON; SHELBY; SPLIT BARREL SAMPLER; AUGER GRAB

CONTRACTOR: CAMBRIAN

INSPECTOR: G. HARRISON

APPROVED

DATE 93/8/31

KGS GROUP

SUMMARY LOG

HOLE NO. TP-5

SHEET 1 of 1

CLIENT CITY WINNIPEG - STREETS & TRANSPORTATION DEPT.

PROJECT FLOODWAY INLET STUDY

SITE RED RIVER FLOODWAY

LOCATION

DRILLING METHOD Backhoe

JOB NO. 93-107-08

GROUND ELEV.

WATER ELEV.

DATE DRILLED 93/8/13

ELEV. (m)	DEPTH (m)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	PIEZ. LOG	DEPTH (m)	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE RECOVERY	P.L. MC L.L. / Cu TORVANE (kPa) ◇ / % - kPa 20 40 60 80
	0		**TOPSOIL** - Grass cover, black organics, clay, silt, moist to wet.				1		
			SILTY CLAY - Brown, moist, firm, high plasticity, blocky, some rootlets and root fibers to 0.9 m. -silt content increasing with depth				2		
							3		
			-mottled brown and grey at 0.9 m						
	1						4		
							5		
							6		
			-occasional sand lense (7.5 cm thick), brown, water bearing, medium dense, poorly graded at 1.7 m				7		
	2		**END OF HOLE at 1.83 m**						
	3								
	4								

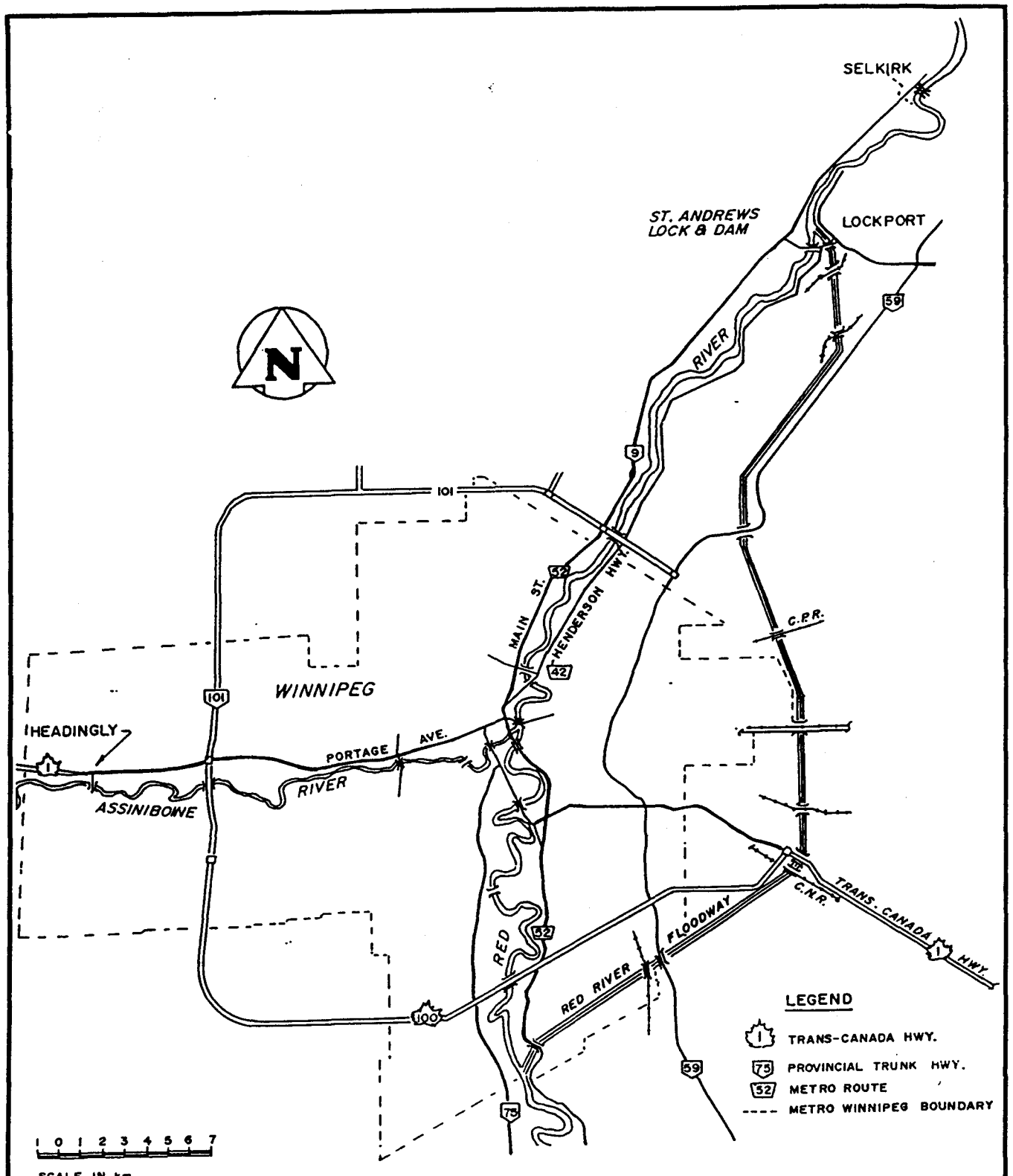
SAMPLE TYPE ⊠ SPLIT SPOON ▤ SHELBY ▮ SPLIT BARREL SAMPLER ⊡ AUGER GRAB

CONTRACTOR CAMBRIAN

INSPECTOR G. HARRISON

APPROVED

DATE 93/8/31



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Waterworks, Waste and Disposal Department

SUMMER FLOODWAY OPERATION STUDY

RED RIVER FLOODWAY
AREA PLAN

SEPT. 1993

FIGURE 1