Appendices No. 3 Royal Commission on Flood Cost Benefit - 1958 and the True Baseline

Existing floodway baseline Inlet elevation for design has been grievously miss-representations by the co-proponents – the FEA and the Provincial Water Branch.

- 1958 Royal Commission on Flood Cost Benefit
  Chapter 11. (Specifically second paragraph, right column of Page 89). Baseline for design, 768.0 plus 3.0 ft for a total flood passage of 200,000 cfs after four feet added to Winnipeg's Primary Dykes.

- IJC Task Force Report of December 1999
  Baseline for design, 771.25 ft ASL.

- Canada / Manitoba / Winnipeg -- Flood Protection Studies for Winnipeg November 2001
  Baseline for design, 778.0 ft ASL under "Emergency Operation".

The below tells the story. It appears that Canada and Manitoba will be truthful to the United States of America, through the IJC. Unfortunately, truthfulness to Canadians is grievously wanting in the current process.

REPORT

OF THE

ROYAL COMMISSION

ON

FLOOD COST BENEFIT

WINNIPEG, MANITOBA
December, 1958

ROYAL COMMISSION ON FLOOD COST-BENEFIT 1958

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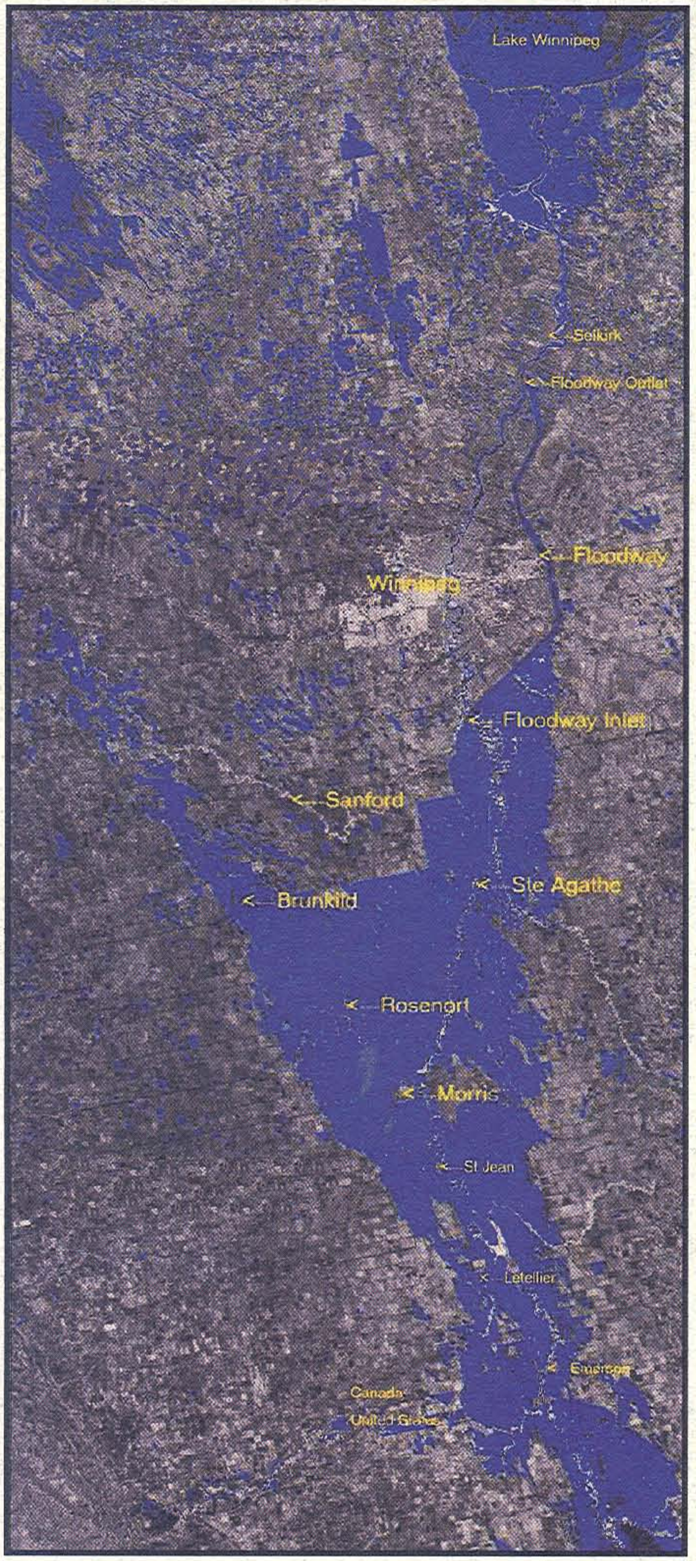

AN INDEPENDENT REVIEW OF ACTIONS TAKEN DURING THE 1997 RED RIVER FLOOD

A REPORT TO THE HON. J. GLEN CUMMINGS MINISTER OF NATURAL RESOURCES

MANITOBA

Manitoba Water Commission
June, 1998

To sum up, the three projects recommended will provide the following benefits:

(a) They will provide complete protection to all parts of Greater Winnipeg outside the primary dyking system for all floods of up to 169,000 c.f.s. A flood flow of 169,000 c.f.s. can be expected to be equalled or exceeded on the average of once in 160 years. With such a flood flow, it can be expected that, on the average, about 76,000 c.f.s. would flow through Winnipeg with a flood elevation **about one foot below the top of the existing dyking system**; some 66,000 c.f.s. would flow through the floodway channel, some 10,000 c.f.s. would be held back by the Russell Reservoir and 25,000 c.f.s. would be diverted into Lake Manitoba by the Portage Diversion. Since not all of the 35,000 c.f.s. withheld or diverted on the Assiniboine produces an equivalent reduction in Winnipeg, the total of the above exceeds 169,000 c.f.s.

In addition, if a larger flood than 169,000 c.f.s. were to occur in the Greater Winnipeg area, there would be a possibility of obtaining a considerable additional margin of protection. Thus, with the construction of temporary dykes that would allow the water level in the channel to be raised by 4 feet, there would be a possibility of carrying an additional 20,000 c.f.s. through the city. Further, if the floodway gates were operated in such a way as to raise the water level at St. Norbert to 3 feet above its natural level in any given flood, it would be possible to pass an additional 11,000 c.f.s. through the floodway. Thus, with this combination of projects it would be possible to fight a flood of up to 200,000 c.f.s. in the Greater Winnipeg area.

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2) The Program of Operation and the 1997 Flood

In 1997, the Floodway was not operated in strict conformance with the 1984 published Program of Operation.

The 1997 flood was the first opportunity for the Water Resources Branch to operate the Floodway under conditions that approached an emergency. The situation demonstrated that some flexibility and judgment are required in applying the Program of Operation. For example, the original design parameters indicate that the water elevation above the Floodway should be 770.25 feet asl at a flow of 169,000 cfs. However, in 1997, a flow of only 162,000 cfs resulted in an actual elevation of 771.50 feet asl at the Floodway with the river held at 24.5 feet James Avenue.

Of the 162,000 cfs, 79,000 cfs flowed through the City, 65,000 cfs through the floodway channel. The remainder was either stored in the Shellmouth Reservoir or directed to Lake Manitoba along the Portage Diversion.

This was a result of a higher proportion of the flow in 1997 originating from the south than may be expected during a design flood. Under a design flood of 169,000 cfs, 77,000 would flow through the city and 60,000 down the Floodway.

The decision to operate the Floodway to maintain a level of 24.5 feet James Avenue within Winnipeg, rather than 25.5 feet James Avenue as outlined in the Program of Operation was made after discussions with City of Winnipeg officials.

In 1997, the Floodway was not operated in strict conformance with the 1984 published Program of Operation.

BENEFIT-COST ANALYSIS OF PROJECTS IN COMBINATION

When two or more flood protection schemes are considered in combination, it is usually found that the total annual benefit provided by the combination is substantially less than the sum of the benefits obtained from each of the projects considered separately. This is due to the fact that in considerable part, the capacity of the separate schemes provides duplicate protection for smaller floods. It is only in the larger, less frequent floods that this duplication disappears. For largely the same reasons the incremental benefit-cost ratio for any project considered as an addition to some existing project is sharply lower than its own separate benefit-cost ratio.

In order to make some selection among the many different possible combinations of projects, the following approach was adopted. As was explained in Chapter 10, in our initial survey of individual projects, it was determined that the Greater Winnipeg Floodway should form a basic part of any combination of schemes designed to provide flood control for Greater Winnipeg. Further, since the Portage Diversion provides a higher benefit-cost ratio than any other alternative plan, it was also decided that it should form part of any combination. Attention was given first to combinations of the three Portage Diversions with the 40-768, 60-768 and 80-768 Greater Winnipeg Floodways. Data on benefits, costs and benefit-cost ratios for each of these projects are given in Table 11.1. All data are for the High Bluff rather than the Fort la Reine Diversion.

