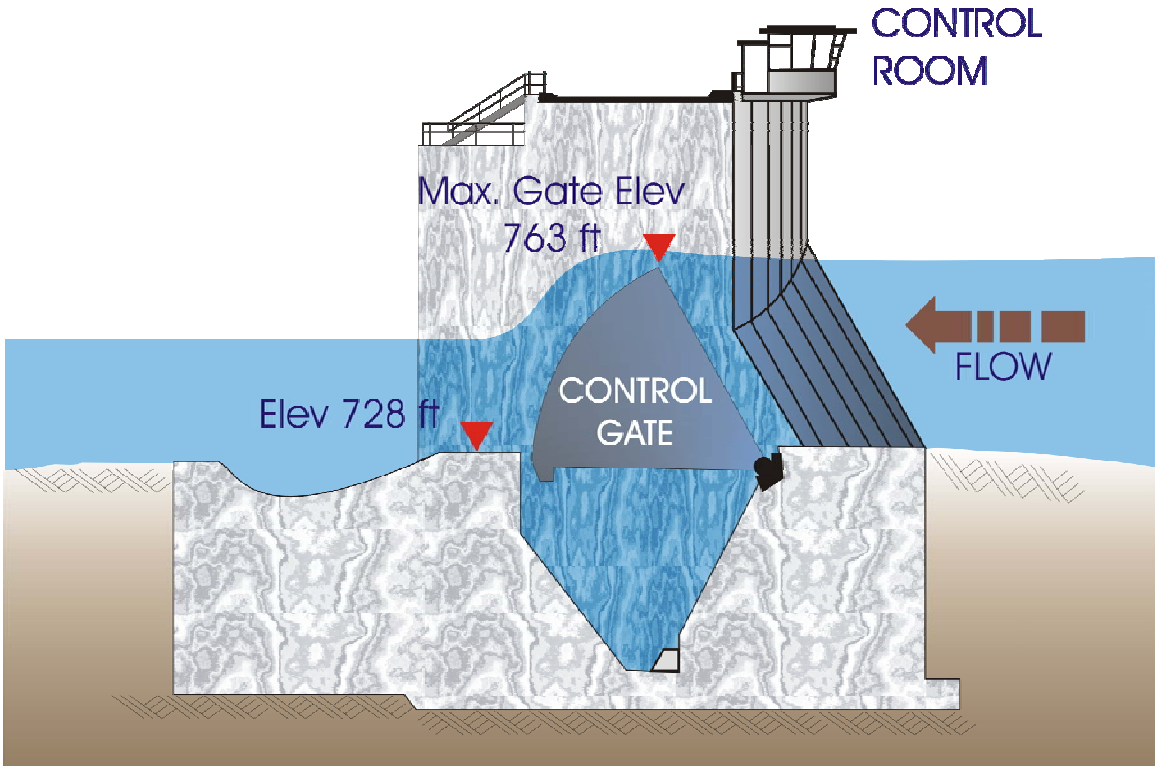
# Red River Floodway Operation Report

# Spring 2005




## THE RED RIVER FLOODWAY
## INLET CONTROL STRUCTURE

**SUBMITTED TO:**
The Hon. Steve Ashton, Minister
Manitoba Water Stewardship

**SUBMITTED BY:**
Water Science and Management Branch
Ecological Services Division
Manitoba Water Stewardship

June, 2005

**Manitoba**

***Water Stewardship*** ***Ecological Services Division*** ***200 Saulteaux Crescent, Box 11***
***Winnipeg MB R3J 3W3***
***CANADA***
***Phone: (204) 945-1967***
***Fax: (204) 945-7419***

June 30, 2005

File: 10.5.1

The Honorable Steve Ashton
Minister
Manitoba Water Stewardship

Dear Minister:

I am pleased to provide a report documenting the 2005 spring operation of the Red River Floodway. The recently proclaimed *Red River Floodway Act* requires that a report be presented to the minister of Water Stewardship by June 30 in any year in which the Floodway is operated during the spring runoff period. In 2005 the Floodway was operated from April 5th until April 20th. This report documents that operation.

The Floodway was put into operation for a second time on June 14th under the non-spring operating rule. That emergency operation was done under the terms of rule 4 to reduce the probability of sewer backup from intense rainfalls in Winnipeg. The floodway was still in operation at the time of preparation of this report. The current report only addresses the April 2005 operation.

Yours truly,

Don Norquay
Assistant Deputy Minister
Ecological Services Division

Attachment

# FORWARD

From its completion in 1968 until 2005 the Red River Floodway has been operated in 24 of the intervening years. Operation of the Floodway has saved many millions of dollars in damage in the City of Winnipeg. However on occasion the operation has aggravated flooding outside of the City of Winnipeg.

In 2005 the *Red River Floodway* Act was proclaimed. One requirement under that Act is the preparation of a report detailing spring Floodway operation and determining if the operation caused Red River levels at the Floodway channel inlet to exceed the computed "natural" level. This report details the operation of the Red River Floodway in the spring runoff period of 2005.

All flows and levels in this report are shown in imperial units. Flows can be converted from cubic feet per second (cfs) to cubic metres per second (m3/s) by dividing by a factor of 35.3148. River levels can be converter from feet to metres by dividing them by a factor of 3.28084.

TABLE OF CONTENTS



TABLES



FIGURES



APPENDICES

INTRODUCTION

During the spring of 2005 the Red River Floodway was operated during the period from 5:15 PM on April 5 to 4:00 PM on April 20. Table 1 lists all of the gate operations during that period. The peak recorded level at the Floodway entrance (Water Survey of Canada station 05OC026) was 759.36 feet at 6:00 PM on April 8th. This level was 0.5 feet below the computed "natural" peak level of 759.86 feet. The computation of the "natural" level is described in a later section of the report.

