Canada

Manitoba CONSERVATION

Winnipeg

FLOOD PROTECTION STUDIES FOR WINNIPEG

APPENDICES A, C, D, E AND F

NOVEMBER 2001

KGS GROUP

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

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APPENDIX A

RIVER HYDRAULICS AND FLOOD DAMAGE POTENTIAL DOWNSTREAM OF FLOODWAY

NOVEMBER 2001

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A.1 INTRODUCTION

This appendix is one of six that accompany and supplement the Main Report on Studies of Flood Protection for Winnipeg. This volume describes findings of hydraulic studies of the Red River downstream of Winnipeg and in particular, downstream of the Floodway Outlet. Four facets of this lowest reach of the Red River have been addressed:

- Hydraulic studies of the river that would lead to the selection of a stage-discharge relationship at the location of the outlet of the Floodway.
- Water levels along the Red River from the Forks to the Floodway Outlet that would be caused by particular river stages at the Floodway Outlet, for a range of flood flows.
- Estimation of water levels that would occur in the Red River between Selkirk and Breezy Point for conditions of the "state-of-nature" (prior to development of the Shellmouth Dam, Portage Diversion, and the Floodway), with the existing flood protection facilities, with various options of Floodway Expansion, and with the Ste. Agathe Detention Structure.
- Estimation of the number of properties that may be affected by high water levels in the zone north of Winnipeg, and approximate quantification of flood damages that could occur.

The first two points provide direct input to the preliminary design of some components of the Floodway Expansion, particularly with respect to required improvements in the flood protection infrastructure in Winnipeg. The last two points provide information that assists the comparison of the options of flood protection for Winnipeg.

A.2 RED RIVER WATER LEVELS – FORKS TO FLOODWAY OUTLET

Extensive studies of the Red River have been done by KGS Group both in this study and previously. Numerical models of the river have been developed on the basis of riverbed surveys from 1951, and calibrated with recorded water levels and measured flows from flood events in the last 30 years. They provide a strong basis for estimating water levels that would occur in the city, concurrent with a given water level at the Floodway Outlet. These water levels would occur under ice free conditions with the St. Andrews Lock and Dam open.

Figure A-1 shows a range of profiles in the Red River for a flow of 80,000 cfs and a range of water levels in the Red River at the Floodway Outlet. The 80,000 cfs is based on the maximum flow that could be reasonably expected to be conveyed through Winnipeg during a major flood. The remaining flood flow would be carried by the existing or expanded Floodway.

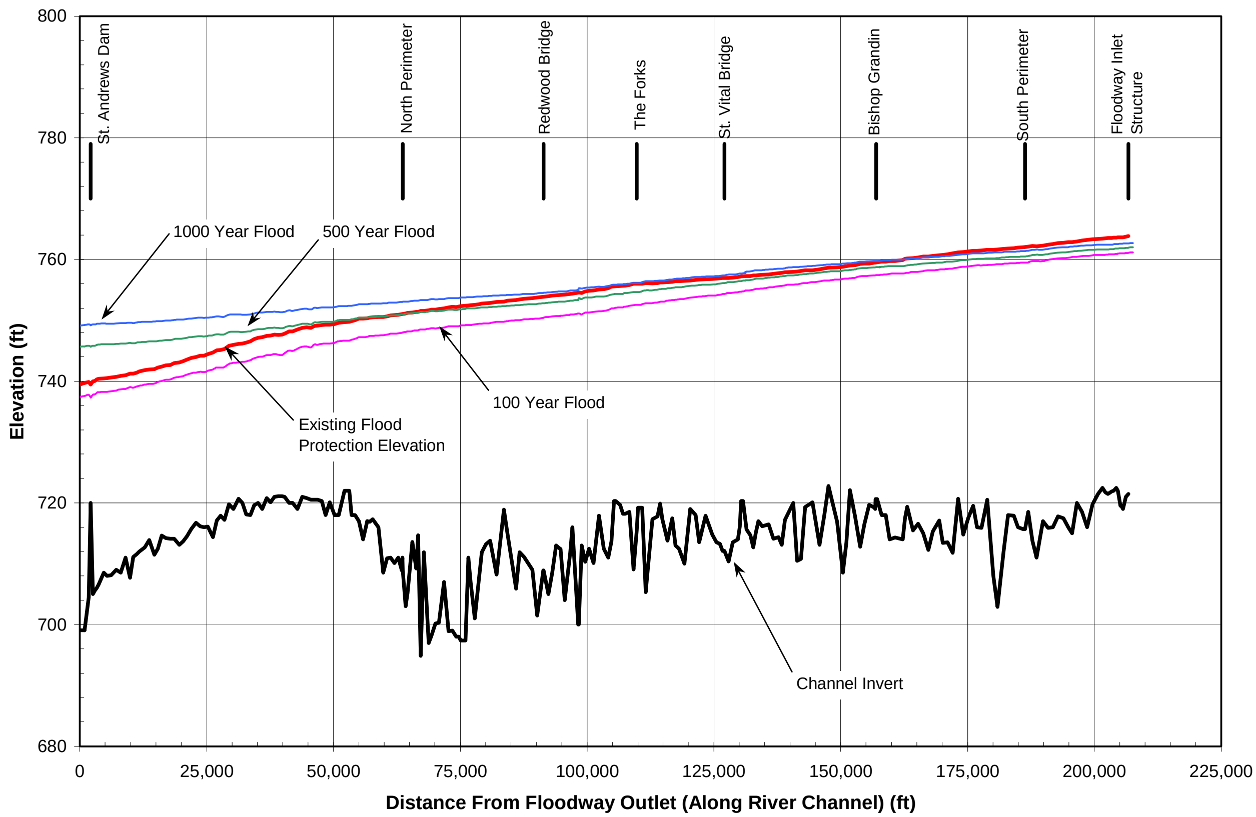


Figure A-1 – Water Surface Profiles for the Red River

Figure A-2 summarizes water level relationships between the Forks and the Floodway Outlet location. Similarly, Figure A–3 summarizes water level relationships between the North Perimeter Bridge and the Floodway Outlet.

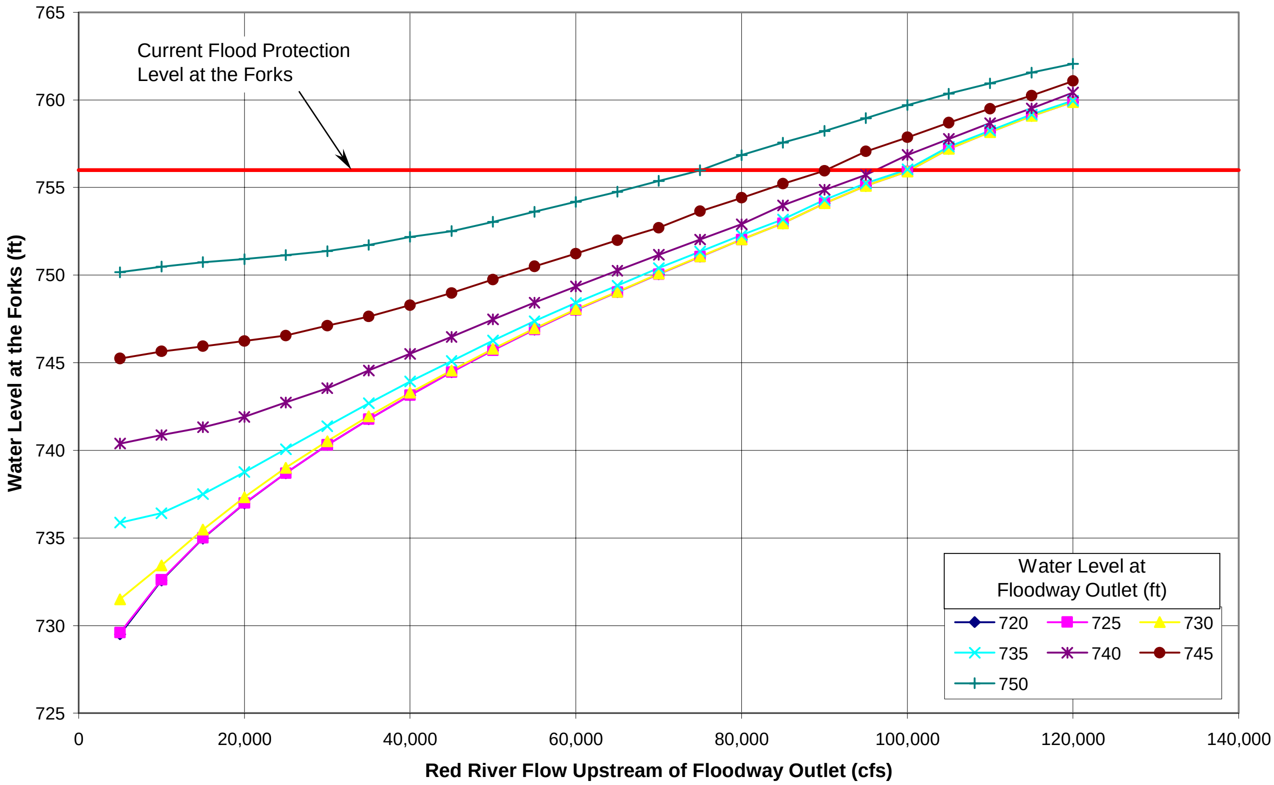


Figure A-2 – Relationship Between Water Level at Floodway Outlet and Water Level at the Forks

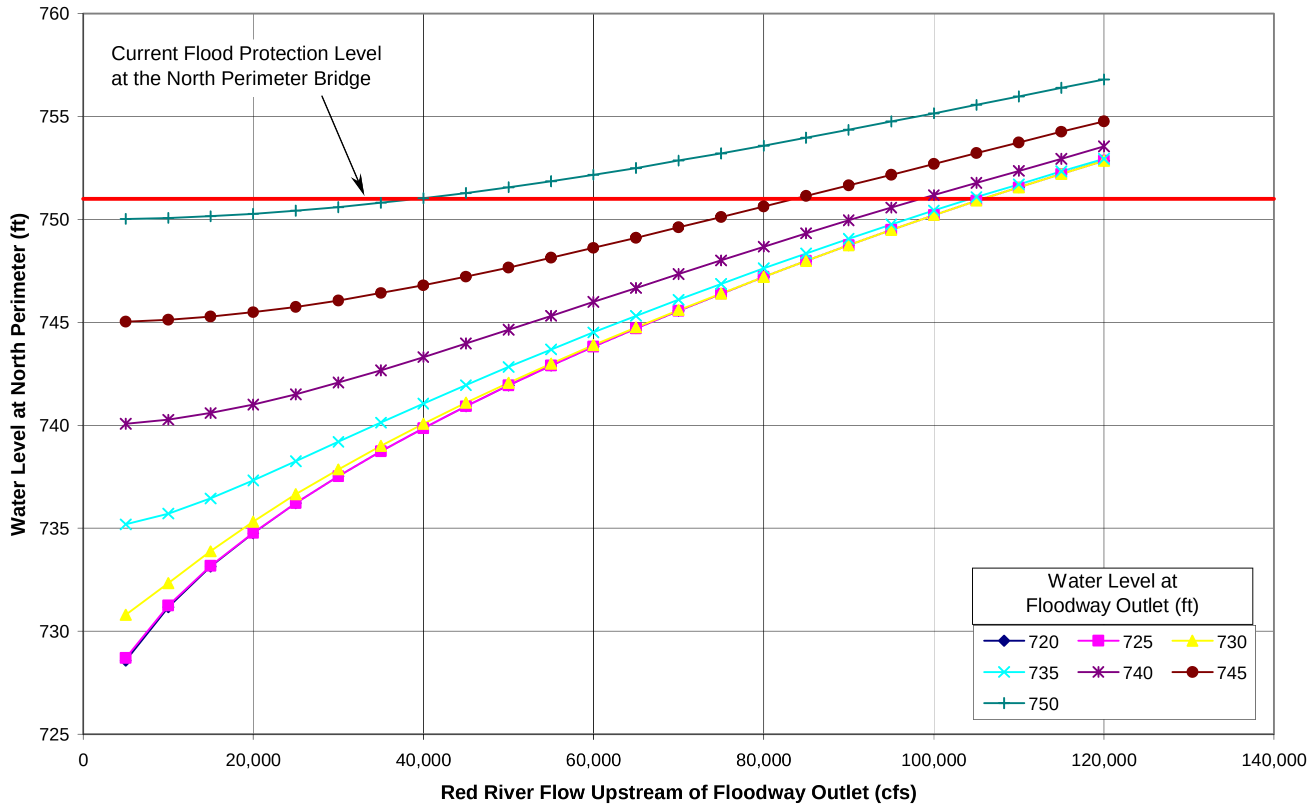


Figure A-3 – Relationship Between Water Level at Floodway Outlet and Water Level at the North Perimeter Bridge

Figures A-1 to A-3 show that for a flow of about 80,000 cfs through the city (a flow that does not cause significant flooding), the water level in the Red River at the Floodway Outlet would have to be a approximately El. 745 ft., or lower. This would be the peak level during a flood of approximately 1 in 700 years (with water levels at the Floodway Inlet raised above the "state-of-nature"), or 1 in 500 years (with no artificial raising of water levels at the Floodway Inlet).