The highest benefit-cost ratio obtained from these combinations is that of 3.44 for a combination of a 40,000 c.f.s. Floodway and a 40,000 c.f.s. Portage Diversion. In general, in all three cases, increasing the size of the Portage Diversion in combination with a given size of Floodway increases the size of the benefit-cost ratio. This is what could be expected because the incremental benefit-cost ratios on the Portage Diversion, when considered separately, remain high right up to a diversion capacity of 40,000 c.f.s. (*See Plate* 27).

Although the Greater Winnipeg Floodway must be relied on to provide a major part of the protection required in Greater Winnipeg, a diversion or retention of some 40,000 c.f.s. on the Assiniboine River is also justified if the most economical form of flood protection is to be provided in the city.

Some question may be raised as to why flood protection measures with a capacity of 40,000 c.f.s. should be provided on the Assiniboine River since in most years the Assiniboine River contributes no more than 20 percent of the peak flood flow at Redwood Bridge. Its justification lies in the lower cost of diversion works on the Assiniboine. A Portage Diversion of 40,000 c.f.s. along the High Bluff would cost only $10,861,000 or just over one-quarter of the cost of a 40,000 c.f.s. floodway and less than 20 percent of the cost of a 60,000 c.f.s. floodway. This lower cost in large measure accounts for the high benefit-cost ratios obtained in the Portage Diversion.

Table 11.1

BENEFIT-COST ANALYSIS
GREATER WINNIPEG FLOODWAY AND PORTAGE DIVERSION IN COMBINATION

Greater Winnipeg Floodways and Portage Diversions	Total Capital Cost	Annual Cost	Annual Benefit	Benefit-Cost Ratio
		(Thousands of Dollars)		
40-768 plus 10,000 P.D.	$47,433	$2,646	$ 8,461	3.20
60-768 plus 10,000 P.D.	63,070	3,505	9,836	2.81
80-768 plus 10,000 P.D.	77,145	4,275	10,691	2.50
40-768 plus 25,000 P.D.	50,396	2,810	9,384	3.34
60-768 plus 25,000 P.D.	66,033	3,668	10,451	2.85
80-768 plus 25,000 P.D.	80,108	4,438	11,178	2.52
40-768 plus 40,000 P.D.	52,585	2,934	10,087	3.44
60-768 plus 40,000 P.D.	68,222	3,792	10,839	2.86
80-768 plus 40,000 P.D.	82,297	4,562	11,465	2.51

In combination with a Greater Winnipeg Floodway, the Portage Diversion retains its very favourable benefit-cost position. This is particularly true of the 25,000 c.f.s. and 40,000 c.f.s. Diversions. The reasons why this is true are fairly clear. If a Greater Winnipeg Floodway with a capacity of 40,000 c.f.s. were constructed, a reasonable degree of protection would have been provided to Greater Winnipeg for all floods of less than 115,000 c.f.s. Thus, the circumstances under which the additional protection provided by the Portage Diversion would be required would be in those very major floods ranging from 115,000 c.f.s. to 200,000 c.f.s. or larger, and in floods of this magnitude it is quite likely that there would be a large flow on the Assiniboine. In controlling this flow, a substantial degree of flood protection on the Assiniboine River would be extremely valuable.

In order to determine the most economical size of floodway, let it be assumed that a 40,000 c.f.s. Greater Winnipeg Floodway plus flood protection works on the Assiniboine River with a capacity of 40,000 c.f.s. have been adopted as the core of the city's flood protection. What additional expenditures would be justified for increasing the size of the floodway? The data in Table 11.2 provide the basis for an answer to this question. These data indicate that in combination with a 40,000 c.f.s. Portage Diversion an increase in the capacity of the floodway from 40,000 c.f.s. to 60,000 c.f.s. yields an incremental benefit-cost ratio of only .88. In other words the additional annual benefit obtained from such an addition to the capacity of the floodway is slightly less than the cost of providing it. This is true even though the overall benefit-cost ratio is 2.86. For the further increase from 60,000 c.f.s. to 80,000 c.f.s., the incremental ratio is lower still, being only .81. However, throughout the range of floodway capacities from 40,000 to 80,000 c.f.s. the additional benefits and additional costs are fairly close together.

The benefits in this comparison are based on present property values and incomes only. If allowance is made for the growth now in prospect for the Greater Winnipeg area, these incremental ratios would be about 50 percent higher, that is, 1.32 and 1.22 instead of .88 and .81. The stage-discharge and frequency-damage charts used in the calculation of benefits for the 25,000 c.f.s. and 40,000 c.f.s. Portage Diversions in combination with the 40-768 to 80-768 floodways are shown in Plates 29 and 30.

Because the separate benefit-cost ratio yielded by the Lister's Rapids removal project, Trial B, was comparatively high, an analysis was made to determine the additional benefit it would provide in combination with a 40,000 c.f.s. Portage Diversion and a major floodway. The results of this analysis are as follows:

	Benefit-Cost Ratio
Trial B plus 40-768 + 40 P.D.	2.87
Trial B plus 60-768 + 40 P.D.	2.44

	Incremental Benefit-Cost Ratio
For addition of Trial B to 40-768 + 40 P.D.	.68
For addition of Trial B to 60-768 + 40 P.D.	.49

These data show that Trial B would not be economically justified when considered as an addition to a project involving a 40,000 c.f.s. capacity Portage Diversion and a 40,000 c.f.s. or 60,000 c.f.s. floodway. Substantially the same results would have been obtained if Trial B had been considered in combination with the Russell Reservoir and the 25,000 c.f.s. Portage Diversion together with a 40,000 c.f.s. or 60,000 c.f.s. Greater Winnipeg Floodway. The incremental-ratios for Trial B in such a combination are well below 1.0, namely, .68 in combination with a 40,000 c.f.s. Portage Diversion and a 40-768 Floodway and .49 in combination with a 40,000 c.f.s. diversion and a 60-768 floodway. Accordingly, no further consideration was given to this project.

Two other projects, which gave very favourable benefit-cost ratios when considered as

Table 11.2

INCREMENTAL BENEFIT-COST ANALYSIS

GREATER WINNIPEG FLOODWAYS AND PORTAGE DIVERSION IN COMBINATION

Increase in Project*	Increase in Annual Cost	Increase in Annual Benefit	Incremental Benefit-Cost Ratio
From 40,000 c.f.s. P.D. to 40,000 c.f.s. P.D. +40-768.......	$2,303,400	$4,650,200	2.02
From 40,000 c.f.s. P.D. +40-768 to 40,000 c.f.s. P.D. +60-768.......	858,300	752,000	.88
From 40,000 c.f.s. P.D. +60-768 to 40,000 c.f.s. P.D. +80-768........	770,100	626,300	.81

*Basis High Bluff Diversion.

separate projects, were also analyzed in combination with the floodway and Portage Diversion. These two projects are the Russell Reservoir and the Eastern Tributaries diversion. The Russell Reservoir was considered primarily as an alternative to the increase in the size of the Portage Diversion from 25,000 c.f.s. to 40,000 c.f.s. The Eastern Tributaries Diversion was analyzed in combination with a 40,000 c.f.s. Portage Diversion and a 40-768 and 60-768 Floodway.

On the Assiniboine River, the benefit-cost analysis indicates that protective works with a capacity of about 40,000 c.f.s. are economically justified. Protection of roughly this amount can be provided either by the construction of a 40,000 c.f.s. diversion at Portage la Prairie or by construction of a 25,000 c.f.s. diversion at Portage together with the Russell Reservoir.

Attention of the Commission was also drawn to the fact that the P.F.R.A. are currently investigating a proposal for the construction of a large storage reservoir west of Portage la Prairie. It is possible that this project might provide substantially the same flood protection benefits in the area downstream from Portage la Prairie as the Russell Reservoir and the 25,000 c.f.s. Portage Diversion. For this reason, the Commission recommends that the benefits and cost of this proposal should be analyzed as soon as the engineering data are available.

A number of considerations favour the choice of the Russell Reservoir plus the 25,000 c.f.s. Diversion in preference to the 40,000 c.f.s. Portage Diversion. The Russell Reservoir provides flood protection to the City of Brandon and to farmlands in the Assiniboine River Valley between the site of the Reservoir and Portage la Prairie, areas which would not otherwise be protected. The Russell Reservoir also makes it possible to maintain higher minimum water levels downstream from the reservoir and thus provides a valuable benefit in the form of a more assured potable water supply and a better sewage dilution for cities and towns along the river. For the City of Winnipeg it provides better sewage dilution and in combination with a water supply channel from Lake Manitoba, should make it possible to avoid the very considerable expense of converting the existing sewage disposal plant from primary to secondary treatment. The Manitoba Hydro-electric steam power plant at Brandon would also benefit from this more assured water supply. While an annual water supply benefit of $128,000 has been included in our benefit-cost analysis on this project, a complete study of the water supply problem has not been made since this is beyond the scope of this Commission's task. However, we are reasonably confident that there are additional water-supply benefits which have not been included in our analysis.

