A REVIEW OF THE RED RIVER FLOODWAY OPERATING RULES

RED RIVER FLOODWAY OPERATION REVIEW COMMITTEE

December, 1999

January 12, 2000

The Honorable Oscar Lathlin
Minister of Conservation
Winnipeg, Manitoba

Dear Mr. Minister

The Floodway Operation Review Committee is pleased to provide its report on the review of the operating rules for the Red River Floodway. In accordance with the Terms of Reference, we have reviewed the current operating rules and have recommended some changes and clarifications. We have also examined other flood-related issues including the management of ice and debris and emergency operation under 1826-type flooding. Finally we have developed operating rules for the control structures on drains through the West Dike including the Manness and Domain Drains.

Rick Bowering, Chair Manitoba Water Resources	Erminio Caligiuri PFRA
* Doug Dobrowolski RM of MacDonald (see note below)	* Herm Martens RM of Morris (see note below)
* Valerie H. E. Rutherford RM of Ritchot (see note below)	Maurice Sydor Environment Canada
Doug McNeil City of Winnipeg	Rick Hay Manitoba Water Resources

** The Rural Municipalities of Ritchot, Morris, and Macdonald are in agreement with the technical recommendations of the report. However they wish to record their objection to the fact that the terms of reference for the Committee have been omitted so as to permit an examination and recommendations with respect to compensation for damages caused by the control structure for persons whose properties are upstream.*

The Rural Municipalities of Ritchot, Morris, and Macdonald are strongly of the view that the Province must recognize as a principle governing the Red River Floodway in the future, that those who suffer from loss due to the existence and operation of the Floodway are entitled to full and fair compensation. A principle such as this applies to similar water control structures, and there is simply no reason that its benefits should not extend equally to all Manitobans.

Executive Summary

In November of 1998 the Minister of Natural Resources appointed the Red River Floodway Operation Review Committee. The Committee developed the recommendations in this report based upon first hand experience in fighting the 1997 flood, upon knowledge of local issues, upon technical experience in a variety of water resources and other related projects, upon technical analysis of issues, and upon review of related engineering studies completed and ongoing. A brief summary of background, observations, and recommendations for each of the five Terms of Reference follows:

1. ***Review present rules and criteria for operation of the Red River Floodway (Inlet) control structure and recommend changes, if necessary.***

Flood control works operated in concert to protect the City of Winnipeg include Shellmouth Dam, the Portage Diversion, the Red River Floodway, and the City of Winnipeg Primary Diking System. These works were designed to pass a flood flow of 169,000 cubic feet per second (4,800 cubic metres per second). In 1997 the works passed an estimated flood flow of 163,000 cubic feet per second (4,600 cubic metres per second).

Works comprising the Red River Floodway include the diversion channel, inlet control structure, outlet structure, and west dike. Manitoba Water Resources regulates the relative amounts of Red River flow through Winnipeg, and down the diversion channel around Winnipeg by controlling upstream water surface elevations through the operation of the inlet control structure gates.

The inlet control structure gates are operated in accordance with established rules of operation. The rules state that under normal flood conditions the Red River water surface elevation at the entrance to the Floodway diversion channel must be at or below the computed "natural" level. This is generally the case for floods up to the design flood flow of 169,000 cubic feet per second (4,800 cubic metres per second).

Recommend that the procedure for determining "natural" levels be recomputed.

In 1997 questions arose about the accuracy of the computed "natural" levels above the Floodway. The procedures specified in the operation plan were developed in the 1960's and have not been reviewed since that time. There is now some uncertainty as to their accuracy under high flow conditions. **The Committee, therefore, recommends that the "natural" water level relationships be recomputed. To assure that the relationships receive broad acceptance, the computation should be done under the supervision of a technical working group comprised of representatives from the provincial and federal governments, from the City of Winnipeg, and from the valley south of the Floodway Control Structure.**

The 1997 flood with a peak natural flow of 163,000 cfs (4,600 m3/s) was an exception, where the operating rule for normal floods could not be applied as it is currently stated. The 1997 combination of higher than design flow on the Red River and lower than design flow on the Assiniboine River produced dangerously high water surface elevations in the south end of the City of Winnipeg. It was necessary for Manitoba Water Resources to raise the Floodway Inlet Control Structure gates to limit water surface elevation increases in Winnipeg, which caused the water surface elevation upstream of the Floodway to rise beyond "natural" flood level. The Committee is of the opinion that this was an appropriate course of action under the circumstances.

When flood flows exceed the system design capacity the upstream water surface elevation must be elevated beyond "natural". There are two additional operating rules to govern operation under such emergency conditions.

For natural flows between 169,000 and 189,000 cfs (4,800 and 5,400 m3/s) the rules allow for upstream water surface elevations to increase up to 775.8 feet (236.46 m.) while holding levels through Winnipeg constant at 25.5 feet (7.77 m.) at James Avenue Pumping Station.

For natural flows above 189,000 cfs (5,400 m3/s) the rules allow for additional flow to be passed through Winnipeg. The rule requires that the primary dikes through Winnipeg be raised to 31.5 feet (9.60 m.). This rule stipulates that if there is not sufficient time to raise all of the primary dikes in Winnipeg, water levels will be maintained at 25.5 feet (7.77 m.) at James Avenue Pumping Station, but the elevation at the Inlet will not be permitted to exceed elevation 778.0 feet (237.13 m.). These conditions will apply until the dikes are raised. The Committee has determined that it may not be possible to raise all of the primary dikes within a reasonable enough time frame. It would be particularly difficult in the event of a major rain event, which would slow construction activities.

When water levels at the Floodway inlet reach 778.0 feet (237.13 m.) the rules require that any additional flow would be passed through Winnipeg. The intent is to prevent sudden inundation of Winnipeg due to catastrophic failure of the Red River Floodway Control Works. The Committee understands that under these extreme conditions, flow increases through Winnipeg would be coupled with orderly evacuation. Selected areas behind the Primary Diking System may be systematically flooded to save the flood control works and minimize damages overall.

The current operating rules were determined to be appropriate under most circumstances, and as such, no major changes to the philosophy of operating the Red River Floodway Inlet Control Structure are required. However, it would be appropriate to modify the way in which the rules are written to make allowances for certain foreseen exceptional circumstances, such as those that occurred in 1997, and to remove ambiguities that exist in the way the rules are currently written. **The Committee, therefore recommends that the following changes be made to the operating rules:**

Recommend Operating Rules:

Rule Number 1:

***Rule 1**: Maintain "natural" levels until James Avenue reaches 24.5 feet.*

Rewrite the operating rule for normal floods to clearly point out that the Floodway would be operated to ensure that the water surface elevation at the entrance to the Red River Floodway channel does not rise above "natural", unless the water surface elevation at James Avenue reaches 24.5 feet (7.46 m.), or the river level anywhere along the Red River within the City of Winnipeg reaches two feet below the Flood Protection Level of 27.83 feet (8.48 m).

Rules Number 2 and 3:

***Rule 2**: For larger floods focus on protecting Winnipeg.*

***Rule 3**: For extreme floods focus on preventing catastrophic failure of works.*

The only changes recommended for flows that exceed the limits specified in Rule 1 are to determine maximum allowable levels based on the safe computed freeboard for dikes and embankments, rather than the two feet (0.6 m) specified in the current rules. Also rearrange the actions under these two rules so that Rule 2 covers emergency operations that could be done once the limits of Rule 1 are exceeded, and Rule 3 covers activities that must be undertaken when flows are so high that it is no longer possible to protect Winnipeg from major flooding.

Others :

Modify the rule delaying gate operation until ice is flowing freely, to permit gate operation with ice in place if flooding in Winnipeg is imminent.

Delete the rule regarding depth of flow over the Floodway lip. Based upon operational experience, this rule is unnecessary.

Modify the rule requiring a minimum final drop of gates such that the final drop (s) be done in consultation with the City of Winnipeg. The intent would be to minimize vulnerability of city residents to sewer backup and riverbank sloughing due to high and fluctuating river levels through the city.

Set up a 1-800 number to inform residents about Floodway gate operations

Modify the rule requiring operation of the horn before each gate rise, so that the horn would only be operated once, before the first gate operation of the flood season. For ongoing information about gate changes a 1-800 number should be established that would provide residents with current and forecast gate settings and flood levels. This information should also be included on the existing Water Resources internet site.

Technical study of wind and wave impacts on the West Dike and Floodway embankment.

The operating rules permit levels upstream of the Control Structure to rise to a maximum elevation of 778 ft. (237.13 m) under extreme flood conditions. With the top of much of the West Dike and part of the Floodway embankment at 780 ft. (237.74 m) this leaves a freeboard of only two feet (600 mm). The Committee is of the view that two feet of freeboard is inadequate to prevent overtopping from wind setup and wave action. Considering the depth of water that would be against the dike and the Floodway embankment, and the length of the fetch to the south, wind setup under a prolonged south wind would in all probability be well in excess of two feet. Therefore permitting levels south of the Control Structure to rise to 778 ft. (237.13 m) would create a serious risk of overtopping and a major dike failure unless the Floodway dike and embankments had been raised to a safe level. **The Committee recommends that a rigorous technical analysis of wind and wave impacts be carried out to determine a safe freeboard for the Floodway embankment, the West Dike, and Winnipeg's Primary Dikes.**

Appointment of a Floodway Operation Advisory Board.

Notwithstanding the fact that the current and proposed operating rules are effective and appropriate, the Committee recognizes that Floodway operation, particularly under serious flooding conditions, is controversial. In particular many residents south of the Floodway Control structure suspect that gate operation increases levels above those that would have occurred in the absence of the flood control works. Participation of the City and valley municipalities in Floodway operating decisions would ensure that local concerns are taken into account. It would also ensure that all facts are fully understood, and would provide direct feedback to the affected residents. The Committee is of the opinion that better understanding of the operation of the Red River Floodway by stakeholders, through participation in operational recommendations, would dissipate many future concerns with respect to operation. **The Committee therefore recommends that a Floodway Operation Advisory Board be created. The Board would be chaired by Manitoba Water Resources, and include representation from the City of Winnipeg, from affected rural municipalities south of Winnipeg, and from the federal government**. **It may also be useful to include a representative from the valley north of Winnipeg.**

Take actions to restore the full design capacity of the Floodway works.

While reviewing the operating rules the Committee became aware that bridges over the floodway channel, and works constructed in the floodplain have reduced the ultimate capacity of the flood control works. The committee also noted that the design capacity of the Outlet structure for the Floodway is less that the maximum channel capacity. **The Committee, therefore, recommends that:**

a. **The possibility of permanently raising the seven upstream bridges crossing the Red River Floodway Diversion Channel (GWWD Railway, PTH #1, CNR Sprague, PTH 59S (two bridges), CPR Emerson, and St. Mary's Road) should be examined.**

b. **The impact of removal or reduction in height of a section of the east embankment of the Floodway channel west of Grande Pointe be assessed before any portion of that dike is incorporated into a community dike.**

c. **No works be constructed in the Red River Valley upstream of the Red River Floodway channel inlet without an assessment of its potential impact on the capacity of the Floodway channel.**

d. **The feasibility of upgrading the capacity of the Outlet Structure should be examined.**

The City of Winnipeg remains vulnerable to flooding for river levels well below the current flood protection level. There are 800 properties that are on the river side of the primary dikes, and require protection by secondary dikes where possible. Also high river levels reduce the capacity of the sewer system. Significant capital improvements to the existing diking and sewer systems are required to provide increased river flood protection, pumping capacity and gates on all sewer and drainage facilities.

Upgrade flood protection infrastructure in Winnipeg

Therefore, the Committee recommends that flood protection infrastructure works in the City of Winnipeg, including works related to the primary diking system and the sewer systems, be upgraded to a level of 27.8 feet equivalent at James Avenue (the legislated Flood Protection Level).

2. ***Review plans for Floodway operation and other remedial measures to be taken in the event of a significant ice/debris jam either in the Floodway Channel, upstream of the Control Structure or in the City of Winnipeg.***

Comprehensive study of ice impacts and behavior.

Management of late spring ice break-up on both the Red and Assiniboine Rivers is an annual problem**. A comprehensive analysis should be undertaken of all ice-related impacts on the flood control and protection infrastructure.** This would include identification of ice jam scenarios not yet experienced and recommendations for effective mitigation, both reactive (blasting, wrecking ball, gate operation) and preventative (dusting, saw cuts, "Swiss-cheesing", etc.) **Furthermore the committee recommends that outside expertise should be solicited to improve our understanding of river ice behavior.**

3. ***Review or prepare contingency plans for operation of the Floodway and for emergency actions such as closures, emergency diking or breaching, etc. required to combat a flood of 1826 proportions.***

The peak flow of the 1826 flood has been estimated to be 225,000 cfs (6,400 m3/s) (RRBI, 1953). This flow is approximately forty percent greater than the 1997 flood peak, and well beyond the design capacity of the current flood control works.

Although it is not possible to predict when it will occur, it is inevitable that a flood equal to or greater in flow than the 1826 flood will occur sometime in the future.

The Committee is of the opinion that it would not be possible to prevent extensive damage to the City of Winnipeg for an 1826 magnitude flood with the current flood control works and

flood fighting measures similar to those undertaken in 1997. The Committee recognizes that much has been done since 1997 through the Canada-Manitoba Partnership Agreement on Red River Valley Flood Protection. However most of this program is focused on flood protection in the Valley south of Winnipeg. More effort is required to reduce Winnipeg's vulnerability to a major flood.

Increase capacity of major flood control works.

The Committee recommends that serious consideration be given to increasing the capacity and reliability of the flood protection works for Winnipeg. This would enable increased protection against an 1826-magnitude flood or larger, and reduce the potential for loss of life and significant damage.

Full protection to Winnipeg would be very costly, and could only be provided by a major expansion of the flood protection works. One obvious option would be to increase the existing capacity of the Floodway channel. However other options are available that could substantially increase flood protection for Winnipeg. The options of permanently raising seven bridges over the Floodway channel, and restricting further development upstream of the Floodway channel inlet have been previously discussed. Other possible suggestions are:

a. Permanently raise the west dike, thereby increasing freeboard, to provide adequate protection from overtopping due to wind setup, wave uprush, and other factors.

b. Permanently raise approximately 10 miles (16 kilometres) of primary dikes within Winnipeg to elevation 27.8 ft. James, to ensure that all of the City of Winnipeg Primary Diking System would be at or above the Flood Protection Level. This would increase flow capacity through the city and reduce the risk associated with raising dikes during floods under poor weather conditions. Concurrently the sewer system would also have to be protected from the impact of high river levels.

c. Permanently raise the west embankment (City side) of the Floodway channel from the channel entrance to PTH #59S, to provide additional emergency capacity in the Floodway channel.

d. Floodproof the inlet control structure. The floor of the machine room in the control structure is at elevation 779.8 feet (237.68 m.). If the water level over the floodway gates needs to be raised above this level, steps would have to be taken to keep water out of the machine room. Also the stability of the structure under such high water conditions would have to be assessed.

Implementation of the above measures, coupled with a significant flood fighting effort as undertaken in 1997, would put the City of Winnipeg in a much stronger position to fight an 1826 magnitude flood event, thereby minimizing the potential for loss of life and significant damage.

4. *Review or formulate operation criteria for control structures on the West Dike of the Floodway, particularly those on the Domain Drain and on the*

Manness Drain.

The West Dike runs approximately twenty miles (32 kilometres) south and west of the Red River Floodway Inlet Control Structure. It was constructed to prevent rising flood waters in the Red River Valley from entering the LaSalle River and causing flooding in Winnipeg. The area south of the West Dike is drained primarily by the Manness Drain and by the Domain Drain. These channels pass through the West Dike via gated control structures, which regulate flows through the West Dike north to the LaSalle River.

The Committee is of the opinion that the control gates on drains crossing the West Dike should be operated under the direction of Manitoba Water Resources, in consultation with the local RM's, to maximize drainage of farmland south of the West Dike, and to maintain the integrity of the West Dike during times of flood.

Keep gates on culverts through the West Dike open whenever floodwaters from the Red are not against the dike.

The Committee recommends that the control structure gates for the Manness and Domain Drains be open as long as possible to maximize drainage of farmland before and after flood waters are against the West Dike. The gates would be kept closed and the structures constantly monitored when flood water from the Red River are against the West Dike, to minimize the possibility of failure of the West Dike and inundation of the City of Winnipeg.

Construct one more drain through the West Dike for the Glenlea area.

The committee recommends that one more drain should be constructed through the West Dike at NE15-8-2E to allow flood water to drain north from the Glenlea area to the La Salle River while the Red River is still high. It is further recommended that no additional drainage or other structures be constructed through the West Dike, as these structures are points of vulnerability during a flood.

5. ***Prepare a report on items 1, 2, and 4 for submission to the Minister of Natural Resources by the end of March 1999, and a final report by December 31, 1999.***

It became apparent late in the winter of 1999 that a serious spring flood would not occur on the Red River. Therefore, it was unnecessary to prepare and submit an interim report for March 1999. The Committee felt strongly that more time should be taken to consult with stakeholders and to carry out analytical work in support of the recommendations, targeting completion of the report by December 1999.

Clearly communicate operating rules to the public.

The Committee recommends that this report be made public, and that the operating rules be clearly documented and available to the public to improve understanding, education, and awareness of the complex set of conditions pertaining to Floodway operation.

The terms of reference for the Floodway Operation Review Committee did not include a review of the government's compensation policies. However the Committee agreed that in reviewing the operating rules it had to start from an assumption of fairness to all Manitobans. This base assumption is in accordance with recommendation number 1 of the Manitoba Water Commission (June, 1998) which states:

> ***"Impacts on residents south of the Floodway gates created through the operation of the Floodway in 1997 should be given due consideration"***

Table of Contents

Executive Summary
Table of Contents
List of Figures
Foreword
1. Introduction
2. Red River Floodway

BACKGROUND
OVERVIEW OF WINNIPEG'S FLOOD CONTROL SYSTEM
OVERVIEW OF RED RIVER FLOODWAY
FLOODWAY CHANNEL CAPACITY
INLET CONTROL STRUCTURE
OUTLET STRUCTURE
WEST DIKE
FLOOD-TIME OPERATIONS

3. City of Winnipeg Flood Protection

THE SEWER SYSTEM
THE FLOOD PROTECTION SYSTEM
1997 FLOOD EXPERIENCE -VULNERABILITY TO BASEMENT FLOODING
A FLOOD LARGER THAN 1997

4. General Observations

THE 1997 FLOOD EXCEEDED THE SYSTEM CAPACITY
LOCAL INPUT TO FLOODWAY OPERATION
FREEBOARD ON THE FLOODWAY EMBANKMENTS AND WEST DIKE
RESTORATION OF FLOODWAY CAPACITY

5. Review of Red River Floodway Operating Rules

INTRODUCTION
RULE FOR FLOWS AT OR BELOW THE DESIGN CAPACITY
RULES FOR FLOWS LARGER THAN THE DESIGN FLOOD
OTHER RULES

6. Operation Under Extreme Flooding (1826)

BACKGROUND
CONCLUSION

7. Ice Jam and Debris Management

8. Operation of Local Drainage Through West Dike

BACKGROUND
IMPACT
CONSTRUCTION AFTER THE 1997 FLOOD
RECOMMENDATIONS

9. Conclusions and Recommendations

References

List of Figures

Figure 1 - Flood Control Works and Corresponding Design Capacities
Figure 2 - Location Plan for Red River Floodway

Figure 3 - Typical Cross Sections of the Floodway Channel
Figure 4 - Longitudinal Profile of the Floodway Channel
Figure 5 - Floodway Bridge Location
Figure 6 - Computed Floodway Channel Capacity Without Influence of Bridges
Figure 7 - Impact of Bridges on Floodway Channel Capacity
Figure 8 - Floodway Inlet Control Structure
Figure 9 - Floodway Outlet Structure
Figure 10 - Location of West Dike
Figure 11 - Primary Diking System in Winnipeg
Figure 12 - Profile of the Primary Dike along the East Side or the Red River
Figure 13 - Profile of the Primary Dike along the West Side or the Red River
Figure 14 - Profile of the Red River at 1997 Peak Level
Figure 15 - Cross-section of Secondary Dike and Sewer Systems
Figure 16 - Cross-section of a Combined Sewer System at the River
Figure 17 - Cross-section of a Separate Sewer System at the River
Figure 18 - Pumping Station, Gate Chamber and Other Activities
Figure 19 - Flooded Areas for an 1826-Magnitude Flood
Figure 20 - 1997 Floodway Entrance Losses
Figure 21 - Local Drainage through the West Dike

Foreword

After the Red River flood of 1997 the Government of Manitoba reconstituted the Manitoba Water Commission and asked it to conduct an independent review of actions taken during the 1997 flood. Its report "An Independent Review of Actions Taken During the 1997 Red River Flood" recommended that

> ***The Red River Floodway Program of Operation should be reviewed and revised for emergency operations by the Province of Manitoba in full consultation with the Government of Canada and the affected municipalities including the City of Winnipeg, and Residents of the Valley.*** **(Recommendation Number 2)**

In November of 1998 the Minister of Natural Resources appointed the Red River Floodway Operation Review Committee. The membership is

Rick Bowering, chair Manitoba Water Resources
Erminio Caligiuri PFRA

Doug McNeil	City of Winnipeg
Valerie Rutherford	R.M. of Ritchot
Herm Martens	R.M. of Morris
Doug Dobrowolski	R.M. of MacDonald
Maurice Sydor	Environment Canada
Rick Hay	Manitoba Water Resources

Eugene Kozera from Water Resources and Tony Kettler from PFRA provided technical support to the Committee. Mr. Kozera acted as secretary. Bob Stefaniuk, Reeve of the RM of Ritchot, also participated in the Committee meetings.

The Terms of Reference for the Committee are:

1. Review present rules and criteria for operation of the Red River Floodway control structure and recommend changes, if necessary.

2. Review plans for Floodway operation and other remedial measures to be taken in the event of a significant ice/debris jam either in the Floodway Channel, upstream of the Control Structure or in the City of Winnipeg.

3. Review or prepare contingency plans for operation of the Floodway and for emergency actions such as closures, emergency diking or breaching, etc. required to combat a flood of 1826 proportions.

4. Review or formulate operation criteria for control structures on the West Dike of the Floodway, particularly those on Domain Drain and Manness Drain.

5. Prepare an interim report on items 1, 2 and 4 for submission to the Minister of Natural Resources by the end of March 1999, and a final report by December 31, 1999.

1 .Introduction

The Red River Floodway, in conjunction with the Portage Diversion and Shellmouth Reservoir, has proven to be very effective in protecting Winnipeg from flooding. However these works were not designed to provide benefits to residents of the valley south of Winnipeg. In fact, in some years (1974, 1976, and 1997) this area has experienced increased water levels as a result of structure operation. There is general acceptance in the valley that protection of Winnipeg must be the highest priority for Floodway operation, even if that protection occasionally results in augmented water levels in the valley. However there are two issues that cause discomfort in the valley:

- Suspicion that operation of the Floodway gates unnecessarily increases flooding in many years, and

- Concern that residents are not adequately compensated when operation of the control works

increases upstream water levels above "natural" as it did in 1997.