A.3 RED RIVER WATER LEVELS – FLOODWAY OUTLET TO LAKE WINNIPEG

A.3.1 BACKGROUND

Previous studies (KGS Group, 2000) showed that under very high river flows, there could be backwater effects in Winnipeg from high river levels downstream of the Floodway Outlet. For extreme floods this could lead to flooding in the city, regardless of the efforts to expand the Floodway. The estimation of the extent of this potential is contingent on interpretation of high water levels that are estimated to have occurred in previous floods, most notably that of 1826. Forensic engineering analysis of those records was not possible within the time and budget restraints of KGS Group's studies in 1999/2000. As a result, a conservative and pragmatic approach was necessary in that previous study. It involved the use of an enveloping relationship that directly simulated both the observed high water levels in the Red River in 1997, as well as those reported to have occurred in 1826. The stage-discharge relationship that was adopted for the IJC study (KGS Group, 2000) is shown in Figure A-4.

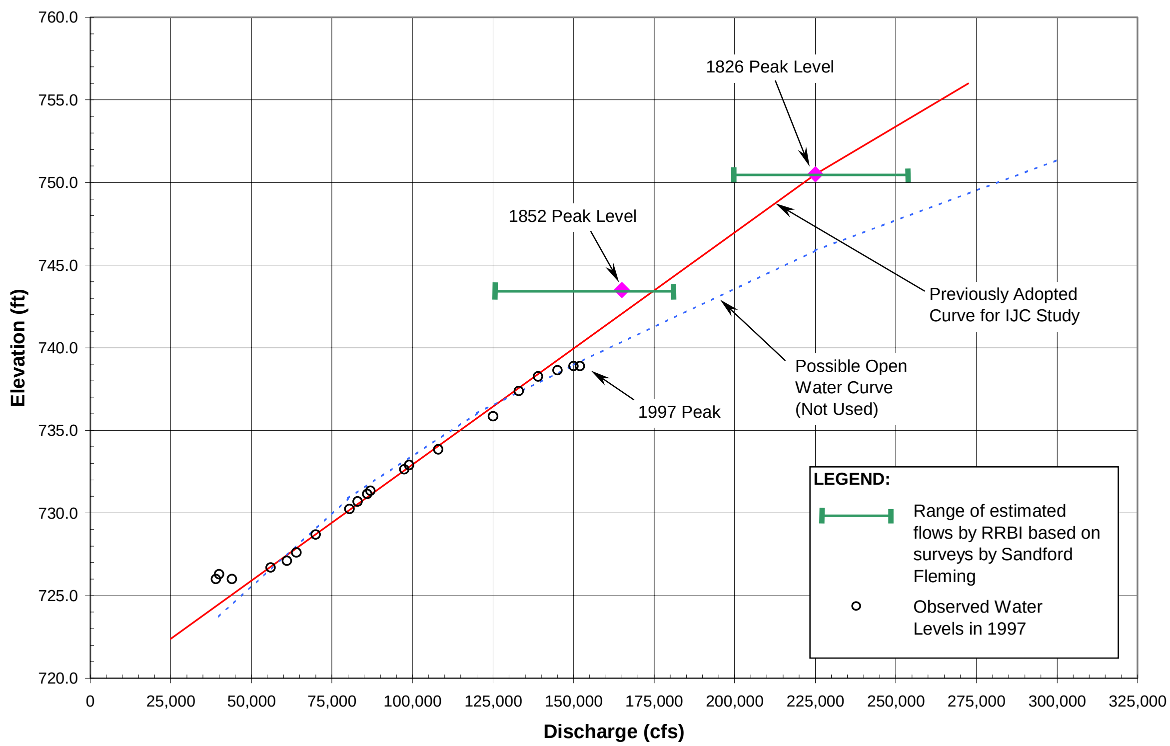


Figure A-4 – Stage-Discharge Relationship for the Red River at Floodway Outlet As Used by KGS Group for IJC Study in 1999-2000

The implication of adopting that relationship was that the water levels at floods exceeding approximately 200,000 cfs were estimated to be so high as to cause flooding in parts of Winnipeg, particularly in the north end of the city. Adoption of that preliminary and conservatively high relationship showed the need for additional protection in Winnipeg. The measures that would be required to provide that protection would include a permanent raise of the crest level of the Primary Dikes in the north end of Winnipeg by as much as 3 ft. The total cost of these measures was estimated in 1999 by KGS Group to be $110,000,000 and formed a substantial component of cost of the preliminary concept of the Floodway Expansion.

The current study has provided the opportunity to more thoroughly investigate the hydraulic characteristics of the lower Red River. The results are described in this section and have been adopted as a basis for the preliminary design of the Floodway Expansion.

A.3.2 OPEN WATER PROFILES BASED ON CONTEMPORARY DATA

Cross sections of the Red River were surveyed in 1951 as part of the Red River Basin Investigation (RRBI). The data has been assembled in a numerical model (HEC-RAS) that includes 99 RRBI cross sections spaced on average approximately 900 ft. apart between Lockport and Breezy Point, a distance of about 16.5 miles. The ground elevations on the overbank areas that would be inundated above bank-full river stage were obtained from 1:20 000 scale topographic maps with contour intervals of 8 ft. The accuracy of this information is questionable, and to improve the estimates of the overbank topography, surveys of specific areas were undertaken by a sub-contractor to KGS Group. Approximately 65 elevations were surveyed at critical areas and the results were used to adjust the estimated topographic contours in the area. Additional information in the form of highway crown elevations were supplied by the Manitoba Department of Highways for routes near the Red River.

As part of the survey initiative, a river channel cross section was surveyed at a location approximately 2 miles downstream of Lockport within about 500 ft. of the Water Survey of Canada #05OJ010. This is an area where the river banks are high and where all flow is through the river channel. There would be no flow over the overbank areas, even at flows up to 300,000 cfs. The surveyed cross section matched well with the data from the RRBI (see Figure A-5).

Furthermore, other cross section surveys conducted since the 1997 flood have also confirmed the similarity of the 1951 cross sections to today's conditions.

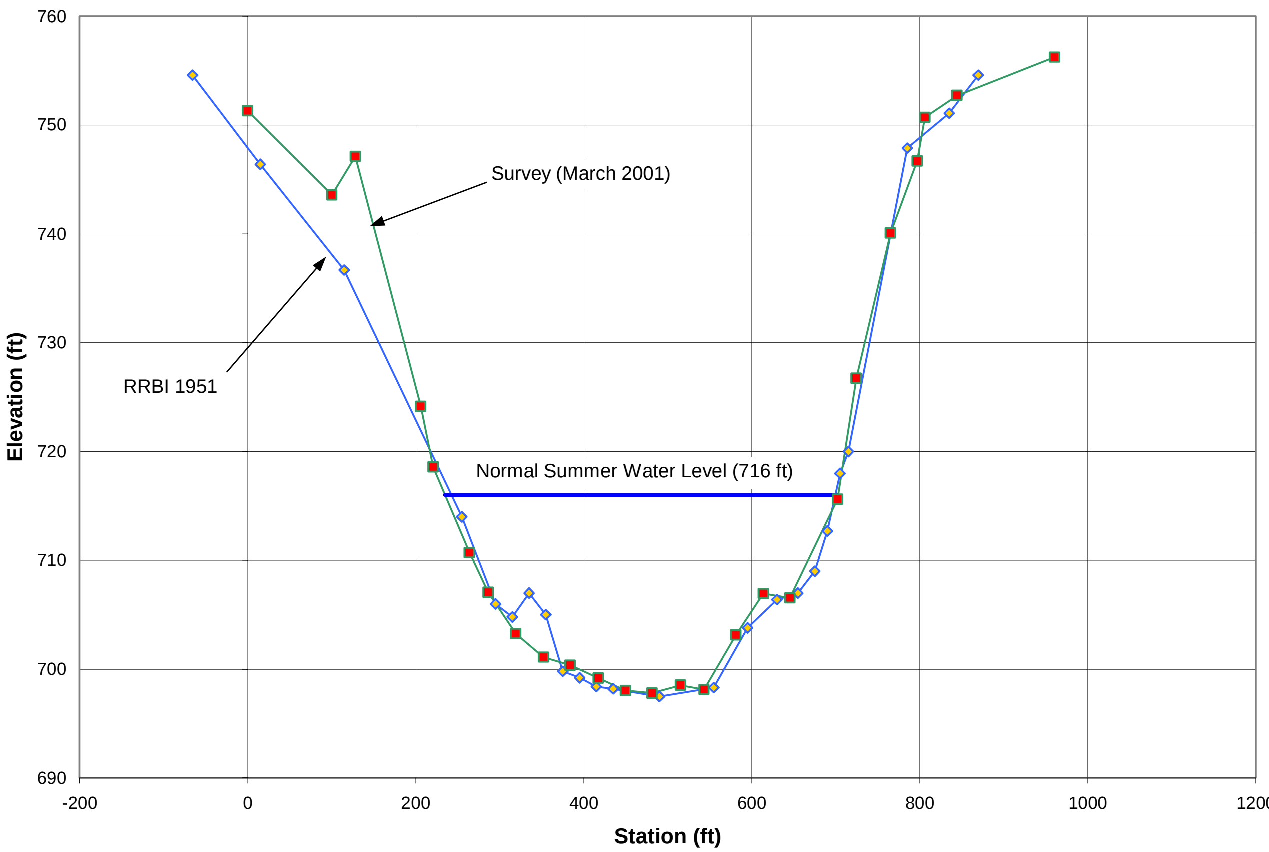


Figure A-5 – Comparison of RRBI 1951 Cross Section #1051 and March 2001 Surveyed Cross Section

The numerical model was calibrated to match recorded water levels in April and May, 1997, at Breezy Point, PTH#4, Selkirk and Lockport. Manning's n values ranging from 0.023 to 0.029 for the river channel, and from 0.03 to 0.08 for overbank areas, were required to provide a good comparison (within 6 inches) of the recorded data.

The numerical model was then used to estimate the water level at the Floodway Outlet for river flows up to 300,000 cfs. This required extrapolation to flows more than twice the maximum recorded (1997), and to stages more than 10 ft. above the peak of 1997. The resulting stage-discharge relationship for the Red River at the Floodway Outlet is shown in Figure A-6.

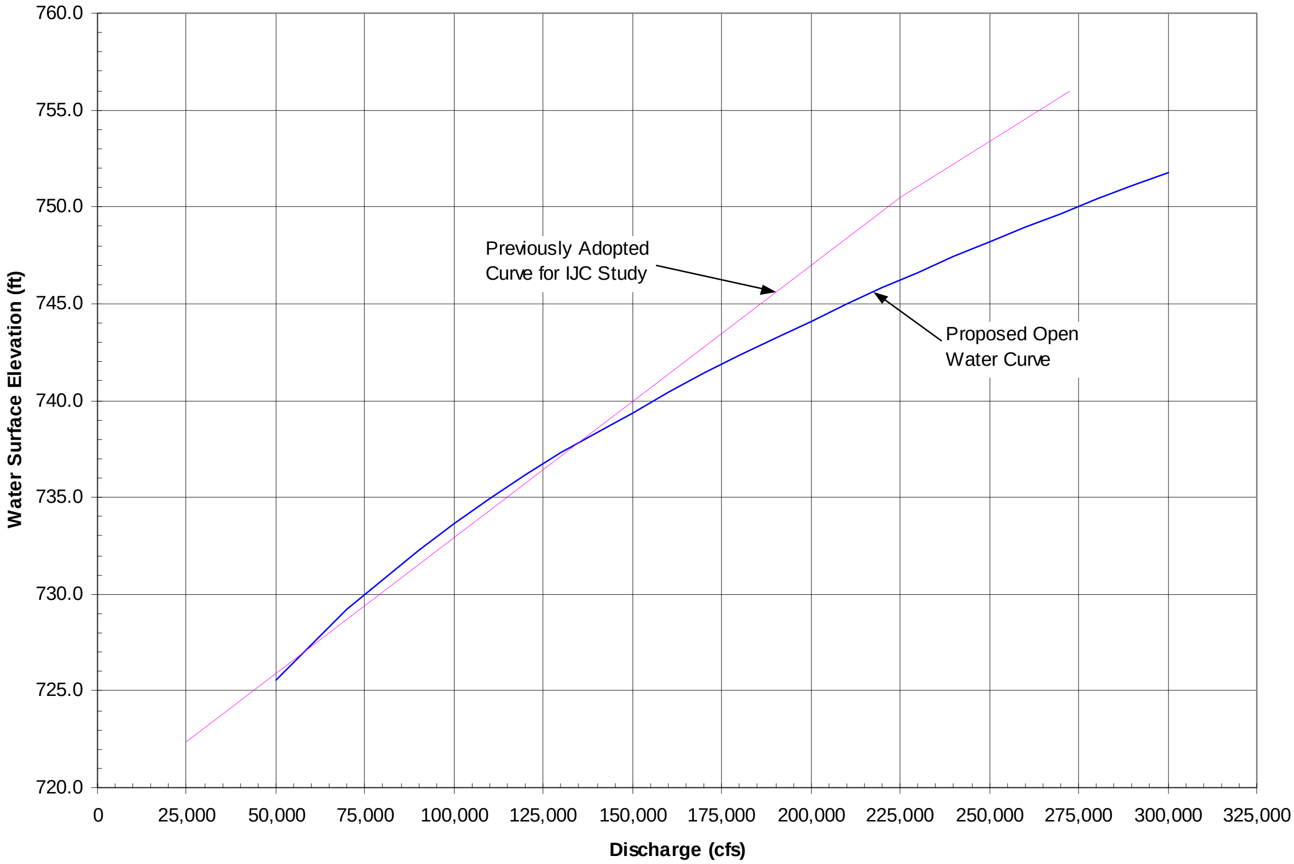


Figure A-6 – Proposed Stage-Discharge Relationship for Red River at Floodway Outlet

This relationship, and the numerical model described in Section A.3.2, are believed to be representative of floods from 1950 to the present, and permit a reasonably accurate simulation of the river for all flow conditions during that period.