**Table 1 – April 2005 Floodway Gate Operations**

| Date | Time* | Start of Operation | End of Operation |
|---|---|---|---|
| April 5, 2005 | 5:15 PM | 728.00 | 738.52 |
| April 6, 2005 | 9:25 AM | 738.52 | 742.15 |
| April 6, 2005 | 5:15 PM | 742.15 | 744.13 |
| April 6, 2005 | 11:10 PM | 744.13 | 745.53 |
| April 7, 2005 | 3:50 PM | 745.53 | 745.16 |
| April 7, 2005 | 6:15 PM | 745.16 | 745.71 |
| April 7, 2005 | 10:45 PM | 745.71 | 746.82 |
| April 9, 2005 | 10:35 PM | 746.82 | 745.99 |
| April 10, 2005 | 9:40 AM | 745.99 | 744.50 |
| April 11, 2005 | 5:20 PM | 744.50 | 743.85 |
| April 14, 2005 | 12:40 PM | 743.85 | 743.28 |
| April 15, 2005 | 12:30 PM | 743.28 | 742.43 |
| April 16, 2005 | 9:30 AM | 742.43 | 741.58 |
| April 17, 2005 | 6:20 AM | 741.58 | 740.53 |
| April 18, 2005 | 12:30 AM | 740.53 | 739.48 |
| April 18, 2005 | 10:35 PM | 739.48 | 738.52 |
| April 19, 2005 | 8:20 AM | 738.52 | 735.67 |
| April 19, 2005 | 4:25 PM | 735.67 | 737.66 |
| April 20, 2005 | 4:00 PM | 737.66 | 728.00 |

* Time of start of gate operation

During this period of operation the approved rules of operation were followed in adjusting the gates. The rules are listed in Appendix A

In June of 2005 the Floodway was operated for a second time. That emergency operation was done under the terms of rule 4 to reduce the probability of sewer backup from intense rainfalls in Winnipeg. This report only addresses the April 2005 operation.

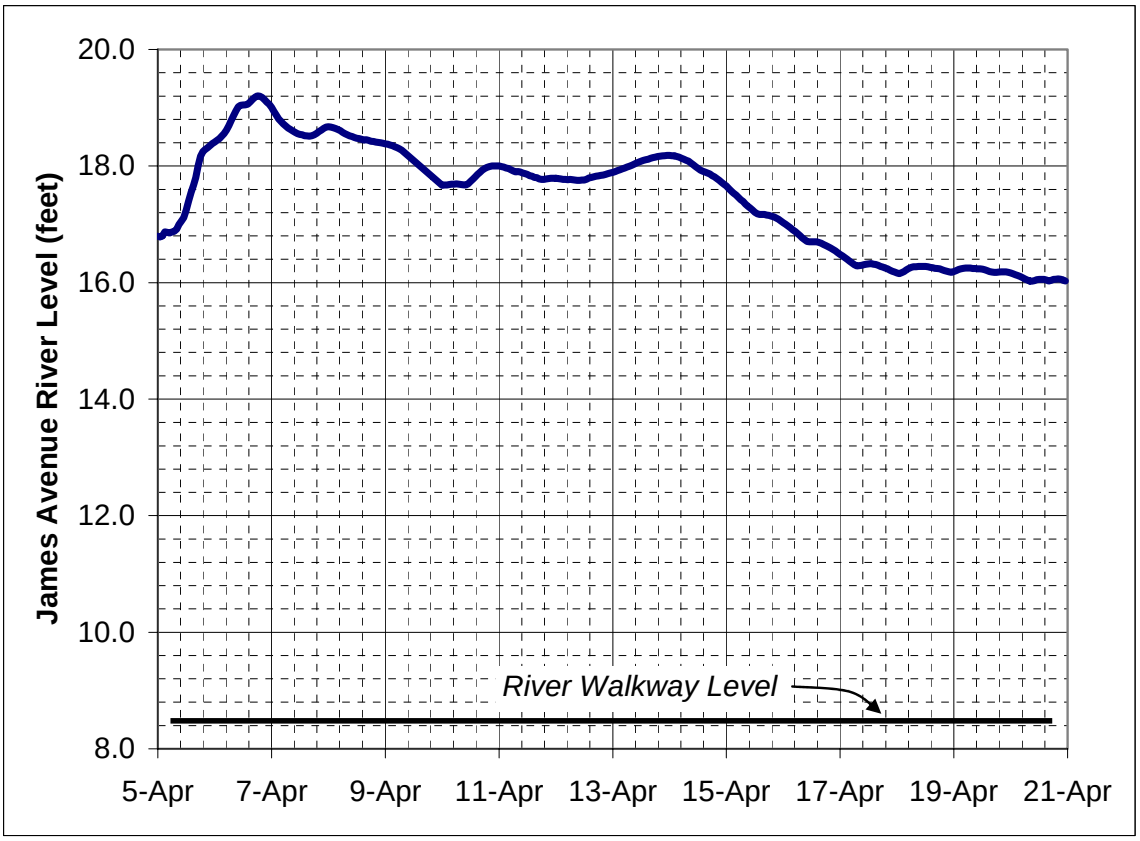
2005 SPRING RUNOFF

The 2005 spring runoff was above average in the portion of the Red River watershed from Grand Forks North Dakota northward and somewhat below average south of Grand Forks. The above average runoff in the more northerly portions resulted from high soil moisture and somewhat above average snow cover. Spring runoff came earlier than usual with crests in the Manitoba portion occurring April 6 to 9.