The Committee was mandated to review the operating rules and to recommend modifications. The terms of reference did not include a review of the government's compensation policies. However the Committee agreed that in reviewing the operating rules it had to start from an assumption of fairness to all Manitobans. This base assumption is in accordance with recommendation number 1 of the Manitoba Water Commission (June, 1998) which states:

> ***"Impacts on residents south of the Floodway gates created through the operation of the Floodway in 1997 should be given due consideration"***

During its review the Committee heard presentations from the following stakeholders:

- Manitoba Water Resources Branch on the current Floodway operating rules and how they were applied in 1997;
- The City of Winnipeg on Winnipeg's flood protection systems (diking and sewer systems) and on Winnipeg's general vulnerabilities to flooding;
- The RM of MacDonald on issues relating to drainage through the West Dike during flood events;
- The North Ritchot Action Committee on flood issues in the RM of Ritchot; and
- The Elm Park Peninsula Flood Committee on flooding concerns along the Red River in Winnipeg.

The Committee members also shared their varied and broad experiences in managing floods on the Red River.

Chapter 2 describes the various components of the Floodway, and discusses problems encountered during the 1997 flood. Chapter 3 reviews Winnipeg's flood protection system, and the City's vulnerability to flooding, with particular reference to 1997 experiences. Chapters 4 and 5 contain recommendations on how flood management in Winnipeg and in the Red River valley can be improved, with Chapter 5 focusing on the Floodway Operating rules. Chapter 6 discusses contingency plans for flood protection under extreme flood conditions such as occurred in 1826. Chapter 7 presents options for managing ice jams, and Chapter 8 provides recommendations for the control of local drainage through the West Dike. Finally, all of the report's recommendations are summarized in Chapter 9.

2. Red River Floodway

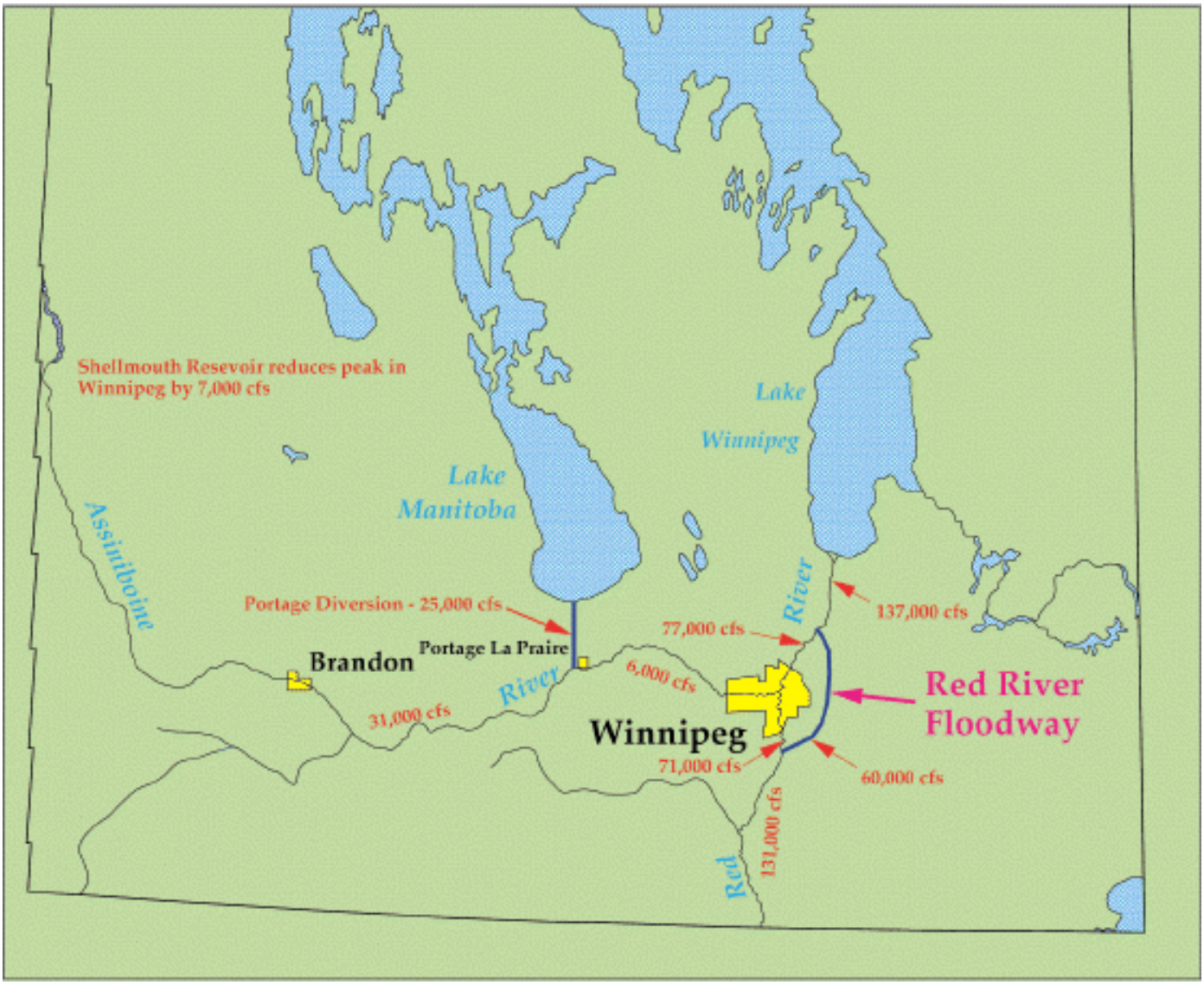
BACKGROUND

Following the disastrous flood of 1950, dikes were constructed in Greater Winnipeg along the Red, Assiniboine and Seine rivers to an elevation 4 ft. (1.2 m) below the peak 1950 water surface profile. In 1956 the Province of Manitoba appointed the Royal Commission on Flood Cost Benefit to examine options for providing structural protection to Winnipeg. In its report (1958) the Commission recommended the construction of the Red River

Floodway, Portage Diversion, and the Shellmouth Reservoir.

In the 1960's (when the Red River Floodway was being designed), it was estimated that the flow capacity of the Red River within the dikes was 77,000 cfs (2,200 m^3/s), with 1 ft. (0.3 m) of freeboard. During the 1997 flood, 80,000 cfs (2,300 m^3/s) was passed down the Red River with two feet (0.6 m) of freeboard at James Avenue, and one foot (0.3 m) of freeboard at the south end of Winnipeg.

Figure 1 - Flood Control Works and Corresponding Design Capacities



OVERVIEW OF WINNIPEG'S FLOOD CONTROL SYSTEM

In the 1960's and early 1970's, three major flood control works were constructed for the reduction of flooding in Winnipeg as shown in Figure 1.

The Red River Floodway channel was constructed to pass a design flood of 60,000 cfs (1,700 m^3/s). The

Portage Diversion was constructed with a capacity of 25,000 cfs (700 m^3/s). The Shellmouth Reservoir was constructed with a storage capacity of 387,000 acre-feet (477,000 dam^3), which was expected to reduce the peak of the design flood in Winnipeg by 7,000 cfs (200 m^3/s).

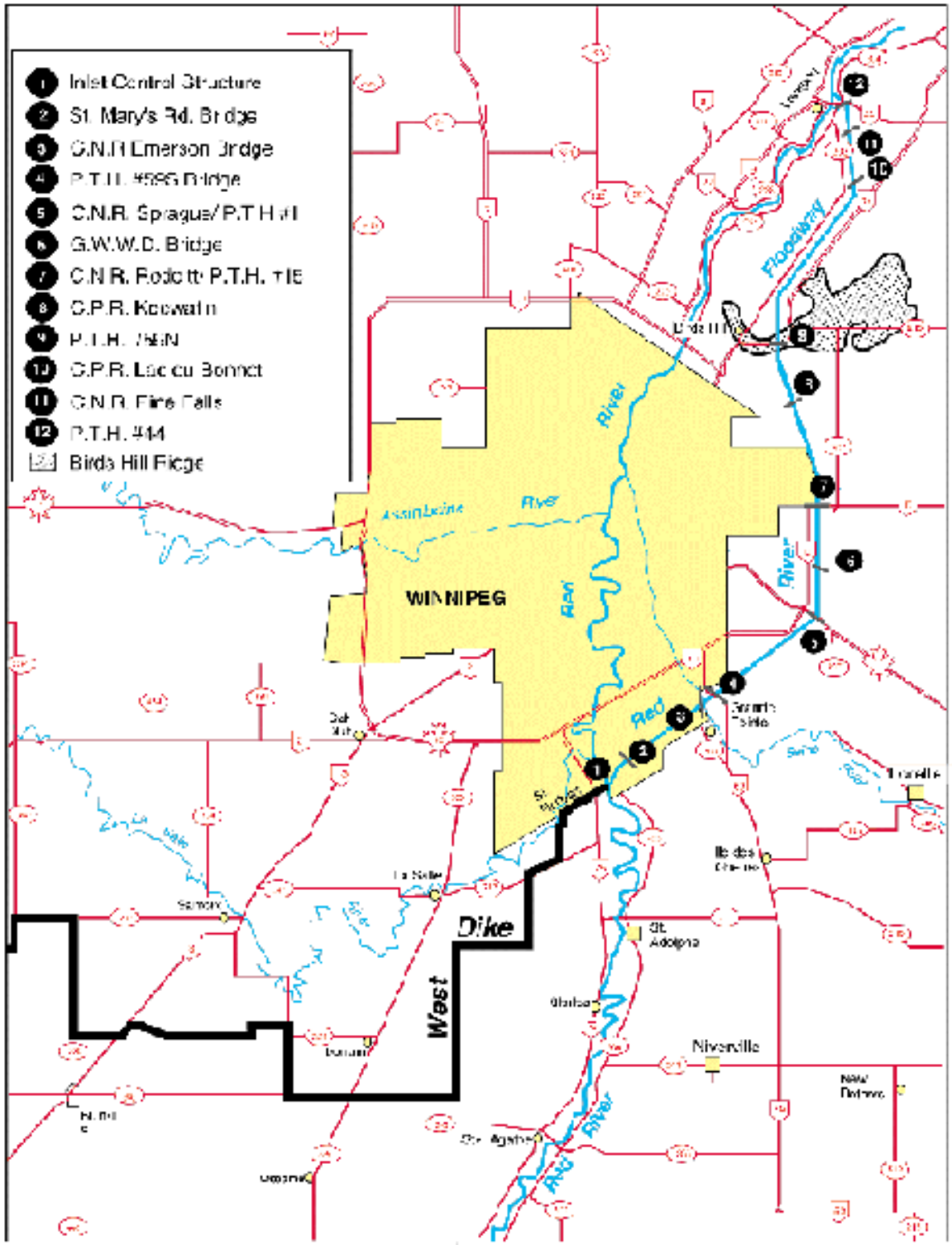
These works were designed to protect Winnipeg from floods with "natural" flows on the Red River downstream of the Assiniboine River up to 169,000 cfs (4,800 m^3/s). During the design of these works, this corresponded to the 160-year flood flow; today it is estimated to have a return period of 130-years. For comparison the estimated "natural" flood peak for the 1997 flood was 163,000 cfs (4,600 m^3/s). This flood has an estimated return period of 110 years.

OVERVIEW OF RED RIVER FLOODWAY

The Red River Floodway was constructed in the 1960's at a cost of $63 million (in 1968 dollars). It was completed in early 1968, and first used in the spring flood of 1969.

The Floodway consists of four components: diversion channel, inlet control structure, outlet structure, and west dike (see Figure 2 [include Bird's Hill ridge]).

Figure 2 - Location Plan for Red River Floodway

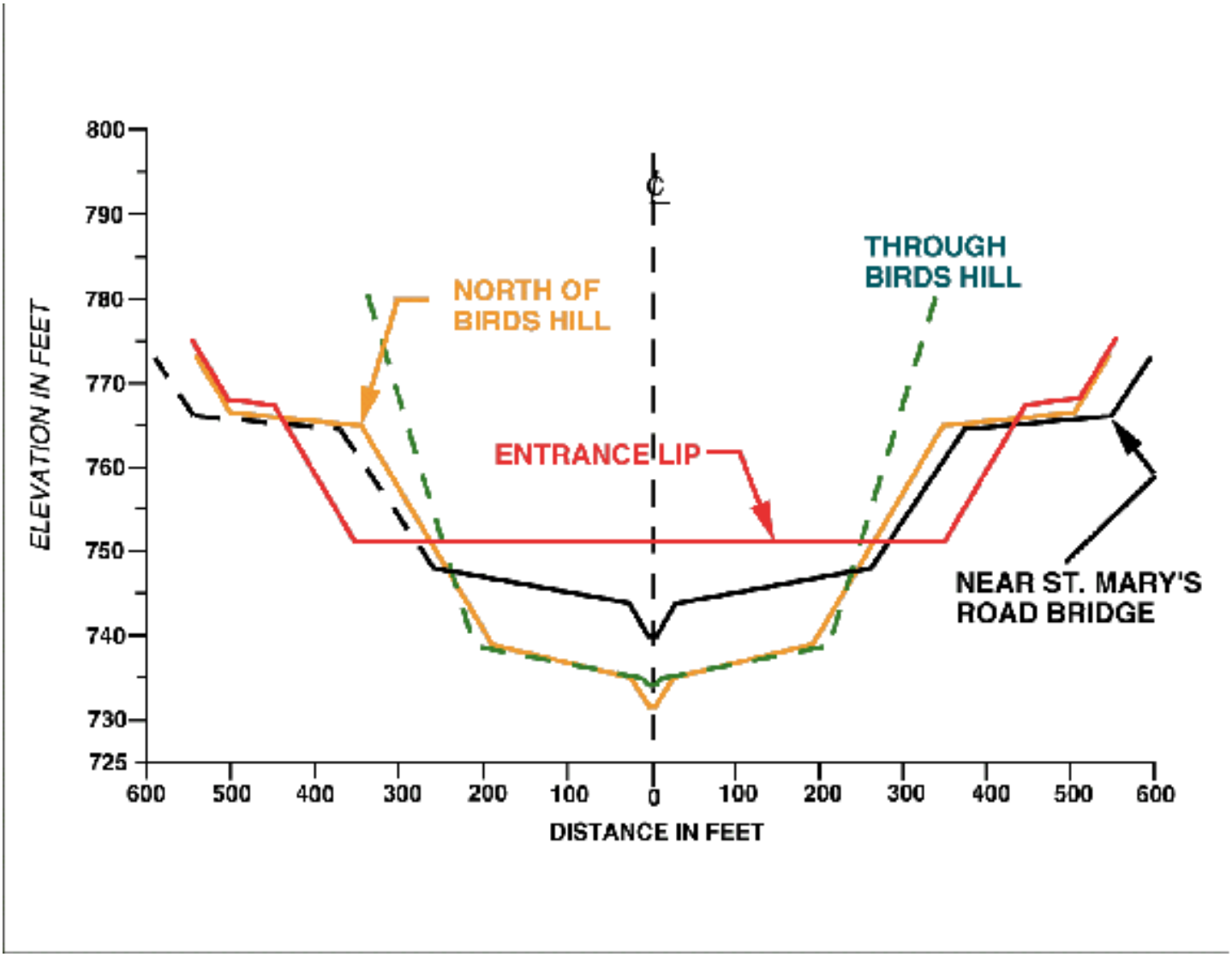


Each component is described below.

FLOODWAY DIVERSION CHANNEL

The 29 mi. (47 km) long diversion channel conveys a portion of Red River flood water around the east side of Winnipeg.

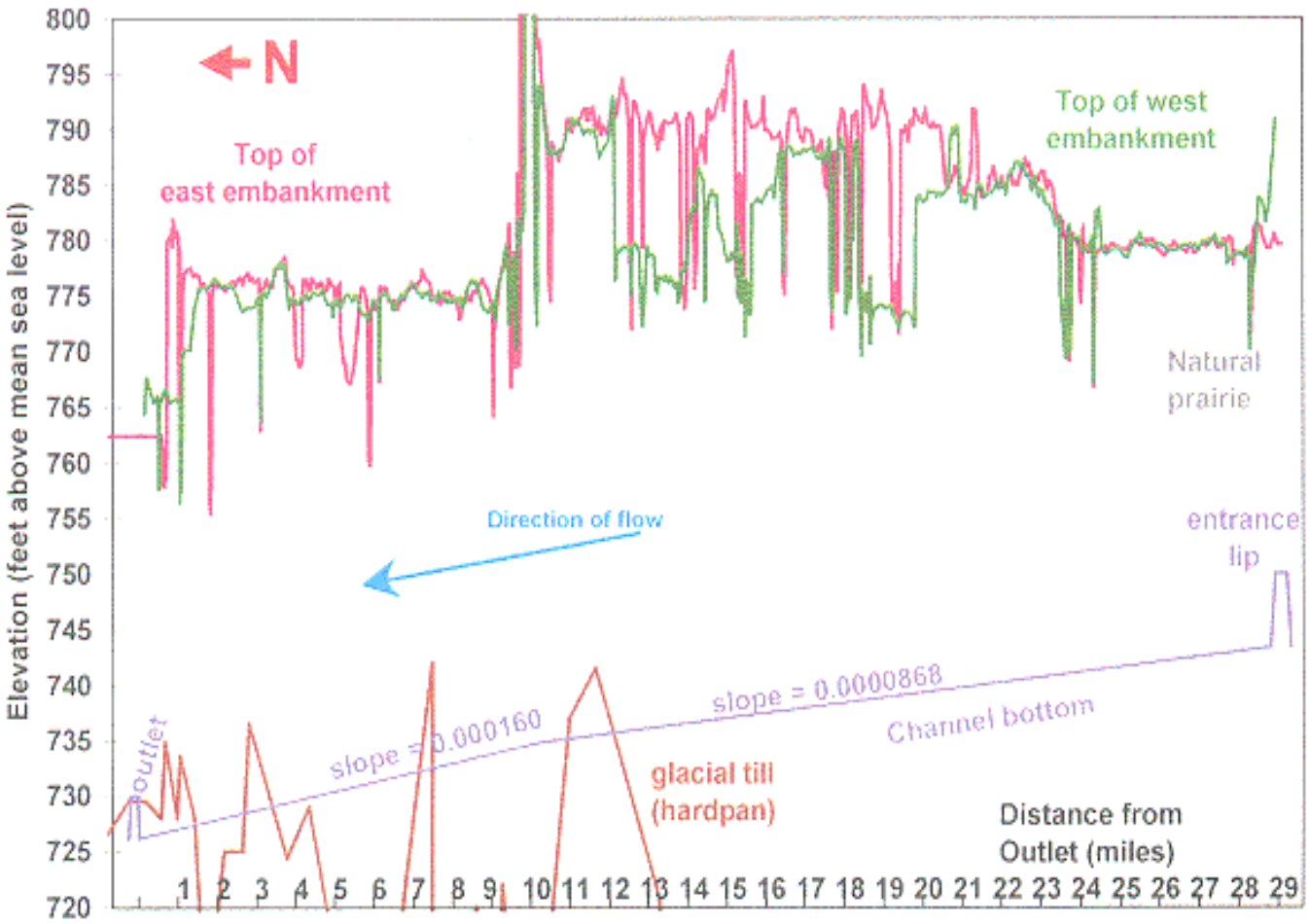
Figure 3 - Typical Cross Sections of the Floodway Channel



Entrance lip: At the very upstream end of the channel is an earth lip[[on Figure 2], with a crest 7 ft. (2.1 m) above the channel bottom. The cross-section of the lip is shown in Figure 3. The function of the lip is to keep river ice out of the Floodway channel, allowing it to break up and flow down the Red River through Winnipeg prior to flows rising and entering the Floodway channel. Ice that enters the Floodway channel can hang up on the lip and can jam against the bridge crossings over the channel, thereby reducing the capacity of the diversion.

Channel: The channel is uniform in cross-section in each of three distinct reaches (see Figure 3). The average channel depth is 30 ft. (9.1 m) except through the Birds Hill ridge where the depth is 66 ft. (20.1 m). The channel's longitudinal slope is 0.0000868 or 0.5 ft./mi. (8.6 cm/km) upstream of Bird's Hill (excluding the entrance lip), and 0.00016 or 0.8 ft./mi. (16 cm/km) downstream (see Figure 4).

Figure 4 - Longitudinal Profile of the Floodway Channel

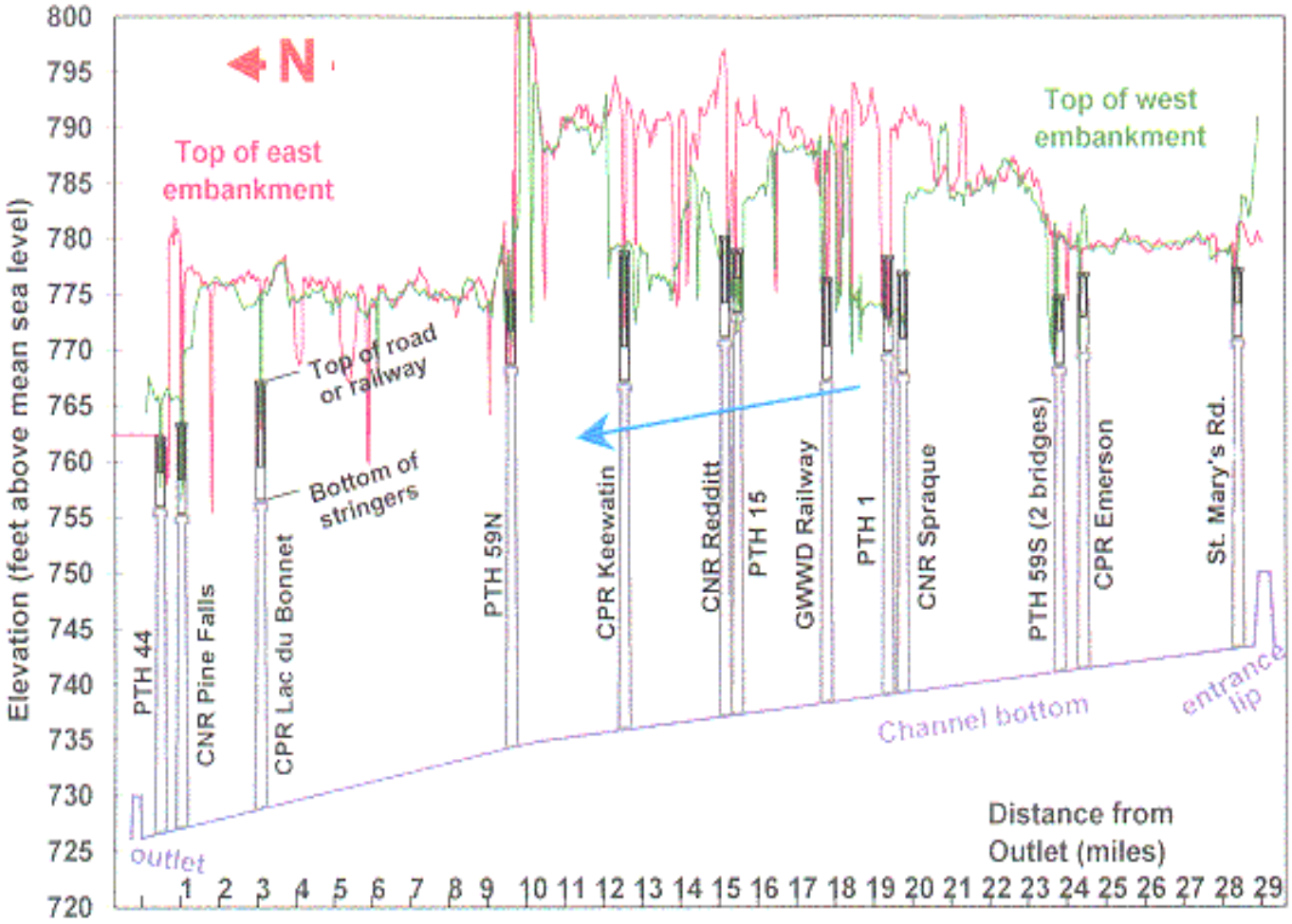


The maximum design water velocity is five feet per second (1.5 m/s) to minimize erosion.