A.3.3 RECONCILIATION OF 1826 FLOOD RECORDS WITH CONTEMPORARY DATA

In addition to the evidence from 1950 to 2001, there is documentation of water levels from several large floods in the 1800's. This data is summarized in the report written by the Canadian Pacific Railway (Fleming, 1879). As part of planning a bridge over the Red River, Sir Sandford Fleming surveyed high water marks for four major floods based on documents available and anectodal evidence gathered through interviews of local long-term residents, and review of documented descriptions from the events. The data is summarized in Table A-1, with corrections of elevations to current datums.

TABLE A-1
Survey Results Reported By Sir Sandford Fleming (1879)

Locality	From mouth of Assiniboine River	Height in Feet Above Sea Level					
		General Prairie Level	Ice Level of 1876	Flood Level			
	Miles			1875	1860	1852	1826
Mouth of Assiniboine	0	759.5	727.5	745.5	760.5	762.5	764.5
Point Douglas	2	757.5	727.5	745.5	----	762.5	764.5
North of St. John's Church	4	756.5	727.5	745.5	758.5	760.5	764.5
North of Kildonan Church	7	756.5	726.5	745.5	753.5	759.5	763.5
South of Tait's Creek	12	754.5	725.5	742.5	-----	754.5	761.5
Near St. Andrew's Church	18	754.5	718.5	737.5	-----	746.5	754.5
About 2 miles above S. Fort	20	755.5	-----	-----	-----	743.5	750.5
Stone Fort	22	753.5	714.5	735.5	-----	737.5	747.5
About 2 miles below S.Fort	24	748.5	-----	731.5	-----	732.5	743.5
Selkirk	27	739.5	713.5	-----	-----	727.5	733.5
St. Peter's Church	31	731.5	-----	-----	-----	720.5	725.5
Lake Winnipeg	40	-----	711.5	-----	-----	-----	-----

This data was reviewed by KGS Group, and compared to the river characteristics described in Section A.3.2 and A.3.3. There are anomalies that can be summarized as follows:

- The water levels for 1826 over a 4 mile length of the Red River near the Forks were reported to be equal (approximately El. 764.5 ft.); this could not be accurate since a gradient in the water surface would be necessary to convey the magnitude of flow that must have occurred.
- The water levels from present-day Lockport to 4 miles downstream of Selkirk are considerably higher than would be expected for peak flows that would be associated with the high water levels reported in Winnipeg. Or, conversely, the levels in Winnipeg are considerably lower than can be explained by flows that would be required to generate the maximum stages that occurred at, and downstream of, present-day Lockport

These anomalies are compounded by the fact that there is evidence of a bypass route of some portion of the flood flow that must have overtopped the riverbanks in the area of present-day north Winnipeg. The estimated areal extent of this bypass in 1826, as based on description from Fleming's report, and hydraulic calculations by KGS Group using the available topographic mapping, is shown in Plate A-1. A flow of some 15,000 cfs to 30,000 cfs is estimated by KGS Group to have occurred via this path. A similar overflow, but of lower magnitude, may also have occurred in 1852.

Simulations with the numerical model described in Sections A.3.2 and A.3.3 indicate that the water levels reported in Winnipeg at the peak of the 1826 flood would be associated with a total river flow of approximately 180,000 cfs. On the other hand, simulation with the same model require a flow of approximately 245,000 cfs in the Red River near Selkirk, in order to match Fleming's surveyed high water marks.

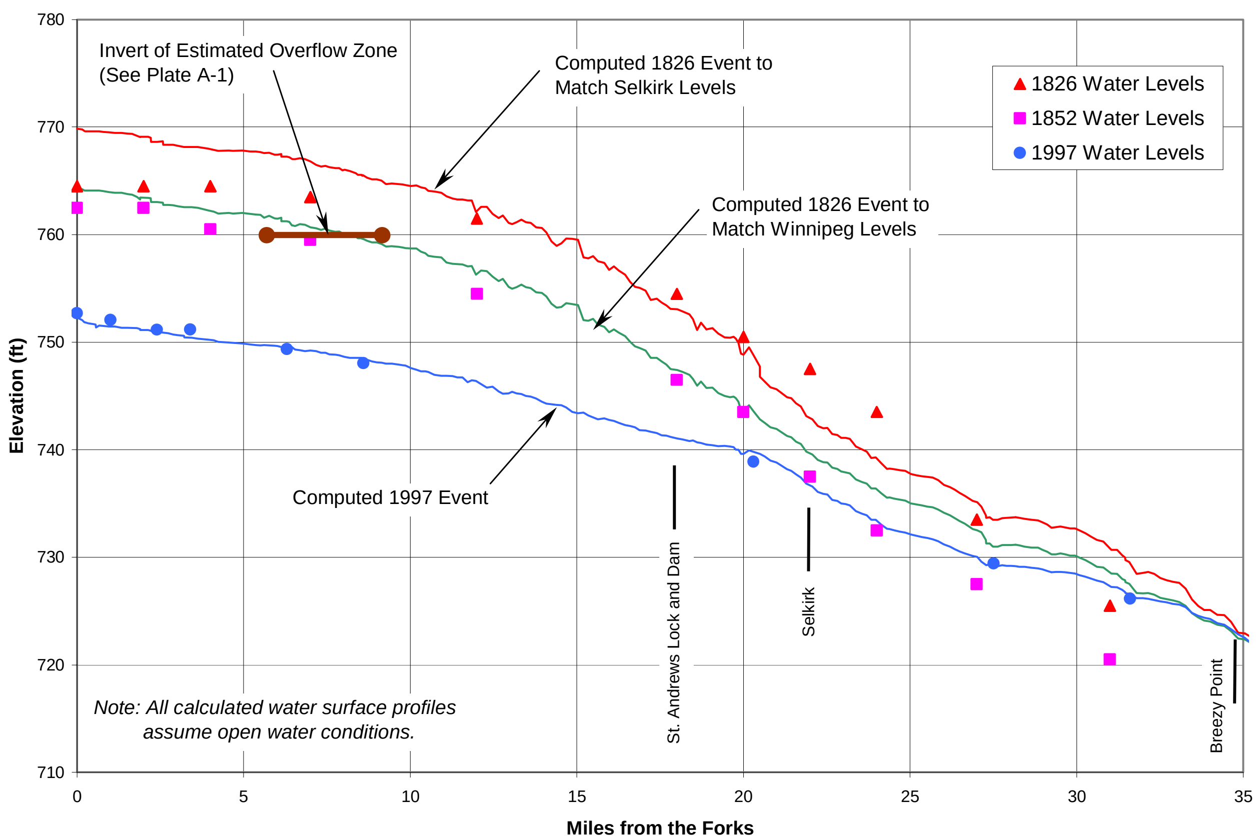


Figure A-7 – Sir Sandford Fleming's Data and Calculated Water Surface Profiles

- Figure A-7 shows the estimated water surface profiles for flows of 180,000 cfs and 245,000 cfs plotted against the historic water levels noted by Sir Sandford Fleming (in Table A-1), as well as the recorded water levels and computed profile for the peak of the 1997 event.

It should be noted that the RRBI estimated the peak flow in 1826 to be 225,000 cfs by a relatively crude technique using two sets of cross sections, and an estimated Manning's roughness value (0.032). That roughness value is more than what is now estimated to exist in the river in this area (0.027), based on a solid database of recorded flows and water levels in the later half of the 20th century.

The estimate of 245,000 cfs by KGS Group as described above, plus the flow estimated to have occurred via the bypass route (Plate A-1), would result in a total estimated peak flow of at least 260,000 cfs in 1826.

Neither scenario (ie. that for Winnipeg compared to that below Selkirk) are compatible with the other on the basis of open water conditions. Consequently, other explanations for the diverse water levels were sought. They included:

- The existence of an ice cover possibly in the form of an ice jam in the river near Selkirk.
- The existence of heavily treed riverbanks in the 1800's that could have impeded flow across the overbank zones and contributed to higher water levels than under current conditions.
- Morphological changes in the river since 1826 that resulted in a larger conveyance in the last 50 years than in the 1800's.
- Differences in sediment content in the river water in the early 1800's when the watershed was in a more pristine state, as compared to recent decades with agricultural development and efficient drainage systems.
- Deltaic deposition near the mouth of the Red River.
- Isostatic rebound in southern Manitoba.

Each hypothesis was considered and two were found to be plausible explanations of the diversity in levels reported for the 1826 flood by Fleming for Winnipeg and Selkirk. Each hypothesis is addressed briefly in Sections A.3.3.1 to A.3.3.6, and the most plausible explanations and their influence on planning of the Floodway Expansion are described in Section A.3.3.7.

A.3.3.1 Ice Effects at the Time of the Peak

The ice cover on the Red River in the spring of 1826 was reported to be 5 ft. thick prior to breakup (Fleming, 1879). The possibility of ice jams or late persistence of intact river ice in the lower river that could have caused higher water levels than under fully open conditions was examined by KGS Group using a series of analyses that are summarized as:

- Estimation of the river flow and / or stage that would incur the onset of ice cover breakup.
- Estimation of the river stage or flow near Selkirk that could be accompanied by an ice jam and water levels corresponding to the high water marks of 1826.

The ability to predict the breakup of river ice covers and the rise in water level that could accompany, or be caused by, ice jams is notoriously fraught with uncertainty. Nevertheless, the science is steadily improving, and procedures have been developed that have been used with some success in other parts of this country and the world. These procedures (summarized in Beltaos, 2000, and Pariset, Hausser, Gagnon, 1966) have been applied to the Red River, and the results led to the following findings:

- Breakup of the river ice in the reach downstream of Lockport would be unlikely to be delayed beyond the point at which the river flow would exceed 90,000 cfs.
- An ice jam in the Selkirk to Breezy Point reach could not be stable and could not resist the large hydraulic forces that would be imposed on it by flows exceeding about 100,000 cfs, at the stages comparable to high water marks of 1826. At flows exceeding this threshold, it is believed that the ice would be forced downstream, probably spreading into the marshy overbank areas downstream of Breezy Point.

The limiting flows mentioned above (90,000 and 100,000 cfs) are not expected to be precise predictions. ***However, their estimated magnitudes are so low that it has been considered very unlikely that ice could be a plausible explanation of high stages that could occur at flows approaching or exceeding 200,000 cfs.***

A.3.3.2 Heavily Treed Overbanks

Evidence exists (Hanuta, 2001) that the areas within 3 miles of the river downstream of Selkirk were covered by trees and heavy brush in the 1800's. This could have prevented free overbank flow and forced more of the flood water through the main channel in 1826. However, sensitivity analyses using the numerical model of the river showed that even using a very high overbank Manning's roughness coefficient of 0.15 would not reduce the estimated peak flow to be less than 235,000 cfs in the river near Selkirk, while matching the high water marks. Even assuming a complete blockage of the overbank areas would only decrease the estimated peak flow to about 232,000 cfs. ***The disparity with the observed water levels upstream in Winnipeg could not be explained by this factor.***

A.3.3.3 Morphological Changes in Red River

There are references in historical documents to the gradual natural process of widening and deepening of the Red River in the early 1800's (Fleming, 1879; Macoun, 1905; Nor'wester, 1861; Notes of Bishop of Rupertsland, 1852). A smaller main channel in 1826 than now exists could possibly explain higher water levels in the Selkirk area than would prevail with the current bathymetry of the river.

