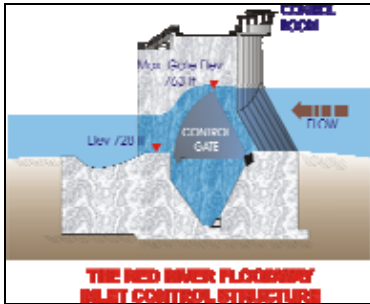


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# RED RIVER FLOODWAY OPERATION REPORT

## SPRING 2010



Manitoba Water Stewardship

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## SPRING 2010

Ecological Services Division  
Manitoba Water Stewardship



*Printed on Recycled Paper*



## **EXECUTIVE SUMMARY**

The Red River spring flood of 2010 was of moderate size, with the natural peak in Winnipeg being the 13<sup>th</sup> highest since operation of the Red River Floodway first began in 1969. Between its completion in 1968 to 2010, the Floodway has been operated in 27 out of the past 42 years to prevent spring flooding.

During the spring of 2010, the Red River Floodway gates were operated for 600 hours over 25 days beginning at 9:30 AM on March 28 and ending at 9:30 AM on April 22. During this period of operation, 47 discrete gate adjustments were made as required at various times throughout any 24 hour period. In the spring of 2010, 0.5 million acre-feet of water were diverted around the City of Winnipeg with a peak flow of 16,200 cfs.

In spring 2010, operation of the Floodway was successful in protecting the City of Winnipeg while minimizing upstream impacts, through normal operation in accordance with Rule 1 of the Floodway Rules of Operation, which requires the Department of Water Stewardship to maintain natural levels on the Red River at the Floodway inlet. In concert with operation of the Portage Diversion and Shellmouth Reservoir, operation of the Floodway reduced the flood crest in the City of Winnipeg by 4.5 feet.

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## INTRODUCTION

On April 20, 2005, *The Red River Floodway Act* was proclaimed in force. Subsection 11(1) of this Act states that:

*“On or before June 30 of any year in which the government operates the floodway during spring flooding to regulate the river level, the director must provide the minister with a report about the operation containing the information the minister requires.”*

The following report details operation of the Red River Floodway in the spring runoff period of 2010 as required by clause 11(1) of *The Red River Floodway Act*, and includes the information specified in subsection 3(1) of The Red River Floodway Regulation.

Within this report, all flows and levels are shown in imperial units. Flows can be converted from cubic feet per second (cfs) to cubic metres per second ( $\text{m}^3/\text{s}$ ) by dividing by 35.3148. River levels can be converted from feet to metres by dividing by a factor of 3.28084.

Manitoba Water Stewardship gratefully acknowledges Water Survey of Canada for providing the provisional flows used in the report.

## 2010 SPRING RUNOFF

The 2010 natural spring flood on the Red River at Winnipeg was the 13<sup>th</sup> largest since operation of major flood control works began in 1969. The flood at Emerson was the 8<sup>th</sup> largest and at St. Agathe, the 12<sup>th</sup> largest for the past 100 years of record. The peak flow in the Red River Floodway was the 12<sup>th</sup> highest on record for the 42 year period since floodway operation began. The recorded peak stage of 18.6 feet at James Avenue in Winnipeg was the 10<sup>th</sup> highest during this same period.

The 2010 spring flood resulted from above average soil moisture at freeze-up in 2009 combined with well above average snow cover in the United States portion of the Red River basin. Snow cover in the Manitoba portion of the basin was close to average. Spring rainfall was negligible in the Manitoba portion of the basin but a few rain events did occur within the United States portion of the basin.

Snowmelt runoff began before mid-March, aided by a 35 mm rain-on-snow event in the United States portion of the basin on March 9 to 12, 2010. Runoff from the Manitoba portion of the basin was delayed until late March but crests from Manitoba tributaries occurred before the arrival of the crest from the United States, resulting in little additional rise as the crest moved through Manitoba. Crests in Manitoba occurred on April 1 at Emerson and April 6 at the Floodway Inlet. The crest was slightly below the levels of major transportation routes such as PTH 75 and PR 200.

The crest at Winnipeg occurred on April 2 due to relatively high runoff from local tributaries including the Assiniboine River. The crest in the Selkirk area occurred on March 28 due to significant ice jamming. Ice jams produced the highest stages on record in the St. Peters

Road area between Selkirk and Breezy Point. Minor flooding occurred at Petersfield due to Red River ice jams backing water into Netley Creek.

The start of operation of the Red River Floodway gates was delayed because of an ice jam that occurred near Lord Avenue in south Winnipeg beginning on Friday evening March 26. The jam raised river levels in the St. Norbert area almost 4 feet to within 1.5 feet of those water levels experienced in 2009. Approximately 10,000 cubic feet per second of water was flowing into the Red River Floodway on the morning of March 27 even though the floodway gates had not yet been operated. The Lord Avenue ice jam broke at 3:15 PM on March 27 with assistance from the Amphibex.