Peak flows and stages on the Red River from Emerson to Ste. Agathe were lower than had been predicted in February and March for median conditions, mainly due to favourable spring weather. There was very little precipitation during March and the first half of April. Points from St. Adolphe to Lockport experienced crests equal to or higher than indicated in the March forecast with median weather, due to heavy runoff from northern tributaries.

Red River levels in Winnipeg at James Avenue During the period of operation are shown on Figure 1.

**Figure 1 – Recorded River Levels at James Avenue**




The level at James Avenue crested at 19.2 feet on April 6th and remained in the 18 foot range until mid April, an unusually long period for a relatively small flood event. This

was the fifth highest peak river level at James Avenue over the 37 year period since the Floodway was put into operation. The relatively high crest in Winnipeg was due to high local flows including the lower Assiniboine River. Also runoff started earlier on the Red River than on the Assiniboine River. Therefore peak flows on the Red River occurred before the flow reductions resulting from operation of the flood control works on the Assiniboine River reached Winnipeg.

Ice runs on the Red and Assiniboine Rivers compounded the high water levels in the City. A large ice jam at the Redwood Bridge on April 4 caused an early rise to near 18 feet in downtown Winnipeg. The jam was broken with the aid of a floating backhoe (Amphibex) brought in from Quebec.

River levels and flows subsided relatively quickly during the second half of April due to favourable weather. By the end of April the level on the Red River at the Floodway Inlet had declined approximately 20 feet to 740 feet and that at James Avenue in Winnipeg to 9 feet.

NATURAL LEVELS

The "natural" water level on the Red River at the Floodway entrance is defined as the water level that would have occurred at this location in the late 1950's, if the flood control works had not been built. These works include Winnipeg's Primary Dikes, the Red River Floodway, the Portage Diversion, Shellmouth Reservoir, and the Assiniboine River dikes. The "natural" water level is the water level that is 'targeted' in the Floodway operation rules, for normal Floodway operation (see Appendix A). That is, during normal Floodway operation, the Floodway is operated so as to keep water levels on the Red River at the Floodway Inlet at or below the "natural" water level.

During the 2005 spring Floodway operation, the "natural" water levels were calculated using the relationship developed by Acres Manitoba Limited in 2004 [*"Re-Computation of Natural Water Levels at the Floodway Inlet (Final Report)", April 2004*]. This relationship requires two input values to calculate this water level. The two input values are the "natural" flow on the Red River downstream of the Assiniboine River, and the "natural" flow of the Assiniboine River into the Red River. These two input values, as well as the "natural" and actual water levels on the Red River at the Floodway Inlet, are shown for the April 2005 flood in Table 2 below.

**Table 2 – Computed 2005 Natural Flows and Levels**

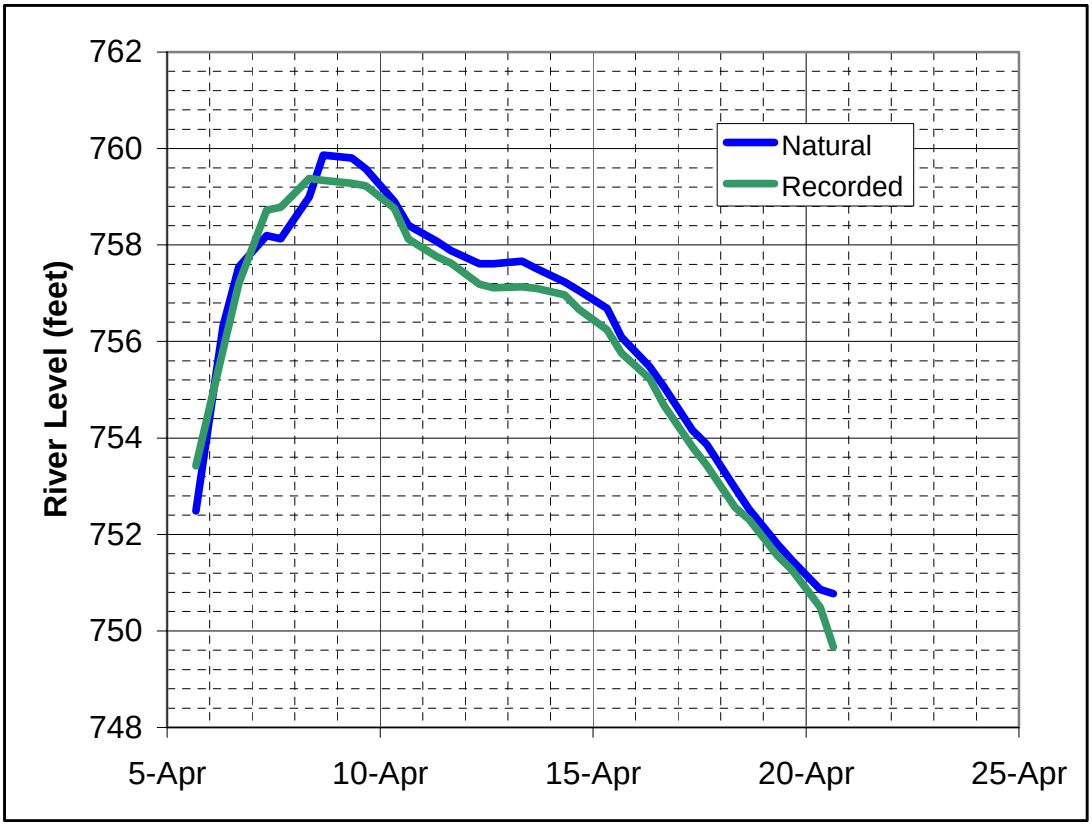
| Date / Time | Natural Red River Flow Below Assiniboine River (cfs) | Natural Assiniboine River Flow at the Forks (cfs) | Recorded River Level at Floodway Entrance (feet) | Computed "Natural" River Level at Floodway Entrance (feet) |
|---|---|---|---|---|
| 05/Apr/2005 4:15 PM | 55,375 | 8,837 | 753.42 | 752.49 |
| 06/Apr/2005 7:30 AM | 64,658 | 10,117 | 755.83 | 756.32 |
| 06/Apr/2005 4:20 PM | 69,018 | 10,837 | 757.20 | 757.54 |
| 07/Apr/2005 8:00 AM | 71,115 | 10,691 | 758.72 | 758.19 |
| 07/Apr/2005 4:00 PM | 71,686 | 11,982 | 758.79 | 758.13 |
| 08/Apr/2005 8:00 AM | 78,023 | 18,214 | 759.38 | 758.99 |
| 08/Apr/2005 4:00 PM | 82,964 | 21,344 | 759.34 | 759.86 |
| 09/Apr/2005 8:00 AM | 84,442 | 24,317 | 759.28 | 759.80 |
| 09/Apr/2005 4:00 PM | 82,879 | 23,047 | 759.23 | 759.58 |
| 10/Apr/2005 8:00 AM | 79,214 | 21,022 | 758.77 | 758.90 |
| 10/Apr/2005 4:00 PM | 76,369 | 18,785 | 758.12 | 758.41 |
| 11/Apr/2005 8:00 AM | 74,414 | 17,195 | 757.76 | 758.07 |
| 11/Apr/2005 4:00 PM | 73,848 | 17,308 | 757.63 | 757.89 |
| 12/Apr/2005 8:00 AM | 73,015 | 17,473 | 757.19 | 757.61 |
| 12/Apr/2005 4:00 PM | 73,151 | 17,702 | 757.12 | 757.61 |
| 13/Apr/2005 8:00 AM | 73,829 | 18,664 | 757.13 | 757.66 |
| 13/Apr/2005 4:00 PM | 73,697 | 19,370 | 757.10 | 757.51 |
| 14/Apr/2005 8:00 AM | 71,611 | 17,187 | 756.97 | 757.23 |
| 14/Apr/2005 4:00 PM | 70,575 | 16,373 | 756.67 | 757.05 |