Sensitivity analyses using the numerical model described in Sections A.3.2 and A.3.3 show that a channel only 10% narrower than currently exists could reduce the disparity of the water levels between the reach near Selkirk and in Winnipeg. However, it is not clear why the channel widening would have only occurred in the Selkirk area and downstream. It is more likely, given the unstable nature of the river banks in Winnipeg, that the enlarging process would have been more pronounced in the Winnipeg area. This would have exacerbated the difference in relative water levels in Selkirk and in Winnipeg. ***It was concluded that morphological changes are unlikely reasons for the relatively high river levels near Selkirk compared to Winnipeg.***

A.3.3.4 Differences in Sediment Transport

It is likely that the sediment transport in floods in the early 1800's would have been less than under current conditions. Tilled farmland and an efficient network of drainage channels favour runoff of greater amounts of sediment than would have been prevalent in the 1800's. This could conceivably have led to:

- More erosion in the channel during a large flood due to the greater propensity of the low-sediment carrying flow to pick up sediment load (counter-productive in explaining higher stages in 1800's).
- Higher stages than with a high sediment load, a phenomenon identified by others (Kuiper, 1967, and Vanoni, 1960)

However, lower sediment loads have no reason to be more prevalent in the Selkirk reach than in Winnipeg. ***This process does not appear to be a source of the disparity in water levels.***

A.3.3.5 Deltaic Deposition at the Mouth of the Red River

There have been serious concerns in recent years for the buildup of deposits in the lower part of Red River, near Lake Winnipeg, particularly since the curtailment of the dredging operations in the area. It is possible that this is occurring, and could conceivably be causing some modest increases in water level. However, it is believed to be highly unlikely that:

- The effects are large enough to affect water levels under extreme flood conditions as far upstream of Lake Winnipeg as the Floodway Outlet where the water level under extreme flood conditions is more than 25 ft. above the level of Lake Winnipeg.
- The effects could have been different in the 1800's to the extent that they could explain the disparity in water levels between Selkirk and Winnipeg in 1826. Furthermore, the sediment buildup would have to be reversed (ie. erosion of the deltaic deposits) to provide the reasoning for the disparity, and this is unlikely.

This process does not appear to be a source of the disparity in water levels.

A.3.3.6 Isostatic Rebound

The ground levels in the entire area from Hudson Bay to the northern U.S. have been increasing since the retreat of the last glaciers in the area 10,000 years ago. Rises of 0.4 inch per year have been known to have occurred in recent centuries. Since 1826, this could have resulted in a substantial rise in ground levels. The possibility that this could be an explanation of differences in water levels in the 1800's was reviewed by KGS Group. It was rejected since the differential rise between Winnipeg and Selkirk is small, and would have to be the inverse from the known trend to provide an explanation. The result was that ***this process could not have caused the water levels that are in dispute.***

A.3.3.7 Most Plausible Explanation of Recorded High Water Marks of 1826

After review of all the available evidence, KGS Group has formulated two probable explanations for the flood water levels of 1826.

Scenario #1 - The peak water levels reported to have occurred in Winnipeg were estimated in error, and the levels in the Lockport to Selkirk reach were caused during open water conditions (no ice effects involved). An estimated flood peak flow exceeding 300,000 cfs for the 1826 event would be required to explain this scenario. An alternate possibility could have been errors in the measured high water marks in the Selkirk area.

Scenario #2 - The water levels in Winnipeg occurred as reported, and the high water levels near Selkirk were caused during the early stages of the flood, and resulted from a temporary ice jam that was subsequently washed downstream and dissipated. An estimated flood peak flow of approximately 180,000 cfs for the 1826 event would be required to explain this scenario. A similar scenario would also explain the relatively high level in 1852 (See Figure A-4).

Either of these two explanations would support the conclusion that the stage-discharge relationship shown in Figure A-6 should be used in planning the Floodway Expansion. The second explanation, however, could adversely affect the Floodway Expansion concept. It may lead to a conclusion that high water levels, exceeding the crest elevations of the Primary Dikes in Winnipeg, could occur due to temporary ice jams in the Lockport/Selkirk area during the rising limb of the flood hydrograph. However, if this were to occur, there is a possible and practical solution, as follows. If ice jams occur in the lower river and cause a water level near Lockport comparable to that reported for the peak of the 1826 event (this has never happened in the 33 years since the implementation of the Floodway and for at least 20 years prior to that), then a cutback of Red River inflow to Winnipeg could prevent flooding in the city. That cutback could be achieved by raising the gates at the Floodway Inlet Control Structure to raise the water level upstream. That would increase the diversion of flow into the Floodway channel and allow a cutback of flow in Winnipeg. While not being a desirable normal mode of operation, it could be resorted as an emergency measure under abnormal and infrequent conditions. Further study would be required to investigate the timing of the ice jam viz a viz the initiation of cutback and the delay in river response. Another mitigative measure could be weakening of the ice by saw-cutting, drilling of holes, or a more intensive program involving an icebreaker. However, those options would require further assessment.

A.4 COMPARISON OF WATER LEVELS ALONG RED RIVER NORTH OF WINNIPEG

The numerical analyses described in Section A.3 also provide a basis for considering the effects of the various options of improving the flood protection for Winnipeg. This has been supplemented by flood routing studies of the variety of conditions south of Winnipeg, which were carried out by Manitoba Conservation. The numerical model, MIKE-11, that was configured in previous studies to assist analyses of floods in the Red River Valley, was used. Figures A-8 and A-12 show the flood hydrographs that were generated by Manitoba Conservation using the MIKE-11 model.

The results of the comparisons are summarized in Tables A-2 to A-6. It should be noted that the “state-of-nature” water levels approximate what the conditions would be without the benefit of the Shellmouth Dam, the Portage Diversion, and the Floodway.