## **THE RED RIVER FLOODWAY**

Following the historic flood of 1950 in the City of Winnipeg, work began on the design and construction of a series of flood control measures including Shellmouth Reservoir, Portage Diversion, and the Red River Floodway to protect the City from significant flood events. All were intended to be operated in concert to reduce flood flows and thus, minimize flood damages in the City of Winnipeg.

Operation of the floodway is guided by a set of rules (Appendix A) intended to provide balanced flood protection to the City of Winnipeg without artificially affecting properties south or upstream of the inlet. Rule 1 requires that natural levels not be exceeded upstream of the floodway inlet structure as long as water levels within the City of Winnipeg are less than 24.5 James Avenue. 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 1950s if Shellmouth Reservoir, Portage Diversion, Assiniboine River dikes, and the Red River Floodway were not in place.

During the 2010 spring floodway operation, the natural water levels upstream of the inlet were calculated with 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: the natural flow in the Red River downstream of the Assiniboine River (at James Avenue) and the natural flow of the Assiniboine River into the Red River. These data along with the natural and actual water levels on the Red River at the floodway inlet are shown for the 2010 spring flood in Appendix B, Table 2. Real-time water level and flow data to guide the operations are obtained at a number of sites including the Red River at James Avenue or Chief Peguis Bridge, above and below the Inlet Control Structure, floodway channel, Assiniboine River at Headingley, Portage Diversion, Sturgeon Creek, and La Salle River along with estimates of un-gauged flow from small streams or overland runoff in the Winnipeg area.

## **OPERATION OF THE FLOODWAY IN SPRING 2010**

Approximately 6,200 cubic feet per second of water was flowing into the Red River Floodway at 8 AM on March 28, 2010. The Red River Floodway gates were operated at 9:30 AM on Sunday, March 28 in accordance with normal operating procedures to reduce river levels in the City of Winnipeg.

Operation of the floodway during open water in 2010 followed normal protocol and was consistent with experience in past spring floods.

The computation of natural water levels at the inlet control structure requires calculation of the natural flow at James Avenue. Natural flow is determined by adjusting the actual flow for the effects of the flood control works. Under open water conditions, the actual flow is estimated from the discharge rating curve for the Red River at James Avenue using Water Survey of Canada levels collected at station 05OC015.

The Red River at James Avenue reached its crest under open water at 18.5 feet on April 2, while an ice jam was occurring on the Assiniboine River in Winnipeg. The peak recorded level at the floodway entrance (Water Survey of Canada station 05OC026) was 759.09 feet at 12:00 AM on April 4 during open water operation and was 0.41 feet lower than the computed natural peak level of 759.50 feet.

During operation, the floodway gates were adjusted in small increments to follow the natural rise in water levels. This was done to avoid large gate raises that may have caused sudden changes in water levels above and below the floodway control structure. Table 1 lists the gate operations that occurred during operation of the floodway in the spring of 2010. The average gate adjustment was 0.38 feet during the period of time that floodway flows were affected by gate operation.

Red River recorded and natural levels in Winnipeg at James Avenue during the period of operation are shown on Figure 1 and similar levels at the floodway entrance are plotted in Figure 2.

Overall, in the spring of 2010, 0.5 million acre-feet of water was diverted around the City of Winnipeg with a peak flow of 16,200 cfs. The recorded river level at the floodway entrance was maintained an average of 0.51 feet below the computed natural level throughout the 25 days of floodway operation.

## CONCLUSIONS

It can be concluded that:

- During the spring of 2010, the Red River Floodway was operated for 600 hours over 25 days and, in combination with other related flood control measures such as operation of the Portage Diversion and storage of flood waters in Shellmouth Reservoir, reduced the flood crest in the City of Winnipeg by 4.5 feet;
- Operation of the Red River Floodway began at 9:30 AM on March 28, 2010, and concluded at 9:30 AM on April 22, 2010. During this period, 47 discrete gate adjustments were made as required and occurred at various times throughout any 24 hour period;
- Throughout its operation in the spring of 2010, recorded water levels upstream of the inlet were, on average, 0.51 feet lower than natural levels;
- The crest at the floodway inlet was 759.09 feet, 0.41 feet lower than the computed natural peak level of 759.50 feet;
- During spring 2010, 0.5 million acre-feet of water were diverted around the City of Winnipeg with a peak flow of 16,200 cfs.