On the other hand, if the Russell Reservoir is to be operated so as to provide an optimum benefit to Greater Winnipeg, an accurate flood forecast would be required. Its location is 200 miles north and west of Greater Winnipeg and the spring break-up is likely to occur later there than it does in Winnipeg. In addition, it normally requires about 10 to 13 days for the flow of water to travel downstream from the site of the Russell Reservoir to Winnipeg. Nevertheless, since the Russell Reservoir has a peak storage capacity of 600,000 acre-feet, it would be possible to reduce the flow immediately below the reservoir by an average of 15,000 c.f.s. per day for a 20-day period, or by an average of 10,000 c.f.s. for a 30-day period. To permit this reduction, the reservoir would have to be completely emptied in advance of the flood period.

It is also true that, from a benefit-cost point of view, the 40,000 c.f.s. diversion is slightly more favourable than the combination of a 25,000 c.f.s. diversion with the Russell Reservoir. In combination with a 60,000 c.f.s. Greater Winnipeg Floodway, the 40,000 c.f.s. High Bluff Diversion gives a benefit-cost ratio of 2.86 compared with a ratio of 2.73 for a 25,000 c.f.s. High Bluff Diversion and the Russell Reservoir. Moreover, the incremental benefit-cost ratio obtained by increasing the size of the diversion from 25,000 c.f.s. to 40,000 c.f.s. is 3.13 whereas the incremental benefit-cost ratio obtained from the Russell Reservoir is only 1.41. As against this, in serious floods, the Russell Reservoir provides more dependable flood protection for the City of Portage la Prairie. If the 40,000 c.f.s. High Bluff Diversion were constructed, flood protection would be provided in the form of a long dyke but this form of protection is less certain.

Taking into account all these considerations, this Commission decided to recommend the Russell Reservoir in combination with the 25,000 c.f.s. High Bluff Portage Diversion in preference to the 40,000 c.f.s. Diversion. The High Bluff route for the Portage Diversion is clearly preferable to the Fort La Reine route because it gives approximately the same benefits and costs $2,338,000 less.

In analyzing the effects of the Eastern Tributaries Diversion in combination, it was assumed that the intake structure of the floodway would be operated so as to maintain natural water levels upstream of the floodway. Under this method of operation the discharge reduction produced by the Eastern Tributaries Diversion at Redwood Bridge gives a larger stage reduction than it would in the absence of the Greater Winnipeg Floodway. Due to the shape of the Redwood Bridge rating curve, a given discharge reduction produces a much larger stage reduction at a low flow than it does at a higher flow. Maintenance of the natural water level upstream of Winnipeg reduces the benefit that would accrue to the area south of Winnipeg. However, because the size of the damages in this area is smaller than in the city, this method of operation attributes a larger benefit to the Eastern Tributaries scheme than any other method of operation.

The benefit-cost data indicate that the additional benefit provided by the Eastern Tributaries Diversion in combination with a floodway and Portage Diversion is not large enough to justify the cost of the project. Thus the incremental benefit-cost ratio for the Eastern Tributaries Diversion in combination with a 40-768 Floodway and a 40,000 c.f.s. Portage Diversion is only .59. Such an expenditure is considerably less economical than the expenditure required to increase the size of the floodway from 40,000 to 60,000 c.f.s. This latter expenditure has an incremental benefit-cost ratio of .88 (*see Table* 11.2).

When considered in combination with a 60,000 c.f.s. Greater Winnipeg Floodway, a 25,000 c.f.s. Portage Diversion and the Russell Reservoir, the Pembina Dam provides only enough flood control benefits to give an incremental benefit-cost ratio of .32. It provides additional flood control benefits of $27,400 in the Red River Valley and additional benefits of $52,000 in Greater Winnipeg. The engineering studies that the Red River Basin Investigation made of this project were not complete and it is possible that more thorough study will show further flood control benefits.

In addition to its flood control benefits the Pembina Dam might provide substantial benefits in the form of an improved and dependable supply of water for the water short Pembina triangle. This water supply would be of substantial value for household, farm, industrial and commercial use, for irrigation and for sewage dilution. However, a major engineering and economic study would be required to determine the dollar benefits that could be attributed to this water supply.

After careful consideration this Commission decided it could not recommend this project as a flood control measure on the basis of the engineering data presently available. However, it does recommend that an exhaustive study be made of the Pembina River with a view to evaluating completely the flood control and water supply benefits that might accrue from the construction of a dam and reservoir on this river.

RECOMMENDATIONS

On the basis of the above analysis and some further considerations explained below, the Royal Commission on Flood Cost-Benefit voted to recommend the following combination of projects:

(a) A 60,000 c.f.s. Greater Winnipeg Floodway;
(b) A 25,000 c.f.s. Portage Diversion on the High Bluff route;
(c) The Russell Reservoir.

In conjunction with the construction of the Portage Diversion, the Commission also recommended that the channel capacity between Portage la Prairie and Winnipeg should be maintained at its present level.

The capital cost of this combination is estimated to be $72.5 million (with a 60-768 Floodway) and its overall benefit-cost ratio based on present property values and incomes is 2.7. If allowance is made for the growth that can be reasonably anticipated to occur in Greater Winnipeg over the next 25 years, a benefit-cost of about 4.1 is obtained for this combination. These ratios are based on a 4 percent interest rate.

In arriving at its final decision, the Commission was guided by two general considerations. It was felt that it would be desirable to provide Winnipeg with protection against at least a 1 percent flood, that is, a flood which can be expected to occur on the average of once in one hundred years, in this instance a flow of about 150,000 cubic feet per second. Beyond that point, the degree of protection should be as large as was consistent with a favourable benefit-cost ratio. In deciding on the final size of the various projects, particular attention was given to the marginal or incremental benefit-cost ratio, which measures the additional benefit obtained from any increase in the size of a project compared with the additional cost of obtaining this benefit.

For various combinations of the Greater Winnipeg Floodway and the Portage Diversion, the benefit-cost analysis indicated that the retention or diversion of 40,000 c.f.s. on the Assiniboine together with a Greater Winnipeg Floodway in the size range from 40,000 c.f.s. to 60,000 c.f.s. would be justified. A 40-768 Floodway plus a 40,000 c.f.s. Portage Diversion would provide protection against a flood of 147,000 c.f.s., with a water level in the Red River through Winnipeg about one foot below the top of the existing dyking system. For the 60-768 Floodway, 40,000 c.f.s. Portage Diversion combination the protection provided is 174,000 c.f.s. Thus, any project in this size range meets one of the general guiding considerations adopted by the Commission, the provision of protection against a 1 percent flood.

By itself, the Portage Diversion has a very high benefit-cost ratio and this is true even for the largest size of this diversion for which designs are available, the 40,000 c.f.s. design. These high ratios reflect the fact that because of the comparatively short length of the diversion, the cost per 1,000 c.f.s. of water diverted is comparatively low. Moreover, once a smaller diversion has been constructed, the additional cost of increasing its capacity is small. Thus, for the High Bluff Diversion, although it costs $5,709,000 to build a 10,000 c.f.s. diversion, it costs only $2,963,000 to increase its size from 10,000 c.f.s. to 25,000 c.f.s. and only $2,189,000 to increase its size from 25,000 c.f.s. to 40,000 c.f.s.

As was pointed out above, when the Greater Winnipeg Floodway is considered in combination with the retention or diversion of 40,000 c.f.s. on the Assiniboine River, the incremental benefit-cost ratio remains above 1.0 until a 40,000 c.f.s. Floodway is reached. Beyond that point the incremental ratio is slightly below 1.0. At 60,000 c.f.s. the incremental benefit-cost ratio is about .9 and at 80,000 it is about .8. This indicates that in combination with flood protection works of up to a capacity of 40,000 c.f.s. for the Asssiniboine River, the additional cost of any increase in the size of the floodway is just slightly larger than the additional benefit obtained from this increase.

In these ratios, benefits are based on present property values and incomes only. When allowance is made for the growth that can be expected in Greater Winnipeg during the next twenty-five years, these ratios can be increased by a factor of 50 percent. On this basis the incremental benefit-cost ratio at 60,000 c.f.s. would be 1.32 and at 80,000 c.f.s. 1.22.

In recommending the construction of a 60,000 c.f.s. Floodway, the Commission felt it was desirable to give some attention to the future growth of Greater Winnipeg. Unless provision is made now for the additional flood protection that this expected growth justifies, it will be very difficult, if not impossible, to do so in the future. In combination with the projects recommended on the Assiniboine River, a 60,000 c.f.s. Floodway around Winnipeg would provide a degree of flood protection for the city that would ensure its continued growth and prosperity.

In addition, it was felt that it was desirable to have a larger proportion of the flood protection works on the main stem of the Red River than would be justified on the basis of the benefit-cost analysis alone. Because about 80 percent of the flood flows in Greater Winnipeg originate on the Red River, flood protection works on the Red provide a more reliable form of protection than projects on the Assiniboine.