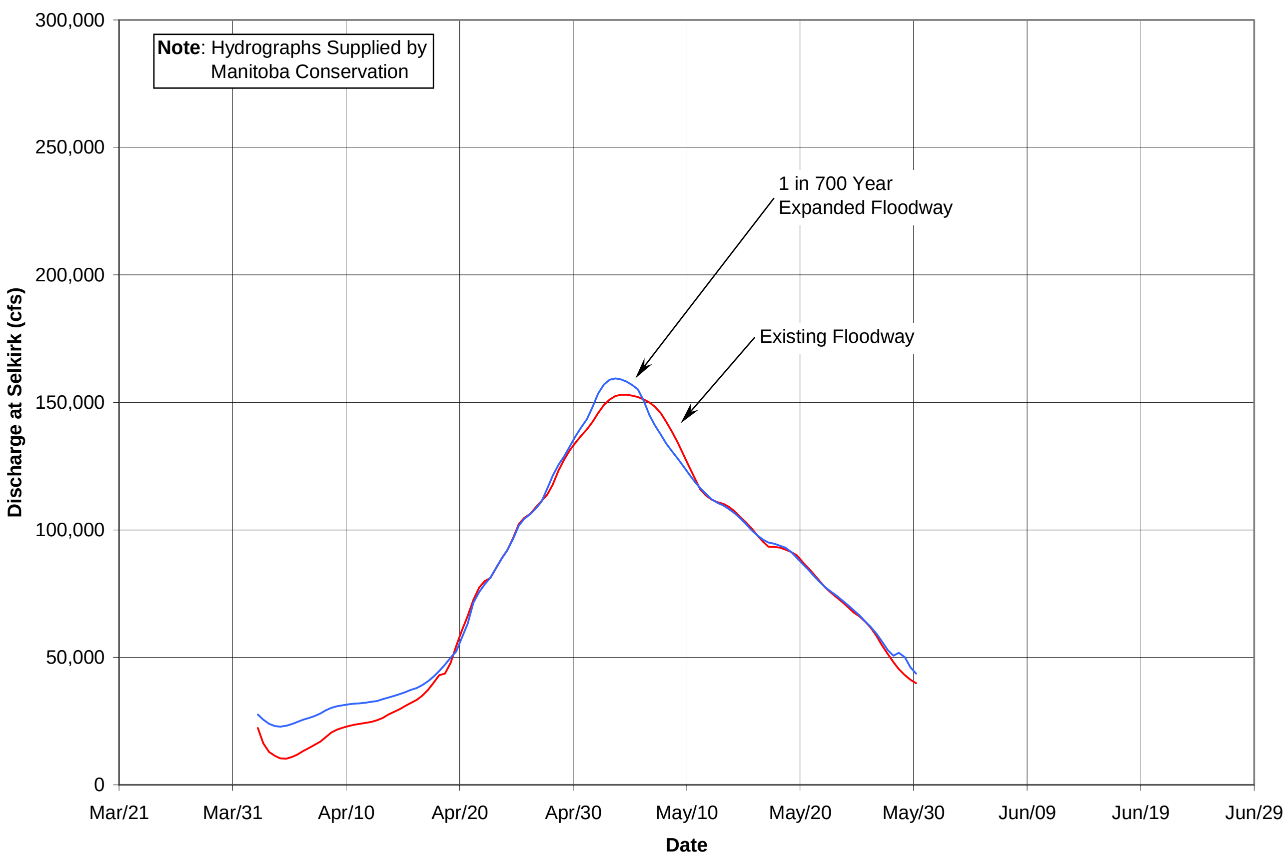


Figure A-8 – 1 in 100 Year Flood Hydrographs from MIKE-11 Model

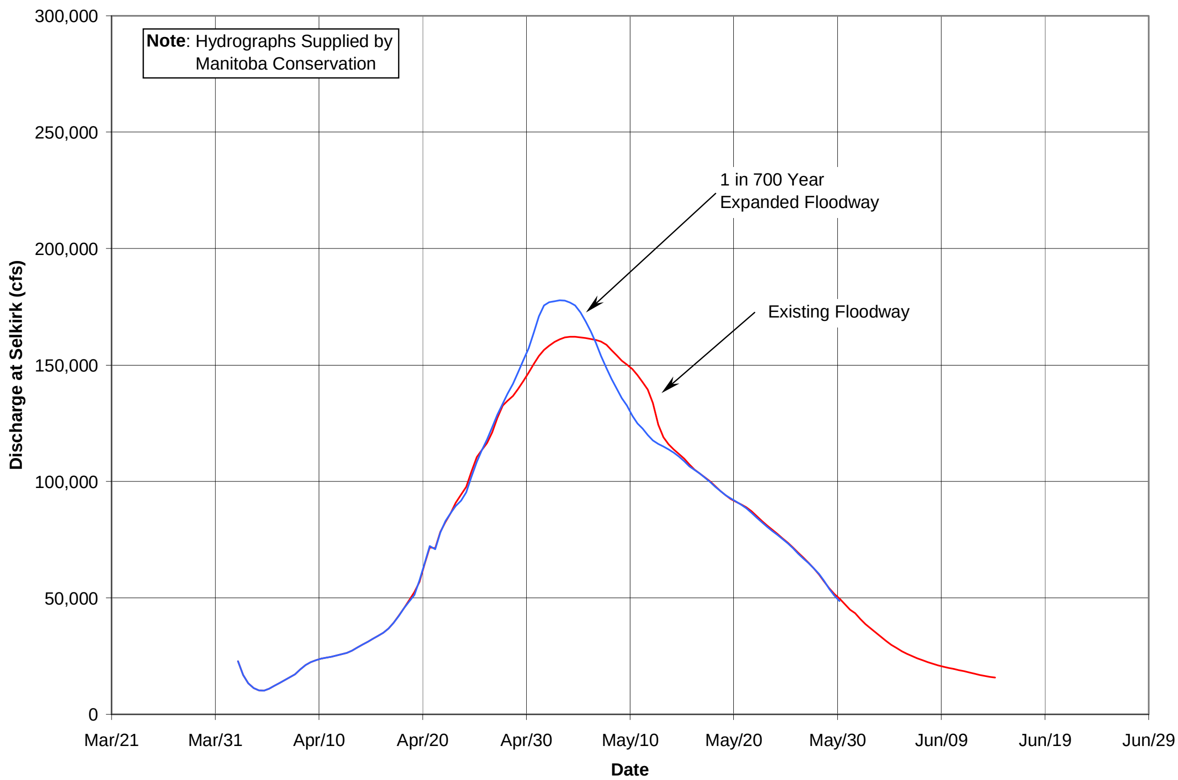


Figure A-9 – 1 in 200 Year Flood Hydrographs from MIKE-11 Model

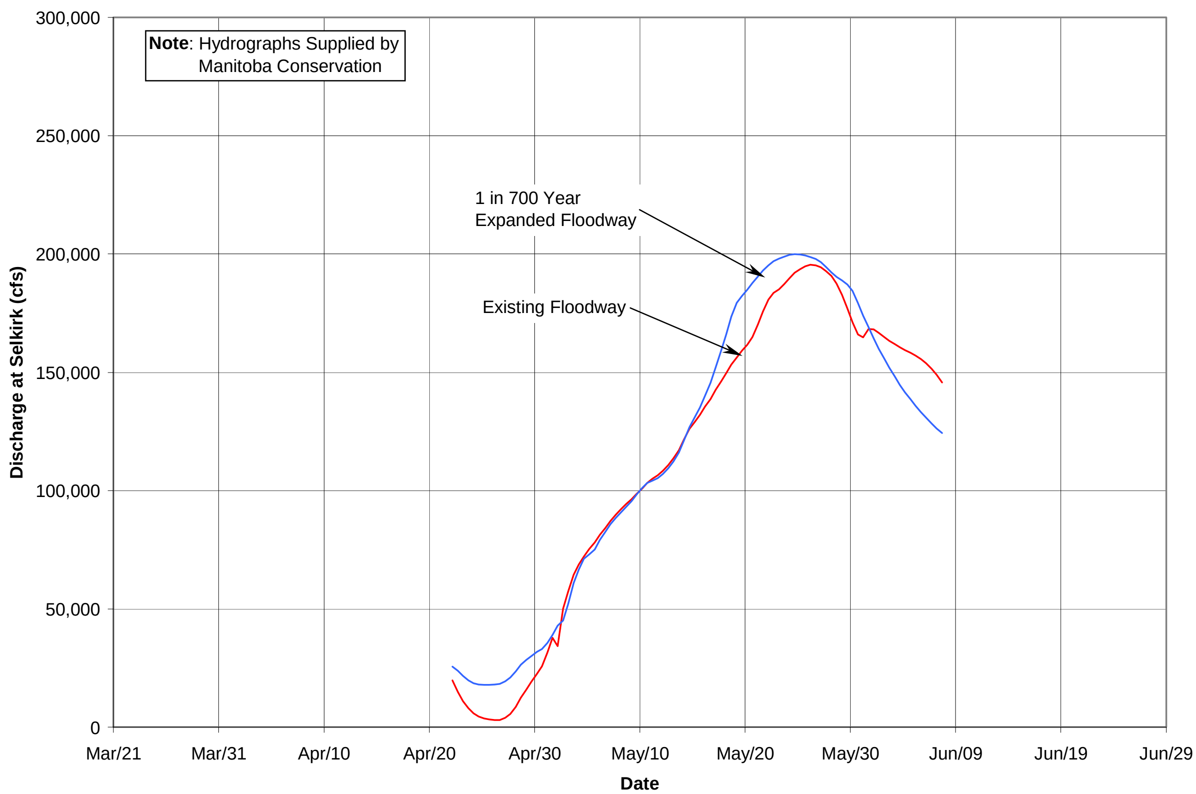


Figure A-10 – 1 in 300 Year Flood Hydrographs from MIKE-11 Model

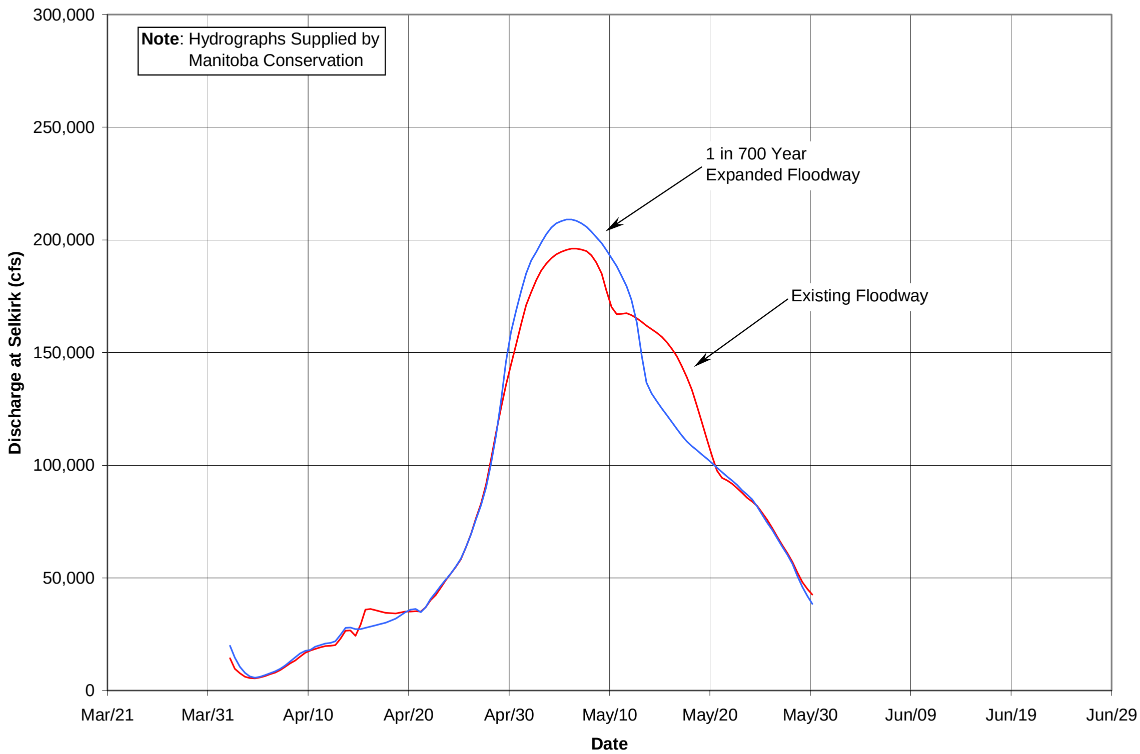


Figure A-11 – 1 in 500 Year Flood Hydrographs from MIKE-11 Model

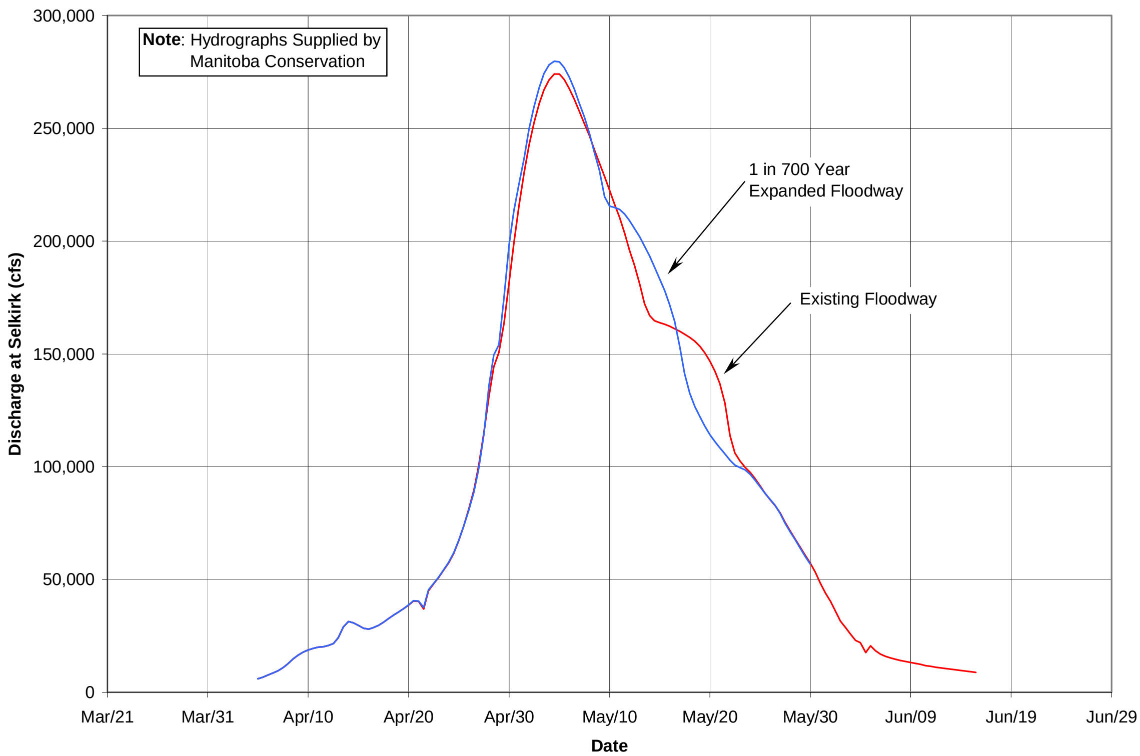


Figure A-12 – 1 in 1000 Year Flood Hydrographs from MIKE-11 Model

TABLE A-2
Comparison of Flood Peak Water Levels

North Perimeter Bridge
Incipient Flood Level At This Location[1]: 746.40 ft.

Flood Event	Estimated State-of-Nature Conditions[1] Prior to 1968	With Existing Flood Protection Facilities	1 in 700 Year Floodway[2]	1 in 1200 Year Floodway	Ste. Agathe Detention Structure in Combination with Existing Floodway[3]
1 in 100 yr	758.3	748.0	747.0	n.a.	748.5
1 in 200 yr	762.2	748.0	749.3	n.a.	748.5
1 in 300 yr	764.7	n.a.	750.3	750.4	748.5
1 in 500 yr	766.9	752.0	750.7	n.a.	748.5
1 in 1000 yr	770.7	762.0	758.6	n.a.	748.5

Notes:
1. Estimated from topographic maps.
2. Assumes water level allowed to rise to El. 778 ft. at the Floodway Entrance under emergency operation, when required.
3. Operation consistent with strategy of operation described in Appendix C.
4. “n.a.” indicates MIKE-11 runs that could not be completed by Manitoba Conservation within the time frame of this study.

TABLE A-3
Comparison of Flood Peak Water Levels

Floodway Outlet
Incipient Flood Level At This Location[1]: 738.25 ft.

Flood Event	Estimated State-of-Nature Conditions[1] Prior to 1968	With Existing Flood Protection Facilities	1 in 700 Year Floodway[2]	1 in 1200 Year Floodway	Ste. Agathe Detention Structure in Combination with Existing Floodway[3]
1 in 100 yr	740.7	739.6	740.3	n.a.	739.6
1 in 200 yr	744.1	740.6	742.1	n.a.	739.6
1 in 300 yr	746.2	n.a.	744.4	745.2	739.6
1 in 500 yr	748.2	744.0	745.1	n.a.	739.6
1 in 1000 yr	751.4	750.2	750.6	n.a.	739.6

Notes:
1. Estimated from topographic maps.
2. Assumes water level allowed to rise to El. 778 ft. at the Floodway Entrance under emergency operation, when required.
3. Operation consistent with strategy of operation described in Appendix C.
4. “n.a.” indicates MIKE-11 runs that could not be completed by Manitoba Conservation within the time frame of this study.

TABLE A-4
Comparison of Flood Peak Water Levels

Selkirk Bridge
Incipient Flood Level At This Location[1]: 733.25 ft.

Flood Event	Estimated State-of-Nature Conditions[1] Prior to 1968	With Existing Flood Protection Facilities	1 in 700 Year Floodway[2]	1 in 1200 Year Floodway	Ste. Agathe Detention Structure in Combination with Existing Floodway[3]
1 in 100 yr	730.4	729.8	730.2	n.a.	729.8
1 in 200 yr	732.7	730.4	731.4	n.a.	729.8
1 in 300 yr	734.0	n.a.	732.8	733.4	729.8
1 in 500 yr	735.2	732.6	733.3	n.a.	729.8
1 in 1000 yr	737.3	736.5	736.7	n.a.	729.8

Notes:
1. Estimated from topographic maps.
2. Assumes water level allowed to rise to El. 778 ft. at the Floodway Entrance under emergency operation, when required.
3. Operation consistent with strategy of operation described in Appendix C.
4. "n.a." indicates MIKE-11 runs that could not be completed by Manitoba Conservation within the time frame of this study.

TABLE A-5
Comparison of Flood Peak Water Levels

PTH #4 Bridge
Incipient Flood Level At This Location[1]: 721.75 ft.

Flood Event	Estimated State-of-Nature Conditions[1] Prior to 1968	With Existing Flood Protection Facilities	1 in 700 Year Floodway[2]	1 in 1200 Year Floodway	Ste. Agathe Detention Structure in Combination with Existing Floodway[3]
1 in 100 yr	726.9	726.4	726.7	n.a.	726.4
1 in 200 yr	728.8	726.9	727.8	n.a.	726.4
1 in 300 yr	730.0	n.a.	729.0	729.4	726.4
1 in 500 yr	731.2	728.8	729.4	n.a.	726.4
1 in 1000 yr	733.1	732.3	732.6	n.a.	726.4

Notes:
1. Estimated from topographic maps.
2. Assumes water level allowed to rise to El. 778 ft. at the Floodway Entrance under emergency operation, when required.
3. Operation consistent with strategy of operation described in Appendix C.
4. “n.a.” indicates MIKE-11 runs that could not be completed by Manitoba Conservation within the time frame of this study.

TABLE A-6
Comparison of Flood Peak Water Levels

Breezy Point
Incipient Flood Level At This Location[1]: 717.75 ft.