**Table 1 –2010 Floodway Gate Operations**

| Date           | Time *   | Start of Operation | End of Operation | Date                              | Time *   | Start of Operation | End of Operation |
|----------------|----------|--------------------|------------------|-----------------------------------|----------|--------------------|------------------|
| March 28, 2010 | 9:30 AM  | 728.00             | 739.95           | April 13, 2010                    | 7:00 PM  | 740.91             | 740.72           |
| March 29, 2010 | 10:10 PM | 739.95             | 740.34           | April 14, 2010                    | 12:20 AM | 740.72             | 740.53           |
| March 30, 2010 | 9:35 AM  | 740.34             | 739.57           | April 14, 2010                    | 9:20 AM  | 740.53             | 740.43           |
| March 31, 2010 | 10:30 PM | 739.57             | 740.05           | April 14, 2010                    | 3:00 PM  | 740.43             | 740.14           |
| April 1, 2010  | 1:10 PM  | 740.05             | 740.24           | April 14, 2010                    | 10:30 PM | 740.14             | 739.86           |
| April 1, 2010  | 5:40 PM  | 740.24             | 740.72           | April 15, 2010                    | 10:30 AM | 739.86             | 739.67           |
| April 2, 2010  | 12:05 AM | 740.72             | 741.19           | April 15, 2010                    | 4:35 PM  | 739.67             | 739.29           |
| April 2, 2010  | 11:30 AM | 741.19             | 742.90           | April 16, 2010                    | 1:00 AM  | 739.29             | 739.09           |
| April 2, 2010  | 11:05 PM | 742.90             | 743.38           | April 16, 2010                    | 9:20 AM  | 739.09             | 738.90           |
| April 3, 2010  | 2:30 PM  | 743.38             | 743.85           | April 17, 2010                    | 10:05 AM | 738.90             | 738.62           |
| April 4, 2010  | 2:00 AM  | 743.85             | 743.47           | April 17, 2010                    | 4:30 PM  | 738.62             | 738.33           |
| April 4, 2010  | 12:05 PM | 743.47             | 743.00           | April 17, 2010                    | 11:00 PM | 738.33             | 738.14           |
| April 4, 2010  | 10:30 PM | 743.00             | 742.62           | April 18, 2010                    | 2:30 PM  | 738.14             | 737.85           |
| April 5, 2010  | 5:30 PM  | 742.62             | 743.00           | April 18, 2010                    | 10:30 PM | 737.85             | 737.57           |
| April 7, 2010  | 10:20 PM | 743.00             | 742.81           | April 19, 2010                    | 10:40 AM | 737.57             | 737.28           |
| April 8, 2010  | 11:10 AM | 742.81             | 742.43           | April 19, 2010                    | 4:30 PM  | 737.28             | 736.90           |
| April 8, 2010  | 11:00 PM | 742.43             | 742.24           | April 20, 2010                    | 12:40 AM | 736.90             | 736.52           |
| April 9, 2010  | 12:30 PM | 742.24             | 742.05           | April 20, 2010                    | 9:10 AM  | 736.52             | 736.14           |
| April 10, 2010 | 12:30 PM | 742.05             | 741.86           | April 20, 2010                    | 4:20 PM  | 736.14             | 735.77           |
| April 10, 2010 | 10:20 PM | 741.86             | 741.48           | April 20, 2010                    | 11:00 PM | 735.77             | 735.39           |
| April 11, 2010 | 12:45 PM | 741.48             | 741.29           | April 21, 2010                    | 10:15 AM | 735.39             | 734.45           |
| April 11, 2010 | 10:45 PM | 741.29             | 741.19           | April 21, 2010                    | 5:00 PM  | 734.45             | 732.97           |
| April 12, 2010 | 10:45 PM | 741.19             | 741.10           | April 22, 2010                    | 9:30 AM  | 732.97             | 728.00           |
| April 13, 2010 | 9:20 AM  | 741.10             | 740.91           | * Time of start of gate operation |          |                    |                  |