To sum up, the three projects recommended will provide the following benefits:

(a) They will provide complete protection to all parts of Greater Winnipeg outside the primary dyking system for all floods of up to 169,000 c.f.s. A flood flow of 169,000 c.f.s. can be expected to be equalled or exceeded on the average of once in 160 years. With such a flood flow, it can be expected that, on the average, about 76,000 c.f.s. would flow through Winnipeg with a flood elevation about one foot below the top of the existing dyking system; some 66,000 c.f.s. would flow through the floodway channel, some 10,000 c.f.s. would be held back by the Russell Reservoir and 25,000 c.f.s. would be diverted into Lake Manitoba by the Portage Diversion. Since not all of the 35,000 c.f.s. withheld or diverted on the Assiniboine produces an equivalent reduction in Winnipeg, the total of the above exceeds 169,000 c.f.s.

In addition, if a larger flood than 169,000 c.f.s. were to occur in the Greater Winnipeg area, there would be a possibility of obtaining a considerable additional margin of protection. Thus, with the construction of temporary dykes that would allow the water level in the channel to be raised by 4 feet, there would be a possibility of carrying an additional 22,000 c.f.s. through the city. Further, if the floodway gates were operated in such a way as to raise the water level at St. Norbert to 3 feet above its natural level in any given flood, it would be possible to pass an additional 11,000 c.f.s. through the floodway. Thus, with this combination of projects it would be possible to fight a flood of up to 200,000 c.f.s. in the Greater Winnipeg area.

(b) They will provide complete protection to the area between Portage la Prairie and Winnipeg for all floods below 55,000 c.f.s. on the Assiniboine.

(c) The Russell Reservoir will provide protection in the Brandon area for all floods of less than 33,000 c.f.s. for the area behind the dyke, and for all floods of less than 16,000 c.f.s. for the area outside the dyke.

(d) The Russell Reservoir will protect the area from Millwood to Brandon for floods of up to about 16,000 c.f.s.

(e) The Russell Reservoir provides a number of important supplementary benefits in the form of improved water supply and sewage benefits and also creates a lake which will have recreational benefits.

Finally, on the basis of existing property and income, this combination of projects gives a benefit-cost ratio of 2.7. In other words, over a long period of time, the expenditure involved, some $72.5 million, will yield a benefit in terms of flood damages prevented, of about $2.70 for every $1.00 invested in this project.

If allowance is made for the growth that may be anticipated for the Greater Winnipeg area, this ratio becomes 4.1, which means that the province and city will get a net return, in terms of flood damages prevented and other ancillary benefits, of $4.10 for every $1.00 invested in these three projects.

For convenient reference, a summary of the benefits, costs and benefit-cost ratios on the various projects is presented in Tables 11.3 to 11.6.

Table 11.3

BENEFIT-COST ANALYSIS — SUMMARY
MAJOR FLOOD PROTECTION PROPOSALS (CONSIDERED SEPARATELY)

Project	Total Capital Cost	Annual Cost	Average Annual Benefit	Benefit-Cost Ratio
GREATER WINNIPEG FLOODWAYS				
40-768 Floodway	$41,724,000	$2,303,400	$ 7,595,000	3.30
60-768 Floodway	57,361,000	3,161,700	9,127,200	2.89
80-768 Floodway	71,436,000	3,931,800	10,151,400	2.58
PORTAGE DIVERSIONS				
10,000 c.f.s. High Bluff Diversion	5,709,000	342,800	2,357,800	6.88
25,000 c.f.s. High Bluff Diversion	8,672,000	506,200	4,586,600	9.06
40,000 c.f.s. High Bluff Diversion	10,861,000	630,100	5,436,900	8.63
10,000 c.f.s. Fort la Reine Diversion	6,584,000	396,100	2,357,800	5.95
25,000 c.f.s. Fort la Reine Diversion	11,010,000	635,900	4,586,600	7.21
40,000 c.f.s. Fort la Reine Diversion	14,097,000	803,100	5,436,900	6.77
EASTERN TRIBUTARIES DIVERSION	11,330,000	652,000	1,483,900	2.28
RUSSELL RESERVOIR	6,450,000	333,900	2,062,400	6.18
STE. AGATHE DETENTION BASIN				
Additional Damage Approach	9,234,000	451,300 (a)	4,475,100	9.92
Flooding Rights Approach	26,804,000	1,269,000 (a)	4,623,000	3.64
PEMBINA RESERVOIR	5,140,000	251,300 (a)	536,700 (b)	2.14
REMOVAL OF LISTER'S RAPIDS				
Trial 12	5,674,000	290,500 (a)	1,294,500	4.46
Trial B	14,925,000	764,200 (a)	3,296,000	4.31
Trial C	29,326,000	1,501,600 (a)	5,156,000	3.43
CHANNEL IMPROVEMENT EXTENDED THROUGH GREATER WINNIPEG				
Plan No. 1 (110,000 c.f.s.)	66,547,000	3,407,600 (a)	7,120,000	2.09
Plan No. 2 (130,000 c.f.s.)	106,936,000	5,475,700 (a)	8,857,500	1.62
Plan No. 3 (140,000 c.f.s.)	122,949,000	6,295,600 (a)	9,395,000	1.49
EXTENSION OF EXISTING GREATER WINNIPEG DYKES	10,000,000	484,100 (a)	581,500	1.20

(a) Excludes Maintenance Costs.
(b) Includes Flood Protection Benefits Only.

Table 11.4

BENEFIT-COST ANALYSIS — SUMMARY
MAJOR FLOOD PROTECTION PROPOSALS (CONSIDERED IN COMBINATION)

Project Combination	Total Capital Cost	Annual Cost	Average Annual Benefit	Benefit-Cost Ratio
40-768 Floodway plus 10,000 c.f.s. High Bluff Diversion	$47,433,000	$2,646,200	$ 8,461,400	3.20
60-768 Floodway plus 10,000 c.f.s. High Bluff Diversion	63,070,000	3,504,500	9,835,900	2.81
80-768 Floodway plus 10,000 c.f.s. High Bluff Diversion	77,145,000	4,274,600	10,690,700	2.50
40-768 Floodway plus 25,000 c.f.s. High Bluff Diversion	50,396,000	2,809,600	9,383,500	3.34
60-768 Floodway plus 25,000 c.f.s. High Bluff Diversion	66,033,000	3,667,900	10,450,800	2.85
80-768 Floodway plus 25,000 c.f.s. High Bluff Diversion	80,108,000	4,438,000	11,178,300	2.52
40-768 Floodway plus 40,000 c.f.s. High Bluff Diversion	52,585,000	2,933,500	10,087,100	3.44
60-768 Floodway plus 40,000 c.f.s. High Bluff Diversion	68,222,000	3,791,800	10,839,100	2.86
80-768 Floodway plus 40,000 c.f.s. High Bluff Diversion	82,297,000	4,561,900	11,465,400	2.51
40-768 Floodway plus 25,000 c.f.s. High Bluff Diversion plus Russell Reservoir	56,846,000	3,143,500	10,090,900	3.21
60-768 Floodway plus 25,000 c.f.s. High Bluff Diversion plus Russell Reservoir	72,483,000	4,001,800	10,921,100	2.73
40-768 Floodway plus 40,000 c.f.s. High Bluff Diversion plus Lister's Rapids Trial B	67,510,000	3,697,700 (a)	10,609,100	2.87
60-768 Floodway plus 40,000 c.f.s. High Bluff Diversion plus Lister's Rapids Trial B	83,147,000	4,556,000 (a)	11,215,600	2.44
40-768 Floodway plus 40,000 c.f.s. High Bluff Diversion plus Eastern Tributaries Diversion	63,915,000	3,585,500	10,473,500	2.92
60-768 Floodway plus 40,000 c.f.s. High Bluff Diversion plus Eastern Tributaries Diversion	79,552,000	4,443,800	11,176,700	2.52
60-768 Floodway plus 25,000 c.f.s. High Bluff Diversion plus Russell Reservoir plus Pembina Reservoir	77,623,000	4,253,100 (b)	11,000,500 (c)	2.50

(a) Excludes maintenance costs on Lister's Rapids—Trial B.
(b) Excludes maintenance costs on Pembina Reservoir.
(c) For Pembina Reservoir, flood protection benefits only are included.