**Table 2 – Computed 2005 Natural Flows and Levels (Continued)**

| Date / Time | Natural Red River Flow Below Assiniboine River (cfs) | Natural Assiniboine River Flow at the Forks (cfs) | Recorded River Level at Floodway Entrance (feet) | Computed "Natural" River Level at Floodway Entrance (feet) |
|---|---|---|---|---|
| 15/Apr/2005 8:00 AM | 70,040 | 17,651 | 756.24 | 756.69 |
| 15/Apr/2005 4:00 PM | 67,854 | 17,086 | 755.76 | 756.09 |
| 16/Apr/2005 8:00 AM | 65,735 | 16,764 | 755.23 | 755.48 |
| 16/Apr/2005 4:00 PM | 64,348 | 16,718 | 754.67 | 755.05 |
| 17/Apr/2005 8:00 AM | 61,622 | 16,973 | 753.81 | 754.15 |
| 17/Apr/2005 4:00 PM | 60,846 | 17,185 | 753.43 | 753.87 |
| 18/Apr/2005 8:00 AM | 57,862 | 16,824 | 752.56 | 752.96 |
| 18/Apr/2005 4:00 PM | 56,352 | 16,453 | 752.31 | 752.52 |
| 19/Apr/2005 8:00 AM | 53,875 | 15,977 | 751.56 | 751.79 |
| 19/Apr/2005 4:00 PM | 52,904 | 15,983 | 751.27 | 751.47 |
| 20/Apr/2005 8:00 AM | 51,218 | 16,240 | 750.49 | 750.86 |
| 20/Apr/2005 3:30 PM | 51,095 | 16,439 | 749.67 | 750.78 |

The recorded and "natural" levels at the Floodway entrance are plotted in the following figure.

**Figure 2 – Recorded and Natural Red River Levels**



Appendix B contains a detailed explanation of how the "natural" flows in Table 2 were computed.

Although the recorded peak river level at the Floodway entrance was below the computed peak "natural" level, there was a one and a half day period as the flood waters were rising when recorded levels did exceed the computed "natural" level. The reason for this discrepancy was that there were ice flows and other debris in the river channel at this time so the federal and provincial hydrometric technicians were unable to directly measure the flows. The flows were therefore estimated, and the gates were set in accordance with the estimated flows. Later flow measurements showed that the actual flows at that period were a little lower than estimated and so the computed "natural" river level was a little lower than had been anticipated.

OPERATIONAL ISSUES

**Flow Measurement**

As noted previously ice and debris in the river channel made it difficult to measure the flow in the river. A flow measurement was not taken on the Floodway channel until April 6th and on the Red River until April 8th. Therefore operational decisions before these measurements were taken had to be based on estimated flows. Although this problem does complicate Floodway operation, ice is normally gone before serious flooding occurs so this would not be an issue during major flood periods. However it would be helpful to purchase a modern ADCP (Acoustic Doppler Current Profiler) flow meter to improve flow measurement capabilities.