Figure 1 – Recorded River Levels at James Avenue Gauge 2010

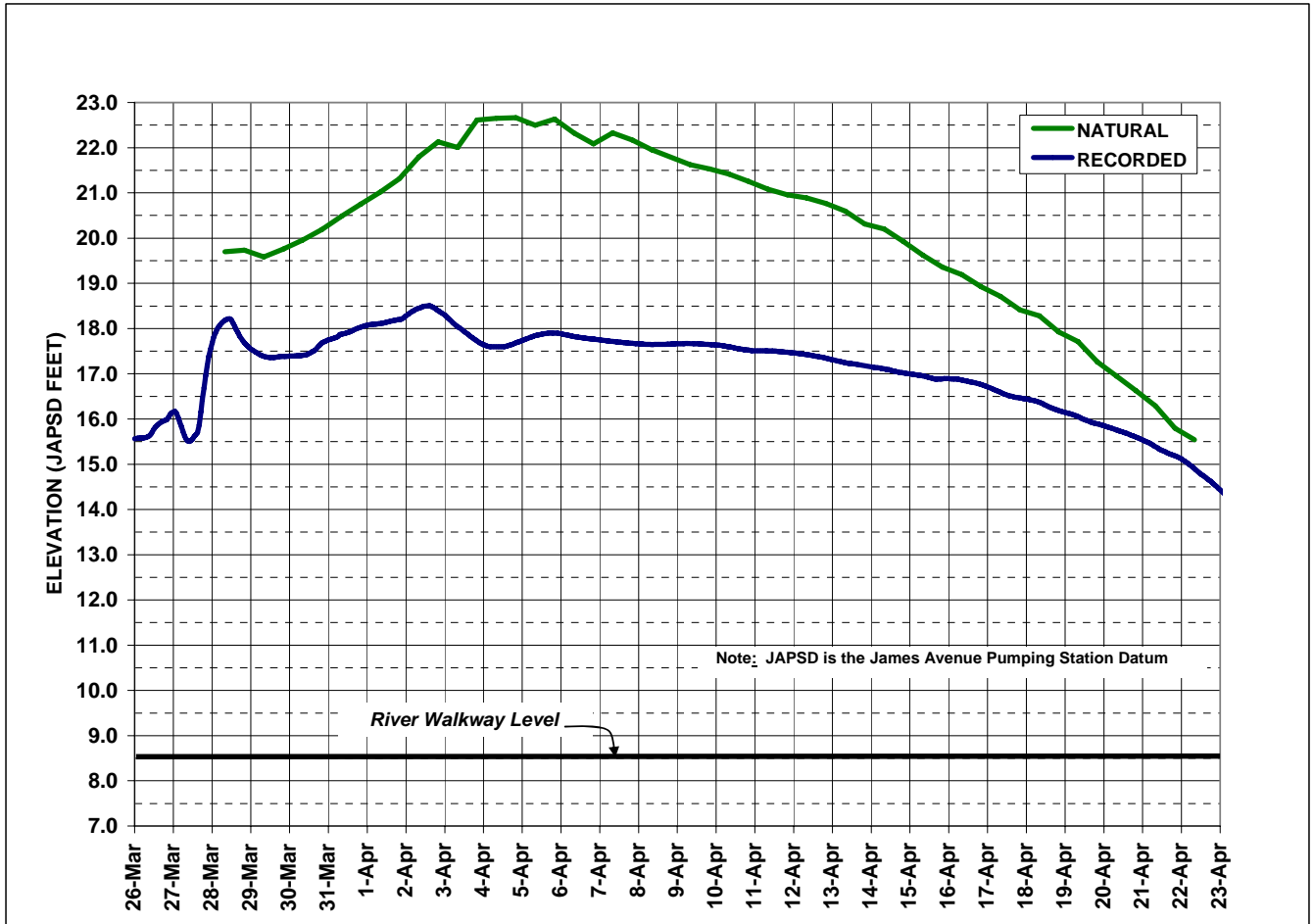
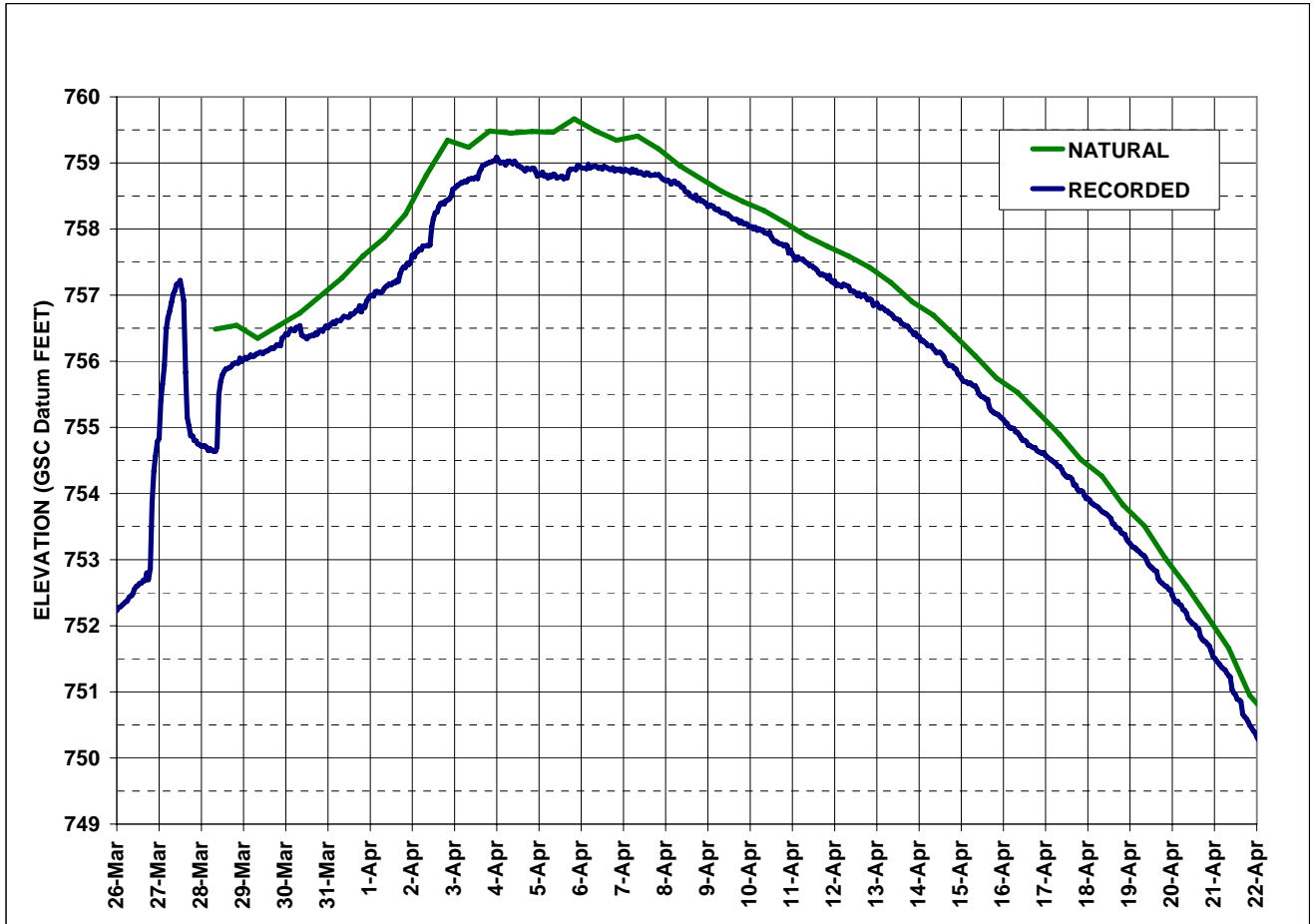