Table 11.5

INCREMENTAL BENEFIT-COST ANALYSIS — SUMMARY
MAJOR FLOOD PROTECTION PROPOSALS (CONSIDERED SEPARATELY)

Increase in Size	Increase in Annual Cost	Increase in Annual Benefit	Incremental Benefit-Cost Ratio
GREATER WINNIPEG FLOODWAYS			
From 40-768 to 60-768	$ 858,300	$1,532,200	1.79
From 60-768 to 80-768	770,100	1,024,200	1.33
PORTAGE DIVERSION (High Bluff Route)			
From 10,000 c.f.s. to 25,000 c.f.s.	163,400	2,228,800	13.64
From 25,000 c.f.s. to 40,000 c.f.s.	123,900	850,300	6.86
REMOVAL OF LISTER'S RAPIDS			
From Trial 12 to Trial C	1,211,100 (a)	3,861,500	3.19
From Trial B to Trial C	737,400 (a)	1,860,000	2.52
CHANNEL IMPROVEMENT EXTENDED THROUGH GREATER WINNIPEG			
From Plan 1 (110,000 c.f.s.) to Plan 2 (130,000 c.f.s.)	2,068,100 (a)	1,737,500	.84
From Plan 2 (130,000 c.f.s.) to Plan 3 (140,000 c.f.s.)	819,900 (a)	537,500	.66

(a) Excludes maintenance costs.

Table 11.6

INCREMENTAL BENEFIT-COST ANALYSIS — SUMMARY
MAJOR FLOOD PROTECTION PROPOSALS (CONSIDERED IN COMBINATION)

Increase in Size	Increase in Annual Cost	Increase in Annual Benefit	Incremental Benefit-Cost Ratio
INCREASE 40-768 FLOODWAY			
(a) by adding 25,000 c.f.s. High Bluff Diversion	$ 506,200	$1,788,500	3.53
(b) by adding 40,000 c.f.s. High Bluff Diversion	630,100	2,492,100	3.96
INCREASE 40-768 FLOODWAY PLUS 25,000 C.F.S. HIGH BLUFF DIVERSION			
(a) to 40-768 Floodway plus 40,000 c.f.s. High Bluff Diversion	123,900	703,600	5.68
(b) by adding Russell Reservoir	333,900	707,400	2.12
(c) to 60-768 Floodway plus 25,000 c.f.s. High Bluff Diversion	858,300	1,067,300	1.24
INCREASE 60-768 FLOODWAY PLUS 25,000 C.F.S. HIGH BLUFF DIVERSION			
(a) to 60-768 Floodway plus 40,000 c.f.s. High Bluff Diversion	123,900	388,300	3.13
(b) by adding Russell Reservoir	333,900	470,300	1.41
INCREASE 40-768 FLOODWAY PLUS 40,000 C.F.S. HIGH BLUFF DIVERSION			
(a) by adding Lister's Rapids Trial B	764,200	522,000	.68
(b) by adding Eastern Tributaries Diversion	652,000	386,400	.59
INCREASE 60-768 FLOODWAY PLUS 40,000 C.F.S. HIGH BLUFF DIVERSION			
(a) by adding Lister's Rapids Trial B	764,200	376,500	.49
(b) by adding Eastern Tributaries Diversion	652,000	337,600	.52
INCREASE 60-768 FLOODWAY PLUS 25,000 HIGH BLUFF DIVERSION PLUS RUSSELL RESERVOIR			
(a) by adding Pembina Reservoir	251,300	79,400	.32

INTERNATIONAL JOINT COMMISSION

PUBLIC CONSULTATIONS
RED RIVER BASIN

* *

WINNIPEG, MANITOBA

WEDNESDAY, FEBRUARY 11, 1998

* *

INTERNATIONAL JOINT COMMISSION

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DON HERNWN, U.S. co-director of task force.

PRESENTERS:

WEDNESDAY, FEBRUARY 11, 1998
Upon commencing at 6:00 p.m.

THE CHAIRMAN: Good evening, ladies and gentlemen. I would like to thank all of you for coming out this evening. We know that a lot of you are still grappling with the effects of the flood, and we appreciate all the more your coming here to share your experiences with us.

That's the reason we are here. We want to hear from you. We want your views on the 40 recommendations made in the interim report that we released last December. We want your comments on the plan of study outlined in that Interim Report, and more generally, we want to know anything you think we need to know.

Pour les francophones, panni vous vous noterez que la traduction sumultanee est disponible, alors si vous voulez nous adresser la parole en francais, soyez les bienvenue.

The agenda for our meeting this evening is as follows. First of all, I am the graph there, you can still see in the pink that he has under forecast the amount of run-off that is going to occur in the basin.

It isn't until April 20th, when he produces his last forecast that he ups the forecast, and you can see from the green bars that he is above the observed levels upstream, from Emerson to St. Adolphe, and then a bit below normal, or a bit below the observed levels from the floodway into James Avenue.

Now the reason why the forecaster had a problem of forecasting the flows --

THE CHAIRMAN: I wonder if I could ask you if you could complete your presentation in the next two minutes?

MR. MORGAN: okay. It wasn't until after Grank Forks flooded, where the forecaster revised his flowed upwards. Initially, the problem is, the forecaster is uncertain how much run-off is going to occur from the tributaries, and it is not until the water is into the Red River, and that is why when he saw the amount of water at Grand Forks that he could better predict what the peaks would be on the Canadian side.

Now, the City at that point had 12 days for warning of the maximum, of when the peak would occur at James Avenue. So it is, even if you have given him another week of notice, the City really only has 21 days of notice of a large flood coming along.

Here is a plot of levels, rise in levels, relative difference going from 1979 to 1997. You can see as levels got closer to the City, the levels were rising quite considerably, but by Emerson and St. Jean they are two feet, but six feet up at the floodway.

I have made a prediction of what would happen under an 1826 flood, and that is levels rising relative to the 1997 flood. You see that levels are rising in Emerson to Moms of about two to three feet, but Ste. Agathe up way to the floodway, you have a rise of six to eight feet in levels, and that is similar to what Qas Booy said. That is based on the assumption that you are going to maximum the floodway flow, that is not necessarily what could happen on the floodway rules.

This is the plot of the same information. The blue plot was the information

that was shown on the last graph, but if you operate it to the floodway current rules, you could see levels in the City rising six to seven feet for an 1826 flood. Well, that would put it three or four feet above the 1950 flood. But even if you went to the flood -- maximizing the floodway, you could see a flood of 1826 in the City equally in the 1950 conditions. So an awful amount of flooding would occur in the basin.

So the planners' questions is knowing the levels, how will the floodway be operated? And a number of speakers have made that point. Who is at risk? What is the economic loss? What is the return period? That return frequency analysis stills comes up. Does the economic loss and return period adjust to the higher level of flood protection? And it appears that Winnipeg and the people just upstream of it are at high risk to a larger flood.

Last line, Mr. Chairman.

My suggestion to the IJC is to add to their conceptual study framework by having an initial planning level study first. And

that planning level study would feed into the data, the tools and the strategies.

Now, I have shown it up front, but it could be maybe down in the strategies box area.

I think what you should be looking at is identify the critical issues, that would help you better define the tool development, and begin the public policy discussion over the floodway operation and the benefit cost analysis.

Thank you very much, Mr. Chairman.

MR. CLAMAN: Paul Clifton, and you have a video that you wanted to show. Paul will be followed by Cec Muldrew.

MR. CLIFTON: Mr. Chairman, while they are setting up the video and before you start your watch, I would be first one to ask the Commission, if you are excavating the floodway and taking out 10 feet clay, river lot 62 South Red River Drive, I could use a lot of it.

Mr. Chairman, my wife and I would like to thank the Commission for the opportunity for me to speak, with our recommendations and conditions. My name is Paul Clifton. *Our* property is located half a mile upstream of the floodway inlet in the RM of Ritchot.

First, I would like in my presentation to present a video clip from the CBC National News relating to the flood. I wish the Commission to note the date, the comments from the Mayor of the City of Winnipeg, Manitoba Water Commission spokesman comments, and the flooded residents' comments.

You can play it, please.

(VIDEO PLAYED)

Mr. Chairman, I wish to note that the intent of this presentation is not to pit the residents within the protection of the Greater Winnipeg floodway against those affected by the control works, but to offer constructive criticism and recommend possible solutions to Red River flooding. Were Winnipeg properly protected -- prepared, I am *sorry,* were Winnipeg properly prepared.

The Winnipeg floodway was

constructed in the mid 1960s and has been seen to be a tremendous engineering marvel, accomplished with limited dollars in 1962, '62 dollars.

Since the completion of the floodway in the late '60s, the growth of Winnipeg, as in most major cities in North America, expanded from the core into the suburbs, with development driven by market demand and hopefully careful considerate development and land use policies.

Here in the Red River Valley, which includes the City of Winnipeg, mother nature, on occasion, shows us the shortfalls of our human interventions. Over the years, man's attempted intervention to redirect river flows has caused tremendous hardships for the powerless people in its way. Dikes are topped, and mounded properties are overcome by flooding. This was evident in the Mississippi Valley flooding, Saguenay in Quebec and most recently Red River flooding.

The development of Winnipeg's southern suburbs has continued without consideration or regulation regarding land use

policy. The City of Winnipeg Act governs the way in which the City is managed and developed. The Province of Manitoba manages land use outside the City boundaries.