The measurement that was eventually made on the Floodway channel indicated that at the levels in the channel at that time there was less flow in the channel than would have been expected. It was determined that the flows were being impeded by vegetation growing in the Floodway channel. In future more effort is required to control this vegetation growth.

**Ice Jams**

Because of the early runoff on the Red River in 2005 the ice at the start of the runoff was stronger than normal. To reduce the chances of major ice jams an ice breaking machine

**Figure 3 – Amphibex Ice Breaker at Redwood Bridge – April 4, 2005**

was brought in on short notice from Quebec (see figure 3). It successfully removed a jam which had formed at the Redwood Bridge.

The ice breaker was then moved to Breezy Point and was successful in preventing a major jam from developing in that area.

**Operating Rules**

Although the approved operating rules require that levels do not exceed "natural" on the Red River at the Floodway entrance for all but very large floods, a small modification to the rules may have resulted in additional benefits in Winnipeg without causing significant additional damage upstream. Figure 1 shows that the peak Red River level of 19.2 feet occurred in Winnipeg at 6:00 PM on April 6th. As noted earlier a level of 19.2 feet in Winnipeg is the fifth highest peak level recorded since the Floodway was put into operation. At that time the level at the Floodway entrance was at 757.7 feet and forecast to increase another foot and a half over the next couple of days. Then two days later on April 8th when the "natural" level at the Floodway entrance was approaching its peak, levels in Winnipeg had dropped a foot. A decision was made not to make the final gate raise. This resulted in a minor rise in the Red River level in Winnipeg but shaved a half foot off of the peak level at the Floodway entrance.

During the next review of the Red River Floodway operating rules consideration should be given to the benefits and costs of permitting some flexibility in setting river levels at the Floodway entrance if the river levels are below a pre-determined threshold. It may be that allowing the river level to exceed "natural" by a small amount during a critical period could reduce the stress on the City's infrastructure while causing very little additional damage in the valley.

## CONCLUSIONS AND RECOMMENDATIONS

Operation of the Red River Floodway Inlet Control Structure during April, 2005 resulted in a peak river level at the Floodway entrance of 759.36 feet which was 0.5 feet lower than the computed "natural" peak level. However on April 7th and 8th the actual level did exceed the "natural" level as a result of inaccurate flow estimates.

It is recommended that an ACDP flow meter be purchased to increase the accuracy of flow metering in the province.

It is recommended that vegetation in the Floodway channel be cut down each fall to ensure that the capacity of the channel is maintained.

It is recommended that during the next review of the Red River Floodway operating rules consideration should be given to the benefits and costs of permitting the levels at the Floodway entrance to exceed "natural" as long as the river levels are below a pre-determined threshold.

# APPENDIX A

## Red River Floodway Rules of Operation

# Rules of Operation
# Red River Floodway Control Structure

*Normal Operation:*
1. Maintain "natural"[1] 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 metres), 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).

*Major Flood Operation:*
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 of Winnipeg 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.

*Extreme Flood Operation:*
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.

*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.

*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:*
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 Stewardship internet site.

[1] The term "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.

**Emergency Operation to Reduce Sewer Backup in Winnipeg**

4(1) This rule defines the circumstances under which the Minister of Water Stewardship ("the Minister") may determine that emergency operation of the Floodway is necessary to prevent widespread basement flooding and resulting risk to health and damage to property within the City of Winnipeg.

4(2) This rule applies after the spring crest from snowmelt runoff at Winnipeg, whenever high river levels substantially impair the capacity of Winnipeg's combined sewer system.

4(3) As long as the Department of Water Stewardship ("the Department") forecasts that river levels for the next 10 days will be below 14 feet James Avenue Pumping Station Datum (JAPSD), the Department will not operate the Floodway Control Structure.

4(4) When the Department forecasts that river levels for the next 10 days are expected to rise to 14 feet JAPSD or higher, the Department will prepare a report that describes:

(a) The basis of the Department's river level forecasts and its risk assessment;

(b) The risk of basement flooding in Winnipeg, including the following factors:

(i) The predicted peak river level in the next 10 days;

(ii) The length of time the Department forecasts the river level will be at 14 feet JAPSD or higher;

(iii) The risk of an intense rainfall event in Winnipeg in the next 10 days;

(c) The benefits and costs of Floodway operation, including:

(i) The extent of basement flooding and damage to property expected from various combinations of intense rainfall events and high river levels;

(ii) The risk to the health of Winnipeg residents from sewer back-up;

(iii) Economic loss and damage caused by artificial flooding south of the Inlet Control Structure;

(iv) Impacts of operation on fish and wildlife and their habitat and on water quality;

(v) The risks and potential costs of riverbank instability that may be caused by artificial river level changes, both upstream and downstream of the Inlet Control Structure;

(vi) During construction of the Floodway expansion, costs and risks associated with any resulting delays of that construction, including the potential average annual expected damages associated with an additional period of risk of a flood event that would exceed the current capacity of the Floodway;

(vii) Such other benefits and costs of operation of which the Department is aware at the time of the preparation of the report, excluding benefits associated with recreational or tourism activities or facilities; and

(d) measures that may be taken to mitigate the costs and impacts of the operation under consideration, including:

(i) minimizing the rate at which river levels are changed both upstream and downstream of the Floodway Inlet Control Structure;

(ii) providing means to assure fish passage.

4(5) The Department will present a draft of the report prepared under rule 4(4) to the Floodway Operation Review Committee and provide an opportunity for the Committee to provide input, before finalizing the report and making recommendations respecting Floodway operation.