Figure 2 – Recorded and Natural Levels at Floodway Entrance 2010



**APPENDIX A**

**Red River Floodway Rules of Operation**

## **Rules of Operation**

### **Red River Floodway Control Structure**

#### *Normal Operation:*

1. Maintain natural<sup>1</sup> 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.

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<sup>1</sup> 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 or her 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 levels by adjusting the control gates so that reservoir outflows are lower than 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 flows 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 at James Avenue, which is downstream of the Forks.

#### NATURAL RIVER LEVELS AT THE FLOODWAY INLET

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 provides natural elevations at the inlet based upon the relative contribution of natural flow at the Forks from the Red and Assiniboine Rivers. The *combined* flow is represented by the values in the left-hand column entitled Red River at James Avenue. The Assiniboine River Contribution amount is shown across the top and is the flow in the Assiniboine River at the Forks.

The natural water level at the inlet can vary by a few feet dependent upon the amount of flow coming from the Assiniboine River (Assiniboine River Contribution). This phenomenon is referred to as a variable backwater effect.

This concept can be illustrated by using the example of 100,000 cfs flow for the Red River at James Avenue in various combinations of Red and Assiniboine River flows. One combination could have 95,000 cfs as Red River flow upstream of the Forks and 5,000 cfs as Assiniboine River Contribution; this combination results in a level at the inlet of 765.6 feet as shown in Table B-2. Similarly, another combination, while still yielding a total James Avenue flow of 100,000 cfs, could be 70,000 cfs as Red River flow upstream of the Forks and 30,000 cfs as Assiniboine River Contribution; the resulting inlet level would be 762.9 feet. The difference in the inlet water elevation between these two flow combinations is 2.7 feet, with the lower elevation occurring when there is relatively more flow on the Assiniboine River.

Natural levels are determined by using the natural Red River flows at James Avenue listed in column 10 of Table B-1, and the natural Assiniboine River flows listed in column 7 of Table B-1 and interpolating between the values listed in Table B-2 to determine the natural levels. These natural levels are listed in column 13 of Table B-1. For comparison, column 14 of Table B-1

lists the recorded levels at the floodway inlet (station 05OC026). Similar levels for James Avenue in Winnipeg are provided in columns 11 and 12.