Approximately 100,000,000 yd^3 (76,000,000 m^3) of material was excavated in creating the channel. The channel is excavated mostly in soil, but downstream of Birds Hill excavation encountered hardpan (see Figure 4).

Bridges: Fourteen bridges cross the channel (their locations are shown on Figures 2 & 5). During the design of the Floodway, the bridges were designed to have a maximum cumulative impact on Floodway channel water levels of 1 ft. (0.3 m) at a design flow of 60,000 cfs (1,700 m^3/s).

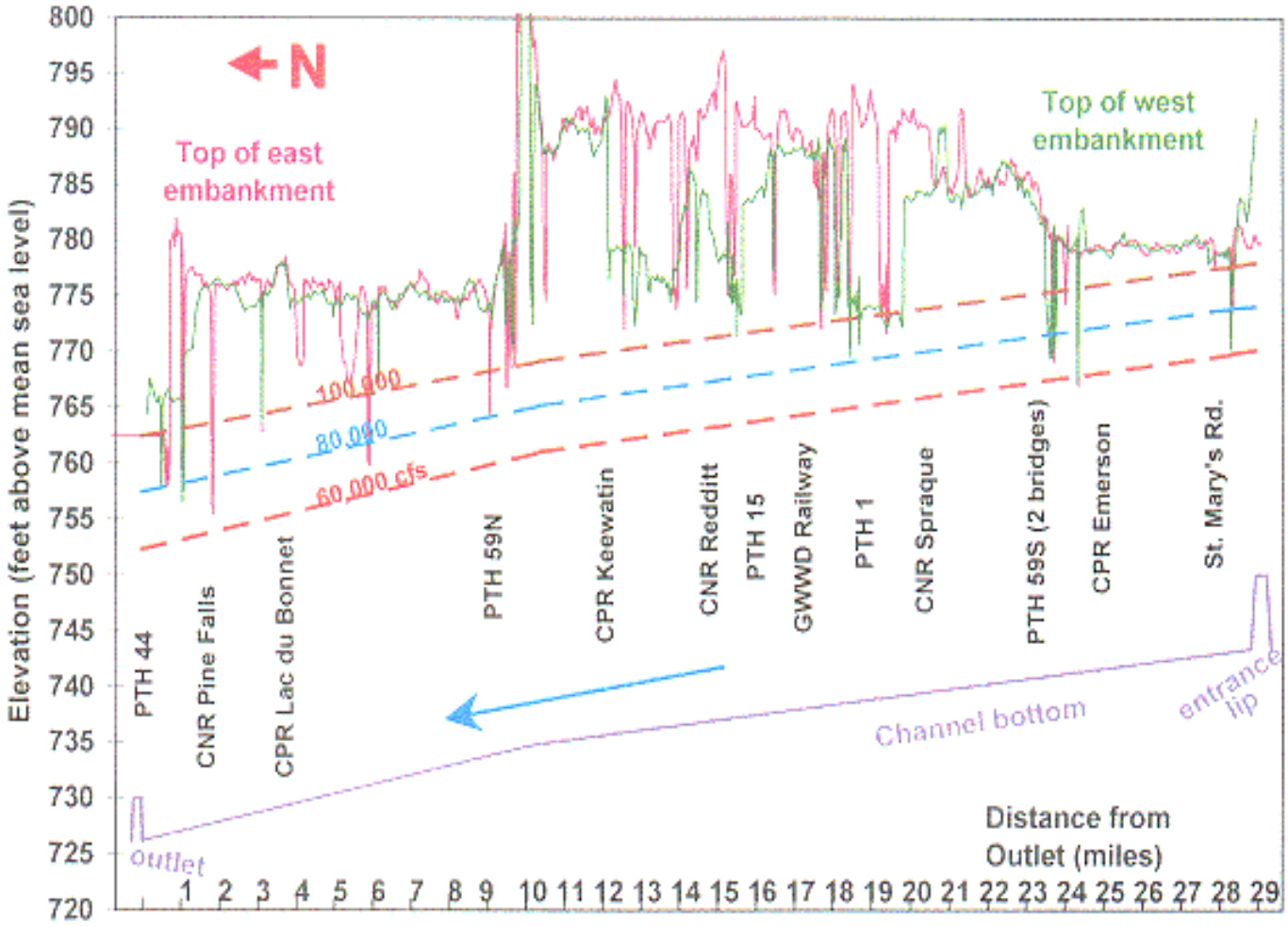
Figure 5 - Floodway Bridge Locations



FLOODWAY CHANNEL CAPACITY

Design capacity: During the design of the Floodway system the channel was designed to pass a flow of 60,000 cfs (1,700 m^3/s) with a water surface elevation on the Red River at the entrance of the Floodway channel of 770.25 ft. (234.77 m). This was determined via backwater calculations using the design cross-sections and longitudinal slope, and using a Manning's roughness coefficient (denoted as "n") of 0.028; this coefficient accounts for the roughness and resistance of the vegetation in the floodwater channel. The designers recognized that "n" was probably somewhat too high, but used it so as to arrive at a conservative channel capacity. The water surface elevation at the Water Survey of Canada gauging station at the St. Mary's road bridge was estimated to be 769.8 ft. (234.64 m). It was estimated that the cumulative head loss through all the bridges was 1 ft. (0.3 m)[RRBI said that!]. This estimated water surface profile is shown on Figure 6.

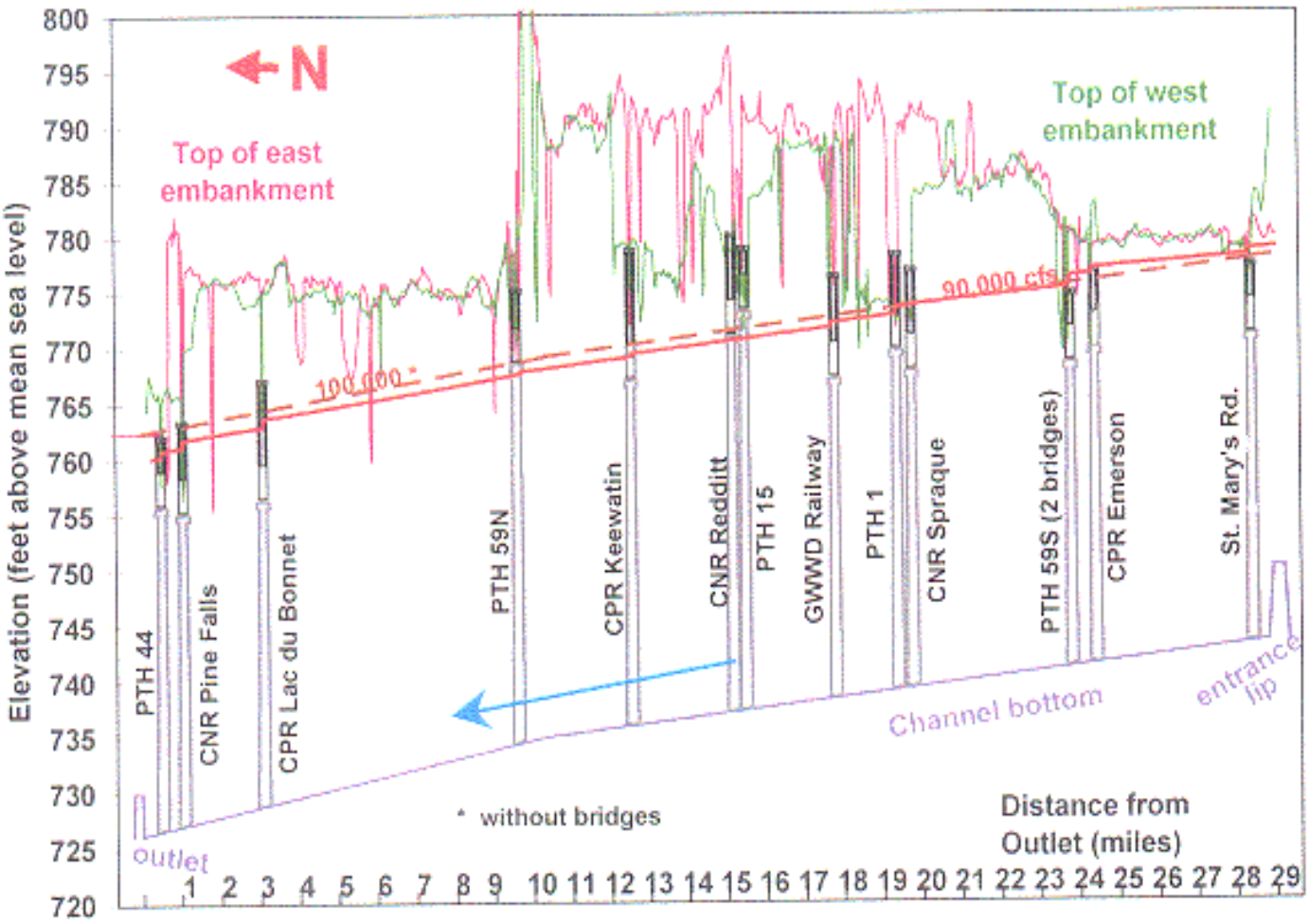
Figure 6 - Computed Floodway Channel Capacity Without Influence of Bridges



The water surface profiles for a number of other discharges were also estimated (see Figure 6). For discharges of 80,000 cfs (2,300 m^3/s) and 100,000 cfs (2,800 m^3/s) it was assumed that the bridges were not in place. Based on this assumption, the ultimate capacity of the Floodway channel was estimated to be 100,000 cfs (2,800 m^3/s). At this discharge, the elevation of the Red River at the entrance of the Floodway channel was estimated to be 778.0 ft. (237.13 m), and the minimum freeboard along the Floodway embankments was 2 ft. (0.6 m). This would be the maximum that levels south of the structure could be allowed to go without overtopping the West dike or the Floodway embankments.

Post-construction: Based on discharge meterings obtained on the Floodway channel from 1969 to 1999 the channel capacity is estimated to be 61,500 cfs (1,700 m^3/s), when the water surface elevation on the Red River at the entrance of the Floodway channel is 770.25 ft. (234.77 m). It has been determined that the channel's Manning's "n" is in fact approximately 0.026. With the bridges in place, the capacity is estimated to be 90,000 cfs (2,500 m^3s) for a level of 778.0 ft. (237.13 m) at the Floodway inlet (Figure 7).

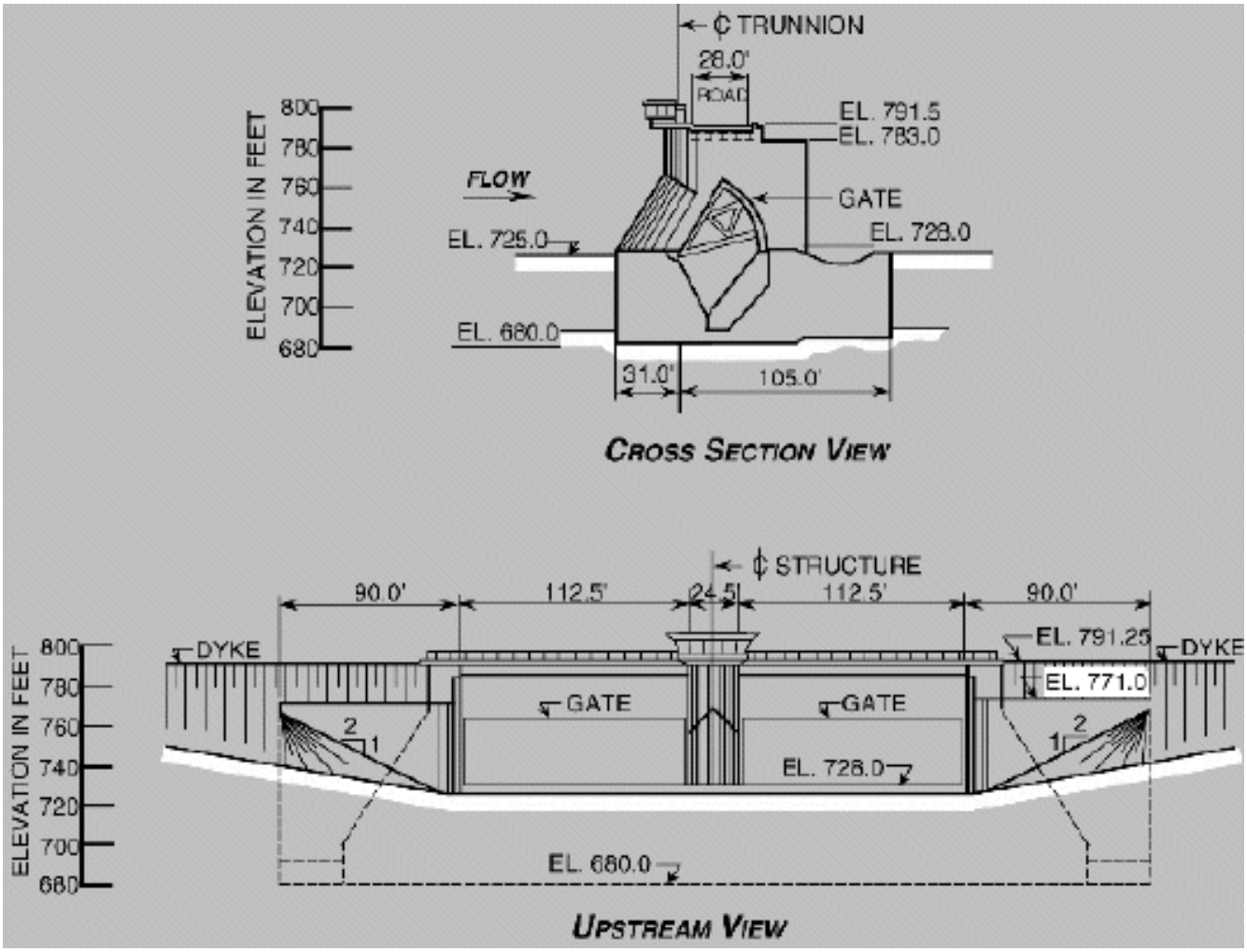
Figure 7 - Impact of Bridges on Floodway Channel Capacity



Without bridge decks: If it is assumed that all of the bridge decks are removed or raised, the ultimate capacity of the Floodway would be close to the design capacity of 100,000 cfs (2,800 m^3/s) (see Figure 7). However it is not necessary to remove all of the bridges. An analysis showed that the capacity of the channel reaches 100,000 cfs (2,800 m^3/s) when the decks and girders of the seven most upstream bridges are raised or removed[check]. It must be recognized that it is probably not possible to remove these bridge decks during a flood emergency. The Committee is of the opinion that serious consideration should be given to permanently raising these seven bridge decks.

INLET CONTROL STRUCTURE

Figure 8 - Floodway Inlet Control Structure



The inlet control structure regulates the Red River water level at the entrance of the Floodway channel. This is done via two gates, housed in a monolithic concrete structure (see Figure 8). During non-flood periods the gates are fully down with the top of the gates at elevation 728 ft. (221.89 m). In summer months, the Red River water surface elevation above the gates is normally at about 733 ft. (223.4 m). During floods, the gates are raised to regulate the Red River water level at the entrance to the Floodway channel, thereby regulating the amount of flow going down the Floodway channel and over the gates into Winnipeg.

Flip bucket: The downstream portion of the concrete structure housing the gates is a concrete flip bucket which was designed to dissipate the energy of the Red River water as it flows over the gates. In the design flood, with a flow through the structure of 71,000 cfs (2,010 m^3/s), the drop in the water surface over the gates is 8.2 ft. (2.5 m).

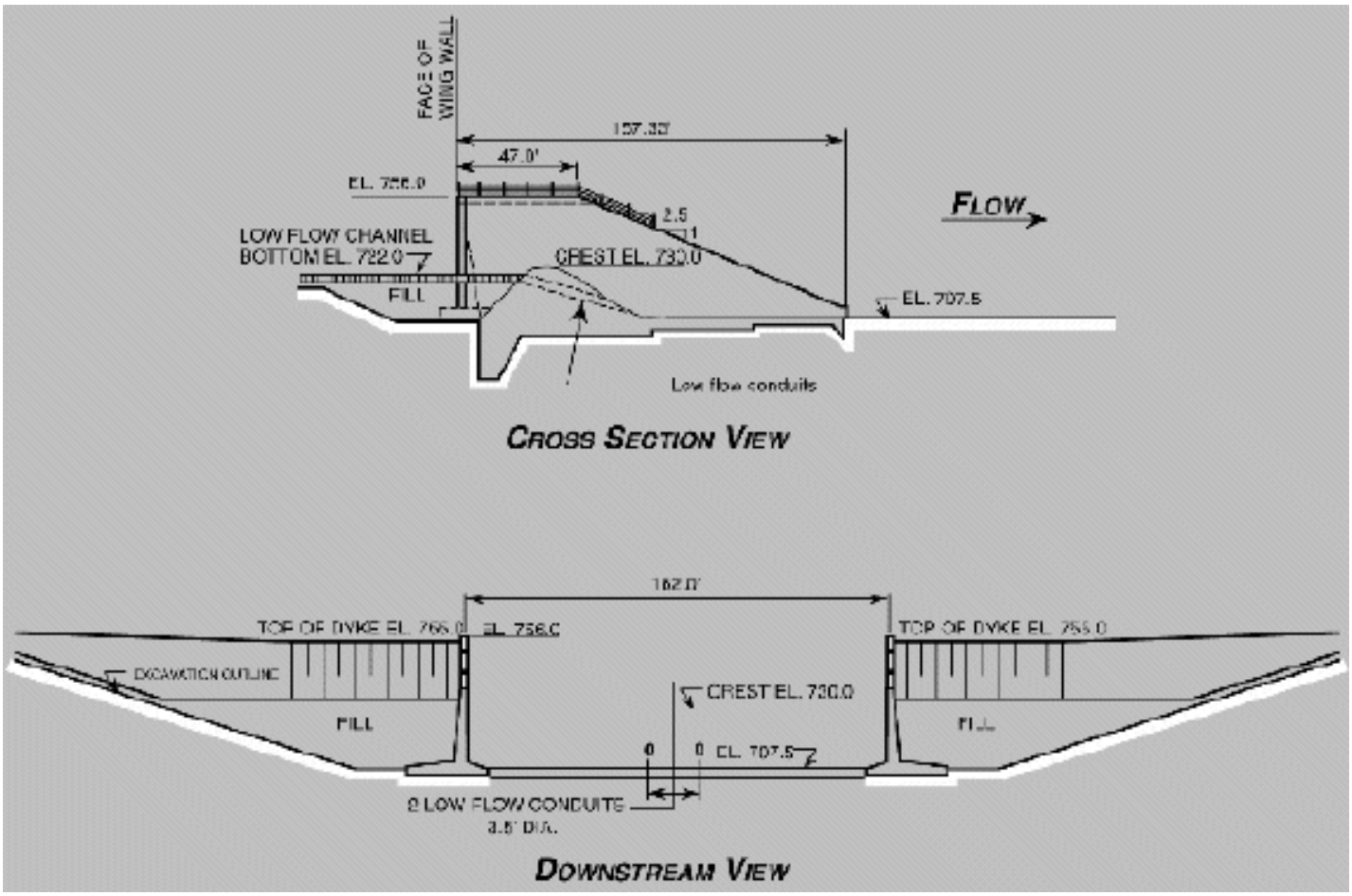
Designed redundancies: The gates were designed in such a way that, should it not be possible to raise one gate for the entire flood period, or should one gate become immobile in a raised position during a flood, the other gate can regulate upstream water levels largely to the same extent as the two functioning gates can. There is also multiple redundancy in the power supply: there are two separate connections to the provincial electric power grid, electricity can be supplied via a mobile diesel-electric generator, and hydraulic power can be supplied directly to the gates via the power takeoff of a tractor. As well, each of the two gate motors can raise and lower both gates, in the situation where one motor is not functioning.

Maximum design conditions: The Inlet Control Structure was designed to pass the probable maximum flood (PMF) without failing. At the time of the design, the PMF was estimated to be 270,000 cfs (7,600 m^3/s) on the Red River downstream of the confluence with the Assiniboine River, and 221,800 cfs (6,300 m^3/s) on the Red River at the Inlet Control Structure. For this flow, the water surface elevation on the Red River at the Floodway channel's entrance would be regulated to 778 ft. (237.13 m); the flow down the Floodway channel would be 100,000 cfs (2,800 m^3/s); the flow through the Inlet Control Structure would be 121,800 cfs (3,400 m^3/s), with the gates being at approximately 749.5 ft. (228.45 m). Floodwaters would not endanger the Structure as the floor of the machine room containing the gate motors is at elevation 779.8 ft. (237.68 m) and the approaches to the structure are at 791.25 ft. (241.17 m) (see Figure 8). These design levels included minimal allowances for wind setup and wave uprush.

OUTLET STRUCTURE

At the downstream end of the channel is a reinforced concrete outlet structure (Figure 9). It maintains a desirable water surface slope in the Floodway channel, so that the maximum design velocity is not exceeded. The drop in the water surface from the Floodway channel to the Red River is 14 ft. (4.3 m) at the design flow. This structure was designed to adequately pass up to 80,000 cfs (2,300 m^3/s).