4(6) The Department will not recommend operation of the Floodway unless the expected benefits of doing so clearly and substantially outweigh the expected costs.

4(7) The Department will present its report and recommendations to the Minister, who, subject to rule 4(8), will make a decision respecting Floodway operation based on his consideration of the report.

4(8) The Department will not operate the Floodway control structure under this rule:

(a) to raise river levels immediately upstream of the control structure to an elevation higher than 760 feet above sea level;

(b) to achieve a river level of less than 9 feet JAPSD; or

(c) except in circumstances of extreme urgency, to lower river levels more than one foot per day.

4(9) The Department will issue a news release announcing a decision to operate the Floodway at least 24 hours before commencing operation.

4(10) The Department will ensure every reasonable effort is made to personally notify landowners who may be directly affected by flooding due to Floodway operation in advance of the operation.

4(11) The Department will sound the horn at the Floodway Inlet Control Structure one-half hour before operation commences.

4(12) The Department will maintain a program of compensation for damages suffered by landowners arising from flooding caused by Floodway operation under this rule.

# APPENDIX B

## Computation of Natural Flows and Levels

# Computation of Natural Flows and Levels On the Red and Assiniboine Rivers

Table 2 in the main report lists the "natural" flows on the Red River below the confluence with the Assiniboine River and on the Assiniboine River at the Forks. This Appendix describes how those flows were determined, and explains how the relationships developed in the Acres 2004 study were applied to compute the "natural" level at the Floodway entrance.

Table B-1 lists the recorded and computed flows and levels for each time step. Columns 1 to 7 list the flows used in computing the "natural" flows on the Assiniboine River, and columns 8 to 10 list the flows used for computing the "natural" flows on the Red River.

NATURAL ASSINIBOINE RIVER FLOW

The "natural" flows on the Assiniboine River are altered by operation of the Shellmouth Dam, the Portage Diversion, and by the presence of dykes along the Assiniboine River.

The Shellmouth Dam can decrease flows below "natural" by adjusting the control gates so that reservoir outflows are lower that the inflows. In this case the reservoir levels rise, and excess water is stored behind the dam.

The Portage Diversion can be used to reduce flows in the lower Assiniboine River by diverting some of the river flow north to Lake Manitoba.

The Assiniboine River dykes were constructed to prevent overflows from the river onto the surrounding lands. Because of the height of the river and the slope of the land much of this overflow did not return to the Assiniboine River. Therefore the dykes have the effect of increasing flows entering Winnipeg on the Assiniboine River during periods of high flow.

Referring to Table B-1, column 1 lists the flow reductions at Winnipeg resulting from storage behind the Shellmouth Dam. It is important to recognize that these flow changes at the dam take some time to reach Winnipeg. The Department uses the Muskingum routing procedure to compute this flow attenuation.

Column 2 shows the flows diverted to Lake Manitoba via the Portage Diversion. Again the flows are routed to Winnipeg to apply the time delay.

Column 3 shows the recorded flows at the hydrometric station at Headingley. These first three columns are summed to determine the total "natural" flow before applying the "natural" breakouts that would have occurred if the dykes were not in place.

Column 4 lists the computed breakouts that would have occurred at those flows if the dykes had not been constructed.

Column 5 lists the computed "natural" flows at Headingley. These are computed by adding the three adjustments to the recorded flows at Headingley.

There is some additional local inflow entering the Assiniboine River between Headingley and the Forks. Most of this flow is recorded on Sturgeon Creek. In column 6 the recorded flow on Sturgeon Creek are increased to include unmeasured local inflows.

Finally columns 5 and 6 are added together to give the computed "natural" flows of the Assiniboine River at the Forks, as listed in column 7.

NATURAL RED RIVER FLOW

On the Red River the primary flow adjustment is caused by the Red River Floodway. During periods of extensive flooding there can also be a flow change resulting from changes in the storage of floodwaters on the land, but as long as flood levels at the Floodway entrance are held at "natural" that change would be negligible.

Column 8 lists the recorded flows in the Floodway channel, and column 9 shows the recorded flows at James Avenue. Column 10 sums the flows in those two columns and adds the three flow adjustments on the Assiniboine River to give the total "natural" flow on the Red River north of the confluence with the Assiniboine River.

NATURAL RIVER LEVELS AT THE FLOODWAY ENTRANCE

Table B-2 is a reproduction of Table 4-7 from the Acres report "*Re-Computation of Natural Water Levels at the Floodway Inlet (Final Report), April 2004*". The table is used by taking the "natural" Red River flows listed in column 10, and the "natural" Assiniboine River flows listed in column 7 and interpolating between the values listed in table B-2 to determine the "natural" levels. These are listed in table B-1 in column 11. Finally column 12 lists the recorded levels at the Floodway entrance (station 05OC026)