Case in point, City of Winnipeg South End Water Pollution Control Centre, commonly known as the South End Sewage Treatment Plant, was constructed and completed in 1974, with the effluent conduit to the Red River. The invert elevation of **this** conduit is 229.057 metres above sea level, or 751.449 feet above sea level, or 25.5 feet James Street. See attachment number one -- A, I mean.

What do these numbers represent? The level of 751.5 is the height above sea level to which the program of operation, dated July '70, was to control the river level at the Redwood Bridge, prior to the advancement of emergency operation.

25.5 James Street is a measure of water feet above normal Red River winter levels at the James Street pumping station, referenced in a revised program of operation dated October '84, prior to the advancement to emergency operation, restricting river flows into

Winnipeg.

The location James Street pumping station is a few miles downstream of the South End Treatment Sewage Plant, and so with the river gradient **this** plant discharge elevations well below, well low at flood levels, **this** potential causing flooding of the plant's mechanical and electrical rooms. In addition, it has been acknowledged that newer or post floodway constructed homes have a storm sewer set at 24.5 James Street, placing these homes at **risk** of basement flooding if the program of operation were followed.

In this past year's flood, an agreement between the Province of Manitoba and the City of Winnipeg **was** created deviating from the program operation, allowing the City Mayor to breathe a little easier.

Were the Clifton's prepared? Our home was protected by its original owners with a two foot sandbag dike in 1979, the highest flood since the completion of the floodway and before 1997. Our home was removed from its foundation, its '79 foundation, and raised on piles and new foundation in May of 1980. This flood-proofing was cost shared by the Province and the resident, Provincial contribution of $11,500.00. See the attachment.

This past year, 14,000 sandbags were placed around our home creating a four-and-a-half foot dike, with an additional 6,000 sandbags brought in by boat to a height of six and a half to seven feet after road access was cut off. We were able to save our home despite the operation of the floodway.

The government or its agents should not be faulted for the flood protection of the City of Winnipeg during the past year, but they should be truthful in that the operation of the floodway doesn't help us at all.

Mr. Chairman, Maxine and I have taken responsibility for where we live.

Has there been precedent set in the Province of Manitoba or North America for such an extensive water management system to provide benefit for so many and affect so few. Ironically, within the same Province, the Province of Manitoba, there is this precedent.

In the same time frame as the

construction of Greater Winnipeg Floodway, the demands for clean, efficient and inexpensive electricity were recognized. Again, civil engineers devised a plan to deviate river flows of a river, the Churchill, into a northern lake, maximizing the water contributions to the Upper Nelson River. The river emptied into Hudson's Bay, providing an abundant hydroelectric resource to the people of Province of Manitoba, which we all enjoy.

Within this project, the Churchill River Diversion and the accompanying Lake Winnipeg Regulation, the Northern Flood Agreement was struck. This agreement was signed by the four principal parties, Government of Canada, the Province of Manitoba, Manitoba Hydro and the affected native bands.

The Government provided the following: Recognition of detrimental effects of the project to communities, lifestyle, and set a compensation benefits package. The agreement also provided proper setbacks, severance lines from rivers and lakes. Resettlement and restricted development was required in hazardous areas.

This brings me back to the Red River dam, within the Red River immediately south of St. Norbert, Mr. Chairman. Some of us live in the reservoir or foray of this dam.

In your task Interim Report, for expediency, item 1, flood preparedness must be part of the culture of the Red River Valley. Put simply, a flood of 1997 or even larger could happen any year.

We should be aware this past year's flood was as good as it could be hoped for -- given the April blizzard; large winter accumulation of snow in the southern basin; our local melt was slowed by overnight temperatures below freezing; and perfect sunny days for the emergency flood preparations. Unlike that of our neighbors in Grand Forks, those who we observed through the local media struggling through the emergency efforts in the cold, wet, accompanying their impending crest.

Fortunately our melt, the local melt crested well before the larger U.S. water crested.

Gentlemen, this is the best of a bad situation, with a flood that was slightly

less than design capacity of the Red River Floodway. Whether there was six inches or three-and-a-half feet of artificial flooding on the doorstep, the present system of flood protection in the north end of the basin is fundamentally flawed and must be corrected.

What do we need from the Commission? We need a comprehensive flood plan. I am not a professional, but I know how high the water was, and I know something must be done. One that can correct the piecemeal plans that have been implemented to date; one that gives equal levels of protection, i.e., one in 150, one in 300, one in 500, for all within the Valley, including the City of Winnipeg, recognizing the higher costs for those requiring higher financial assistance within the northern reaches of the basin.

We need establishment of a resettlement for those of us who are unable to undertake the personal flood protection, for both geographic or demographic limitations. We need better social supports to prevent mental breakdown and marital breakup. The rebuilding and recovery will take many years and all this, throughout this entire period, many years.

I would also like to say that we must manage the release of water in to the basin in high water years. This had been noted by many. This limitation of the flood waters into the basin must be compensated to the land owners protected by the water management actions.

MR. Chairman, we request the recommendations and actions be considered within this presentation. We need your help. We need it yesterday. El Nino is not here every year. Thank you, Mr. Chairman.

MR. CLAMAN: Cecil Muldrew. And the next presentation will be Bob Stefaniuk.

MR. MULDREW: Good evening. I would like to start by congratulating the Task Force for an excellent report. I have prepared copies of this report and given them to a staff member. It will take me seven minutes to make my presentation.

First, I am not a professional in these matters, but after many years of science teaching, when I read the Interim Report of the International Red River Basin Task Force, I

jotted down thoughts that came to me. Forgive me if they are too simplistic, but if any of them have merit, this is not time wasted.

My comments seem to belong largely under recommendation 12:

"Plans to implement new flood mitigation and flood-proofing measures for individuals in communities -- if sound in economic, environmental, engineering and social terms -- should continue as rapidly as possible. All such measures, whether by government or individuals, should be coordinated and examined to determine possible damage to others within the basin."

And my comments I think are my, I am really working with ideas for the study organization in the flood strategy subgroup.

In 1972, a United Nations conference put the precautionary principle in

to international law. It was reinforced in 1982 when the World Charter of Nature passed in the United Nations, in the general assembly, and it was reinforced again in 1992 at the big Brompten (ph.) Development Conference in Rio.

Precautionary principle applies where there is a threat of serious environmental degradation. I am hopeful that we can apply it in the beautiful 45,000 square miles of the Red River Basin and have a better environment for the generations that come after us.

My thoughts concern landowners in the higher levels, individuals, organizations and governments. I will leave activities in the floodplain to the experts.

To start, I needed to visualize the physical nature of the basin. I understand it to be about 400 miles at its widest and 500 miles long, with about 11 per cent of it in Canada. The elevation of the river drops from about a thousand feet at its southern end to 750 feet in the northern end, almost 300 and feet in 500 miles, which is only about six-tenths of a foot per mile.

The upper margin of the basin is given as 1,200 to 1,600 feet in elevation, which would give a drop of about 600 feet to the river at the wider areas. This works out to an average drop of about three feet per mile, and would be much more because of the wide flat floodplain.

It is for the upper part of the watershed that I would like to make my comments. Land owners should be knowledgeable about the ways to reduce run off. As much of the area should be, as can be, should be covered with trees or bushes to retain snow and improve absorption. Wood lots and wooded breaks between open areas are also helpful. Satellite or aerial surveys could be used to identify possible changes.