Figure 9 - Floodway Outlet Structure



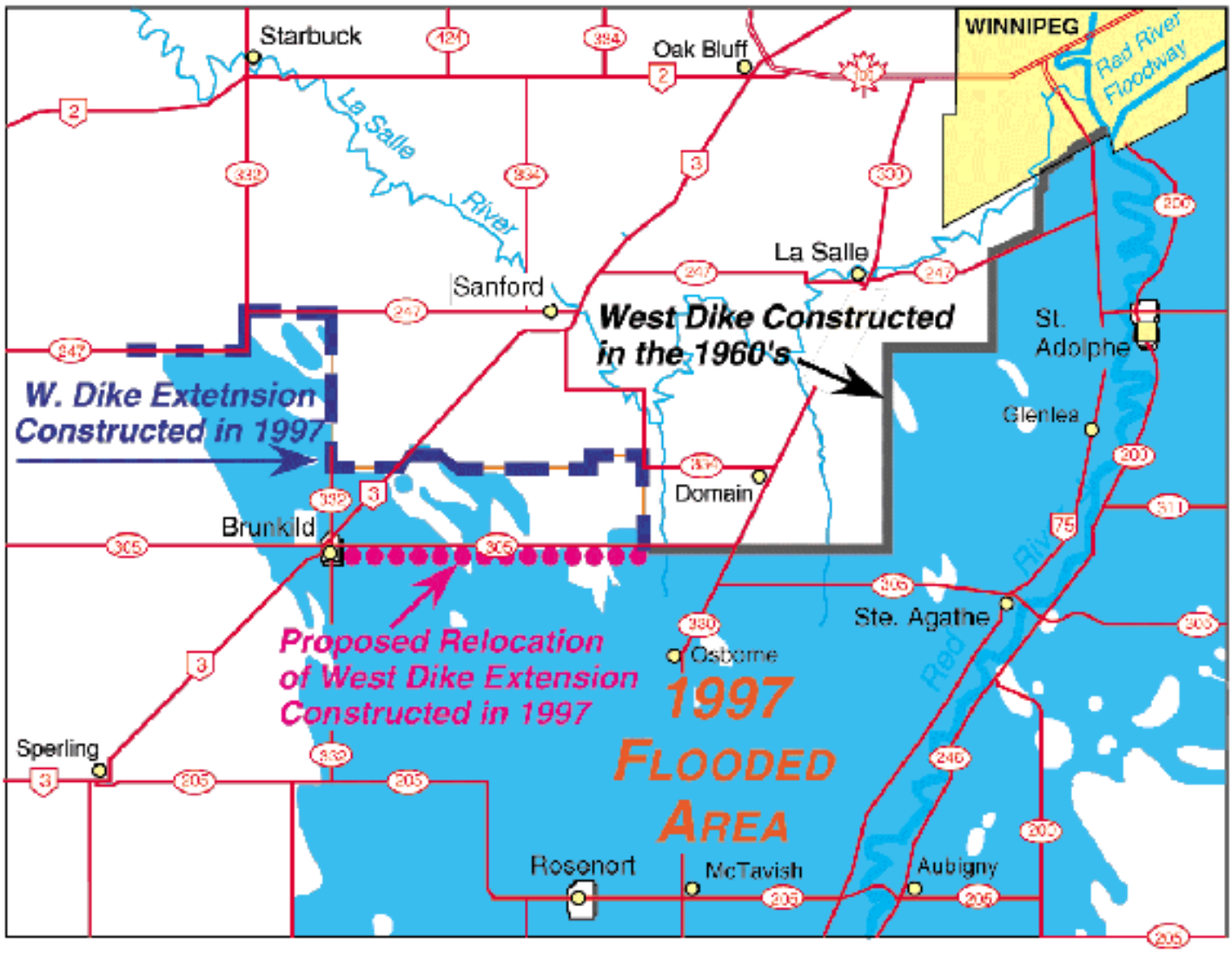
WEST DIKE

Pre-1997

The West Dike prevents Red River flood waters from entering Winnipeg on the west side of the Red River (see Figure 10). The dike was 20 mi. (32 km) long when constructed in the 1960's.

Design standard at time of design: The dike was designed to protect against very large floods at the Inlet Control Structure and progressively smaller floods for more westerly portions of the dike. The design standard decreased towards the west because of the shallower water to the west, and the decreasing consequences of dike failure. At the Inlet Control Structure, the dike top is at 791.25 ft. (241.17 m), which is 13.25 ft. (4.04 m) above the water surface elevation of 778 ft. (237.13 m) estimated for the PMF at the time of design. At P.T.H. #75, which is 2,400 ft. (730 m) west of the Inlet Control Structure, the top is at 780.8 ft. (238 m). This level is 2.8 ft. (0.85 m) above the water surface elevation that was estimated at the time of the design to occur for all floods larger than the 400-year flood. At the western extremity of the dike, the crest is mostly above elevation 779.2 ft. (237.5 m), which, at the time of the design, was expected to be exceeded by all floods larger than the 333-year flood.

Figure 10 - Location of West Dike



Design standard as of 1997: The 1997 flood, with a peak "natural" flow at Winnipeg of 163,000 cfs (4600 m^3/s), has been estimated to have a 110-year return period. Prior to the peak of the 1997 flood, 9.3 mi. (15 km) of the West Dike was raised, as forecasted water levels would have resulted in the dike being overtopped in several locations in its more southerly and westerly reaches. As well, the West Dike was extended by 20 mi. (32 km), to prevent flood waters from flowing into the La Salle River Watershed (and then into Winnipeg) around the west end of the original dike (see Figure 10)

Post-1997

Dike enhancements: Following the 1997 flood, the west dike extension was torn down because it was constructed in a suboptimal location and using only marginally adequate construction techniques (due to the speed with which it was built). It is currently proposed that it be re-located due west of the original west dike (see Figure 10).

Design standard: The dike enhancements that have taken place, and the proposed extension to the west dike, are all designed for the 1997 flood event, but with wind setup, wave runup and freeboard of a magnitude typically used in the design of flood control works in the Red River valley. However the 1997 flood showed that these typical freeboard values might not be valid for an inundated prairie valley. Given the complexity of

overland flooding and the impact of the road network, relationships developed for shallow lakes may not be appropriate. The Committee is of the opinion that further study is required to define appropriate freeboards for the Red River Valley structures.

FLOOD-TIME OPERATIONS

Initial gate raise: with ice conditions

Operation rationale: Keeping ice out of the Floodway channel is an important consideration because ice can hang up on the channel's entrance lip and ice can jam up against the bridges crossing the Floodway channel. This results in a decreased flow in the Floodway channel. It has been found that, while the ice is stationary or moving in very large pans, raising the Floodway gates results in ice flowing into the Floodway channel. However, once the ice on the Red River has broken up and is flowing in relatively small pans, raising the Floodway gates does not have this effect. Therefore, the first gate raise is normally postponed until the river ice is flowing in relatively small pans.

1997 experience: In 1997, the ice remained largely stationary and in large pans for much longer than any other year since the Floodway was completed. The depth of flow over the lip was over 4 ft. (1.2 m), with approximately 7,000 cfs (200 m^3/s flowing into the channel, and the ice was still stationary. The water level at James Avenue had reached 18 ft. (5.5 m) local datum and was forecasted to go up an additional foot (0.3 m) over the next twenty-four hours. Levels in this range would have threatened homes outside the primary dikes which had not yet been protected by sand bag dikes. Therefore, it was decided to raise the Floodway gates. Some large ice pans did flow into the Floodway channel, and an ice jam occurred at St. Mary's Road bridge. This jam did temporarily reduce the rate of flow in the channel, but it broke up within 8 hours of its formation. The experience verified that operation of the gates under ice conditions would increase the potential for jamming in the Floodway channel. However when river levels in Winnipeg are threatening to flood homes along the river, it is preferable to allow some ice to flow into the Floodway channel than to allow river levels in Winnipeg to continue to rise.

Initial gate raise: depth of flow over channel's entrance lip

Operation rationale: To minimize erosion on the channel's entrance lip, the operation rules require that the initial gate operation result in a minimum depth of flow over the channel's entrance lip. In the early years of the Floodway, this depth was 1 ft. (0.3 m), which corresponds to a river level of 751 ft. (228.9 m). Through the 1980's it was found that an initial water elevation of 752 ft. (229.2 m) was more desirable.

Experience in the 1990's: By the 1990's a very thick and solid vegetative cover had been established on the entrance lip and erosion of the lip did not occur when the depth of flow was much smaller than prescribed. It is therefore no longer necessary to require a minimum depth of flow over the lip.

Final gate drop

Operation rationale: The original operation rules for the final gate drop considered only the erosion on the channel's entrance lip. They stated that the gates should be dropped when the water level at the entrance to the Floodway channel approached 751 ft. (228.0 m), so that flow shallower than 1 ft. (0.3 m) did not occur.

However, it was found that such an operation resulted in a fairly large wave down the Red River through Winnipeg, causing anxiety for some citizens observing the wave, and potentially aggravating bank stability problems. Therefore, the rules were revised in 1984 so that the final drop of the gates was done in two steps: one would result in the water level at the channel entrance dropping quickly below the level of the top of the lip, and the second one (taking place several hours later) would have the gates dropped all the way down. In addition, these last two gate drops would be postponed until water levels in Winnipeg were below 15 feet (4.6 metres), as the City's drainage runoff pumping activities increase dramatically when river levels are above that value and a coincident rain occurs.

Experience in the 1990's: As noted earlier, by the 1990's the thick and solid vegetative cover on the channel's entrance lip had eliminated erosion on the lip. Therefore, it seems reasonable to dispense with the requirement for a minimum depth of flow over the lip.

3. City of Winnipeg Flood Protection

Flood protection works in the City of Winnipeg consist of components of the sewer systems and more typical structural and non-structural flood control systems such as primary dikes and flood proofing legislation, respectively.

THE SEWER SYSTEM

History

The City of Winnipeg was incorporated in 1873 with a population of 2000. There was no drainage system, and sewage collection and removal was primitive. The first drainage sewers were constructed in 1876, which led to the beginnings of the combined sewer system in 1882 when sewage was also directed to the land drainage sewers. Even at that time there was a concern about both basement and Red River flooding.

By 1915 most of the sewers in the former City of Winnipeg were complete. This was also the beginning of the era of combined sewers (1915 to 1960) in the adjacent municipalities. The year 1960 signified the beginning of the era of separate sewers, which are the systems still built today. The construction of relief sewers, to improve the capacity of the older combined sewers, also began in the 1960's. In 1972, the City of Winnipeg and the adjacent 12 municipalities amalgamated.

Components of the Sewer System

Winnipeg's sewer system includes combined and separate sewers. Combined sewers transport land drainage runoff and wastewater (residential, commercial and industrial) together. Approximately 40% of Winnipeg, primarily the central older area, is served by combined sewers. Separate sewers include two pipes: a land drainage sewer and a wastewater sewer. There are 42 combined sewer districts and 30 separate sewer districts. A sewer district is the geographical area served by the trunk sewer and is usually named after the street beneath which the trunk sewer runs. For example, the trunk sewer in the Bannatyne Combined Sewer District runs

beneath Bannatyne Avenue to the Red River.

The sewer systems consist of several elements: the building service or service connection, local or lateral sewer, collector sewer, trunk sewer, interceptor sewer, relief sewer, lift station, flood pumping station, gate chamber or gate structure (with flap and/or positive gates) and outfalls to the rivers. An outfall is the end of the pipe that protrudes through the riverbank into the river and is usually submerged below the normal summer river level.

Sewage or wastewater is first discharged from buildings through the service connections to local sewers that run down most streets. These sewers discharge to collector sewers and then to trunk sewers. Prior to the construction of the first treatment plant in the north end of Winnipeg in 1935, trunk sewers discharged directly to the rivers through outfalls.

The interceptor sewer "intercepts" the wastewater or combined wastewater and land drainage before it discharges through the outfall to the river. The interceptor sewer carries wastewater and land drainage runoff to one of the three sewage treatment plants (in the north end, south end and west end). The diversion to the interceptor sewer is achieved by a weir (or dam) in the trunk sewer positioned just before the outfall. When wastewater flow hits the weir, it is then redirected and flows to and through another pipe in the side of the trunk sewer. If the interceptor sewer is lower than the trunk sewer, then the wastewater flows by gravity to the interceptor sewer. If the interceptor sewer is higher than the trunk sewer, then the wastewater flows to a pump and is lifted to the interceptor sewer. The pumps are housed in a sanitary lift station adjacent to the trunk sewer. Sanitary lift stations are also utilized anytime a sewer is too deep to discharge by gravity into the next downstream sewer. This can occur when servicing a relatively low area or extending a sewer district beyond its original boundaries.

Generally, the combined sewer system can handle wet weather flows (combined wastewater and land drainage) up to 2.75 times average dry weather flow (wastewater flow only). When rainfall runoff in the trunk sewer exceeds the capacity of the diversion to the interceptor sewer, the excess flow spills over the weir and discharges directly to the river through the outfall. This occurs for every major rainstorm.

Separate sewer systems include two pipes: 1) a wastewater sewer for carrying sanitary or wastewater flow to one of the three sewage treatment plants, and; 2) a land drainage or storm sewer to transport land drainage runoff (from snowmelt or rainstorms) directly to the rivers. Some land drainage sewer systems include stormwater retention basins (SRBs). These SRBs are utilized for retaining land drainage flows during and following a runoff event. By directing the drainage to an SRB, the piping between the SRB and the river can be much smaller than would be without the SRB. The SRB water level rises as water is directed to it and then recedes slowly to its normal water level as the water is discharged through the downstream pipe.

Storm relief sewers are installed to "relieve" existing sewers of some of the extraneous flow from land drainage runoff. Typically, storm relief sewers parallel existing sewers, are installed slightly lower to receive the overflow, and discharge directly to the rivers. Storm relief sewers are required in those sewer districts that do not meet minimum design standards. The minimum design standard is a five-year return frequency rainstorm for combined sewers and up to a ten-year event for separate land drainage sewers. These design criteria are deemed to be cost effective and therefore are typical for most jurisdictions for the reduction of incidence of basement flooding.

Since the mid-1970's, the City has invested more than $200 million to increase basement flooding protection to the current standard. The program has upgraded both combined and separate sewer systems throughout Winnipeg, but a majority of the funding has been spent on combined sewer systems. Homeowners are encouraged to take additional preventive measures such as improving drainage around the house, installing backwater valves and installing sump pits and pumps, to increase their protection against sewer backup.

Gate chambers or gate structures and flood pumping stations were constructed on the existing combined sewer systems when the primary diking system was constructed in 1950/1951. Gate chambers contain flap and/or sluice gates which, when closed, prevent river water (especially high river levels) from backing up into the sewer system. A flap gate is hinged at the top and opens towards the river when there is wastewater flow against it. It automatically closes when the river level rises and when the pressure of the river water is greater than the combined wastewater and land drainage in the sewer. Typically, a sluice gate is manually operated and slides up and down in a guide. The gate is attached to a threaded rod, which extends to the top of the chamber and is turned by a hand wheel or by an electric driven device similar to a power drill or screw gun.

The flood pumping stations are operated when river levels are too high for the sewers to flow by gravity and when the combined wastewater/land drainage flow exceeds the capacity to divert to the interceptor sewer. They pump combined wastewater and land drainage (snowmelt and/or rainfall runoff) accumulated behind the closed gates up and over the primary dikes. Without the flood pumps, the combined flow could surcharge and "backup" into basements. There is still a risk of this occurring if rainstorm runoff exceeds the design capacity of the pump station.

Since the completion of the primary diking system in 1951, all new sewer systems (combined, separate, and storm relief) with outfalls (holes through the dike) have been protected as necessary to the design level in effect at the time. If the land behind the dike served by the sewer system is below the flood protection level (design water level plus two feet freeboard), then gates are installed and the gate chamber is designed with provision for a temporary pumping operation. Conversely, if the land behind the dike served by the sewer system is above the flood protection level, no gate chamber is installed. Since 1980, the City has had a policy that if the land behind the dike served by the sewer system is below the 50-year return frequency spring flood event, then a permanent pumping station is also installed.

Effect of High River Levels

The City of Winnipeg's combined sewers and separate land drainage sewers are dependent upon gravity flow to the City's rivers and streams during periods of significant rainfall. When the rivers are in flood stage, the gravity flow capacities of these sewers are significantly reduced or even eliminated and the water in the sewers must be pumped. Similarly, water in major drains or ditches, including drainage received from outside the City (for example Lot 16 Drain) must be pumped when the rivers are in flood stage.

The section titled "1997 Flood Experience - Vulnerability to Basement Flooding" discusses the effect of high river levels on the sewer systems in more detail.

THE FLOOD PROTECTION SYSTEM

The City of Winnipeg's flood protection system consists of non-structural and structural components. The non-

structural components include items and activities such as legislation, policies, studies, and regular reporting. The structural components are the physical structures that divert or hold back water.

Legislative Framework

In early 1980, legislation came into effect which established the floodway and floodway fringe areas along the rivers in Winnipeg, a design flood protection level (level to which all development shall be protected to), and flood proofing criteria. The specific legislation is within the City of Winnipeg Act and the associated Designated Floodway Fringe Area Regulation. The floodway and floodway fringe are delineated on the Interim Flood Risk Maps. The Flood Protection Level (FPL) is defined as the maximum static water level that occurs with a 160-year return frequency spring runoff event plus two feet freeboard. The FPL is equivalent to 27.8 feet at the City's James Avenue Station (City datum of zero feet is 727.57 feet above sea level).

All development in Winnipeg since 1980 has adhered to the requirements of the legislation. After the 1950 flood but prior to the 1980 legislation, the unofficial flood protection level was equivalent to the constructed top elevation of the primary dikes (equivalent to approximately 26.5 feet at James Avenue datum). This equates to a water level of 24.5 feet at James Avenue when a two-foot freeboard is assumed. Therefore, flood protection systems and sewer systems were designed in that 30-year period based on a water level of 24.5 feet at James Avenue. There is more discussion on this point in the following section.

A summary of the legislation related to flood protection follows.

- The Dyking Authority Act (1952) - legislation providing for the maintenance of the primary dikes and flood pumping stations in Winnipeg.

- The Dyking Commissioner - the Dyking Authority Act establishes this position within the Provincial Water Resources Branch for the administration of the Act, and annual reporting to the Provincial Minister of Conservation on the condition of the system. For example the report identifies any improvements to flood pumping stations or gate chambers or extensions to the primary diking system.

- Canada - Manitoba Flood Damage Reduction Agreements - provided for the study and preparation of the Interim Flood Risk Maps, which outline the Floodway Areas, the Floodway Fringe Areas, and the Primary Line of Defence (primary dikes). The maps also indicate the Flood Protection Level along regular intervals of the rivers. The information on these maps is referenced in the City of Winnipeg Act.

- The City of Winnipeg Act - establishes the Floodway Area and Floodway Fringe Area development regulations (Designated Floodway Fringe Area Regulation - current version is Manitoba Regulation 266/91), and zoning and development approvals process.

- The Emergency Measures Act - permits City Council to declare a local state of emergency**.**

Other Non-structural Components

There are several other non-structural flood protection items that help to protect the City of Winnipeg against flooding. These are:

- Floodway Operating Rules - discussed in a separate section in this report.

- City of Winnipeg Flood Manuals - these manuals describe the operation of permanent and temporary gate structures and permanent and temporary pumping stations on the sewer systems. There is a separate manual on the temporary secondary dikes. The manuals are generally organized in relation to river level.

- The Manitoba River Forecast Centre - provides the long range and daily river level forecasts. This information is fundamental to the City's flood protection operations. The forecasts are critical as they form the basis for all planning, preparations and operations before and during a high river level event.

- Weather and radar reports - forecasts assist in preparing for inclement weather.

- River ice monitoring - this is during river ice break-up and in recent years this major role has been played by the Amateur Radio Operators Association of Manitoba.

- The City's Emergency Operations Centre - is activated for all major flood events to assist in the co-ordination of the resources needed for flood protection operations.

- Manitoba Disaster Assistance Board - Provides the guidelines for eligible and non-eligible items for flood fighting and damage costs.

- Manitoba Emergency Measures Organization - Assists the City as necessary in the provision of resources, such as Canadian Armed Forces personnel.

- Public Education - Primarily an activity during a flood event, but is critical for public understanding of the facts surrounding any emergency situation.

- On-going studies/projects - the City of Winnipeg has, at any time, several flood related studies and capital improvement projects underway. These may involve sewer relief programs, flood pumping station upgrades, gate chamber upgrades, permanent secondary dikes, and more.

Structural Components

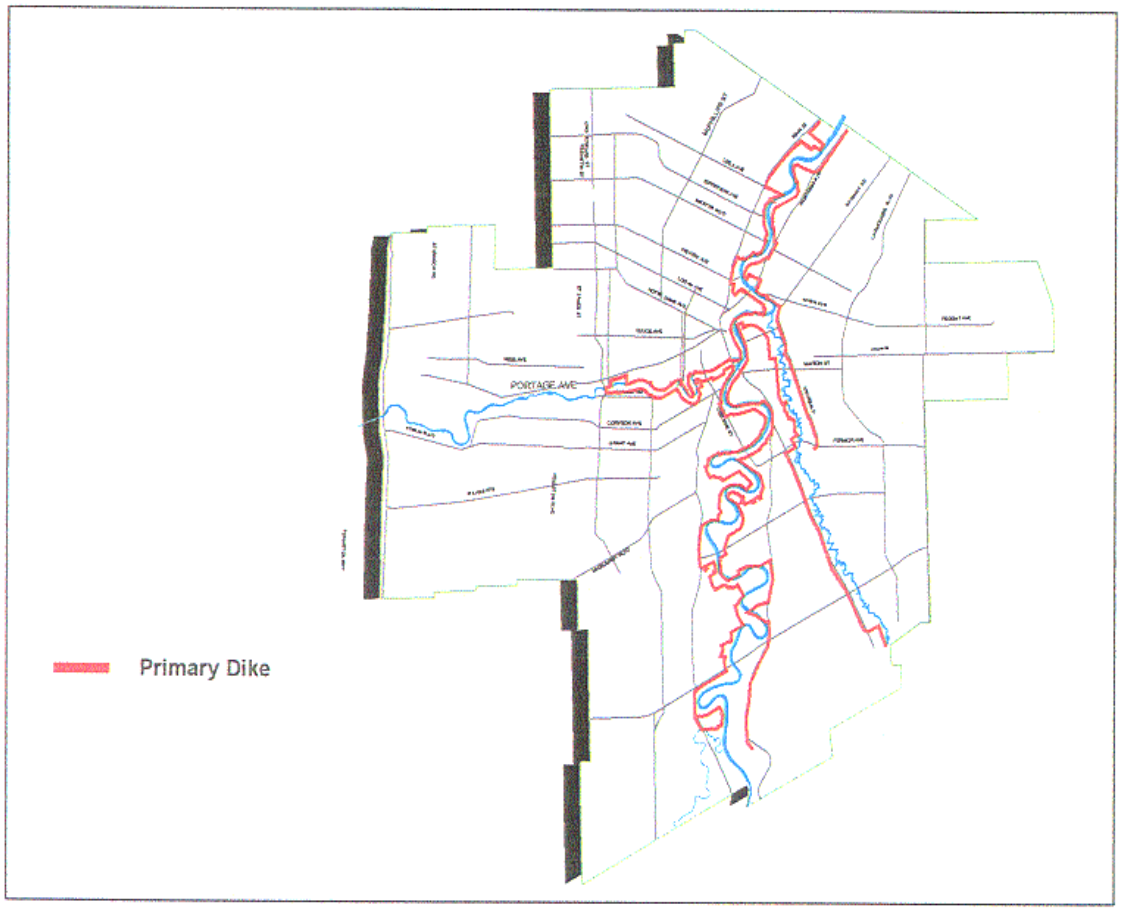
The structural components include the major flood control works (Shellmouth Dam and Reservoir, Assiniboine River Diversion and the Red River Floodway), as well as all the structures associated with the City's primary diking system and other miscellaneous controls. The major flood control works are presented in Section 2.0.

The primary diking system falls under the jurisdiction of the City of Winnipeg but is monitored by the Provincial Dyking Commissioner. The system consists of primary dikes, gate chambers and flood pumping stations. The secondary dikes in Winnipeg are also integral to protecting the properties on the river side of the primary diking system, however these structures are mostly temporary and are not recognized in the legislation for flood protection.

The primary dikes were constructed in 1950 by the Greater Winnipeg Dyking Board. They were constructed to

a uniform elevation of 26.5 feet equivalent at James Avenue (two feet (0.6 m) above the 1948 flood level) and are generally located along street rights-of-way. They parallel the Red River (from the north limit to the south limit of Winnipeg), the Assiniboine River (from the confluence with the Red River to St. James Street) and a portion of the Seine River, as shown in the Figure 11.

Figure 11 - Primary Diking System in Winnipeg



The standard width of the primary dikes was set at 50 feet to permit the temporary raising of the dikes by six feet (1950 flood level plus two feet freeboard) and to provide for two lanes of traffic on the dry side of the temporary dike.