**Table B-1 Spring 2010 Flows and Levels**

| Column =>           | 1  | 2   | 3  | 4                            | 5  | 6  | 7  | 8                       | 9                            | 10                                     | 11                                      | 12                                       | 13   | 14  |  |
|---------------------|--|---|--|------------------------------|--|--|--|-------------------------|------------------------------|--|---|--|--|---|--|
|                     | Assiniboine Flows                              |   |  |                              |  |  | Red River Flows                            |                         |                              |  |   |  |  |   |  |
|                     | Shellmouth Flow Changes (Routed to Headingley) | Portage Diversion flow (Routed to Headingley) | Actual Assiniboine R. 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 River flow at James Avenue | Natural Water Level at James Ave (feet) | Recorded Water Level at James Ave (feet) | 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                                     | Rec. & Est.                                | =5+6                                       | Recorded                | Recorded                     | =1+2-4+8+9                             | Computed                                | Recorded                                 | Computed   | Recorded  |  |
| 28-Mar-2010 8:00 AM | -225   | 0   | 2,330                                    | 0                            | 2,105  | 173  | 2,278                                      | 6,234                   | 54,320                       | 60,329                                 | 19.70                                   | 18.18                                    | 756.49   | 754.64  |  |
| 28-Mar-2010 8:00 PM | -225   | 0   | 2,207                                    | 0                            | 1,982  | 191  | 2,173                                      | 8,344                   | 52,352                       | 60,471                                 | 19.74                                   | 17.69                                    | 756.55   | 755.97  |  |
| 29-Mar-2010 8:00 AM | -162   | 0   | 2,269                                    | 0                            | 2,107  | 189  | 2,296                                      | 8,724                   | 51,314                       | 59,877                                 | 19.58                                   | 17.39                                    | 756.35   | 756.11  |  |
| 29-Mar-2010 8:00 PM | -132   | 0   | 2,291                                    | 0                            | 2,159  | 196  | 2,356                                      | 9,320                   | 51,369                       | 60,557                                 | 19.76                                   | 17.38                                    | 756.54   | 756.25  |  |
| 30-Mar-2010 8:00 AM | -102   | 0   | 2,418                                    | 0                            | 2,316  | 217  | 2,534                                      | 9,915                   | 51,520                       | 61,333                                 | 19.96                                   | 17.41                                    | 756.73   | 756.54  |  |
| 30-Mar-2010 8:00 PM | -74  | 0   | 2,571                                    | 0                            | 2,497  | 224  | 2,722                                      | 9,786                   | 52,644                       | 62,355                                 | 20.19                                   | 17.68                                    | 756.99   | 756.47  |  |
| 31-Mar-2010 8:00 AM | -46  | 0   | 2,878                                    | 0                            | 2,832  | 509  | 3,340                                      | 10,188                  | 53,522                       | 63,664                                 | 20.48                                   | 17.88                                    | 757.26   | 756.64  |  |
| 31-Mar-2010 8:00 PM | -20  | 0   | 3,027                                    | 0                            | 3,007  | 422  | 3,429                                      | 10,560                  | 54,333                       | 64,872                                 | 20.75                                   | 18.03                                    | 757.60   | 756.83  |  |
| 01-Apr-2010 8:00 AM | 6  | 0   | 3,558                                    | 0                            | 3,564  | 273  | 3,837                                      | 11,236                  | 54,811                       | 66,053                                 | 21.01                                   | 18.11                                    | 757.86   | 757.10  |  |
| 01-Apr-2010 8:00 PM | 28   | 0   | 3,519                                    | 0                            | 3,547  | 255  | 3,802                                      | 11,972                  | 55,258                       | 67,258                                 | 21.31                                   | 18.20                                    | 758.22   | 757.41  |  |
| 02-Apr-2010 8:00 AM | 50   | 0   | 3,246                                    | 0                            | 3,296  | 303  | 3,599                                      | 12,755                  | 56,370                       | 69,175                                 | 21.79                                   | 18.45                                    | 758.81   | 757.75  |  |
| 02-Apr-2010 8:00 PM | 69   | 0   | 2,608                                    | 0                            | 2,677  | 301  | 2,978                                      | 14,449                  | 56,124                       | 70,642                                 | 22.13                                   | 18.39                                    | 759.34   | 758.44  |  |
| 03-Apr-2010 8:00 AM | 100  | 0   | 2,148                                    | 0                            | 2,248  | 334  | 2,582                                      | 15,354                  | 54,551                       | 70,004                                 | 22.00                                   | 18.04                                    | 759.24   | 758.75  |  |