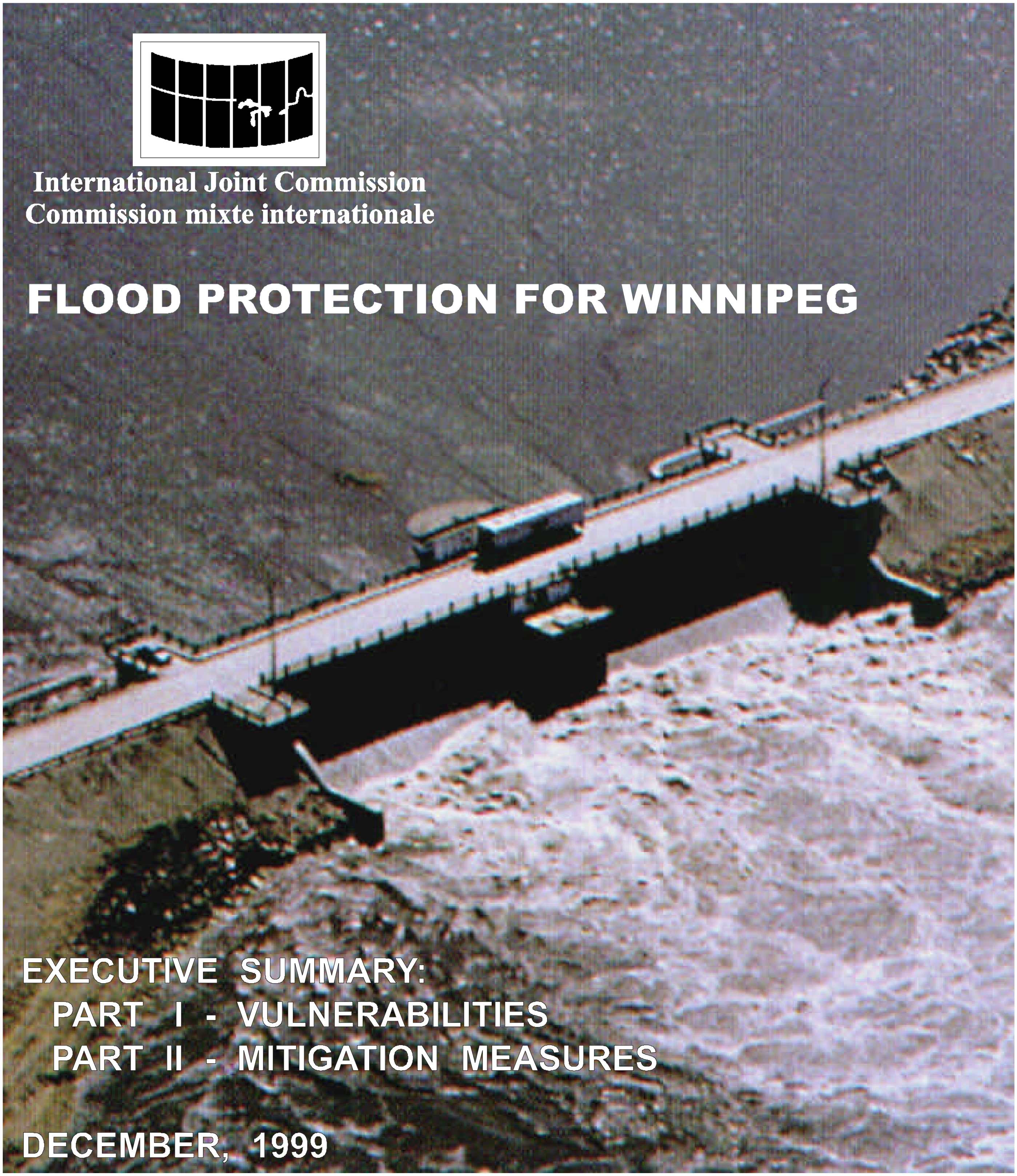
It may be necessary to use or develop crops that have a shorter growing season. I suggest hemp. On crop lands, stubble -- in crop land, stubble should be left using zero till and not burning it off. Trash can be left on open areas.

Past history should be investigated for logging or overgrazing areas.

SPECIAL EXAMINER'S CERTIFICATE

I, LOA M. EYJOLFSON, a DULY APPOINTED SPECIAL EXAMINER in and for the Province of Manitoba, do hereby CERTIFY the foregoing pages, numbered 1 to **128,** inclusive are a true and correct transcript of my stenotype notes as taken by me at the time and place hereinbefore stated.

LOA M. EYJOLFSON
SPECIAL EXAMINER Q.B.



International Joint Commission
Commission mixte internationale

FLOOD PROTECTION FOR WINNIPEG

EXECUTIVE SUMMARY:
PART I - VULNERABILITIES
PART II - MITIGATION MEASURES

DECEMBER, 1999

Submitted by:

KGS GROUP

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

INTERNATIONAL JOINT COMMISSION

FLOOD PROTECTION FOR WINNIPEG

DECEMBER 1999

FLOOD PROTECTION FOR WINNIPEG

EXECUTIVE SUMMARY

I. Introduction

Flood Protection for Winnipeg, is one of several studies the International Joint Commission has commissioned in its investigation of the 1997 Red River "Flood of the Century" for the Governments of Canada and the United States. For this study the Commission is working in partnership with the City of Winnipeg and the Province of Manitoba to fund the analysis of the flood risk for the City of Winnipeg. The consulting firm KGS Group of Winnipeg is conducting the study and a steering committee of representatives from the city, province and federal governments is overseeing the work.

The study has found that in 1997, the Winnipeg flood defen ses worked to the limit of their capacity. Winnipeg escaped the damage that could have occurred if the capacity of the flood protection works had been exceeded, or if there had been failures in one or more of the flood protection structures. There is little margin of error if the City was to face a flood similar to the one in 1997. For a larger flood, the City flood protection defenses need to be improved.

This study has examined the flood defenses, identified areas of vulnerability, and proposed options for reducing the flood risks to the City. The final phase of this study, to be completed in January, 2000, will recommend the highest priority options to improve flood defenses that should be investigated in more detail.

The study reviewed the major flood control facilities that currently provide protection for Winnipeg - the Red River Floodway, the Portage Diversion, the Shellmouth Dam, and the diking systems and related flood protection infrastructure within the City.

The flood protection system in place has limited hydraulic capacity. If that capacity is exceeded there is a high risk of major flood damage. The study estimated potential flood damages using an approach that combines:

- hydraulic information on maximum water levels for a range of flood events
- an economic database of assessed values of residential, commercial and public buildings in Winnipeg that were provided by the City of Winnipeg Property Assessment Department
- a Geographic Information System (GIS) database showing the location of properties, buildings, and infrastructure within the City of Winnipeg
- a GIS database of manhole rim elevations (also from the City of Winnipeg) from which to determine topographic variations throughout the City
- estimates of damages that would occur as a function of the assessed value and depth of flooding at a building. This projection was based on a variety of actual damages that have been documented on flood events in other cities, including the massive flooding at Grand Forks, North Dakota in 1997.

II. Potential Damages

The analysis of potential flood damages demonstrated that, had flood control measures failed in 1997, the total damages to Winnipeg could have been about $7 60 million. These damages could result from:

- damages to buildings and contents
- temporary relocation costs
- damages to City infrastructure
- flood fighting and emergency response costs

If a major flood occurs on the scale of that which was estimated to have occurred in 1826 , an estimated $5.8 billion (1999 dollars) in flood damages could be incurred. This flood has approximately a 20% chance of occurring or being exceeded within the next 50 years. (There is also an estimated 10% chance of damages over $10 billion in the same period.) These damage estimates exclude loss of income caused by the extended shutdown of the majority of the businesses in Winnipeg , and the adverse social implications that would accompany it .

III. Current Capacity of Flood Protection Works

KGS Group has reviewed the individual capacities of each of the major flood protection works and estimated the overall ultimate discharge capacities of the existing system. The values are presented below:

- Flow through Winnipeg downstream of the confluence with the Assiniboine River, 71,000 cubic feet per second (cfs)
- Flow through the Red River Floodway, 73,000 cfs, associated with a maximum upstream water level of 774 ft (a tentative estimate of the level that would not compromise the West Dike from erosion that south winds blowing over the “Red Sea” could cause.)
- Maximum diverted flows of 25,000 cfs from the Assiniboine River at the Portage Diversion, and a reduction of 7,000 cfs due to the Shellmouth Dam

1.0 INTRODUCTION

The study reported in this document is one of several that have been, or are being conducted for the International Joint Commission (IJC). These studies have been commissioned subsequent to the occurrence of the "Flood of the Century" in 1997 that caused massive damages in the Red River Valley. Fortunately, the City of Winnipeg escaped the major damage that could have occurred if the capacity of the flood protection works had been exceeded, or if there had been failures in one or more of the flood protection structures. Nevertheless, the event demonstrated that the protection is limited, and the purpose of this study is to investigate that concern.

In the execution of this work, KGS Group interacted with several outside groups and agencies:

- A Steering Committee for this study which was comprised of :
  - R.Halliday , International Joint Commission
  - L.Whitney, Manitoba Water Resources Branch
  - D.McNeil, City of Winnipeg
  - M.Sydor, Environment Canada

- The U.S. Army Corps of Engineers, St. Paul office, graciously provided information and perspectives from their broad experience in flood control in the north-central United States

- KGS Group retained a group of distinguished engineers whose backgrounds and knowledge of the flood control facilities in Manitoba are well known and respected. This group has been designated in this study as the Panel of Experts. These engineers and their affiliations are listed in Appendix A. They provided advice on the identification of vulnerabilities and mitigation measures that should be considered

- KGS Group retained a Consulting Economist, Mr. Ken Boire, who served for many years as the Chief Economist for the U.S. Army Corps of Engineers, Pacific Northwest Region, and has a strong background in flood control economics. Mr. Boire reviewed the procedures proposed for use in assessing flood damage potential in Winnipeg, and provided advice based on his experience.

2.0 MAJOR FLOOD CONTROL WORKS FOR WINNIPEG

The major flood control works that provide protection for Winnipeg are the Red River Floodway, the Portage Diversion, the Shellmouth Dam, and the diking system and related infrastructure within the City. The locations of these facilities are shown in Figure 2.1[1*]. Descriptions of each are provided in the subsections that follow.

2.1 RED RIVER FLOODWAY

Construction of the project was started in 1962 and completed in 1968. The total cost of the Red River Floodway was approximately $63,000,000. The Red River Floodway consists of four components namely the Floodway channel (see Figure 2.2 for general location), the Inlet Control Structure, the dikes and the outlet structure. These components are described below.