Flood Event	Estimated State-of-Nature Conditions[1] Prior to 1968	With Existing Flood Protection Facilities	1 in 700 Year Floodway[2]	1 in 1200 Year Floodway	Ste. Agathe Detention Structure in Combination with Existing Floodway[3]
1 in 100 yr	720.3	720.1	720.2	n.a.	720.1
1 in 200 yr	721.0	720.1	721.0	n.a.	720.1
1 in 300 yr	721.4	n.a.	721.0	721.2	720.1
1 in 500 yr	721.7	721.0	721.2	n.a.	720.1
1 in 1000 yr	722.3	722.1	722.2	n.a.	720.1

Notes:
1. Estimated from topographic maps.
2. Assumes water level allowed to rise to El. 778 ft. at the Floodway Entrance under emergency operation, when required.
3. Operation consistent with strategy of operation described in Appendix C.
4. “n.a.” indicates MIKE-11 runs that could not be completed by Manitoba Conservation within the time frame of this study.

A.5 FLOOD AFFECTED PROPERTIES DOWNSTREAM OF WINNIPEG

The accuracy of topographic data along the Red River north of Winnipeg is questionable. Consequently, detailed studies of potential flood damages in this zone were not considered appropriate at this time. However, it was considered important to identify in approximate terms the numbers of residences and businesses that could be affected. Information from a variety of sources were consulted:

- Tax assessment data for affected areas of Selkirk in the R.M. of St. Andrews and East Selkirk in the R. M. of St. Clements.
- Aerial photographs of the area, taken in 1997, at a scale of 1 to 20:000, and showing the locations of residences, businesses, cottages and other buildings.
- Topographic mapping and spot elevation data described in Section A.3.2.
- Maps showing the limits of flooding in the Lockport / Selkirk area in 1997.
- Maps of low lying residences and businesses in the R.M. of West St. Paul.

The information was analysed in combination with depth / damages relationships developed in previous studies of flood damage potential in Winnipeg (KGS Group, 1999). First floor elevations of affected buildings were assumed to be 3 ft. above the estimated ground level. Assessed values of buildings were based on actual tax assessments in East Selkirk obtained from the R.M. of St. Clements. Assessed values for other locations were approximated as follows:

- Houses $50,000
- Out Buildings $15,000
- Commercial Buildings $150,000
- Churches $150,000

The results are summarized in Table A-7.

It has been recognized that for flood between about the 1 in 100 year to the 1 in 300 year magnitude, the expanded Floodway will actually cause higher water levels in the Selkirk to Lake Winnipeg zone than would occur under existing conditions. Indications of increased level for these conditions are summarized in Tables A-2 to A-6. However, the accuracy of the topographic mapping in this area is so poor, and the differences in flood water levels between Floodway schemes (including existing) are so small that comparisons of potential flood damages between the existing Floodway and the options of the Floodway Expansion are not appropriate. Only a comparison between existing conditions and those with the Ste. Agathe Detention Structure in place have been attempted, and are included in Table A-7. Furthermore, it should be noted from Tables A-2 to A-6, that although the Floodway Expansion would exacerbate flood levels downstream of the Floodway for some conditions, they would still not be as high as under state-of-nature" conditions. The "state-of-nature" conditions would represent the era prior to the completion of the Shellmouth Reservoir and the Portage Diversion.

The affected number of residences in the Winnipeg to Lockport reach of the river are not available. Existing topographic mapping of the area is not adequate to permit a reasonable approximation of this information. It is believed, however, to be similar in magnitude to that shown for the area north of Lockport.

TABLE A-7
Estimated Building Damages for Existing Floodway and Ste. Agathe Detention Structure

		EXISTING FLOODWAY								STE. AGATHE DETENTION STRUCTURE	
		1 in 100 Year Flood		1 in 300 Year Flood		1 in 500 Year Flood		1 in 1000 Year Flood		100, 300, 500, 1000 Year Floods	
Area	**Building Type**	**Number of Inundated Buildings**	**Estimated Building Damages**	**Number of Inundated Buildings**	**Estimated Building Damages**	**Number of Inundated Buildings**	**Estimated Building Damages**	**Number of Inundated Buildings**	**Estimated Building Damages**	**Number of Inundated Buildings**	**Estimated Building Damages**
Floodway Outlet to Southern Boundary of Selkirk	Houses	3	$50,000	4	$132,000	10	$231,000	13	$490,000	3	$50,000
	Out Buildings	0	$0	0	$0	7	$41,000	8	$91,000	0	$0
	Sub - Total	**3**	**$50,000**	**4**	**$132,000**	**17**	**$272,000**	**21**	**$581,000**	**3**	**$50,000**
City of Selkirk	Houses	0	$0	7	$138,000	8	$154,000	15	$420,000	0	$0
	Out Buildings	3	$14,900	26	$1,947,000	29	$2,294,000	42	$3,822,000	3	$14,900
	Sub - Total	**3**	**$14,900**	**33**	**$2,085,000**	**37**	**$2,448,000**	**57**	**$4,242,000**	**3**	**$14,900**
East Selkirk	Houses[1]	0	$0	7	$240,000	19	$616,000	35	$2,008,000	0	$0
	Sub - Total	**0**	**$0**	**7**	**$240,000**	**19**	**$616,000**	**35**	**$2,008,000**	**0**	**$0**
Northern Boundary of Selkirk to Breezy Point	Houses	1	$17,000	28	$462,000	43	$710,000	47	$1,480,000	1	$17,000
	Out Buildings	7	$35,000	60	$297,000	74	$366,000	90	$868,000	7	$35,000
	Large Buildings	0	$0	2	$99,000	3	$149,000	3	$281,000	0	$0
	Church	0	$0	1	$50,000	1	$50,000	1	$116,000	0	$0
	Sub - Total	**8**	**$52,000**	**91**	**$908,000**	**121**	**$1,275,000**	**141**	**$2,745,000**	**8**	**$52,000**
	TOTALS	**14**	**$116,900**	**135**	**$3,365,000**	**194**	**$4,611,000**	**254**	**$9,576,000**	**14**	**$116,900**

Notes: 1. Values include Out Buildings
2. Numbers of buildings affected between the North Perimeter Highway and Lockport are not included.

Figure A-13 shows the damage-frequency relationship for the area north of the Floodway Outlet. The area under the curve represents average annual damages that could be used to justify flood protection works for the area. The maximum value of the average annual damages is estimated to be $38,000.

This amount would have to be more than 500 times the current estimate to begin to approach a point of economic justification of major works such as extension of the Floodway.

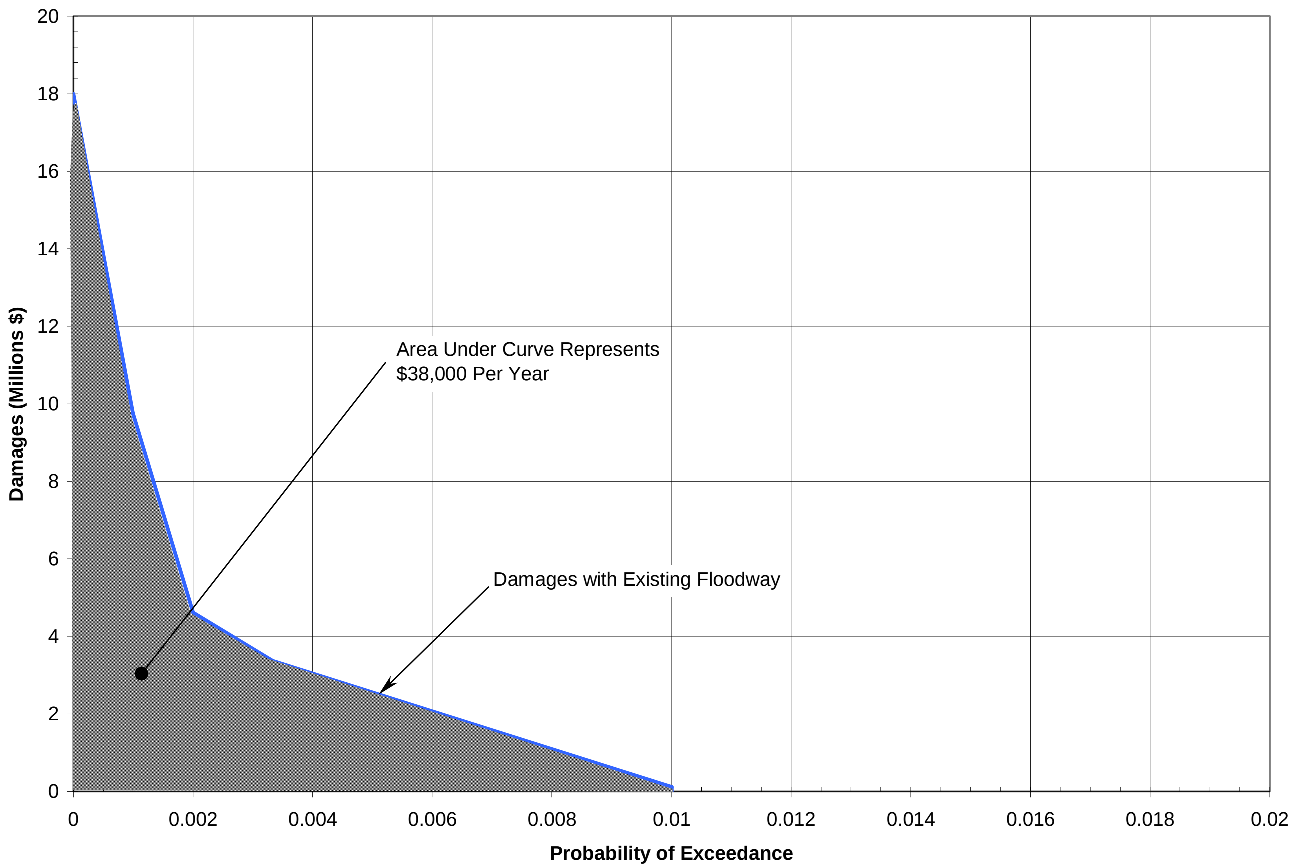


Figure A-13 – Damage-Frequency Relationship for Area North of Floodway Outlet

A.6 FUTURE STUDY REQUIREMENTS

Future studies are recommended to confirm and refine results in this preliminary study:

1. More accurate topographic mapping of the areas adjacent to the river (within about 3 miles on either side) to assist the identification of potentially inundated areas north of Winnipeg.

2. Preparation of a GIS database of residential, commercial, and institutional establishments to assist better estimates of flood damage potential north of Winnipeg.

3. Review and update of backwater analyses of the lower river with improved estimates of overbank topography that would generated by point #1, above.

4. Undertake more definitive studies of potential flood damages, and specifically, prepare a damage-frequency relationship that could be used to refine the results presented in this report.

5. Conduct additional flood routing studies to supplement the information on impacts of the Floodway Expansion, and the Ste. Agathe Detention Structure, on the area at and north of Selkirk. A range of possible flood hydrograph shapes should be addressed.

6. Undertake studies of ice conditions in the Red River to improve the predictive capability of ice jam problems and assist planning of operation of an expanded Floodway (if that option is ultimately selected). This should also include studies of the operation of the expanded Floodway during extreme ice jam events in the lower river so that the potential for flooding in the lower river and in Winnipeg may be reduced.

REFERENCES

REFERENCES

1. *KGS Group, March 2000, "Flood Protection for Winnipeg", Parts II and III.*

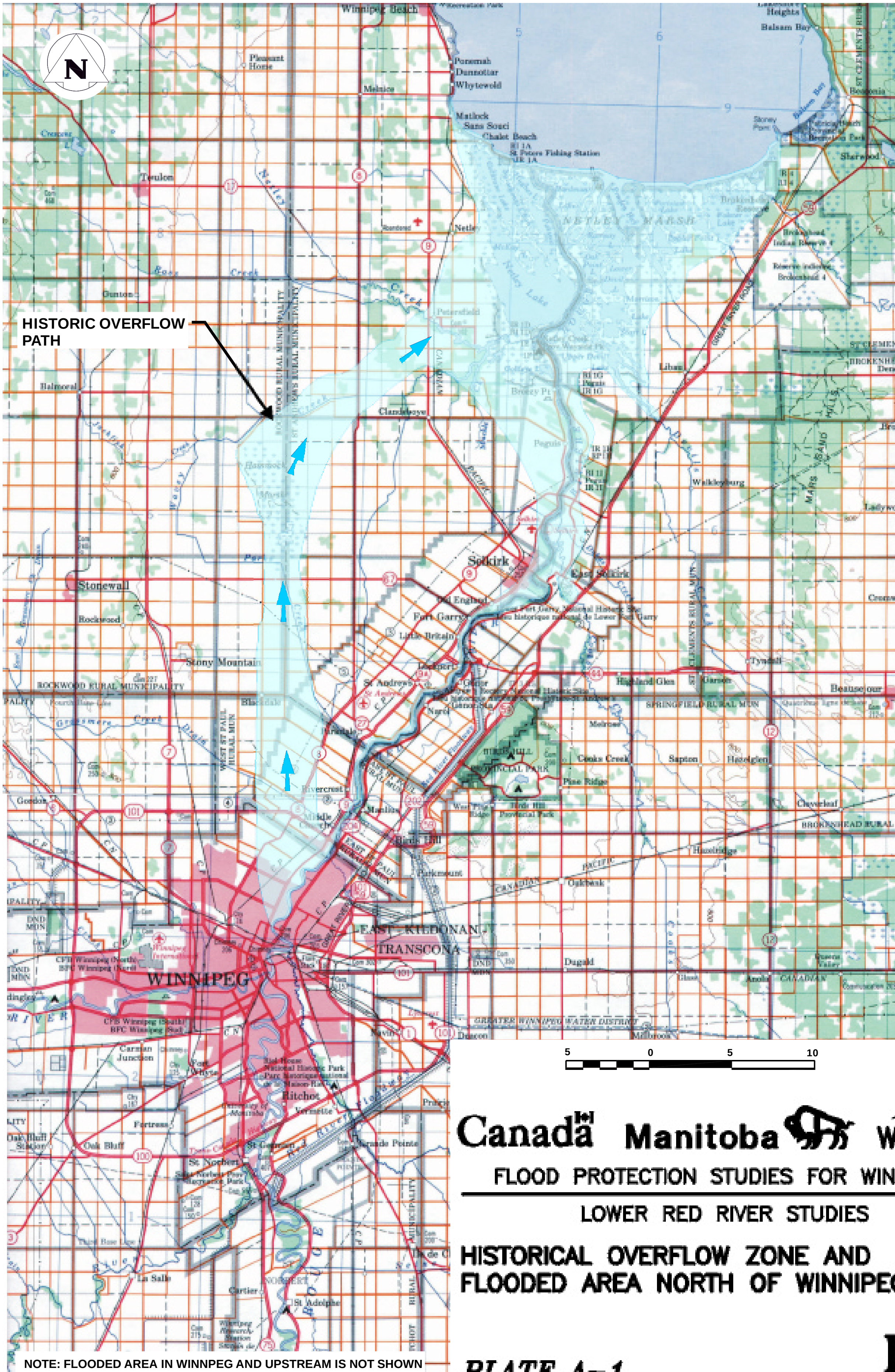
2. *Sir Sandford Fleming, 1879, "Appendix 16 of Sessional Paper No. 123 (report to CPR)".*