## Table B-1 Spring 2005 Flows and Levels

| Column => | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Assiniboine Flows** | | | | | | | **Red River Flows** | | | | |
| | Shellmouth Flow Changes (Routed to Headingley) | Portage Diversion flow (Routed to Headingley) | Assiniboine R. actual flow at Headingley | Natural breakouts from river | Natural Assiniboine River flow at Headingley | Sturgeon Cr. Flow plus other local inflows | **Natural Assiniboine R. flow into Red River** | Red River Floodway flow | Red River flow at James Ave. | **Natural Red R. flow downstream of the Assinboine R.** | Natural water level on Red R. at Floodway Inlet (feet) | Recorded Water level on Red R. at Floodway Inlet (feet) |
| *Date / Time* | *Recorded* | *Recorded* | *Recorded* | *Computed* | *=1+2+3-4* | *Recorded & Est'd* | ***=5+6*** | *Recorded* | *Recorded* | ***=1+2-4+8+9*** | *Computed* | *Recorded* |
| 05/Apr4:15 PM | 0 | 385 | 6,052 | 0 | 6,437 | 2,400 | **8,837** | 3,093 | 51,897 | **55,375** | 752.49 | 753.42 |
| 06/Apr7:30 AM | 0 | 369 | 7,238 | 0 | 7,607 | 2,510 | **10,117** | 8,007 | 56,282 | **64,658** | 756.32 | 755.83 |
| 06/Apr4:20 PM | 0 | 560 | 7,677 | 0 | 8,237 | 2,600 | **10,837** | 10,716 | 57,742 | **69,018** | 757.54 | 757.20 |
| 07/Apr8:00 AM | 0 | 1,300 | 6,891 | 0 | 8,191 | 2,500 | **10,691** | 14,007 | 55,808 | **71,115** | 758.19 | 758.72 |
| 07/Apr4:00 PM | 0 | 2,231 | 7,352 | 0 | 9,582 | 2,400 | **11,982** | 14,202 | 55,253 | **71,686** | 758.13 | 758.79 |
| 08/Apr8:00 AM | 0 | 7,255 | 8,912 | 153 | 16,014 | 2,200 | **18,214** | 15,478 | 55,443 | **78,023** | 758.99 | 759.38 |
| 08/Apr4:00 PM | 0 | 11,563 | 8,906 | 1225 | 19,244 | 2,100 | **21,344** | 17,657 | 54,969 | **82,964** | 759.86 | 759.34 |
| 09/Apr8:00 AM | 0 | 18,289 | 7,551 | 3422 | 22,417 | 1,900 | **24,317** | 15,350 | 54,225 | **84,442** | 759.80 | 759.28 |
| 09/Apr4:00 PM | 0 | 17,170 | 6,512 | 2502 | 21,180 | 1,867 | **23,047** | 15,245 | 52,966 | **82,879** | 759.58 | 759.23 |
| 10/Apr8:00 AM | 0 | 14,485 | 6,253 | 1316 | 19,422 | 1,600 | **21,022** | 14,202 | 51,843 | **79,214** | 758.90 | 758.77 |
| 10/Apr4:00 PM | -300 | 11,734 | 6,311 | 461 | 17,285 | 1,500 | **18,785** | 12,822 | 52,574 | **76,369** | 758.41 | 758.12 |
| 11/Apr8:00 AM | -300 | 10,071 | 6,253 | 130 | 15,895 | 1,300 | **17,195** | 12,036 | 52,736 | **74,414** | 758.07 | 757.76 |
| 11/Apr4:00 PM | -200 | 9,987 | 6,191 | 122 | 15,855 | 1,453 | **17,308** | 11,867 | 52,317 | **73,848** | 757.89 | 757.63 |
| 12/Apr8:00 AM | 0 | 10,006 | 6,028 | 131 | 15,903 | 1,570 | **17,473** | 10,985 | 52,154 | **73,015** | 757.61 | 757.19 |
| 12/Apr4:00 PM | 100 | 9,995 | 6,162 | 168 | 16,089 | 1,613 | **17,702** | 10,894 | 52,330 | **73,151** | 757.61 | 757.12 |
| 13/Apr8:00 AM | 300 | 9,875 | 7,161 | 372 | 16,964 | 1,700 | **18,664** | 10,924 | 53,102 | **73,829** | 757.66 | 757.13 |
| 13/Apr4:00 PM | 367 | 9,274 | 7,762 | 386 | 17,017 | 2,353 | **19,370** | 10,826 | 53,616 | **73,697** | 757.51 | 757.10 |
| 14/Apr8:00 AM | 500 | 6,989 | 7,768 | 20 | 15,237 | 1,950 | **17,187** | 10,594 | 53,548 | **71,611** | 757.23 | 756.97 |
| 14/Apr4:00 PM | 423 | 7,405 | 7,007 | 0 | 14,836 | 1,537 | **16,373** | 10,037 | 52,709 | **70,575** | 757.05 | 756.67 |
| 15/Apr8:00 AM | 570 | 9,909 | 6,205 | 243 | 16,441 | 1,210 | **17,651** | 9,193 | 50,611 | **70,040** | 756.69 | 756.24 |
| 15/Apr4:00 PM | 647 | 9,464 | 6,023 | 147 | 15,986 | 1,100 | **17,086** | 8,200 | 49,691 | **67,854** | 756.09 | 755.76 |
| 16/Apr8:00 AM | 800 | 9,363 | 5,825 | 124 | 15,864 | 900 | **16,764** | 7,434 | 48,263 | **65,735** | 755.48 | 755.23 |
| 16/Apr4:00 PM | 877 | 9,249 | 5,769 | 109 | 15,785 | 933 | **16,718** | 6,512 | 47,820 | **64,348** | 755.05 | 754.67 |
| 17/Apr8:00 AM | 1030 | 9,140 | 6,249 | 195 | 16,223 | 750 | **16,973** | 5,328 | 46,319 | **61,622** | 754.15 | 753.81 |
| 17/Apr4:00 PM | 1103 | 8,910 | 6,725 | 253 | 16,485 | 700 | **17,185** | 4,694 | 46,393 | **60,846** | 753.87 | 753.43 |
| 18/Apr8:00 AM | 1250 | 7,396 | 7,773 | 195 | 16,224 | 600 | **16,824** | 3,155 | 46,257 | **57,862** | 752.96 | 752.56 |
| 18/Apr4:00 PM | 1317 | 6,464 | 8,303 | 139 | 15,945 | 508 | **16,453** | 2,503 | 46,208 | **56,352** | 752.52 | 752.31 |
| 19/Apr8:00 AM | 1450 | 5,014 | 9,221 | 78 | 15,607 | 370 | **15,977** | 1,306 | 46,183 | **53,875** | 751.79 | 751.56 |
| 19/Apr4:00 PM | 1510 | 4,560 | 9,646 | 83 | 15,633 | 350 | **15,983** | 943 | 45,974 | **52,904** | 751.47 | 751.27 |
| 20/Apr8:00 AM | 1510 | 4,217 | 10,291 | 129 | 15,890 | 350 | **16,240** | 149 | 45,470 | **51,218** | 750.86 | 750.49 |
| 20/Apr3:30 PM | 1510 | 4,217 | 10,529 | 168 | 16,089 | 350 | **16,439** | 102 | 45,433 | **51,095** | 750.78 | 749.67 |