Today there are 68 miles (110 kilometres) of primary dike and the top elevation varies considerably. This is illustrated in Figures 12 and 13, which include the primary dike along the east and west sides of the Red River, respectively. It is presumed that the dike top elevation has been modified over the years due to temporary raising (1956 and 1966 floods) and due to modifications required for street renewals. As well, any additions or extensions to the primary diking system since 1980 have included a minimum top elevation of 27.8 feet equivalent at James Avenue (to meet the Flood Protection Level), in accordance with Manitoba Regulation 266/91 of the City of Winnipeg Act. In some cases, an extension to the primary dike has been constructed even higher, up to the "Primary Dike Level" which is equivalent to 31.8 feet at James Avenue (and is known as the 300-year flood level). An example of such an extension is the primary dike through the Riverpointe residential subdivision just south of Bishop Grandin Boulevard off River Road, which is at a minimum of 29.8 feet equivalent to James Avenue.

Figure 12 - Profile of the Primary Dike along the East Side of the Red River

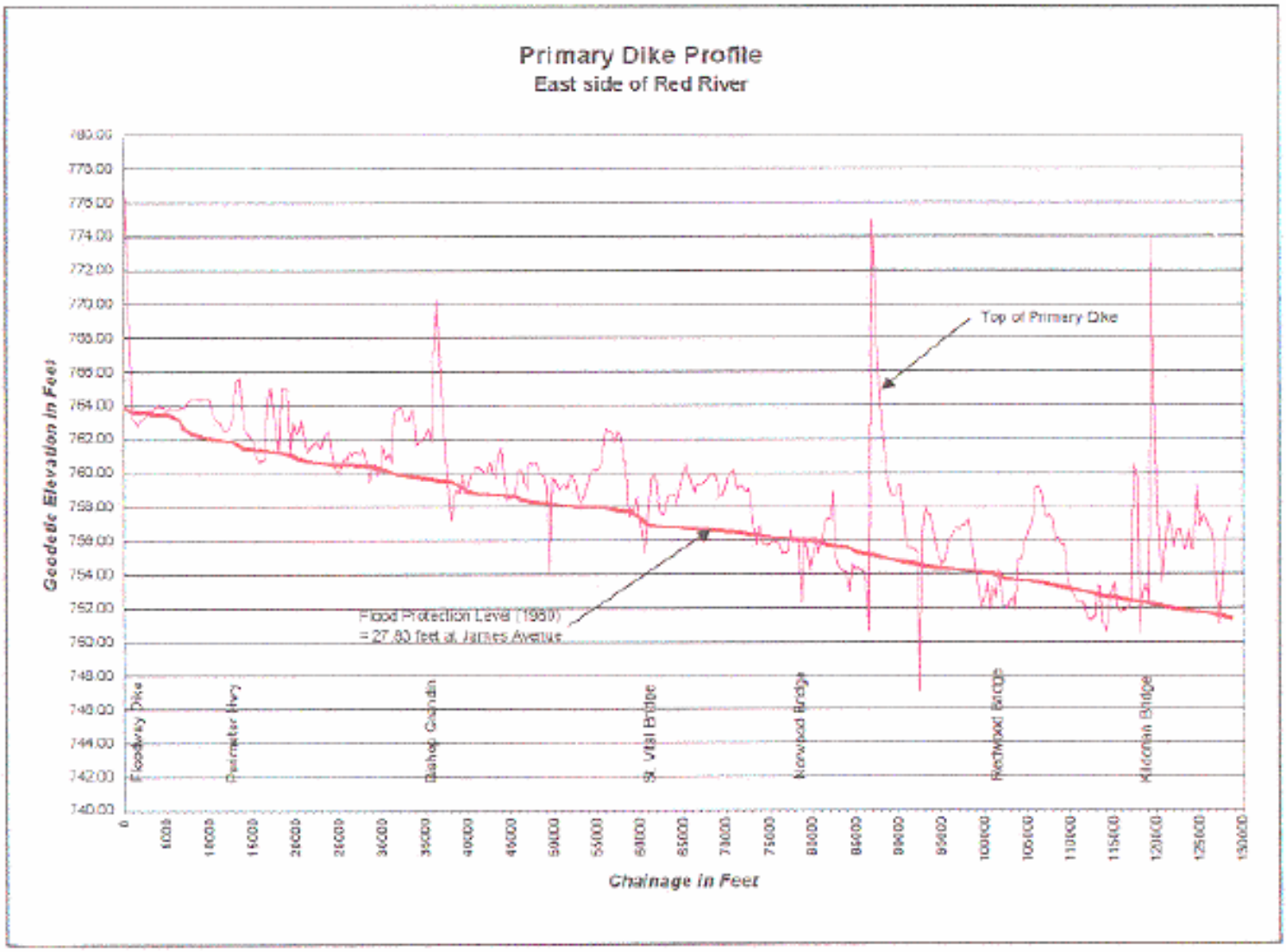
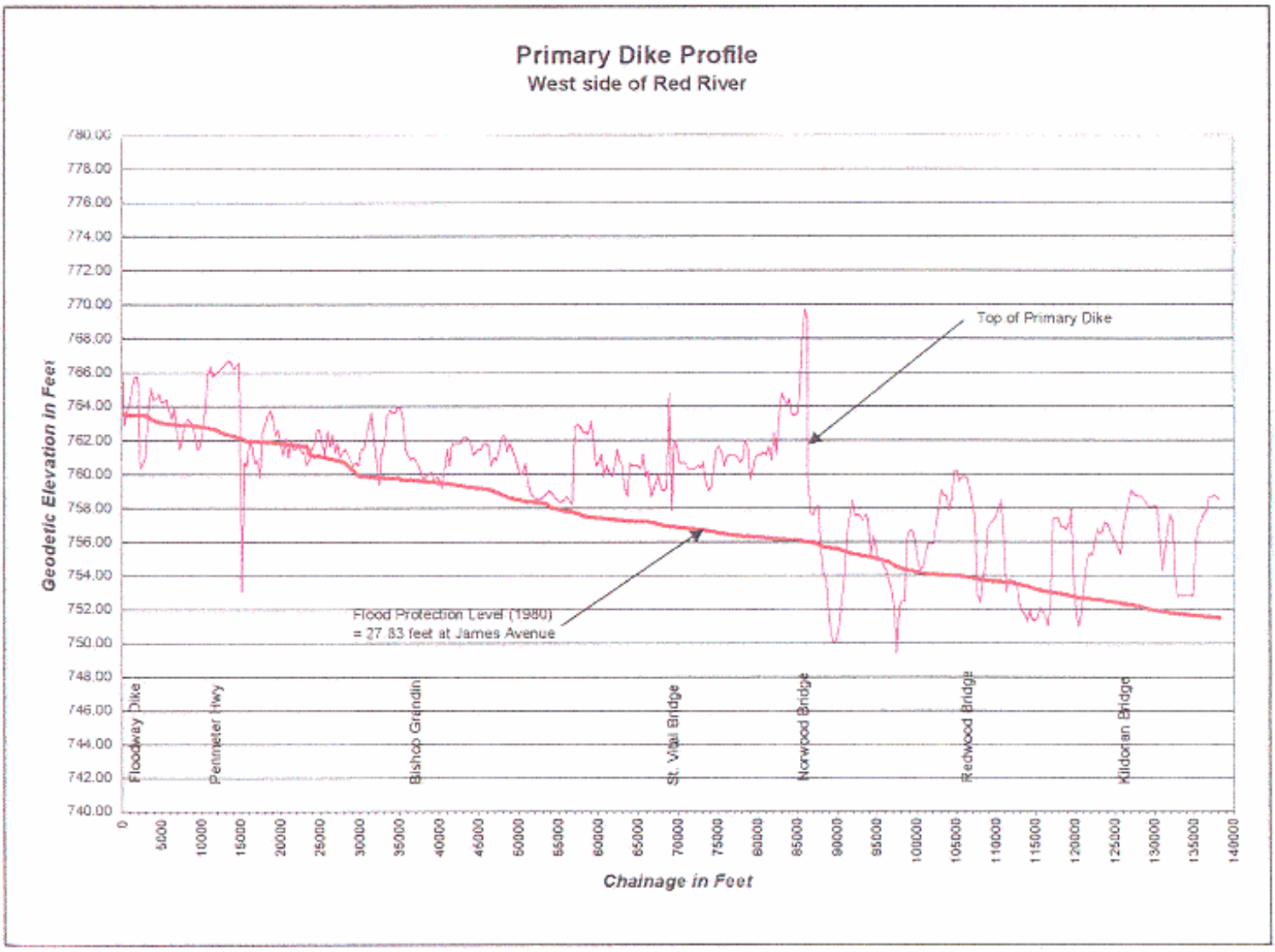


Figure 13 - Profile of the Primary Dike along the West Side of the Red River



There are other works within and outside of Winnipeg which provide flood control, some of which were discussed in the section titled "Components of the Sewer System". These are:

- The sewage treatment plant main pumps - utilized to "dewater" the sewer system faster to reduce the incidences of basement flooding.

- Stormwater retention basins - these can be utilized to store greater runoff than under normal operating conditions.

- Pipe storage/overflows - components of the sewer systems can be "manipulated" to help reduce the incidence of basement flooding. Under-utilized pipes can be temporarily blocked to store more water thereby reducing discharges downstream where there are significant flows. Some components of the sewer system have overflows to the river to "relieve" the sewer and reduce the incident of basement flooding.

- Seine River Diversion - reduces peak flows on the Seine River.

- St. Andrews Lock and Dam - utilized to control the level of the Red River in Winnipeg. This structure is "wide open" during spring runoff but "closed" during summer. It can be opened for summer high river level events thereby increasing the gravity capacity of the sewer systems and reducing the risk of basement flooding.

1997 FLOOD EXPERIENCE -VULNERABILITY TO BASEMENT FLOODING

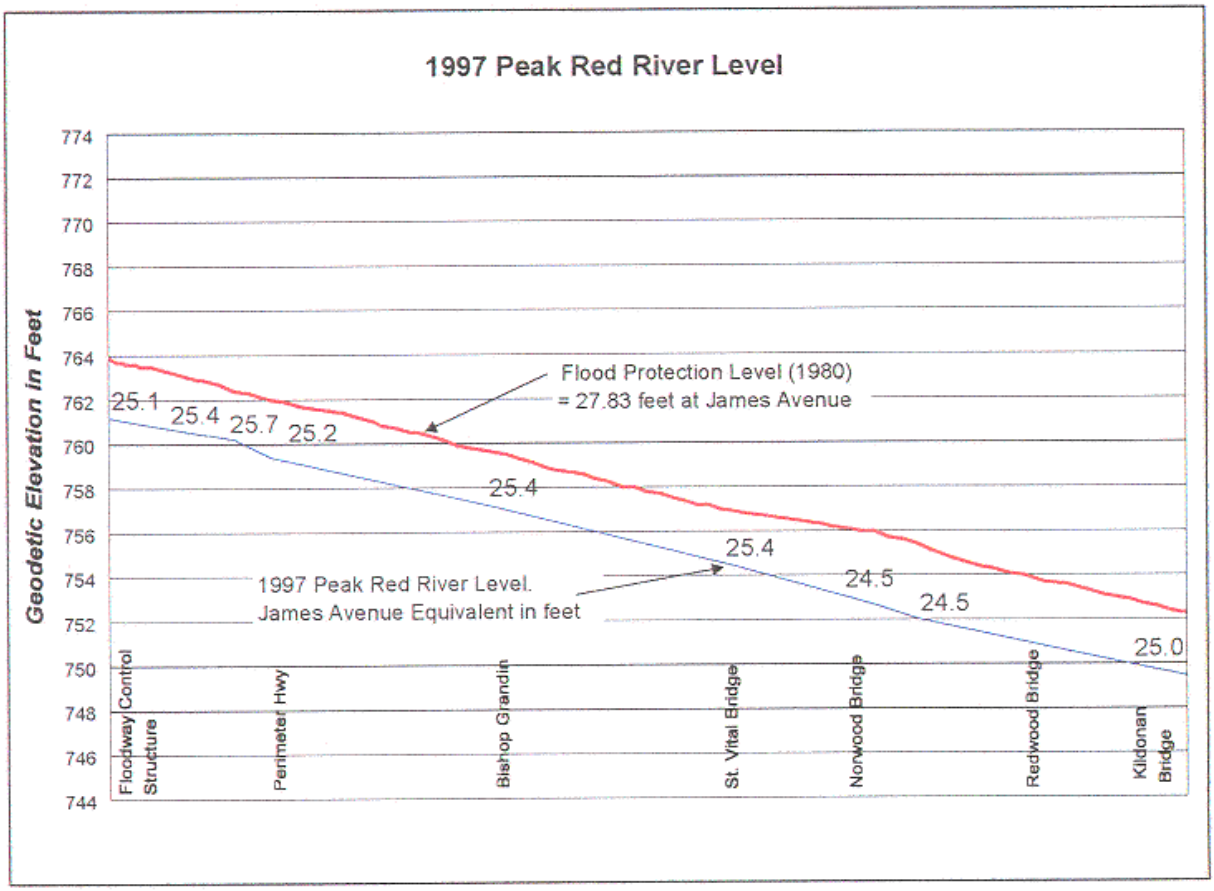
During the flood of 1997, the City of Winnipeg was vulnerable to basement flooding due to several different types of possible failure modes. These include a primary dike breach, a secondary dike breach, wastewater or combined sewer system breaches, land drainage sewer or ditch breaches, and pump failures.

For most part, the flood protection and sewer systems in Winnipeg are protected to a water level corresponding to 24.5 feet at James Avenue. This is because the primary diking system was originally constructed to 26.5 feet at James Avenue, allowing for a freeboard of 2.0 feet, and many of the systems were constructed prior to the 1980 legislation wherein the Flood Protection Level (27.8 feet at James Avenue) was established. There is evidence that prior to 1980, planners and engineers were aware of the impending Flood Protection Level legislation, and attempted to introduce this standard in developments. However, without the enactment of the legislation there was no method to legally enforce the standards and the flood protection conditions were not met. Therefore, most of the flood protection and sewer systems constructed prior to 1980, are vulnerable to water levels above 24.5 feet equivalent at James Avenue.

1997 Peak Red River Level

During the flood of 1997, the peak level reached at the James Avenue Station was 24.5 feet above City datum (datum is 727.57 feet above sea level). North of James Avenue to the north limit of the City, the peak level gradually rose to a level equivalent to 25.0 feet at James Avenue. However, in the south end of Winnipeg, peak levels were higher, as shown in Figure 14. Between the Floodway and the St. Vital Bridge, the peak level varied from 25.4 feet to 25.7 feet equivalent at James Avenue. The actual slope of the river was not uniform and had the level been raised above 24.5 feet at James Avenue, the flood protection and sewer systems would have been compromised to a greater degree than experienced in 1997, as discussed below.

Figure 14 - Profile of the Red River at 1997 Peak Level



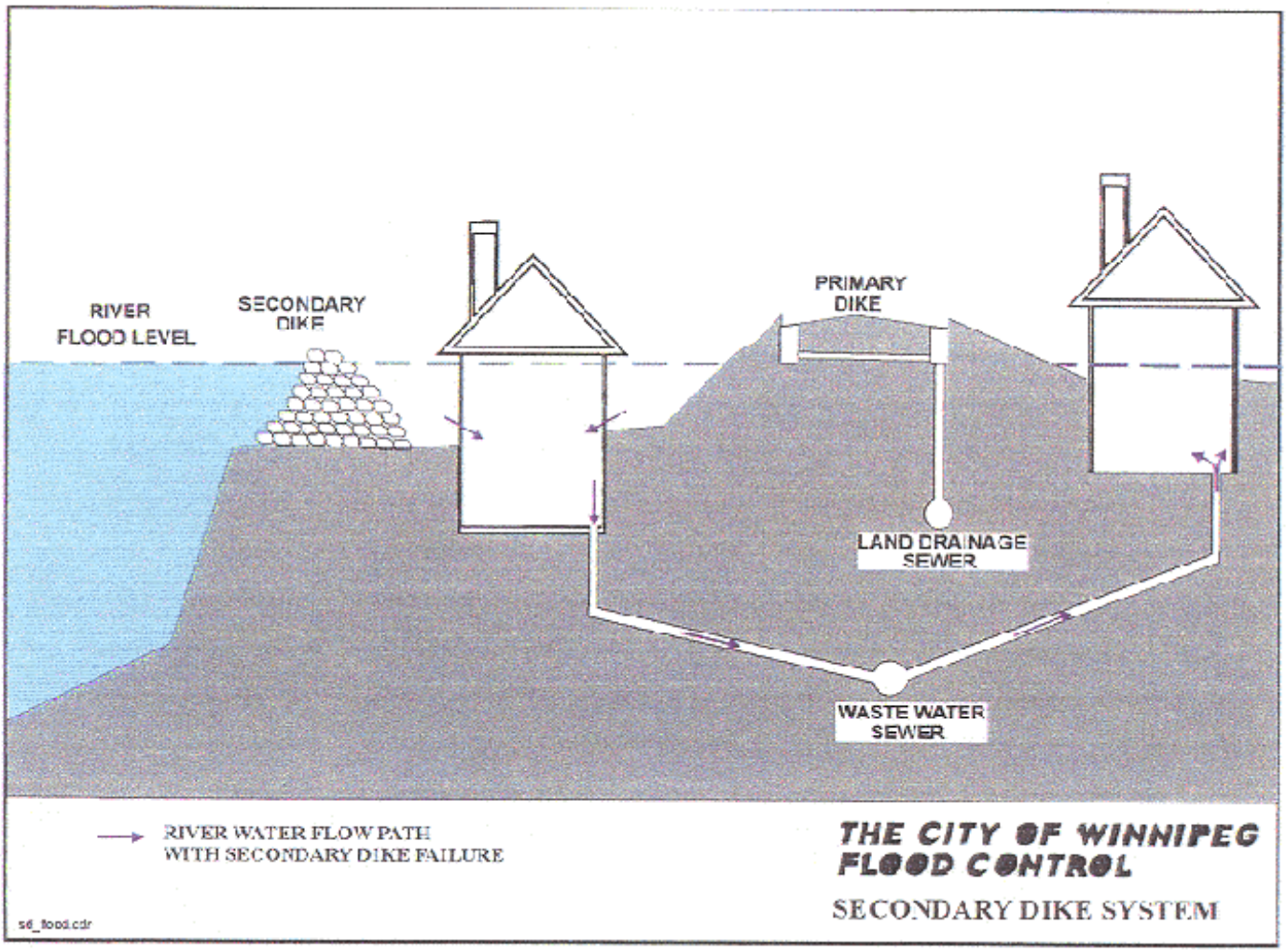
Potential Primary Dike Breaches

In 1997, specific locations of the primary diking system throughout Winnipeg, but primarily in the south end of Winnipeg, were raised in preparation for the potential Z-dike failure scenario. Approximately three miles of the total 68 miles of primary dike had to be raised approximately three feet to 27.5 feet equivalent at James Avenue. This was undertaken in one week and fortunately frost and frozen material, which would have hampered production seriously, was not much of an issue during the 1997 flood. Had these locations along the primary dike not been raised for the potential event, many of them would have been overtopped for the actual 1997 peak Red River level.

Secondary Dike Breaches

There were 800 properties protected by secondary dikes in 1997, most of these by 8,000,000 sandbags and 50 locations by earth fill dikes. At 500 of these locations, modifications were made to the building plumbing system (basement floor drains, toilets, sinks and other plumbing fixtures) to isolate them from the wastewater sewer system on the "dry" side of the primary dike. In the case of a secondary dike failing and flooding a basement, river water would otherwise be able to enter the wastewater sewer system via the building service connection. This would overload the wastewater system and would result in basement flooding in areas that were protected by the primary diking system, as shown in Figure 15. In the south end of Winnipeg, a sandbag secondary dike did fail and flooded the basements of two houses. The plumbing system modifications had already been completed, thus preventing river water from entering the wastewater sewer system that serves the St. Norbert area.

Figure 15 - Cross-section of Secondary Dike and Sewer Systems



Sewer System Breaches

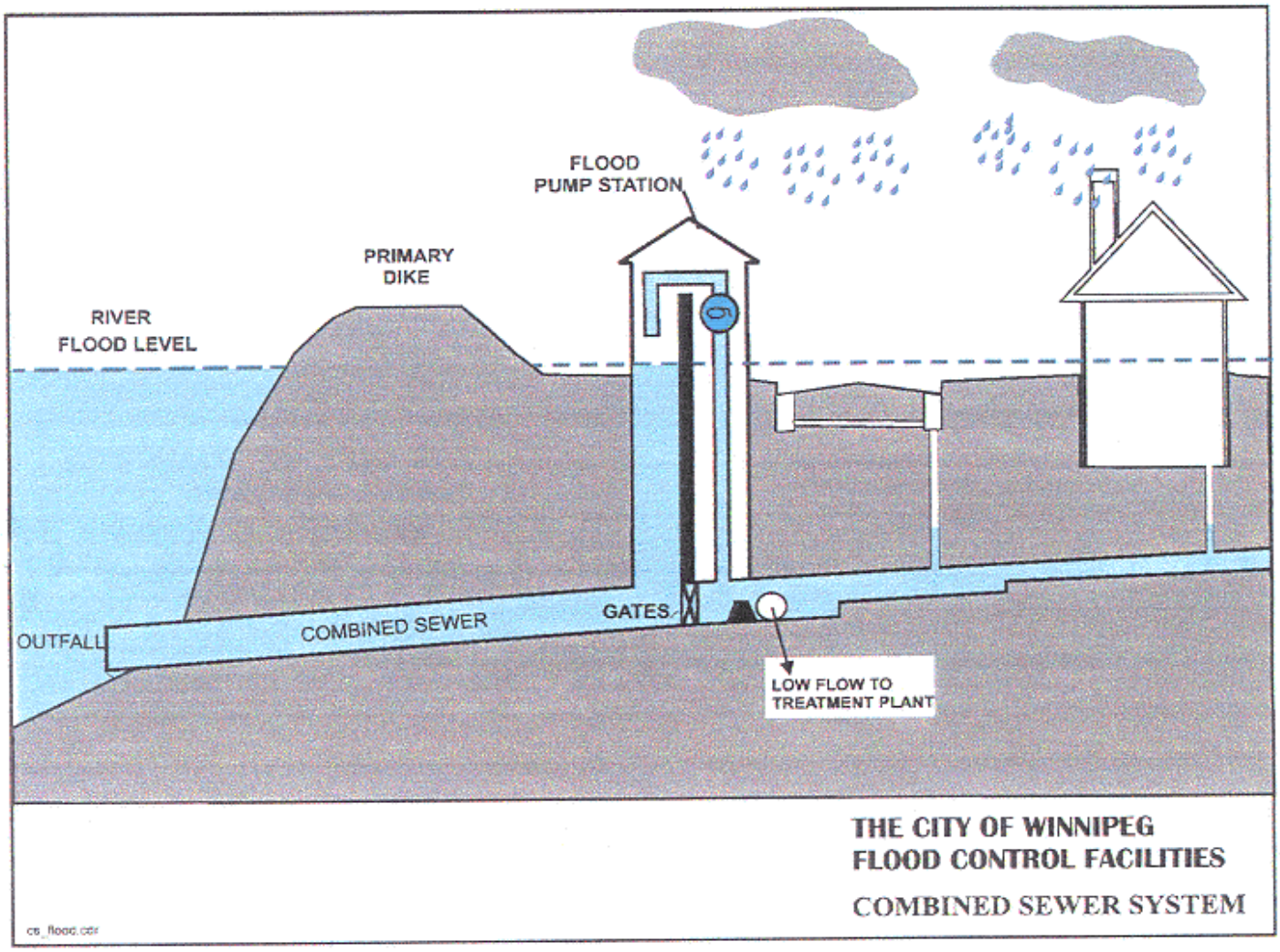
There is little or no hydraulic grade in the combined sewers or land drainage systems (sewers, channels and creeks) above a river water level equivalent to 24.5 feet at James Avenue. Also, there are numerous "holes" in the primary diking system that had to be plugged in 1997. Many of the holes were the land drainage system outfalls that have no gate protection and/or permanent pumping station. These situations lead to insufficient capacity to accommodate rainfall.