| 03-Apr-2010 8:00 PM | 124  | 3,635   | 1,962                                    | 0                            | 5,720  | 340  | 6,060                                      | 16,101                  | 53,183                       | 73,042                                 | 22.61                                   | 17.73                                    | 759.48   | 759.01  |  |
| 04-Apr-2010 8:00 AM | 147  | 4,250   | 1,892                                    | 0                            | 6,289  | 294  | 6,583                                      | 16,119                  | 52,709                       | 73,224                                 | 22.64                                   | 17.60                                    | 759.45   | 759.01  |  |
| 04-Apr-2010 8:00 PM | 158  | 4,250   | 1,860                                    | 0                            | 6,268  | 281  | 6,549                                      | 15,867                  | 53,025                       | 73,300                                 | 22.66                                   | 17.68                                    | 759.48   | 758.92  |  |
| 05-Apr-2010 8:00 AM | 169  | 3,069   | 1,709                                    | 0                            | 4,947  | 268  | 5,216                                      | 15,558                  | 53,699                       | 72,495                                 | 22.50                                   | 17.84                                    | 759.46   | 758.83  |  |
| 05-Apr-2010 8:00 PM | 180  | 3,145   | 1,583                                    | 0                            | 4,909  | 244  | 5,153                                      | 15,890                  | 53,959                       | 73,174                                 | 22.63                                   | 17.90                                    | 759.66   | 758.91  |  |
| 06-Apr-2010 8:00 AM | 186  | 1,861   | 1,419                                    | 0                            | 3,465  | 232  | 3,697                                      | 15,950                  | 53,627                       | 71,624                                 | 22.32                                   | 17.83                                    | 759.48   | 758.95  |  |
| 06-Apr-2010 8:00 PM | 194  | 903   | 1,308                                    | 0                            | 2,405  | 211  | 2,616                                      | 15,944                  | 53,367                       | 70,408                                 | 22.08                                   | 17.77                                    | 759.34   | 758.91  |  |
| 07-Apr-2010 8:00 AM | 201  | 2,449   | 1,268                                    | 0                            | 3,918  | 234  | 4,152                                      | 15,831                  | 53,146                       | 71,628                                 | 22.33                                   | 17.72                                    | 759.41   | 758.85  |  |
| 07-Apr-2010 8:00 PM | 216  | 2,334   | 1,265                                    | 0                            | 3,815  | 225  | 4,039                                      | 15,692                  | 52,618                       | 70,860                                 | 22.17                                   | 17.67                                    | 759.21   | 758.82  |  |
| 08-Apr-2010 8:00 AM | 220  | 2,143   | 1,285                                    | 0                            | 3,648  | 188  | 3,836                                      | 15,376                  | 52,077                       | 69,816                                 | 21.95                                   | 17.65                                    | 758.96   | 758.67  |  |
| 08-Apr-2010 8:00 AM | 220  | 2,143   | 1,285                                    | 0                            | 3,648  | 188  | 3,836                                      | 15,376                  | 52,077                       | 69,816                                 | 21.95                                   | 17.65                                    | 758.96   | 758.67  |  |
| 09-Apr-2010 8:00 AM | 249  | 2,183   | 1,263                                    | 0                            | 3,695  | 176  | 3,872                                      | 14,376                  | 51,681                       | 68,489                                 | 21.62                                   | 17.67                                    | 758.56   | 758.24  |  |
| 09-Apr-2010 8:00 PM | 272  | 2,392   | 1,266                                    | 0                            | 3,929  | 173  | 4,102                                      | 13,922                  | 51,522                       | 68,107                                 | 21.53                                   | 17.65                                    | 758.41   | 758.08  |  |
| 10-Apr-2010 8:00 AM | 294  | 2,401   | 1,261                                    | 0                            | 3,956  | 160  | 4,116                                      | 13,616                  | 51,340                       | 67,651                                 | 21.41                                   | 17.60                                    | 758.28   | 757.95  |  |
| 10-Apr-2010 8:00 PM | 326  | 2,406   | 1,225                                    | 0                            | 3,956  | 160  | 4,116                                      | 13,227                  | 51,061                       | 67,020                                 | 21.26                                   | 17.52                                    | 758.09   | 757.76  |  |
| 11-Apr-2010 8:00 AM | 357  | 2,415   | 1,196                                    | 0                            | 3,967  | 157  | 4,124                                      | 12,558                  | 51,000                       | 66,330                                 | 21.08                                   | 17.51                                    | 757.89   | 757.49  |  |
| 11-Apr-2010 8:00 PM | 399  | 2,423   | 1,193                                    | 0                            | 4,015  | 145  | 4,160                                      | 12,099                  | 50,891                       | 65,812                                 | 20.96                                   | 17.48                                    | 757.74   | 757.25  |  |