**Table B-2 Floodway Inlet "Natural" Rating Table**

| RED RIVER DOWNSTREAM OF ASSINIBOINE RIVER CONFLUENCE (cfs) | ASSINIBOINE RIVER CONTRIBUTION (cfs) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| cfs | 0 | 5,000 | 10,000 | 15,000 | 20,000 | 25,000 | 30,000 | 35,000 | 40,000 | 45,000 | 50,000 |
| 20,000 | 742.1 | 740.4 | 738.7 | 737.4 | | | | | | | |
| 30,000 | 746.6 | 745.2 | 743.9 | 742.6 | 741.5 | | | | | | |
| 40,000 | 750.4 | 749.2 | 748.0 | 746.9 | 745.8 | 744.9 | | | | | |
| 50,000 | 753.8 | 752.7 | 751.7 | 750.7 | 749.7 | 748.8 | 747.9 | | | | |
| 60,000 | 756.8 | 755.9 | 754.9 | 754.0 | 753.1 | 752.2 | 751.4 | | | | |
| 70,000 | 759.7 | 758.8 | 758.0 | 757.1 | 756.3 | 755.5 | 754.7 | | | | |
| 80,000 | 762.4 | 761.6 | 760.8 | 760.1 | 759.3 | 758.5 | 757.8 | | | | |
| 90,000 | | 763.9 | 763.2 | 762.6 | 761.9 | 761.2 | 760.6 | 759.9 | | | |
| 100,000 | | 765.6 | 765.3 | 764.8 | 764.1 | 763.5 | 762.9 | 762.3 | | | |
| 110,000 | | 766.7 | 766.3 | 765.9 | 765.5 | 765.2 | 764.7 | 764.2 | | | |
| 120,000 | | 767.6 | 767.5 | 767.2 | 766.8 | 766.5 | 766.1 | 765.7 | 765.4 | | |
| 130,000 | | 768.5 | 768.2 | 768.0 | 767.7 | 767.5 | 767.3 | 767.0 | 766.6 | | |
| 140,000 | | | 768.7 | 768.7 | 768.6 | 768.4 | 768.1 | 767.9 | 767.6 | 767.4 | |
| 150,000 | | | 769.1 | 769.0 | 768.8 | 768.7 | 768.6 | 768.5 | 768.5 | 768.3 | |
| 160,000 | | | 769.6 | 769.4 | 769.2 | 769.1 | 768.9 | 768.8 | 768.7 | 768.5 | 768.5 |
| 170,000 | | | 770.1 | 769.9 | 769.8 | 769.6 | 769.5 | 769.3 | 769.2 | 769.0 | 768.8 |
| 180,000 | | | 770.5 | 770.4 | 770.3 | 770.2 | 770.0 | 769.9 | 769.7 | 769.5 | 769.4 |
| 190,000 | | | | 770.5 | 770.5 | 770.5 | 770.5 | 770.3 | 770.2 | 770.1 | 769.9 |
| 200,000 | | | | 770.7 | 770.6 | 770.6 | 770.5 | 770.5 | 770.5 | 770.5 | 770.5 |
| 210,000 | | | | 770.9 | 770.8 | 770.7 | 770.7 | 770.6 | 770.6 | 770.5 | 770.5 |
| 220,000 | | | | 771.1 | 771.0 | 770.9 | 770.8 | 770.7 | 770.7 | 770.6 | 770.5 |
| 230,000 | | | | 771.2 | 771.2 | 771.1 | 771.0 | 770.9 | 770.8 | 770.7 | 770.7 |
| 240,000 | | | | | 771.5 | 771.4 | 771.3 | 771.2 | 771.1 | 771.0 | 770.9 |
| 250,000 | | | | | 771.8 | 771.7 | 771.6 | 771.6 | 771.5 | 771.4 | 771.3 |
| 260,000 | | | | | 772.1 | 772.0 | 772.0 | 771.9 | 771.8 | 771.7 | 771.6 |
| 270,000 | | | | | 772.4 | 772.4 | 772.3 | 772.2 | 772.1 | 772.1 | 772.0 |
| 280,000 | | | | | 772.8 | 772.7 | 772.6 | 772.5 | 772.5 | 772.4 | 772.3 |
| 290,000 | | | | | 773.1 | 773.0 | 772.9 | 772.8 | 772.8 | 772.7 | 772.6 |
| 300,000 | | | | | 773.3 | 773.3 | 773.2 | 773.1 | 773.1 | 773.0 | 772.9 |

Notes:
- Steady state conditions
- Open water conditions (no ice)