Basement flooding occurred on May 7,1997 near the flood peak in various areas throughout Winnipeg during a rainstorm. In most of these cases the basement flooding was a result of reduced sewer system capacity because the rivers were in flood stage, reducing the gravity capacity of the system. The remainder of Winnipeg was protected only to the level of the permanent or temporary pumping capacity installed and available. The rainstorms that occurred in 1997 did not exceed that capacity.

It was fortunate that very little rain was experienced in Winnipeg during the peak river elevations in 1997. Had there been a significant spring rainstorm, there would have been extensive basement flooding in both the combined and separate sewer areas.

Most of the combined sewer trunk outfalls are equipped with permanent flood pumping stations, as shown in Figure 16. When the river is in flood stage, the gate will close preventing the river from backing up into the combined sewer system and flooding basements. If it rains during river flood stage, the flood pumping station will activate before the level in the sewer system backs up into basements. Should significant rainfall occur which produces runoff flows that are in excess of the pumping capacity, the sewers will surcharge above basement floor levels. A recent study has also shown that the capacity of each pump station varies.

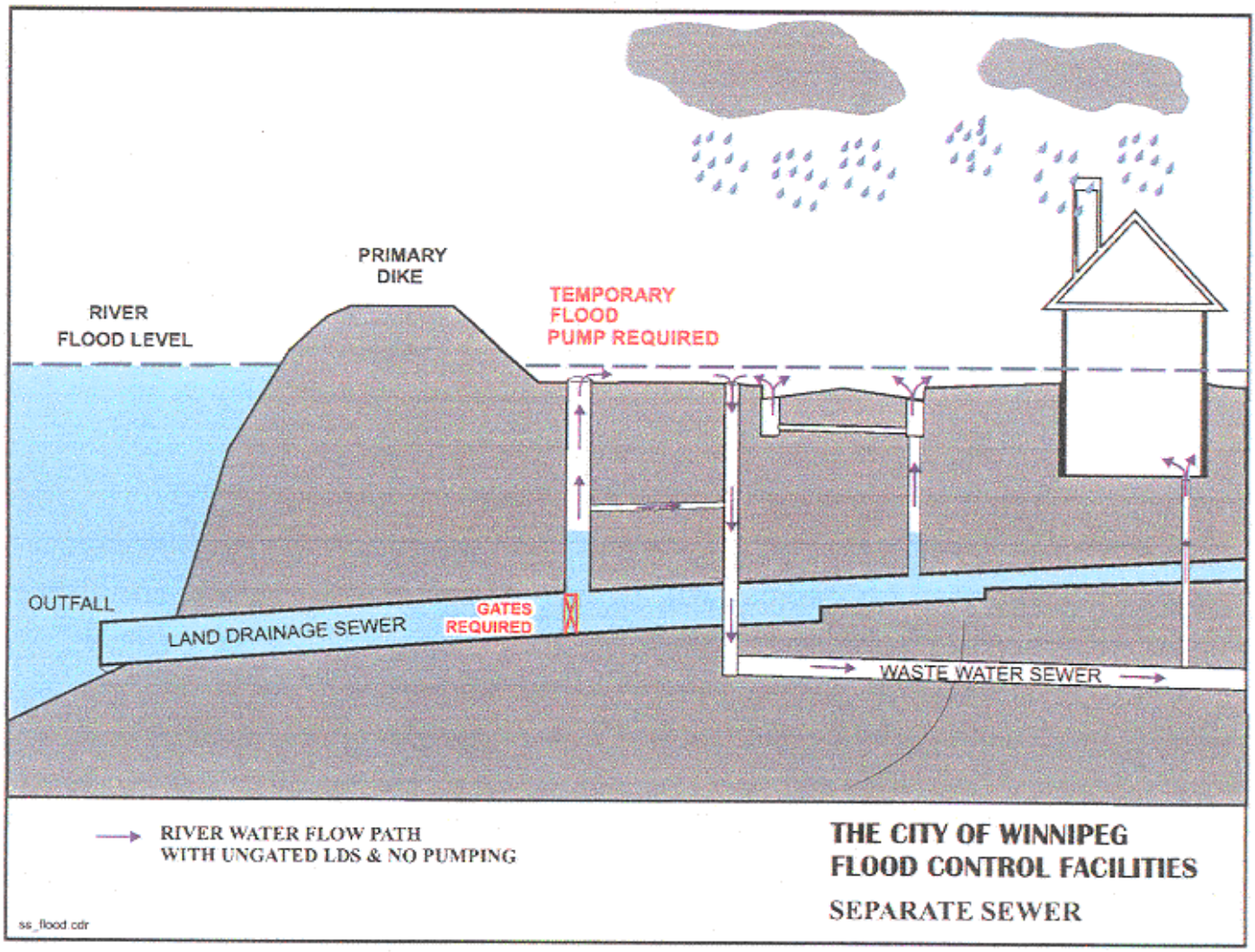
Figure 16 - Cross-section of a Combined Sewer System at the River



In the south end of Winnipeg where water levels exceeded 24.5 feet equivalent at James Avenue, the river water rose to a point that it backed up into the un-gated land drainage sewers, channels and creeks. The river water therefore surcharges to the point that it and land drainage flow (when raining) will pond on the surface of the streets and boulevards and eventually find its way overland into the wastewater sewer system through the manholes, as shown in Figure 17. The wastewater sewers were not designed to carry this extraneous land

drainage water thereby exceeding the sewer capacity, and backing up into the service connections and flooding basements.

Figure 17 - Cross-section of a Separate Sewer System at the River



Many of these un-gated facilities were temporarily plugged, preventing river water from backing up into the system but at the same time eliminating any flow from these systems to the rivers. As a result, snow melt or rainfall could not find its way out of the system. The land drainage works surcharged except where limited temporary pumping was able to lower water levels. Temporary pumping was not able to keep up with the amount of rain that fell. Sealing of wastewater manholes was undertaken as a precautionary measure in some areas and as an emergency measure in others. Further, there was a problem with unidentified cross-connections between the wastewater and land drainage sewer systems. If the river ever reaches elevations higher than 1997, more of these cross-connections will become evident.

The 1997 flood could have been much worse had more significant rainfall occurred. In 1974, heavy rains preceded and occurred during the weekend of May 18th/19th, which was followed by a downpour on May 20th. As this coincided with still high river levels, the gravity and pumping capacity of the system was greatly reduced and resulted in 9,500 flooded basements. Approximately 95% of these were in combined sewer districts.

In order to protect Winnipeg from overland flooding and basement flooding during significant river flooding events, significant capital improvements to the existing diking and sewer systems are required to provide increased river flood protection, pumping capacity and gates on all sewer and drainage facilities. It has been estimated that $270 million is required to upgrade the systems in Winnipeg to the Flood Protection Level (27.8 feet at James Avenue). These proposed mitigative works include: permanently raising primary dikes, upgrading flood pumping station reliability and capacity, installing land drainage sewer outfall gate structures, constructing permanent secondary dikes, installing permanent land drainage pump stations, and isolating sewer systems in areas protected by secondary dikes, to name a few.

A FLOOD LARGER THAN 1997

For a flood larger than 1997, such as an 1826-magnitude event, there are several serious issues facing the City of Winnipeg. These are: 1) timeliness and accuracy of flood forecasts; 2) provision of materials and/or construction for/of temporary secondary dikes; 3) raising primary dikes; 4) activities related to protecting the sewer system; and, 5) the potential evacuation of 300,000 residents.

Flood Forecasts

The forecasts provided by the Manitoba Flood Forecast Centre are absolutely fundamental to the City of Winnipeg's flood protection. They form the basis of all planning, preparations and operations before and during an event. They also provide the framework for communicating with the public, elected officials and the media. The flood forecasts are the basis for decisions involving operation of all City facilities, optimal use of resources and volunteers, secondary and primary dike construction, declaration of a state of emergency, and public safety (evacuation).

Timeliness and accuracy of the flood forecasts are essential for any flood but especially for a large flood. Will we know of a large flood potential early in the new year or will the flood evolve as it did in 1997? This impacts how the City will respond to a flood event.

Secondary Dikes

There are approximately 3,000 houses outside the primary diking system in Winnipeg. Approximately 800 locations required protection in 1997. It is estimated that 1000 houses are below the flood protection level. Likely all locations outside the primary diking system would be a low priority in a flood that required raising the primary dikes.

Primary Diking System

For a major flood, the Floodway Operating Rules envisage the temporary raising of the primary dikes in theory. The City would have tremendous difficulty protecting against the resultant water levels, which could reach 31.5 to 32.5 feet equivalent at James Avenue.

To raise the entire primary diking system approximately six feet would require 3,800,000 cubic metres of clay. It is estimated that with ideal weather and working conditions, and all necessary equipment was available and

working 24 hours per day, 7 days per week, this could be done around in approximately 33 days.

However, there are several potential construction difficulties that can occur, such as working in fully developed areas, cold temperatures causing clay to freeze in transit, improper compaction, frozen ground and/or snow on the ground, requirement to subcut a "key" along the dike route, and rain. Therefore it may be more realistic to assume that at least eight weeks are required to raise the primary dikes for an 1826-magnitude event.

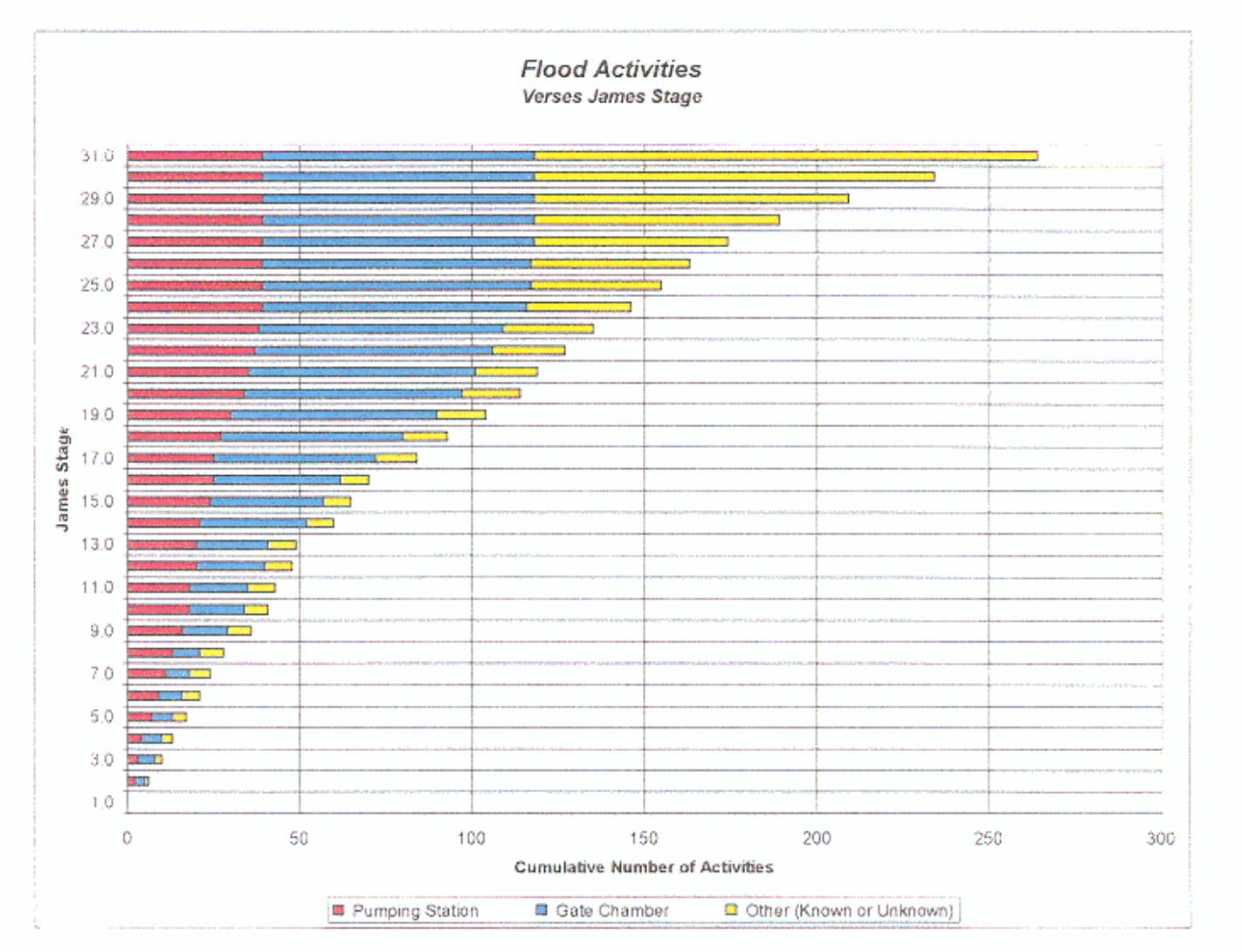
If the peak could be expected by mid-May, then this event would have to be forecast by mid-March. Clearly the decision to raise the primary dikes must be made early on and there is a risk of expending significant dollars if the event does not peak as high as the forecast. If there is insufficient time to raise the entire diking system, areas would have to be priorized.

Sewer Systems

The issues and problems with the sewer systems that were identified in the previous section titled "Sewer System Breaches" would be expanded significantly as the river level rises above 24.5 feet equivalent at James Avenue. This is illustrated in Figure 18 where the number of activities related to emergency flood operation of pumping stations, gate chambers and other activities, such as blocking sewer cross-connections, would almost double.

The concern with these activities is the limited availability of resources. The experience in 1997 was that both human and equipment resources were almost at their limit. The civic workforce continues to be reduced, the Canadian Armed Forces has also been experiencing reductions, and it is questionable as to whether the temporary equipment required for a flood larger than 1997, such as pumps, inflatable dams, heavy machinery, etc., would be available. More permanent works would therefore provide a level of protection with much less risk of failure. It is estimated that it would cost a minimum $400 million to provide sewer system upgrades to protect to the level of an 1826-magnitude event.

Figure 18 - Pumping Station, Gate Chamber and Other Activities as the River Rises

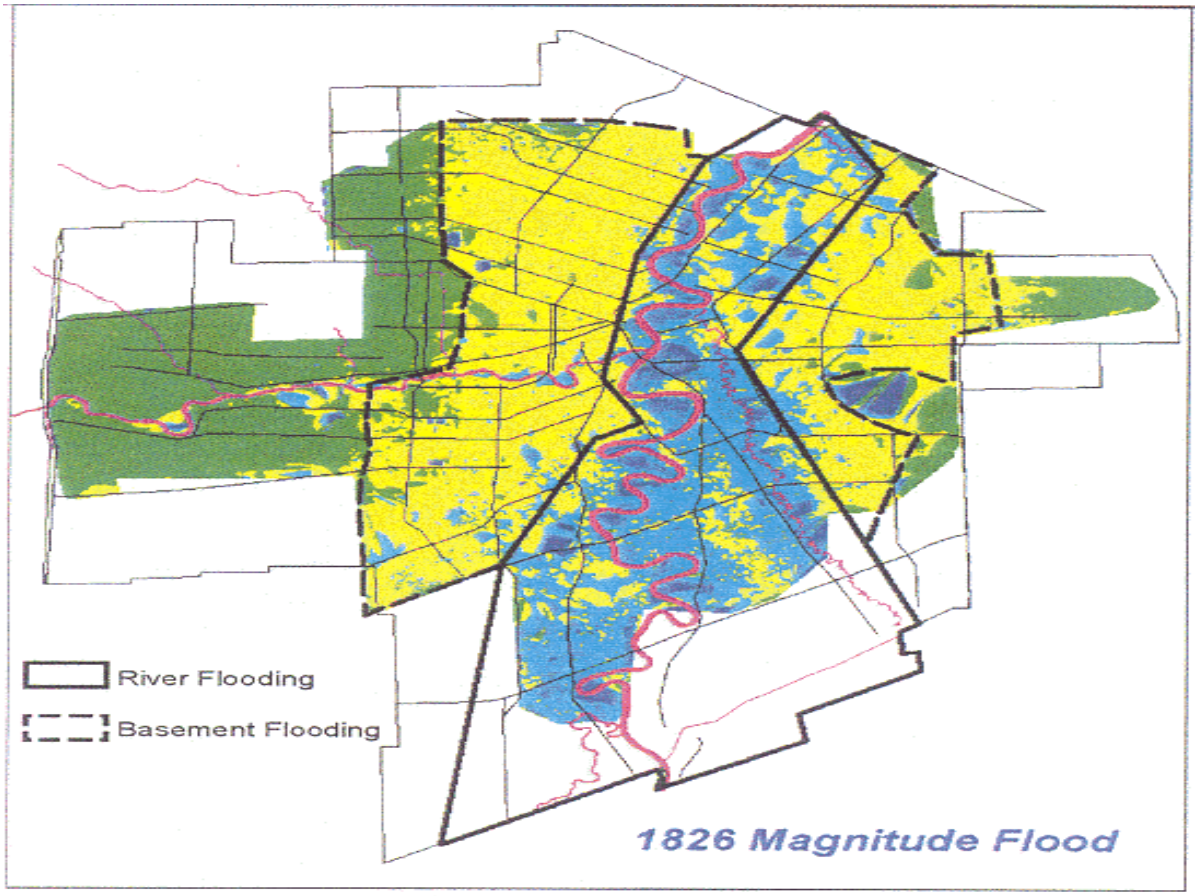


Evacuation

It is estimated for an 1826-magnitude flood that a total of 300,000 residents of Winnipeg would potentially have to be evacuated. This is based on 150,000 people (55,000 dwelling units: houses, condominiums, apartments) affected by river flooding and another 150,000 people (40,000 dwelling units) affected by sewer backup. The affected areas are shown in Figure 19. Add to this the estimated 30,000 people that would be evacuated from the Red River Valley south of Winnipeg.

The effort required to manage an evacuation of these magnitudes demands that a well-coordinated plan be developed to maximize use of available resources. It will also require the effective integration of all government, military, social agency and civilian services.

Figure 19 - Flooded Areas for an 1826-Magnitude Flood



A plan to evacuate 100,000 people was developed during the 1997 flood and was considered achievable. A plan to evacuate 330,000 people is an enormous task considering that all basic needs and major services will have to be provided on a temporary basis and most away from Winnipeg and the Valley. These would include accommodation, meals, health care, emergency services, security and communications. Further, the evacuation would be considerably more complicated for a sudden failure scenario, such as a break in the Floodway dike.

4. General Observations

Before examining the Floodway operating rules in detail, there are a few general observations and recommendations that can be made. This chapter summarizes the Committee's findings on overall operation of the Floodway system.

THE 1997 FLOOD EXCEEDED THE SYSTEM CAPACITY

The first observation of the Committee was that the 1997 flood exceeded the design capacity of the Floodway channel and control structure. The water managers were under considerable pressure to operate the structure so as to prevent flooding in Winnipeg, and minimize damages elsewhere through emergency actions and dissemination of forecast information. The emergency response in 1997 was commendable, but it pushed available resources to the limit. Reacting to a larger flood would be an enormous task. The 1997 flood experience has demonstrated that the current flood control system does not provide adequate protection for Winnipeg.

Therefore, the Committee recommends that flood protection infrastructure works in the City of Winnipeg, including works related to the primary diking system and the sewer systems, be upgraded to a level of 27.8 feet equivalent at James Avenue (the legislated Flood Protection Level).

LOCAL INPUT TO FLOODWAY OPERATION

The Committee recognizes that Floodway operation, particularly under serious flooding conditions, is controversial. In particular many residents south of the Floodway Control structure suspect that gate operation increases levels above those that would have occurred in the absence of the flood control works. Participation of the City and valley municipalities in Floodway operating decisions would ensure that local concerns are taken into account. It would also ensure that all facts are fully understood, and would provide direct feedback to the affected residents. For example in 1997 an employee of the City was located in the Water Resources office to communicate City concerns, and to ensure that decision makers in the City always had the latest information. This was very helpful to the City.

Therefore the Committee recommends that the Minister of Conservation appoint a Floodway Operation Advisory Board. The Board would be chaired by Water Resources, and would have representation from the City of Winnipeg, the valley south of Winnipeg, and the federal government. It may also be useful to include a representative from the valley north of Winnipeg. The purpose of the Board would be to provide advice on gate operations during all periods when the Floodway Control structure is in use. The Board would ensure that the operating rules are fairly applied, advise on temporary adjustments to the rules when unique conditions warrant, and facilitate communication with the residents of Manitoba.

The Advisory Board would meet at least once each year, normally after the March forecast is released by the Manitoba Government. In major flood years the Board would continue to meet until the flood threat is passed.

FREEBOARD ON THE FLOODWAY EMBANKMENTS AND WEST DIKE

The operating rules permit levels upstream of the Control Structure to rise to a maximum elevation of 778 ft. (237.13 m) under extreme flood conditions. With the top of much of the West Dike and part of the Floodway embankment at 780 ft. (237.74 m) this leaves a freeboard of only two feet (600 mm). The Committee is of the view that two feet of freeboard is inadequate to prevent overtopping from wind setup and wave action**.** Considering the depth of water that would be against the dike and the Floodway embankment, and the length of the fetch to the south, wind setup under a prolonged south wind would in all probability be well in excess of two feet. Therefore permitting levels south of the Control Structure to rise to 778 ft. (237.13 m) would create a serious risk of overtopping and serious dike failure unless the Floodway dike and embankments had been raised to a safe level. However standard methods for computing wind setup on a lake are not directly applicable to a river. A more rigorous analysis is required to determine an acceptable freeboard for the dike and embankments.

The Committee recommends that a rigorous technical analysis of wind and wave impacts be carried out to determine a safe freeboard for the Floodway embankment, the West Dike, and Winnipeg's Primary Dikes.