**Table B-1 Spring 2010 Flows and Levels *continued***

| Column =>           | 1  | 2   | 3  | 4                            | 5  | 6  | 7  | 8                       | 9                            | 10                                     | 11                                      | 12                                       | 13   | 14  |  |
|---------------------|--|---|--|------------------------------|--|--|--|-------------------------|------------------------------|--|---|--|--|---|--|
|                     | Assiniboine Flows                              |   |  |                              |  |  | Red River Flows                            |                         |                              |  |   |  |  |   |  |
|                     | Shellmouth Flow Changes (Routed to Headingley) | Portage Diversion flow (Routed to Headingley) | Actual Assiniboine R. 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 River flow at James Avenue | Natural Water Level at James Ave (feet) | Recorded Water Level at James Ave (feet) | 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                                     | Rec. & Est.                                | =5+6                                       | Recorded                | Recorded                     | =1+2-4+8+9                             | Computed                                | Recorded                                 | Computed   | Recorded  |  |
| 12-Apr-2010 8:00 AM | 441  | 2,692   | 1,194                                    | 0                            | 4,327  | 143  | 4,471                                      | 11,670                  | 50,697                       | 65,500                                 | 20.89                                   | 17.42                                    | 757.59   | 757.13  |  |
| 12-Apr-2010 8:00 PM | 492  | 2,717   | 1,169                                    | 0                            | 4,377  | 141  | 4,518                                      | 11,329                  | 50,405                       | 64,943                                 | 20.77                                   | 17.34                                    | 757.42   | 756.94  |  |
| 13-Apr-2010 8:00 AM | 542  | 2,719   | 1,175                                    | 0                            | 4,437  | 140  | 4,576                                      | 10,889                  | 50,041                       | 64,192                                 | 20.60                                   | 17.25                                    | 757.19   | 756.72  |  |
| 13-Apr-2010 8:00 PM | 601  | 2,206   | 1,205                                    | 0                            | 4,012  | 138  | 4,149                                      | 10,267                  | 49,847                       | 62,920                                 | 20.32                                   | 17.19                                    | 756.90   | 756.45  |  |
| 14-Apr-2010 8:00 AM | 659  | 2,443   | 1,174                                    | 0                            | 4,275  | 137  | 4,412                                      | 9,760                   | 49,531                       | 62,393                                 | 20.20                                   | 17.11                                    | 756.70   | 756.19  |  |
| 14-Apr-2010 8:00 PM | 726  | 2,166   | 1,155                                    | 0                            | 4,047  | 137  | 4,184                                      | 9,133                   | 49,180                       | 61,204                                 | 19.92                                   | 17.02                                    | 756.40   | 755.90  |  |
| 15-Apr-2010 8:00 AM | 792  | 1,932   | 1,164                                    | 0                            | 3,889  | 136  | 4,025                                      | 8,501                   | 48,797                       | 60,023                                 | 19.62                                   | 16.95                                    | 756.08   | 755.63  |  |
| 15-Apr-2010 8:00 PM | 864  | 1,929   | 1,160                                    | 0                            | 3,953  | 135  | 4,088                                      | 7,790                   | 48,415                       | 58,997                                 | 19.36                                   | 16.89                                    | 755.75   | 755.20  |  |
| 16-Apr-2010 8:00 AM | 935  | 1,951   | 1,154                                    | 0                            | 4,041  | 135  | 4,176                                      | 7,282                   | 48,190                       | 58,358                                 | 19.19                                   | 16.86                                    | 755.53   | 754.92  |  |
| 16-Apr-2010 8:00 PM | 1009   | 1,706   | 1,170                                    | 0                            | 3,885  | 135  | 4,020                                      | 6,806                   | 47,756                       | 57,277                                 | 18.93                                   | 16.76                                    | 755.22   | 754.63  |  |
| 17-Apr-2010 8:00 AM | 1083   | 1,731   | 1,201                                    | 0                            | 4,015  | 134  | 4,149                                      | 6,457                   | 47,060                       | 56,332                                 | 18.71                                   | 16.59                                    | 754.89   | 754.41  |  |
| 17-Apr-2010 8:00 PM | 1154   | 1,447   | 1,232                                    | 0                            | 3,833  | 134  | 3,967                                      | 5,853                   | 46,562                       | 55,015                                 | 18.41                                   | 16.47                                    | 754.51   | 754.05  |  |
| 18-Apr-2010 8:00 AM | 1224   | 1,713   | 1,219                                    | 0                            | 4,156  | 134  | 4,291                                      | 5,329                   | 46,181                       | 54,447                                 | 18.28                                   | 16.37                                    | 754.27   | 753.73  |  |
| 18-Apr-2010 8:00 PM | 1287   | 1,452   | 1,211                                    | 0                            | 3,949  | 134  | 4,084                                      | 4,731                   | 45,459                       | 52,929                                 | 17.93                                   | 16.19                                    | 753.83   | 753.39  |  |
| 19-Apr-2010 8:00 AM | 1347   | 1,738   | 1,161                                    | 0                            | 4,246  | 134  | 4,381                                      | 4,122                   | 44,921                       | 52,128                                 | 17.71                                   | 16.06                                    | 753.51   | 753.06  |  |
| 19-Apr-2010 8:00 PM | 1398   | 1,521   | 1,156                                    | 0                            | 4,075  | 134  | 4,209                                      | 3,283                   | 44,265                       | 50,467                                 | 17.26                                   | 15.89                                    | 753.02   | 752.60  |  |
| 20-Apr-2010 8:00 AM | 1449   | 1,522   | 1,190                                    | 0                            | 4,161  | 134  | 4,296                                      | 2,583                   | 43,727                       | 49,281                                 | 16.95                                   | 15.76                                    | 752.60   | 752.19  |  |
| 20-Apr-2010 8:00 PM | 1486   | 1,559   | 1,186                                    | 0                            | 4,231  | 134  | 4,366                                      | 1,854                   | 43,097                       | 47,995                                 | 16.62                                   | 15.60                                    | 752.14   | 751.72  |  |
| 21-Apr-2010 8:00 AM | 1522   | 1,586   | 1,163                                    | 0                            | 4,271  | 134  | 4,405                                      | 1,281                   | 42,257                       | 46,646                                 | 16.29                                   | 15.39                                    | 751.66   | 751.24  |  |
| 21-Apr-2010 8:00 PM | 1544   | 1,706   | 1,159                                    | 0                            | 4,410  | 134  | 4,544                                      | 0                       | 41,447                       | 44,698                                 | 15.80                                   | 15.19                                    | 750.95   | 750.50  |  |
| 22-Apr-2010 8:00 AM | 1566   | 1,725   | 1,164                                    | 0                            | 4,454  | 134  | 4,589                                      | 0                       | 40,389                       | 43,680                                 | 15.54                                   | 14.90                                    | 750.58   | 749.99  |  |

**Table B-2 Red River Floodway Inlet Natural Rating Table**

|                                 |         | 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 |       |
| RED RIVER AT JAMES AVENUE (cfs) | 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  |       |

Note: Open water conditions under steady state (no ice)