3. *I. Hanuta, 2001, Report to KGS Group on review of parish papers and historical documents.*

4. *E. Kuiper, 1965, "Water Resources Development", Butterworths PP. 83-84.*

5. *V.A. Vanoni, 1960, "Resistance Properties of Sediment Laden Streams", Transactions ASCE Vol. 125 (Laboratory experiments showing friction factor of a stream carrying sediment is less than a comparable one without sediment).*

PLATES



Canada Manitoba Winnipeg

FLOOD PROTECTION STUDIES FOR WINNIPEG

LOWER RED RIVER STUDIES

HISTORICAL OVERFLOW ZONE AND FLOODED AREA NORTH OF WINNIPEG

PLATE A-1

FINAL REPORT SEPTEMBER 2001

KGS GROUP

KGS FILE NO.: P:/00-311-07/ADMIN/ADMINDOCS/FINAL REPORT/APPENDIX A/PLATES/PLATE A-1.CDR

Canada

Manitoba CONSERVATION

Winnipeg

FLOOD PROTECTION STUDIES FOR WINNIPEG

APPENDIX C
STE. AGATHE DETENTION STRUCTURE

NOVEMBER 2001

KGS GROUP

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

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C.1 INTRODUCTION

This appendix is one of six that accompany and supplement the Main Report on Studies of Flood Protection for Winnipeg. This volume describes findings of studies of the Ste. Agathe Detention Structure.

The study of flood protection improvements for Winnipeg that was carried out by KGS Group for the International Joint Commission (IJC) included pre-feasibility assessments of optional measures. A preliminary project design for the option called the Ste. Agathe Detention Structure was prepared, and is described in some detail in KGS Group's report to the IJC (KGS Group, 2000). It was recognized at that time that there were some features of the scheme that should be improved. Although the main focus of the current study has not been on additional engineering of the Ste. Agathe Detention Structure, a limited amount of work has been done. That work has concentrated on three key improvements in the concept:

- Elimination of the small backwater effect that would be caused by the original layout of the structures for floods less than about the 1 in 90 year magnitude. With that original arrangement, water levels upstream of the structure would exceed what would occur under current conditions without the structure, even for floods less than the 1 in 90 year magnitude that would trigger the use of the gates to protect Winnipeg.
- Replacement of the fuseplug dike with a more secure system involving an increased flood discharge capacity through the concrete control structure. The fuseplug dike was an economical means of providing discharge capacity for extreme floods approaching the Probable Maximum Flood[1] (PMF). However, the fuseplug was argued to be undesirable for a water retention structure upstream of a major city.
- Provision of adequate flood discharge capacity in the concrete control structure(s) so that a freeboard of about 6 ft. could be available during passage of the PMF. This would comply with the current design guidelines recommended by the Canadian Dam Association (CDA, 1995).

1 The Probable Maximum Flood is defined as the largest flood that could reasonably be expected to occur in the watershed.

The improvements in the pre-feasibility design of the project have been made and are described in the next section. It should be noted that the design is still considered preliminary. Full feasibility of the project could only be confirmed with considerably more detailed engineering based on sub-surface investigation at the proposed site. Such a level of investigative detail was not considered appropriate until social issues are resolved and the concept is deemed to be acceptable to Manitobans.

The concept of the Ste. Agathe Detention Structure that is described herein is designed to provide flood protection in the area north of Ste. Agathe to Lake Winnipeg for floods up to the 1 in 1000 year magnitude (approximately 295,000 cfs, or about 80% greater than the 1997 flood).

It should also be noted that the magnitude of the Probable Maximum Flood, as explained in the Main Report, Section 1, has been approximated by an estimation of the 1 in 10,000 year flood in the Red River. If further, more refined studies and planning of the Ste. Agathe Detention Structure are carried out, the magnitude of the PMF should be examined more thoroughly. There would also be justification for studies of the PMF to be carried out if the Floodway Expansion option is selected, as described in Appendix B, and in the Main Report.

C.2 DESCRIPTION OF PROJECT ARRANGEMENT AND OVERALL FLOOD PROTECTION SCHEME

The principal structures comprising the Ste. Agathe Detention Structure are shown on Plate C-1. The project would consist of the following:

- An earth dike across the valley extending from approximately Brunkild on the west side to Tourand on the east side (PTH 59). The axis of the structure at the Red River would be approximately 1.5 miles south of the town of Ste. Agathe. The total length of the dike would be about 25 miles, and its maximum height in the Red River would be about 70 ft., with a height ranging from a few feet to 25 ft. on the flood plain.

- Two control structures; the primary structure would be located adjacent to the Red River and would discharge approximately 70 percent of the Red River flood discharge. An auxiliary control structure would be located just west of the Marsh River to handle the remainder of the flood discharge.

- A downstream flood discharge channel, approximately 5 miles long, would be constructed with the exit located just upstream from the Rat River confluence with the Red River, and the channel entrance located on the Red River approximately 0.5 miles upstream from the primary control structure.

- A smaller diversion channel connecting the downstream flood diversion channel to the Rat River would also be constructed from the downstream flood diversion channel just downstream from the Marsh River Control Structure.

- A gated control structure on the Rat River. Its purpose would be to allow the Rat River to discharge past the Ste. Agathe Structure without impedance during non-flood conditions on the Red River.

In addition, the scheme is proposed to include:

- Upgrades to the flood protection infrastructure in the City of Winnipeg, as described in Appendix B, Section B.6.16.

- Improvements at the Floodway Inlet Control Structure consisting of:

    - increased security against fires in the control facilities (see Appendix B, Section B.6.9)
    - improvement in erosion protection on the downstream side of the embankments adjacent to the structure (see Appendix B, Section B.6.9)
    - tentative improvement in the erosion protection on the upstream side of the embankments adjacent to the structure (requires further investigation, see Appendix B, Section B.6.9)

C.3 PRELIMINARY DESIGN CRITERIA OF STE. AGATHE DETENTION STRUCTURE

The primary design criteria for the revised Ste. Agathe Detention Structure are listed below:

- Flood discharges up to the 1997 flood of 135,000 cfs at the Floodway Inlet to be discharged without attenuation at the Ste. Agathe Detention Structure (approximately 1 in 90 annual probability of being exceeded).

- No increase in water levels upstream for all floods up to the 1 in 90 year flood.

- Allowance for boat and fish passage on the Red River to be provided through low level sluiceways with the invert level at approximate river bottom level.

- Capability of passing the Probable Maximum Flood (PMF) with a minimum of 6 ft. freeboard above the static reservoir level (no wind).

- The control structure bays would be equipped with gates. The gates would be closed as required to limit the total discharge downstream from the structure to a maximum of 135,000 cfs for Red River flood discharges between 135,000 cfs and approximately 260,000 cfs. (inflow from Red River, not including the Assiniboine River contribution, during 1 in 1000 year event).

- The reservoir storage volume would be sufficient to store the flood volume for the 1 in 1000 year flood event, without causing the outflow from the structure(s) to exceed 135,000 cfs (approximately the "state-of-nature" flow for a 1 in 90 year flood).

- The flood discharge channel would have the capacity to pass approximately 30 percent of the Red River flow during the 1 in 1000 year flood event.

- The maximum flow velocity in the flood discharge channels (upstream and downstream) would be limited to 3 ft. per second. This criteria is based on limiting head losses in the channel.

- The upstream flood discharge channel from the Red River to the Marsh River Control Structure would be constructed with an adverse slope to permit draining of the channel back (south) to the Red River, when the Red River water level recedes below the Marsh River spillway crest level.

- There would be no control structures on the flood discharge channels (at either the upstream or downstream ends). The depth of water in the channels would be governed by the Red River water level at the entrance and at the exit. Flow would only occur when the Red River water level exceeds the crest level of the Marsh River spillway crest level. This corresponds to a Red River flow of approximately 20,000 cfs.

- Fish passage on the Rat River would be provided by a gated control structure on the Rat River. The structure would have capacity to discharge the 1 in 100 year flood on the Rat River with velocities less than 5 ft. per second. The base slab elevation of the control dam (invert level) to be set at the channel invert level.

- Side slopes of excavated flood discharge channel 6H:1V.

- Side slopes of earthfill structures 6H:1V.

C.4 DESCRIPTION OF STRUCTURES

C.4.1 RED RIVER CONTROL STRUCTURE

The axis of the Ste. Agathe Detention Structure at the Red River is proposed to be located at a meander bend in the Red River, approximately 1.5 miles upstream from the town of Ste. Agathe. The general arrangement of the control structure is shown on Plates C-2 and C-3.

The control structure would consist of 6 water passage bays. The two centre bays would be low level open sluiceways, each 60 ft. wide, with their invert level at El. 730 ft., which approximates the existing channel invert elevation. The backwater effect at low discharges would therefore be eliminated. The low level bays would serve to provide for boat passage and for fish passage during periods of low flow on the Red River. These bays would be ungated.

At maximum reservoir level, the discharge capacity of the two open bays would be approximately 125,000 cfs. The stage-discharge relationship for these bays is illustrated on Figure C-1.

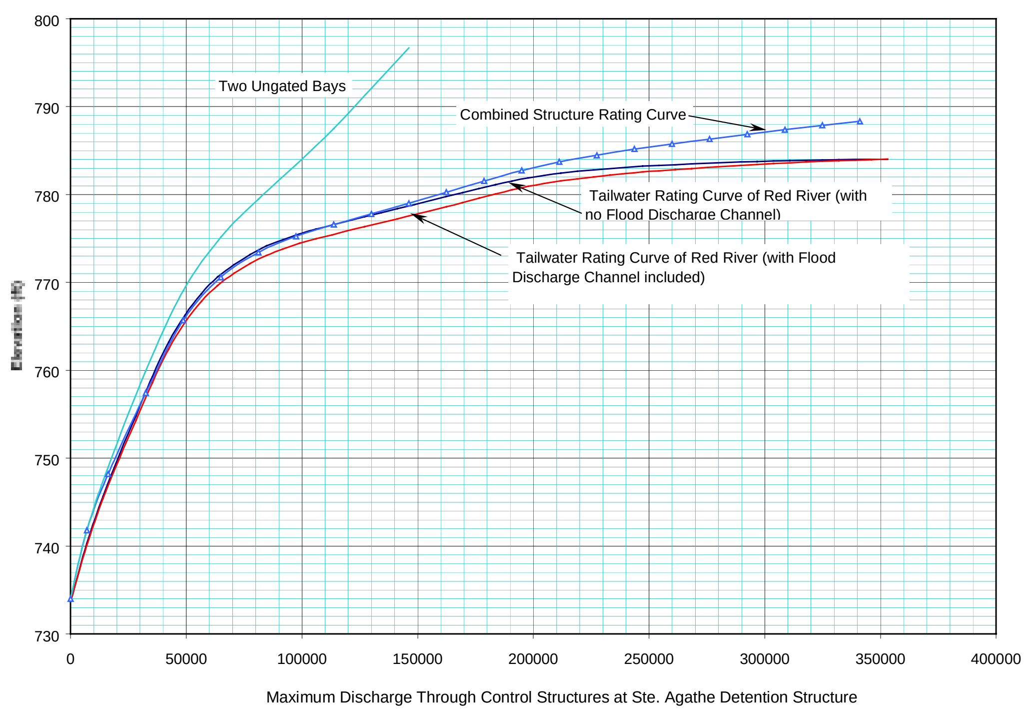


Figure C-1 – Stage-Discharge Relationships at Ste. Agathe Detention Structure

It should be noted that two-dimensional hydraulic analyses of flow conditions upstream of the structure have not been included in the limited engineering scope for this study. It is possible that in more detailed design phases, it may be shown that further minor adjustment of the discharge capacity of the structures may be required. This adjustment would eliminate any minor backwater effects at the periphery of the flooded areas upstream. Any required adjustment to the current design would clearly be minor and would not affect the conclusions of this study.