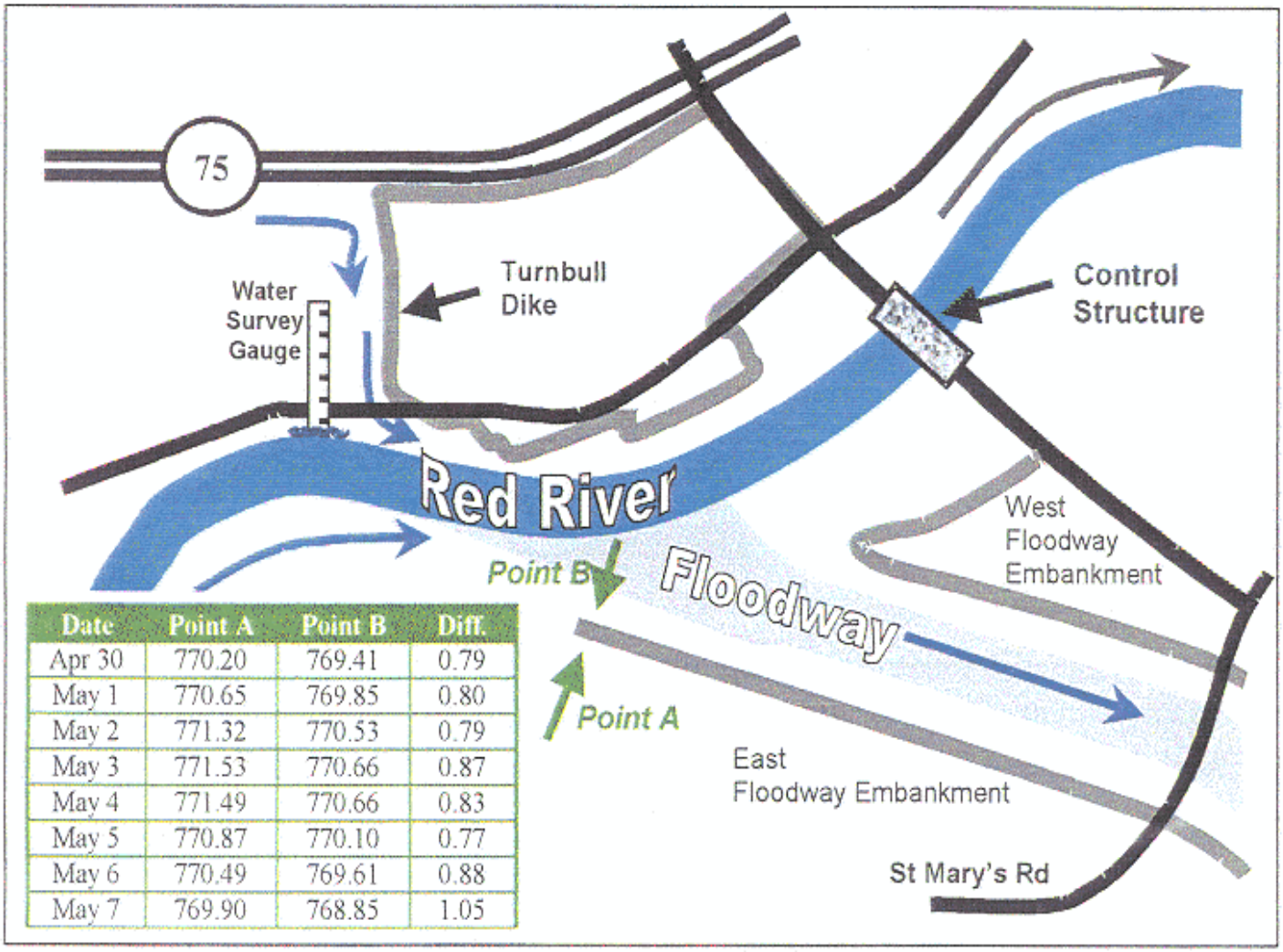
RESTORATION OF FLOODWAY CAPACITY

As discussed in chapter 2 the 14 bridges crossing the Floodway channel have reduced the maximum capacity of the Floodway channel from a design maximum of 100,000 cfs to an actual maximum of 90,000 cfs. Furthermore the possible constriction caused by the Turnbull Dike and the east embankment of the Floodway channel appears to result in high flow velocities and a drop in water levels in the section of the river from the Water Survey gauge to the control structure. In the 1997 flood, measured water levels at the west end of the east Floodway embankment were consistently 0.8 to 0.9 feet higher on the south side of the embankment than on the channel side as shown in Figure 20.

Modification to the crossings, particularly the first seven crossings, could restore the Floodway channel capacity to the original design maximum capacity, thereby restoring the flood control capability of the Floodway channel to its original capacity. **Therefore, the Committee recommends that the possibility of permanently raising the seven upstream bridges crossing the Red River Floodway Diversion Channel (GWWD Railway, PTH #1, CNR Sprague, PTH 59S (two bridges), CPR Emerson, and St. Mary's Road), should be examined.**

It appears that removal of the portion of the Floodway east embankment west of Grande Pointe may have no negative impacts, and would provide a much larger entrance to the Floodway channel under high flow conditions. In fact, in 1997 if this section of dike had not been in place, peak levels along St Mary's Road just south of the Floodway could have been almost one foot lower than experienced in 1997. The Committee notes that consideration is currently being given to constructing a community dike just south of the Floodway that would incorporate part of the east embankment of the Floodway channel.

Figure 20 - 1997 Floodway Entrance Losses



Date	Point A	Point B	Diff.
Apr 30	770.20	769.41	0.79
May 1	770.65	769.85	0.80
May 2	771.32	770.53	0.79
May 3	771.53	770.66	0.87
May 4	771.49	770.66	0.83
May 5	770.87	770.10	0.77
May 6	770.49	769.61	0.88
May 7	769.90	768.85	1.05

The Committee recommends that the impact of removal or reduction in height of a section of the east embankment of the Floodway channel west of Grande Pointe be assessed before any portion of that dike is incorporated into a community dike.

Considerable work has been undertaken in the valley since the 1997 flood to increase flood protection. The Committee supports this action and recognizes that permanent works constructed now will reduce flood damages in the future. However it is possible that some works could inadvertently result in a reduction in the hydraulic capacity of the flood control works, or could cause water surface elevations to be higher upstream of the inlet for a given flood condition. **Therefore, the Committee recommends that no works be constructed in the Red River Valley upstream of the Red River Floodway channel inlet without an assessment of its potential impact on the capacity of the Floodway channel.**

As noted earlier the Outlet Structure was designed to pass 80,000 cfs (2,300 m^3/s). During the 1997 flood concern was expressed about the capability of the Outlet Structure to pass flows that might develop in the event of a failure of the West Dike extension. Emergency work was done to protect the structure. It would appear advisable to increase the capacity of this structure to the maximum capacity of the Floodway Channel, or 100,000 cfs (2,800 m^3/s). **Therefore the Committee recommends that feasibility of upgrading the capacity of the Outlet Structure should be examined.**

5. Review of Red River Floodway Operating Rules

INTRODUCTION

The Committee's focus in the present review of the operating rules is short term in scope. That is, the review deals only with the current flood control structures, dikes, and channels. The Committee recognizes that the flood of 1997 pushed the flood control system to its limit, and discussions and studies about improvements to the flood control systems are under way. Such changes might well require further changes to the operating rules. However the current review is limited to answering the question: "Given the current flood control works, how should the Floodway be operated in the best interest of all Manitobans?"

The original operating rules were documented in a report entitled *"Red River Floodway Program of Operation"* (1970) prepared by the Water Control and Conservation Branch of the Department of Mines and Natural Resources. A revision to the rules was documented in the report *"Red River Floodway Program of Operation,"* (1984). This report was written by the Manitoba Water Resources Branch of the Department of Natural Resources in response to recommendations made by the Manitoba Water Commission (1980).

After considerable review the Committee agreed that there are no major changes required in the operating rules. However a few modifications could make the rules more consistent, and could remove some of the ambiguity in the present rules. One suggested change is to tie the rules to river levels rather than flows, since it is water levels that result in flooding. The 1997 flood demonstrated the problem of having the operating rules tied to flows rather than levels. The current rules prescribe that "natural" levels be maintained at the Floodway channel's entrance when the estimated "natural" flow at James Avenue is below 169,000 cfs (4800 m^3/s). For higher flows the level at James Avenue should be held at 25.5 ft. (7.8 m.). The purpose of these limiting flow and stage values is to keep water levels from exceeding the primary dikes in Winnipeg. However in 1997 the primary dikes were threatened at a flow less than 169,000 cfs (4800 m^3/s). The problem is that the relationship between levels and flows changes for different floods and at different reaches of the river. Also the "natural" flow is a computed value whereas the levels are measured directly, and so are less open to dispute.

The primary operating rules give direction to gate operation during flood conditions. Additional rules provide detailed direction for initiation and termination of operation.

RULE FOR FLOWS AT OR BELOW THE DESIGN CAPACITY

For flows at or below the design capacity, the operating rules stipulate that the Floodway gates must be operated so that water levels at the Floodway channel's entrance are at or below "natural". In this context the term "natural" does not mean flows and levels that would have occurred with no man made impacts, such as agricultural development in the valley, or urbanization in Winnipeg. Rather "natural" refers to the level that would have occurred in the absence of the flood control works, with the level of urban development in place at the time of the construction of these works.

The Committee considered three questions:

i. Are the "natural" levels being computed correctly?
ii. How is the "design capacity" of Winnipeg's flood protection system defined?
iii. Does it ever make sense to deviate from this rule?

Determination of "natural" levels:

The current procedure for computing the "natural" level at the Floodway channel's entrance is based on relationships developed in the 1960's. However there was no data available to extend these relationships to flows above those experienced in 1950. There is some indication of levels in Winnipeg in 1852 and 1826, but these floods happened before bridges were constructed across the Red River and before any significant settlement in Winnipeg, and so are not directly applicable to current conditions.

After the 1997 flood, questions arose about the accuracy of the computed "natural" levels above the Floodway. The Manitoba Water Commission (June, 1998) reviewed the computed peak level and reported an error of approximately half a foot. An internal review by Water Resources also raised questions about the accuracy of the computed peak "natural" water level.

Therefore the Committee recommends that the "natural" water level relationships be recomputed. To assure that the relationships receive broad acceptance, the computation should be done under the supervision of a technical working group comprised of representatives from the provincial and federal governments, from the City of Winnipeg, and from the valley south of the Floodway Control Structure.

Definition of design capacity

The original rules stated that "natural" water levels be maintained at the Floodway channel's entrance until the water level at the James Avenue gauge in downtown Winnipeg reaches 25.5 feet (7.77 m.). Then the James Avenue water level should be maintained at this level while the water level at the Floodway channel's entrance goes above "natural". The primary dikes through Winnipeg are at a minimum design elevation of 26.5 feet (8.08 m.) equivalent James Avenue datum. Therefore, applying the original rules would leave one foot of freeboard on the dikes. However, in a year like 1997 the local stage is not constant along the river. For example, on May 3, 1997 the stage at James Avenue was 24.5 feet (7.47 m.), but the stage along the river through the south end of Winnipeg was generally around 25.5 feet (7.77 m.) equivalent James Avenue datum (see Figure 14). If levels had been permitted to rise another foot the dikes at the south end of Winnipeg would have definitely been overtopped. Therefore, in 1997 "natural" water levels at the Floodway channel's entrance were maintained only until the James Avenue water level reached 24.5 feet (7.47 m.) rather than 25.5 feet (7.77 m.).

In the mid 1980's it was recognized that a freeboard of one foot is inadequate for Winnipeg's primary dikes. Furthermore, many of Winnipeg's sewer systems become ineffective above 24.5 feet (7.47 m.). Therefore, a James Ave. water level of 25.5 feet (7.77 m.) could result in widespread basement flooding in the event of a rainstorm even if the primary dikes are not overtopped.

RULE 1:

The Committee recommends that the operating rules continue to require that the Floodway be operated

so as to maintain "natural" water levels on the Red River at the entrance to the Floodway channel, until the water surface elevation at James Avenue reaches 24.5 feet (7.46 m.), or the river level anywhere along the Red River within the City of Winnipeg reaches two feet below the Flood Protection Level of 27.83 feet (8.48 m)).

Should deviation from the "natural" levels be permitted?

During the 1997 flood, concern was expressed in the valley south of Winnipeg that levels were rising too quickly. Some suggested that levels in Winnipeg should be allowed to rise quickly to 24.5 ft. and then held there. This would keep levels from overtopping the primary dikes in Winnipeg, and would provide additional time for emergency flood preparation in the valley. However Winnipeg is vulnerable to sewer backup whenever river levels exceed normal levels, and the vulnerability increases rapidly with increasing levels. Therefore this change could result in considerable basement flooding in Winnipeg.

Conversely**,** an economic analysis might indicate that there are overall benefits to allowing levels in the valley to rise above the computed "natural" level up to a pre-defined level where damages are known to be small. For example, with the current dike and pad raising program in the valley**,** damages may be minor as long as the roadway system is not flooded. This would allow lower levels through Winnipeg, reducing flood fighting costs and the potential for sewer backup damages. However**,** this operation could lead to numerous disputes. A system would have to be in place to compensate the resulting "minor" damages, and the bureaucracy required to administer it would be unwieldy. Therefore the Committee decided against including in the operating rules a provision for deviating from the computed "natural" level when water levels within Winnipeg are not threatening to overtop the primary dikes.

RULES FOR FLOWS LARGER THAN THE DESIGN FLOOD

The current operating rules for larger floods stipulate the following. For natural flows at James Ave. between 169,000 cfs (4800 m^3/s) and 189,000 cfs (5400 m^3/s), water levels in Winnipeg should be held constant while water levels at the Floodway channel entrance continue to rise. This would continue until the water level at the channel entrance reaches 775.8 ft (236.46 m.). At this level the designers computed that the Floodway flow would be approximately 90,000 cfs (2500 m^3/s), or 90% of its original computed maximum capacity. Once the water level at the channel's entrance reaches 775.8 ft (236.46 m.), additional flows should be passed through Winnipeg. The assumption is that forecasts would have provided the City with sufficient warning to raise the primary dikes up to a James Ave. level of 31.5 feet (9.6 m.), so that additional flows could be passed safely through Winnipeg.

Once water levels at James Ave. reach 29.5 feet (9.0 m.), the full capacity of the Floodway channel should be used. That is, Floodway channel flows would increase to 100,000 cfs (2800 m^3/s), and the water level at the Floodway channel's entrance would rise to 778 feet (237.13m.), which is two feet below the top of the Floodway east embankment and the West Dike.

There are a number of problems with the assumptions inherent in these high flow rules:

1. A recent Water Resources Branch analysis of the Floodway capacity has shown that the channel only has a maximum capacity of 90,000 cfs (2500 m^3/s), not 100,000 (2800 m^3/s). The problem

is that at these high flows the bridges crossing the Floodway channel are submerged, thereby restricting the flow. Therefore with the current channel and its bridge crossings, the rule requiring that 100,000 cfs (2800 m^3/s) flow down the Floodway channel is not tenable.

2. The City has estimated that it could take six to eight weeks to raise all of the primary dikes through Winnipeg by a full six feet. It is more reasonable to assume that the dikes could be raised to a lesser degree, or only fully raised in high priority areas of Winnipeg. Therefore the requirement in the rules that James Avenue river levels be allowed to reach 29.5 feet (9.0 m.) once the primary dikes are raised would be difficult to apply, and would require considerable discussion among all affected stakeholders.

3. Two feet of freeboard on the Floodway embankments and on the West Dike is inadequate. Considering the depth of water that would be against the embankments and the dike, and the length of the fetch to the south of them, wind setup under a prolonged south wind would in all probability be well in excess of two feet. The accompanying wave action would result in wave runup and erosion. Therefore permitting water levels south of the Control Structure to rise to 778 feet (237.13 m.) would create a serious risk of overtopping and a major dike failure unless the Floodway embankments and the West dike had been raised to a safe level.

The Committee recommends that the current operating rule for larger floods be replaced with the following rule:

RULE 2:

Once the river levels within Winnipeg reach the limits described in Rule 1, the level in Winnipeg should be held constant while levels south of the Control Structure continue to rise. Furthermore if forecasts indicate that levels south of Winnipeg will rise more than two feet (0.6 metres) above natural, the City must proceed with emergency raising of the dikes and temporary protection measures on the sewer systems in accordance with the flood level forecasts within Winnipeg. The levels in Winnipeg should be permitted to rise as construction proceeds, but not so as to encroach on the freeboard of the dikes or compromise the emergency measures undertaken for protecting the sewer systems. At the same time the Province should consider the possibility of an emergency increase in the height of the Floodway embankments and the West Dike. At no time will the water level at the Floodway channel's entrance be allowed to rise to a level that infringes on the allowable freeboard on the Floodway west embankment (Winnipeg side) and the West Dike.

Under extreme floods that are beyond the flood control capabilities of system, operating decisions would have to focus on protecting the flood control works from catastrophic failure. All additional flows must be sent through Winnipeg, no matter what the impact. The Committee recognizes that under such extreme conditions operating decisions would be under the full control of the Minister of Conservation, in consultation with the Floodway Operation Advisory Board. Decisions would have to be made based on a thorough analysis of the developing flood conditions.

RULE 3:

For extreme floods, where the water level at the Floodway channel's entrance reaches the maximum level that can be held by the Floodway west embankment and the West Dike, the river level must not be permitted to exceed that level. All additional flows must be passed through Winnipeg.

OTHER RULES

Initial gate operation with ice

This rule is designed to prevent ice from entering and potentially blocking the Floodway channel. It states that the gates should not be operated until ice on the river is flowing freely. This rule was followed in 1997 until the river level reached a height where ice pans were flowing into the Floodway channel even without gate operation. The gates were then put into operation because flooding in Winnipeg was imminent. **The Committee affirms that this was the correct decision for the conditions in 1997 and recommends that this rule be retained. However the Committee recommends that it be overridden when flood damages in Winnipeg are imminent.**

Initial depth of flow over Floodway lip

To reduce the amount of erosion on the lip at the entrance to the Floodway Channel, which can occur when water starts flowing into the channel, this rule stipulates that the initial gate rise should result in a minimum depth of flow over the lip. With the current heavy vegetative cover on the lip there has been no evidence of erosion of the lip in recent years. **The Committee therefore recommends that this rule be deleted.**

Final drop of gates

The current operating rules stipulate that the final Floodway gate operations during a flood should consider three factors:

- erosion of the Floodway channel's entrance lip,
- water level fluctuations downstream of the gates, and
- Winnipeg's vulnerability to sewer backup as a result of heavy rains and vulnerability to riverbank sloughing.

This is done by, respectively, maintaining a minimum depth of water over the entrance lip, by dropping the gates in two 'shots' when lowering the water below the top of the entrance lip, and by maintaining water levels at the Floodway channel's inlet between 751 ft. and 752 ft. until levels in Winnipeg have receded below prescribed levels. As with the previous rule erosion on the lip is no longer a concern. Also information on the impact of river level fluctuations and the potential for sewer backup and riverbank sloughing should come from City engineers. **Therefore the Committee recommends that this rule be modified to state that once the level at the entrance to the Floodway Channel recedes to elevation 752 feet (229 metres), final gate operations be carried out in consultation with the City of Winnipeg.**

Operation of horn at Floodway Control Structure

The current rules of operation require that a horn be sounded before each rise. The horn is required to sound for

one full minute a half-hour before the gate operation. Then at the time of gate operation three short blasts are required.

There are a number of problems related to the horn operation. The main problem is the anxiety it often causes during an already stressful time. The resident hears the horn, but receives no information of how high the flood waters will rise as a result of the gate operation. Also there is very little he can do to increase his protection in the half-hour period between the horn sounding and the gate operation. Another problem is that the impact of the gate changes extends beyond the audible range of the horn. Therefore it does not provide equal warning to all residents of the valley that may be affected.

What is required is a more effective way to relay gate operation information to valley residents. If flood fighters had easy access to accurate and timely information about gate changes and the forecasted impact they would be able to respond in a more effective manner.

Much has been done over the past few years to get flood information to the public. The forecast center distributes daily flood information sheets to all flood fighters. News releases are issued for each significant development, and recently the Internet has become a very effective medium for informing the public about flood conditions. These sources of information are much more effective than simply sounding the horn at the structure. However still more could be done to provide specific information about planned gate operations.

Therefore the Committee recommends that the horn only be operated once, before the first gate operation of the year. The horn should be sounded a half-hour before the first gate operation to alert residents that the Floodway Structure is being put into operation. For ongoing information a 1-800 number should be established that would provide current information of gate operations, potential impacts on water levels, and forecasts for the next few days. This information should also be included on the existing Water Resources internet site.

6. Operation Under Extreme Flooding (1826)

BACKGROUND

The third reference given to the Committee was to review or prepare contingency plans for operation of the Floodway and for emergency actions such as closures, emergency diking or breaching, etc. required to combat a flood of 1826 proportions. The 1826 flood has been estimated to have peaked at 225,000 cfs in Winnipeg (RRBI, 1953). This is 40% larger than the 1997 flood, and well beyond the design capacity of the flood control system. It would be a very rare event, with a probability of recurrence of only once in 360 years. However it has happened before, and some year in the future a flood equal in size or even larger will occur. It is therefore reasonable to consider what can be done to manage such a flood.

Simulations carried out for the IJC Red River Task Force for an 1826 flood (Klohn-Crippen, 1999) show that levels between Emerson and Morris would be less than one foot (0.3 metres) higher than the 1997 flood, so the protection works currently being put in place in that area should be sufficient. However RM of Ritchot levels

would be up to six feet (1.8 metres) higher than the 1997 flood.

A modeling study conducted in 1999 by a Master's student of the Faculty of Civil and Geological Engineering, University of Manitoba (Gonzales 1999) demonstrated that with an extreme flood, similar in magnitude to the 1826 flood, attempting to hold river levels through Winnipeg below the primary dikes would result in overtopping of the Floodway embankments. This overtopping would send a wave of water into Winnipeg, which would increase in magnitude as the overflows eroded the embankments, resulting in widespread flooding.

The modeling study conducted for the IJC Red River Task Force (Klohn-Crippen, 1999) simulated the impact of managing a flood of 1826 proportions in strict accordance with the current operating rules. As the peak flows approach Winnipeg, levels at the entrance to the Floodway channel would be limited to a maximum of 778 feet (237.13 m.) and all additional flows would pass through Winnipeg. The simulation showed that levels in Winnipeg would rise to 32 feet (9.8 m.) at James Avenue. This is 5.5 feet (1.7 m.) above the current top of the Primary Dikes. In all likelihood there would not be enough time to raise the Primary Dikes sufficiently high to prevent overtopping, and much of Winnipeg would flood. Even if the dikes could be raised to a sufficient height many of the residents would have to be evacuated because of loss of municipal services.

Both of these studies indicate that with the current flood control works in place it would not be possible to prevent extensive flooding in Winnipeg under 1826 runoff conditions. While it may be possible to evacuate 300,000 people from Winnipeg with proper advanced planning and cooperation from the weather, it is neither desirable nor practical. In short, it would not be possible to prevent extensive damage to the City of Winnipeg for an 1826 magnitude flood with the current flood control works and flood fighting measures similar to those undertaken in 1997. The emergency response to the 1997 flood was commendable, but it pushed available resources to the limit. Reacting to a larger flood under similar circumstances would be an enormous task

The Committee recognizes that much has been done since 1997 through the Canada-Manitoba Partnership Agreement on Red River Valley Flood Protection. However most of this program is focused on flood protection in the Valley south of Winnipeg. More effort is required to reduce Winnipeg's vulnerability to a major flood.

The Committee, therefore, recommends that serious consideration be given to increasing the capacity and reliability of the flood protection works for Winnipeg. This would enable increased protection against an 1826-magnitude flood or larger, and reduce the potential for loss of life and significant damage.

Full protection to Winnipeg would be very costly, and could only be provided by a major expansion of the flood protection works. One obvious option would be to increase the capacity of the floodway channel. However other options are available that could increase flood protection for Winnipeg. Chapter 4 describes the need to restore the Floodway to its design capacity by permanently raising seven bridges over the Floodway channel, removing a portion of the east embankment of the Floodway channel, and restricting further development upstream of the Floodway channel inlet. Other possible suggestions are:

Raise the West Dike

The top of the West Dike is at elevation 780 feet (237.74 m.) near the Inlet Control Structure, and rises to 784 feet (239.0 m.) along its southern section. The West Dike could be raised further to protect Winnipeg from a major flood. This was done in 1997, and could be done again under emergency conditions. However a permanent raise would be more desirable.