The basis of the design of the City of Winnipeg flood protection works was to provide protection for the 1:160 year flood of 169,000 cfs at Redwood Bridge downstream from the confluence of the Assiniboine River. The following discharges and water levels applied to the 1962 design.

Design Flood (natural)	169,000 cfs
Return Period	1:160 years (1962)
Assiniboine River contribution to peak	38,300 cfs (average)
Portage Diversion	25,000 cfs
Reduction of flow due to Shellmouth Reservoir	7,000 cfs
Redwood Bridge (controlled)	752.5 ft
	25 ft (JAPSD)
Floodway Discharge	60,000 cfs
Control Structure Discharge	70,700 cfs
Controlled Discharge James Avenue	77,000 cfs
Water level U/S of Inlet	770.25 ft

[*] References are indicated by superscripts , and are listed prior to Appendix A

inlet at elevation 750 ft permits flows to enter the Floodway when the Red River discharge exceeds approximately 30,000 cfs. As natural stage increases above 30,000 cfs there is a division in flow between the Floodway and the River. The purpose of the inlet control structure is to counteract this drawdown and to regulate the division in flow between the Floodway and the River. The gates in the Inlet Control Structure are normally operated so as to maintain a water surface elevation upstream of the structure at the level that would occur under natural conditions. This normal mode of operation can be contravened for very large floods, however, to prevent to the extent possible, the overtopping of the dikes in Winnipeg.

2.1.3 Dikes

Dikes on either side of the Inlet Control Structure retain the flood waters. East of the Red River the East Dike is incorporated into the embankment created by the Floodway channel excavation. The dike extends parallel to the Floodway and on its west side for a distance of 6 miles. West of the Red River, the West Dike extends a distance of about 20 miles in southern and a westerly direction from the Inlet Control Structure up to the point where the natural ground is above the design flood elevation. The West Dike contains the floodwaters of the Red River and prevents the flow from passing into the La Salle River watershed, where it would bypass the Floodway Inlet Control Structure and enter Winnipeg directly. During large floods, the river water level is well above the natural bank level and flooding extends laterally over many miles (some 25 miles in 1997, for example). This wide body of water has been called the “Red Sea” in local engineering circles, and this name has been used throughout this report.

A current proposal is being considered to extend the West Dike westward along Highway 305, to the vicinity of Brunkild.

2.1.4 Floodway Outlet Structure

The difference in water level over the entire reach of the floodway channel from inlet to outlet is 18 ft under design conditions but the corresponding difference of the Red River between those same points is about 32 ft. The purpose of the outlet structure therefore is to dissipate the energy in the water at its point of re-entry into the Red River near Lockport, thereby preventing damage and erosion to the channel and in the River. The outlet structure is founded on bedrock

Construction of this project was initiated in 1964 and was completed in 1972 at a cost of $10.8 million.

2.4 WINNIPEG DIKING SYSTEM

The diking system within the City of Winnipeg was built immediately after the 1950 Flood. The dikes enclose the Red, Assiniboine and Seine Rivers. They consist mainly of broad boulevard type dikes referred to as the Primary Line of Defence (PLD), mostly built to the designated Flood Protection Level (FPL) or higher. The FPL is defined as the profile along the Red and Assiniboine Rivers that corresponds to the design flood, plus 2 ft of freeboard. The FPL that is currently in use was based on an estimate of the 1 in 160 year flood as determined[31] in 1981. Locations are shown in Figure 2.3. Pumping stations to lift storm water into the rivers are an important element of the diking system. Temporary Secondary dikes for properties between the PLD and the rivers are also required during flood events.

operating rules and the means of selecting gate openings. The City would be vulnerable if there would be an accident or illness that would debilitate the few knowledgeable engineers that were available in 1997.

3.2.2 Embankments Adjacent to Inlet Control Structure

The Inlet Control Structure for the Red River Floodway is adjoined on the east and west sides by granular fill structures that are up to 55 ft in height from the bottom of the river to the top of the structure, and approximately 195 ft in length. The design details of these granular structures were reviewed by KGS Group from design drawings and specifications. The granular fill section consists of a core of fine grained clean sands (Class 3, maximum 3/8 inch), with 10 ft wide filters of nominal 3/8 inch diameter clean sands and gravels (Class 4, maximum 6 inch), and shells of nominal 5/8 inch sands and gravels (Class 5, maximum 12 inches). A zone of selected impervious silt/sand/gravel was placed as a contact on bedrock and the foundation soils. The granular zone transitions into a homogeneous impervious clay section 195 ft from the inlet structure.

There is concern regarding the water retaining capability of this structure for extreme water levels which exceed the design condition of El 771 ft on the upstream side of the structure.

There are no as-built drawings of the structure, and there was no construction report or quality testing report available on materials placed. The design details were reviewed from three perspectives:

- Filter criteria which assess the potential for movement of particles from the base, and the head loss within the filter. The specified grain size distributions were used and assumptions were made about the extreme combination of sizes, but still within the specifications (i.e., a fine base size and a coarse filter size). The filter criteria for particle movement which are commonly used today were not satisfied for the extreme combinations.

- Seepage rates were estimated using a computer model “SEEPW” for estimated permeability conditions (10^{-4} cm/s for Class 3, 10^{-3} cm/s for Class 4). Seepage rates up to 500 gallons/minute were estimated for each of the granular dike sections. Relatively high

Canada

Manitoba CONSERVATION

Winnipeg

FLOOD PROTECTION STUDIES FOR WINNIPEG

MAIN REPORT

NOVEMBER 2001

KGS GROUP

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

1.0 INTRODUCTION

In early 2000, KGS Group submitted a study report on "Flood Protection for Winnipeg" to the International Joint Commission (IJC). That report identified two major flood protection schemes that, if constructed, could substantially reduce Winnipeg's exposure to the risk of major flood damages. It also listed over fifty recommended actions that should be undertaken to move towards the objective of improved flood protection.

In November, 2000, the IJC issued its report "Living with the Red" (IJC, 2000), and recommended a number of actions. A key recommendation was :

"*The City of Winnipeg, the Province, and the federal government should cooperatively develop and finance a long-term flood protection plan for the city that fully considers all social, environmental, and human effects of any proposed flood protection measures and respects both the needs of Winnipeg and the interests of those outside the city who might be affected by such a plan.*"

In December, 2000, the Province of Manitoba commissioned KGS Group to carry out additional studies of the two major flood protection options – the Red River Floodway expansion and the Ste. Agathe Detention Structure. These additional studies were subsequently approved under the Canada-Manitoba Partnership Agreement on Red River Valley Flood Protection. The City of Winnipeg also agreed to become a funding partner and to participate in the study. KGS Group is reporting to a Steering Committee that was appointed by the client group, and consists of the following individuals :

- L. Whitney (Chairman of Steering Committee) – Manitoba Conservation
- D. Bodaly - Government of Canada – Fisheries and Oceans
- R. Halliday - Consultant
- B. Lukey - Consultant, previously Chief Engineer for PFRA
- M. Shkolny/D. McNeil - City of Winnipeg
- H. Schellenberg - Manitoba Agriculture and Food
- A. Vermette – Prairie Farm Rehabilitation Administration (PFRA)

4.0 EXISTING FLOOD PROTECTION FACILITIES FOR WINNIPEG

The major flood control works that provide protection for Winnipeg are the Red River Floodway (Floodway), the Portage Diversion, the Shellmouth Dam, and the diking system and related infrastructure within the City. The locations of these facilities are shown in Plate 1. Descriptions of each are provided in the subsections that follow.

4.1 RED RIVER FLOODWAY

Construction of the project was started in 1962 and completed in 1968. The total cost of the Floodway was $62,700,000. The Floodway consists of four main components, namely the Floodway channel, the Inlet Control Structure, the dikes, and the Outlet Structure. These components are described below.

The basis of the design of the flood protection works was to provide protection for the 1 in 160 year flood of 169,000 cfs at Redwood Bridge, located a short distance downstream from the confluence of the Assiniboine River. The following discharges and water levels applied to the 1962 design.

Design Flood (natural)	169,000 cfs.
Return Period[1]	1 in 160 years (1962)
Assiniboine River contribution to peak	38,300 cfs. (average)
Portage Diversion	25,000 cfs.
Reduction of flow due to Shellmouth Reservoir	7,000 cfs.
Redwood Bridge (controlled)	El. 752.5 ft. el. 25 ft. (JAPSD)
Floodway Discharge	60,000 cfs.
Control Structure Discharge	70,700 cfs.
Controlled Discharge James Avenue	77,000 cfs.
Water level upstream of Inlet for design condition	El. 770.25 ft.
Water level upstream of Inlet for emergency operation	El. 778.0 ft.

1 The current design flood return period, based on today's knowledge of the hydrology of the Red River, is approximately 1 in 90 years.