Raise the Primary Dikes and Protect the Sewer Systems in Winnipeg

The rules of operation require the City to start raising the Primary Dikes when a major flood is forecast. As discussed, this would present numerous problems. The City has estimated that raising all the primary dikes on a temporary basis by six feet would require at least 30 days of trouble free construction. It is estimated to take six to eight weeks if construction difficulties arise. Associated with dike raising is the requirement to flood proof the sewer systems, since they have no hydraulic capacity above a water level equivalent to 24.5 feet at James Avenue. The City estimates that the activities related to setting up temporary pumps, plugging sewers, etc. would almost double from those associated with a 1997-magnitude flood. Further, it is questionable as to whether all the equipment, labour and machinery would be available for an 1826-magnitude flood.

It would be preferable to permanently raise approximately 10 miles (16 kilometres) of primary dikes within the city to elevation 27.8 ft., to ensure that all of the City of Winnipeg Primary Diking System would be to the Flood Protection Level. This would increase flow capacity through the city and reduce the risk associated with raising dikes during flood under poor weather conditions. Concurrently the sewer system would also have to be protected from the impact of high river levels.

Raise the West Embankment of the Floodway Channel

From P.T.H. 59 South to the outlet of the Floodway Channel the Floodway embankments are high enough to pass flows much higher than the maximum prescribed flow of 100,000 cfs (2800 m^3/s). Therefore protection for Winnipeg could be increased by permanently raising the Floodway west embankment from the inlet to P.T. H. 59S. Increasing the embankment height would allow additional flows to be sent down the Floodway Channel thereby reducing the flows in the Red River through Winnipeg. The necessary volume of material is available right beside the embankments, using excess material excavated from the original Floodway Channel.

Floodproof the Inlet Control Structure

The maximum effective amount that the Floodway west embankment could be raised would be limited by the Inlet Control Structure itself. The bridge deck at the control structure is at elevation 791 feet (241.09 m.), but the floor of the machine room in the Control Structure is at elevation 779.8 feet (237.68 m.). If the water level over the floodway gates needs to be raised above this level, steps would have to be taken to keep water out of the machine room. Also the stability of the structure under such high water conditions would have to be assessed.

CONCLUSION

Implementation of the above measures, coupled with a significant flood fighting effort as undertaken in 1997, would put the City of Winnipeg in a stronger position to fight an 1826 magnitude flood event. With a good forecast and reasonable construction conditions much could be done to reduce damages in Winnipeg. Operation

in accordance with the recommended operating rules would provide time for significant construction activities as well as an orderly evacuation of threatened portions of Winnipeg. However there will be a point where nothing more can be done to prevent flooding in Winnipeg. Emergency activities would then focus on orderly evacuation, and minimizing damage to the Floodway channel, dikes, and structure so that the capability will remain to regain control as water levels recede, and so that the works will remain in place for use in future years.

7. Ice Jam and Debris Management

Late spring ice break-up on the Red River in the vicinity of the Floodway Inlet Control Structure can necessitate implementation of ad hoc operating decisions for the facility. Persistent ice pans between the Control Structure and the Floodway channel inlet delayed initial gate raising in 1996 and 1997 with the result that early flood levels were abnormally high within Winnipeg. An ice jam at the South Perimeter Highway bridge in 1999 again resulted in temporarily high water levels immediately upstream of the bridge early in the runoff period

On the Assiniboine River, ice jamming and ice pan management is an annual problem, particularly at the Portage Reservoir. Ice pans in the Portage Diversion channel have resulted in overtopping of the channel dikes, and there is a possibility that a major ice run could result in overtopping of the Portage dam itself.

Therefore the committee recommends that a comprehensive analysis be undertaken of all ice-related impacts on the flood control and protection infrastructure. This would include identification of ice jam scenarios not yet experienced and recommendations for effective mitigation, both reactive (blasting, wrecking ball, gate operation) and preventative (dusting, saw cuts, "Swiss-cheesing", etc.).

The Committee noted that fairly extensive anecdotal information exists both from City and Provincial departments responsible for operation and maintenance of the infrastructure. Despite this, the Committee is of the opinion that outside expertise with respect to detailed knowledge of river ice behavior, including break-up and jamming formation, and mitigation techniques must be solicited.

It is therefore recommended that Manitoba Conservation, in consultation with the City and PFRA, be charged with developing the terms of reference for a study of river ice behavior, including break-up and jamming formation, and mitigation techniques.

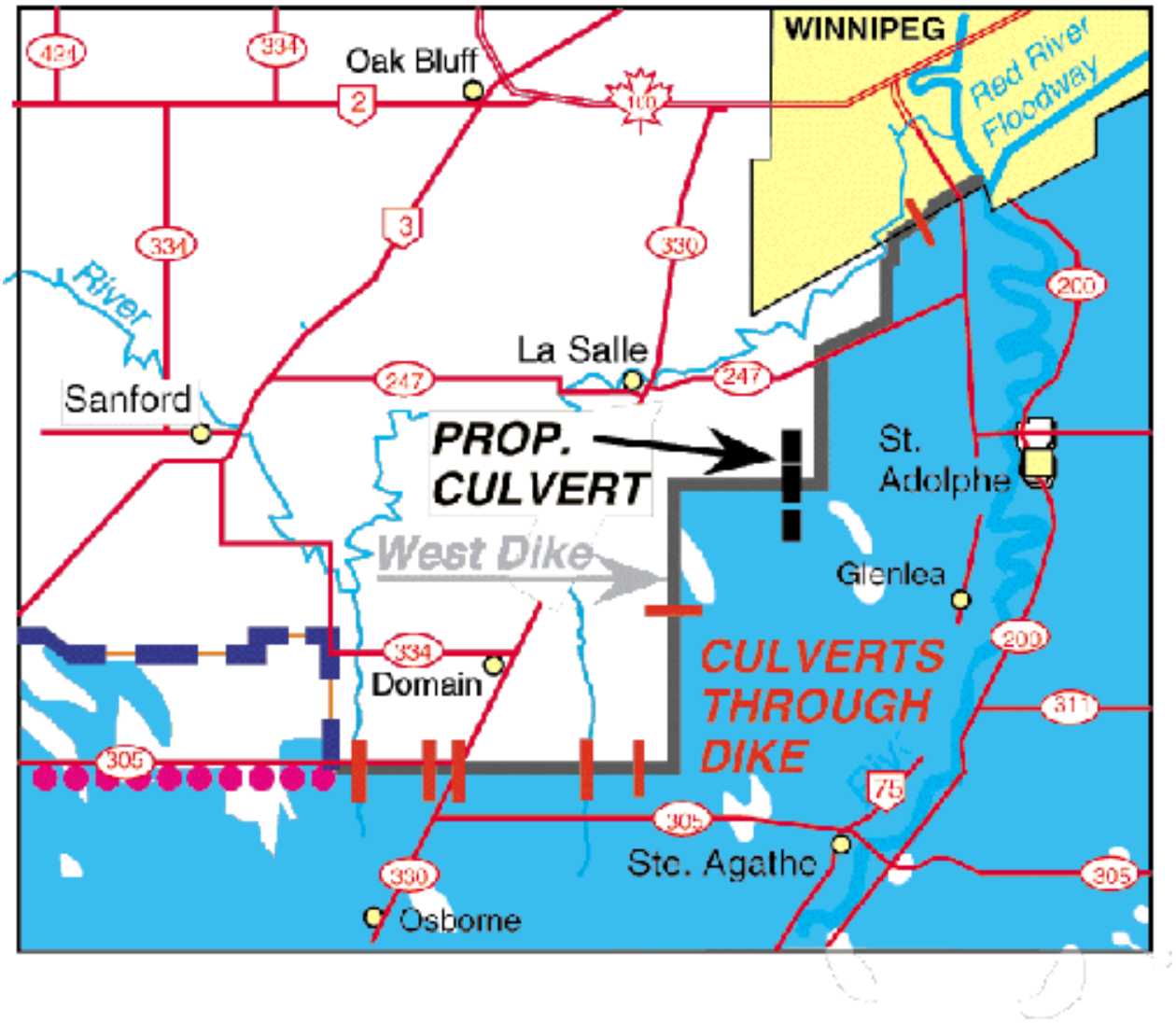
In the interim the Province has updated its operation plan for the Floodway Inlet Control Structure based on the experience gained in 1997. A principal element of the new plan is to use wrecking ball equipped cranes to initiate upstream pan movement and thereby prevent ice floes from entering the Floodway channel.

8. Operation of Local Drainage Through West Dike

BACKGROUND

In 1968, construction on the West Dike was completed. The West Dike runs from the Red River Floodway approximately 20 miles south and west. The West Dike was constructed to prevent flood water from entering the LaSalle River. During the 1997 flood, the West Dike was extended and raised to prepare for the high water. At the same time all culverts going through the West Dike were blocked. The culverts through the dike had not been designed to withstand the pressure of high water against the dike and it was determined that if they were not blocked they may blow out, resulting in a breach of the dike. Therefore the water from this area had to flow east along the south face of the dike toward the Floodway inlet. Figure 21 shows the culverts that cross the West Dike.

Figure 21 - Local Drainage through the West Dike



IMPACT

The area south of the West Dike is drained primarily by the Domain Drain and Manness Drain. With record snowfall in 1997, and the blocking of all culverts going through the West Dike, the people directly south of PR

305 were actually flooded first by local spring melt before the Red River water arrived.

The culverts were blocked in such a way that they could not easily be opened once the risk of failure due to spring flooding had passed. The water had already receded in Morris and Ste. Agathe, yet the land directly south of the West Dike was still under water. The water remained for an extra 20 days while coffer dams were being built on the Domain and Manness drains so the water could be released at a controlled rate. This extra 20 days delayed seeding, and in fact some land could not be seeded at all due to saturation of the soil.

CONSTRUCTION AFTER THE 1997 FLOOD

In the summer of 1998, the Manness Drain was cleaned out north of the West Dike, increasing the capacity of the drain. A third 60 inch (152 mm) culvert was installed through the dike on PR 305. Control gates were installed, so that any release of water could be controlled.

Drainage along the south side of the West Dike was improved, and culverts east and north of the Domain Drain were upgraded to allow more water to flow along the dike. Control gates were also installed on the four 60 inch (152 mm) culverts in the Domain Drain. By the fall of 1998, all major culverts going through the West Dike had control gates installed on them, designed to permit operation during periods of extended high levels and flows without jeopardizing the integrity of the West Dike.

The land directly east of the West Dike, known as the Glenlea area, only drains through the Glenlea drain, which enters the Red River north of Ste. Agathe. When the water on the Red River is high, this land does not drain. After the 1997 flood water also remained for a long time on this land, delaying seeding.

While it is recognized that some culverts are needed to permit drainage of flood waters, it is also recognized that every opening through the dike is a potential weak point. A program of regular maintenance and inspection is required to ensure that the security of this important structure is not compromised.

RECOMMENDATIONS

The Committee recommends the following:

a. **The control gates on the Manness and Domain drains at the West Dike should remain open to allow all local spring runoff to drain before flood water encroaches upon the West Dike.**

b. **The control structures through the West Dike for the Manness and Domain drains should be operated to pass flows up to the downstream channel capacity whenever the local drainage area is isolated from the Red River flooded area.**

c. **The council of the Rural Municipality of Macdonald should be consulted before any closure of the control gates.**

d. **One more drain should be constructed through the West Dike at NE15-8-2E to allow flood water to drain north from the Glenlea area to the La Salle River while the Red River is still high.**

e. **It is further recommended that no additional drainage or other structures be constructed through the West Dike, as these structures are points of vulnerability during a flood.**

f. **All openings through the West Dike should be inspected annually and monitored continually during a major flood event.**

9. Conclusions and Recommendations

The Committee has concluded that major changes to the Floodway operating rules are not required. However a few modifications would remove some of the ambiguity in the present rules. The Committee also believes that broader involvement of stakeholders in the application of the rules, particularly during major flood years, would improve communication and reduce conflict.

Recommendations of the Committee are summarized below:

1. UPGRADE FLOOD PROTECTION INFRASTRUCTURE IN WINNIPEG

   Flood protection infrastructure works in the City of Winnipeg, including works related to the primary diking system and the sewer systems, should be upgraded to a level of 27.8 feet equivalent at James Avenue (the legislated Flood Protection Level).

2. FLOODWAY OPERATION ADVISORY BOARD

   A Floodway Operation Advisory Board should be appointed by the Minister of Conservation. The Board would be chaired by Water Resources, and would have representation from the City of Winnipeg, the valley south of Winnipeg, and the federal government. It may also be useful to include a representative from the valley north of Winnipeg. The purpose of the Board would be to advise on operating decisions during all periods when the Floodway gates are in use. The Board would ensure that the operating rules are fairly applied, advise on temporary adjustments to the rules when unique conditions warrant, and facilitate communication with the residents of Manitoba.

3. DIKE FREEBOARD

   A rigorous technical analysis of wind and wave impacts should be carried out to determine a safe freeboard for the Floodway embankment, the West Dike and Winnipeg's Primary Dikes.

4. RESTORATION OF FLOODWAY CAPACITY

   The possibility of raising the seven upstream bridges crossing the Red River Floodway Diversion Channel (GWWD Railway, PTH #1, CNR Sprague, PTH 59S (two bridges), CPR Emerson, and St. Mary's Road) should be examined.

   The impact of removal or reduction in height of a section of the east embankment of the Floodway

channel west of Grande Pointe should be assessed before any portion of that dike is incorporated into a community dike.

No works should be constructed in the Red River Valley upstream of the Red River Floodway channel inlet without an assessment of its potential impact on the capacity of the Floodway channel.

The feasibility of upgrading the capacity of the Outlet Structure should be examined.

5. FLOODWAY OPERATING RULES

The following table shows the current operating rules and the recommended operating rules for the Floodway control structure.

Current Rule	**Recommended Rule**
For "natural" discharges up to 169,000 cfs (4800 m^3/s; 160-year flood (1958)): For discharges which result in water levels at James Avenue Pumping Station not exceeding 25.5 feet (7.77 m), the water levels at the Inlet will be maintained at levels corresponding to natural conditions.	1. Maintain "natural" water levels on the Red River at the entrance to the Floodway channel, until the water surface elevation at James Avenue reaches 24.5 feet (7.46 m.), or the river level anywhere along the Red River within the City of Winnipeg reaches two feet below the Flood Protection Level of 27.83 feet (8.48 m).
For "natural" discharges between 169,000 cfs (4800 m^3/s) and 189,000 cfs (5400 m^3/s; 250-year flood (1958)): For discharges which will result in water levels at James Avenue Pumping Station exceeding 25.5 feet (7.77 m) but if the peak level could be regulated to 25.5 feet (7.77 m) without exceeding elevation 775.8 feet (236.46 m) at the Inlet, then the Inlet Control Structure will be operated to raise water levels at the Inlet above natural levels up to a maximum of 775.8 feet (236.46 m).	2. Once the river levels within Winnipeg reach the limits described in Rule 1, the level in Winnipeg should be held constant while levels south of the Control Structure continue to rise. Furthermore if forecasts indicate that levels at the entrance to the Floodway channel will rise more than two feet (0.6 metres) above natural, the City must proceed with emergency raising of the dikes and temporary protection measures on the sewer systems in accordance with the flood level forecasts within Winnipeg. The levels in Winnipeg should be permitted to rise as construction proceeds, but not so as to encroach on the freeboard of the dikes or compromise the emergency measures undertaken for protecting the sewer

	systems. At the same time the Province should consider the possibility of an emergency increase in the height of the Floodway embankments and the West Dike. At no time will the water level at the Floodway channel's entrance be allowed to rise to a level that infringes on the allowable freeboard on the Floodway west embankment (Winnipeg side) and the West Dike.
For "natural" discharges above 189,000 cfs (5400 m^3/s) : If the peak discharge will result in the water level at James Avenue Pumping Station exceeding 25.5 feet (7.77 m) when the Inlet elevation is at 775.8 feet (236.46 m) then those portions of the Primary Diking System which correspond to elevation 26.5 feet (8.08 m), City Datum, will be raised at 31.5 feet (9.60 m). This condition is expected to prevail when the discharge exceeds 189,000 cfs (5400 m^3/s). In the event that construction difficulties delay raising the dikes, the Inlet Control Structure will be operated to maintain an elevation of 25.5 feet (7.77 m) at James Avenue Pumping Station but the Inlet elevation will not be allowed to exceed elevation 778.0 feet (237.13 m). These conditions will apply until the dikes are raised. Once the dikes are raised, the Control Structure will be operated to maintain the stage at James Avenue at 29.5 feet (8.99 m), City Datum, two feet (61 cm) below the emergency dike level. Water levels at the Inlet will be raised as required, to the maximum elevation of 778.0 feet (237.13 m)..	❍ For extreme floods, where the water level at the Floodway channel's entrance reaches the maximum level that can be held by the Floodway west embankment and the West Dike, the river level must not be permitted to exceed that level. All additional flows must be passed through Winnipeg.
Initial Gate Operation with Ice The Floodway gates should not be operated until ice on the river is flowing freely.	*Initial Gate Operation with Ice* The Floodway gates should not be operated until ice on the river is flowing freely, unless flooding in Winnipeg is imminent.

Initial Depth Over Floodway Lip To reduce the amount of erosion damage on the lip, delay raising of the Floodway gates until such time as a minimum depth of flow occurs over the lip.	*Initial Depth Over Floodway Lip* (Delete this rule)
Final drop of Gates To reduce erosion of the Floodway channel's entrance lip, water level fluctuations downstream of the gates, and Winnipeg's vulnerability to sewer backup under heavy rain conditions near the end of the flood, when water levels are falling, maintain a 2 foot (0.6 metre) depth of water over the entrance lip. Drop the gates in two steps when lowering the water level below the top of the entrance lip, once levels in Winnipeg drop below 15 feet (4.6 metres).	*Final drop of Gates* To minimize bank slumping along the river in Winnipeg and at the same time reduce the probability of sewer backup problems, final gate operations, once the level at the entrance to the Floodway Channel recedes to elevation 752 feet (229 metres), shall be carried out in consultation with the City of Winnipeg.
Operation of Horn Horn warning shall be issued for each gate rise. One-half hour prior to gate operation, the horn shall be operated for a period of one full minute. At the time of gate operation the horn shall be operated by giving three short blasts. No horn warning is required during the falling stage of the flood.	*Operation of Horn* The horn at the Floodway Structure shall only be operated once, before the first gate operation of the year. The horn should be sounded a half-hour before the first gate operation to alert residents that the Floodway Structure is being put into operation. For ongoing information a 1-800 number should be established that would provide current information of gate operations, potential impacts on water levels, and forecasts for the next few days. The information should also be included on the existing Water Resources internet site.

6. COMPUTATION OF "NATURAL" WATER LEVELS

The relationships for computing the "natural" water level at the Floodway channel's entrance are suspect for high flow conditions and should be recomputed. To assure that the relationships receives broad acceptance the computation should be done under the supervision of a technical working group comprised of representatives from the provincial and federal governments, from the city of Winnipeg, and from the valley south of the Floodway Control Structure.

7. INCREASE FLOOD PROTECTION FOR WINNIPEG

Serious consideration be should be given to increasing the capacity and reliability of the flood protection works for Winnipeg. This would enable increased protection against an 1826-magnitude flood or larger, and reduce the potential for loss of life and significant damage.

8. ICE IMPACTS ON CONTROL STRUCTURES

A comprehensive analysis should be undertaken of all ice-related impacts on the flood control and protection infrastructure. This would include identification of ice jam scenarios not yet experienced and recommendations for effective mitigation, both reactive (blasting, wrecking ball, gate operation) and preventative (dusting, saw cuts, "Swiss-cheesing", etc.)

9. STUDY OF ICE BEHAVIOR

Manitoba Conservation, in consultation with the City and PFRA, should develop the terms of reference for a study of river ice behavior, including break-up and jamming formation, and mitigation techniques.

10. DRAINAGE OUTLETS THROUGH WEST DIKE

a. The control gates on the Manness and Domain drains at the West Dike should remain open to allow all local spring runoff to drain before flood water encroaches upon the West Dike.

b. The control structures through the West Dike for the Manness and Domain drains should be operated to pass flows up to the downstream channel capacity whenever the local drainage area is isolated from the Red River flooded area.

c. The council of the Rural Municipality of Macdonald should be consulted before any closure of the control gates.

d. One more drain should be constructed through the West Dike at NE15-8-2E to allow flood water to drain north from the Glenlea area to the La Salle River while the Red River is still high.

e. It is further recommended that no additional drainage or other structures be constructed through the West Dike, as these structures are points of vulnerability during a flood.

f. All openings through the West Dike should be inspected annually and monitored continually during a major flood event.

11. PUBLIC EDUCATION

One of the problems recognized by the Committee was that controversy about Floodway operation is often based on a misunderstanding of the rules of operation. Much of the effort in the current review was directed at clarifying the rules of operation and removing ambiguity. The Committee recommends that a brochure be developed which clearly explains the rules of operation. This brochure should be

distributed to residents in the Valley south of Winnipeg as well as in the City.

References:

City of Winnipeg. Waterworks, Waste and Disposal Department. *Basement Flooding Relief Program Review - 1986,* November, 1986.

City of Winnipeg. *Flood Activity Manual*, 1997

City of Winnipeg. *Brief to the Manitoba Water Commission*, December 2, 1997

City of Winnipeg, *"Flood of the Century" - Report on the City of Winnipeg Response to the 1997 Flood,* February 27, 1998.

Clark, R. H., *Notes on Red River Floods,* Winnipeg, Manitoba, 1950.

Environment Canada and Manitoba Natural Resources. *Canada - Manitoba Flood Damage Reduction Agreements and Interim Flood Risk Maps for the City of Winnipeg*, 1980.

Gonzalez N., *Two Dimensional Modeling of the Red River Floodway*, University of Manitoba, M.Sc. Thesis, Civil Engineering, August, 1999.

Greater Winnipeg Dyking Board, *Final Report describing The Nature of the Emergency Precautions Carried Out in the Greater Winnipeg Area to Guard Against the Recurrence of Major Flood Conditions*, October 1, 1951.

Klohn-Crippen Consultants Limited, *Red River One-Dimensional Unsteady Flow Model*, May, 1999.

Manitoba Department of Mines and Natural Resources, *"Red River Floodway Program of Operation*, Winnipeg, Manitoba, July, 1970

Manitoba Natural Resources, *"Red River Floodway Program of Operation*, Winnipeg, Manitoba, October 1984

Manitoba Water Commission, *Review of the Red River Floodway, Portage Diversion and Shellmouth Reservoir*; Winnipeg, Manitoba, November, 1980.

Manitoba Water Commission, *An Independent Review of Actions Taken During the 1997 Red River Flood*; Winnipeg, Manitoba, June, 1998.

M.M. Dillon Limited, *Winnipeg Flood Protection High River Levels Engineering Review Report*, 1982.

Province of Manitoba. *The Dyking Authority Act*, 1952.

Province of Manitoba, *The City of Winnipeg Act*, 1999

Province of Manitoba. *The Emergency Measures Act*.

Red River Basin Investigation (RRBI), *Report on Investigations into Measures for the Reduction of the Flood Hazard in the Greater Winnipeg Area, Appendix C*, Canada, 1953

Royal Commission on Flood Cost Benefit, Winnipeg, Manitoba, 1958.

Return to **Manitoba Water Resources** Main