The four outside bays would be 66 ft. wide each, and would be equipped with gates to regulate the flow of water past the control structure when the discharge in the Red River exceeds approximately 135,000 cfs. The four bays would have standard ogee spillways with the crest level at El. 745.0 ft. At maximum reservoir level, the combined capacity of the 6 bay Red River Control Structure, with all gates fully opened, is approximately 77 percent of the total Red River discharge.

The construction of the Detention Structure in the river and Control Structure would be a two-stage process. The location of the structure at the meander bend would be used to facilitate the construction of the structure and spillway. During Phase 1, the Control Structure, the approach channel, and discharge channel would be constructed in the meander bend in the dry with upstream and downstream earth plugs remaining in place until the channels have been completed. Water would continue to flow in the natural channel. During Phase 2, the earth plugs in the upstream and downstream channels would be removed and an earth cofferdam or dike would be constructed across the river to divert the flow through the completed control structure.

There is a concern with respect to the future upkeep of the Ste. Agathe Detention Structure. It is, by its nature, a structure that will not require gate operation frequently. It is likely that the gates would only have to be lowered once or twice to control floods in a 100 year period. Because of this infrequent usage, there is a concern that due diligence in maintenance of the gates and the hoisting system will not persist over many decades. It is conceivable that the gates and the related equipment, possibly even the concrete or earth structures, could suffer some reduction in reliability. On the other hand, there is no doubt that given appropriate annual funding, this risky situation could be avoided, by an operation and maintenance program which includes regular gate activation and repair.

C.4.2 MARSH RIVER CONTROL STRUCTURE AND FLOOD DISCHARGE CHANNEL

The Marsh River Control Structure and flood discharge channel is an integral part of the Ste. Agathe project. The general arrangement of the structure is shown on Plate C-4. The major components include:

- A two-bay gated control structure,
- A five-mile long downstream flood discharge channel, with the downstream channel exit located near the confluence of the Rat River and Red River and with the entrance to the upstream channel located approximately 0.6 miles upstream from the Red River Control Structure, and
- Interconnecting channels to the Marsh River upstream and to the Marsh and Rat Rivers on the downstream.

The purpose of these project components is to provide additional discharge capacity for floods up to the 100 year return event and to provide additional capacity at the maximum reservoir level to eliminate the need for the fuse plug dike concept adopted in previous studies. Flood routing studies by Manitoba Conservation using the MIKE-11 hydrodynamic model showed that under existing natural river conditions, approximately 25 percent of the total Red River discharge flowed on the east flood plain of the Red River Valley (Rat/Marsh). Without these facilities, the flow would be concentrated in the Red River channel, thus resulting in higher tailwater levels at the main structure that would also produce increased upstream water levels. The structure is located near the Marsh River, with an interconnecting channel to the Rat River, and facilitates the spreading of the flow onto the flood plain, thus reducing the water level at the main structure in the river.

The arrangement of the control structure and channels is shown on Plate C-1 and on Plate C-4. The Marsh River Control Structure would be a two-bay gated control structure, each 66 ft. wide with a standard ogee crest having a crest level at El. 750 ft. The control structure would be equipped with radial gates, similar to those in the Red River Control Structure. The gates would normally be in the open position except during floods greater than 135,000 cfs (approximately 90 year return period). At maximum reservoir level, the Marsh River Control Structure would discharge approximately 23 percent of the total Red River discharge.

The flood discharge channel is shown on Plate C-1. The dimensions of the channel include:

- Base width of 160 ft.
- Side slopes of 6H:1V.
- The invert of the downstream flood discharge channel varies from El. from 730 ft. at the exit and El. 735 ft. at the Marsh River Control Structure.
- The invert elevation of the upstream flood discharge channel varies from El. 735 ft. at the channel entrance at the Red River, to El. 736 ft. at the Marsh River Control Structure. This adverse slope from the inlet at the river to the structure from the inlet at the river to the structure allows for the draining of water back from the upstream flood discharge channel to the Red River. This condition would automatically occur when river stages after a flood event subside below the crest level of the Marsh River Control Structure.

The flood discharge channels are an integral part of the Marsh River Control Structure. Their purpose is to provide flow through the Marsh River Control Structure when the water level in the Red River is below the flood plain level. The general flood plain elevation in the vicinity of Ste. Agathe is approximately 776 ft., which corresponds to a Red River water level that would occur at a river flow of more than 100,000 cfs. It also provides additional capacity to the Red River channel and to the east flood plain, in excess of the existing natural channel capacity. This additional flow capacity in the Red River will result in a lowering of the tailwater level at the Ste. Agathe Detention Structure compared to the “state-of-nature” water level at that location. The lower water level thus enables the passage of flood discharge with upstream water levels no higher than the “state-of-nature” levels.

The tailwater rating curves at the Ste. Agathe Control Structures for the flood discharge channel and for the existing conditions are illustrated on Figure C-1. For example, the tailwater is lowered by approximately 1.2 ft. with the flood discharge channel from the “state-of-nature” water levels when the river flow is 135,000 cfs.

The rating curve for the operation of the combined Red River and Marsh River Control Structures is also shown in Figure C-1. The combined effect of the Marsh River Control Structure and the flood discharge channel results in upstream water levels that are no higher than the existing water level, for floods up to 135,000 cfs. Also, the total capacity of the combined structures at reservoir El. 791 ft. exceeds the estimated PMF discharge of 400,000 cfs in the Red River.

C.4.3 RAT RIVER CONTROL STRUCTURE

The general arrangement of the Rat River Control Structure is illustrated on Plate C-5. The structure would consist of the following:

- A gated two-bay control structure with each bay being 20 ft. wide,
- An invert level at approximate stream invert elevation at the Rat River,
- Vertical slide gate and hoist each 20 ft. wide and 20 ft. high, and
- A horizontal breast wall spanning each bay from El. 768 ft. to the top of the structure at El. 798 ft.

During periods when the Red River is below flood stage, the gates in the structure would remain open and water would flow in the Rat River, as under existing conditions. The gates would be closed during flood conditions when Red River water levels exceed the flood plain elevation. Rat River discharge would then be diverted overland to the Marsh and Red River Control Structures.

C.4.4 MANAGEMENT OF TOURAND CREEK

Flow in Tourand Creek is relatively small, and is frequently zero. It is proposed that a drainage ditch be constructed adjacent to the upstream toe of the Ste. Agathe Detention Structure to convey the runoff from Tourand Creek into the Rat River at the Rat River Control Structure.

C.5 OPERATING CONDITIONS

The Red River Control Structure and the Marsh River Control Structure would be operated to achieve the following conditions:

- The gates would remain fully opened in the raised position for Red River discharges less than 135,000 cfs (approximately the 1 in 90 year flood peak). This would result in "state-of-nature" water levels upstream from the Ste. Agathe Detention Structure.
- The gates would be lowered as required for Red River discharges greater than 135,000 cfs with a maximum release through the structures limited to 135,000 cfs. Excess water would be stored in the reservoir that would already exist under flood conditions of this magnitude. This would cause water levels in that area that would exceed the "state-of-nature" condition.
- The maximum reservoir level attained at the structure during a flood event would depend on the volume of the flood event in excess of the 135,000 cfs controlled release.

The Rat River Control Structure would be closed during floods that exceed the bank-full capacity of the Red River.

C.6 RESERVOIR FLOOD LEVELS

C.6.1 SPRING ICE CONDITIONS

The Ste. Agathe Detention Structure will have relatively wide discharge bays (66 ft. each). While this is wide for conventional spillway structures, it is not as wide as the water passages in the Floodway Inlet Control Structure (112 ft. each). It is possible that some river ice jamming could be expected during spring breakup, and generally cause delay of release of the river ice during the spring freshet. It is likely that some additional backwater effects could occur upstream of the lodged/jammed ice cover. It is likely that such a jam would clear from the river long before bank full stage is reached. However, the possible effects of more frequent and longer lasting ice jam conditions upstream of the Ste. Agathe Detention Structure should be addressed in more detail at the next phase of study.

C.6.2 MAJOR FLOOD CONDITIONS

Maximum water levels reached at various locations in the reservoir (“Red Sea”) are illustrated on Figure C-2. The lines shown on the Figure C-2 are envelope curves defining maximum water levels at any location and are not water surface profiles for a given instant during a flood event. For the 1 in 1000 year flood event, for example, the maximum water level at Emerson would occur approximately 16 days earlier than at the Ste. Agathe Detention Structure. These maximum water levels were computed by Manitoba Conservation using a flood routing numerical model of the Red River Valley, called “MIKE-11 hydrodynamic model”.

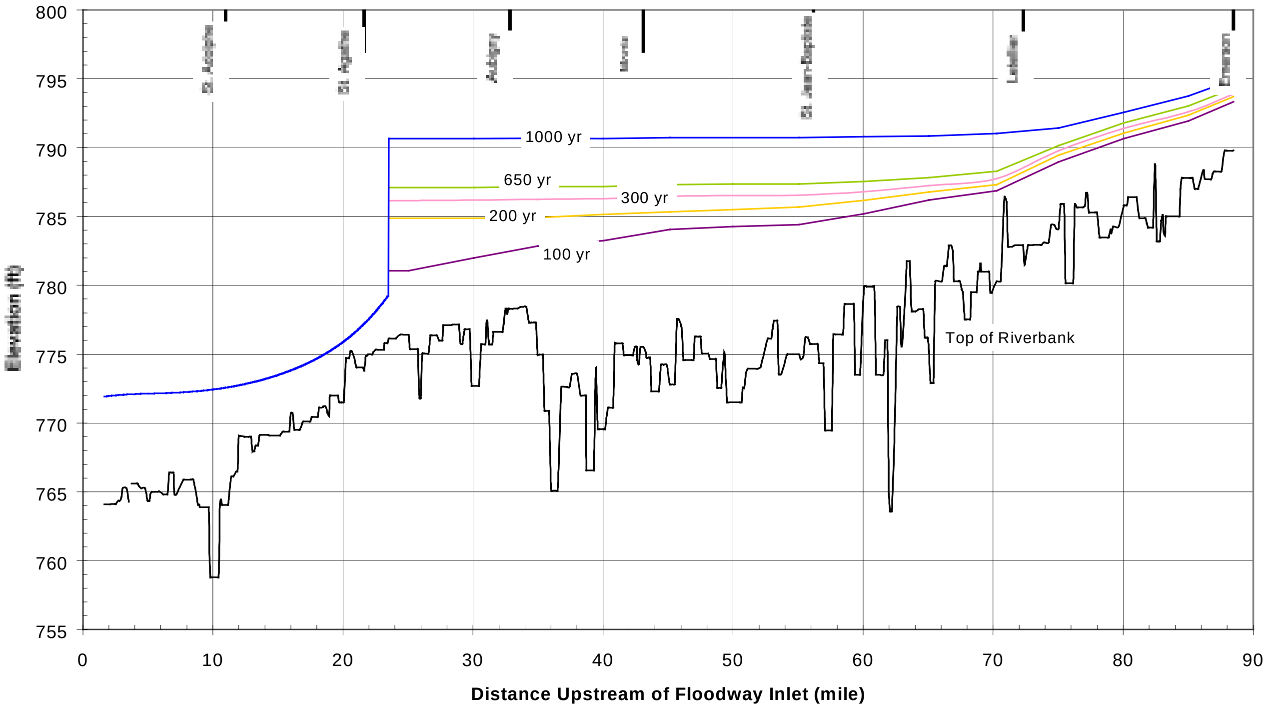


Figure C-2 – Maximum Water Surface Levels with Ste. Agathe Detention Structure

A comparison of the 1 in 1000 year water level hydrographs at Morris are shown in Figure C-3 for both "state-of-nature" conditions and with the Ste. Agathe Detention Structure. The backwater effect, defined as the difference in the water level from the "state-of-nature" condition that would occur on any particular day during the flood event, is also evident in Figures C-2 to C-4. As shown in Figure C-3, the backwater effect at Morris would be 6.9 ft. at the time of the peak stage shown on May 10, and would continue to be above the natural water level as the flood recedes.

Similar conditions are shown on Figure C-4 for a 1 in 300 year flood event, with and without the Ste. Agathe Detention Structure. All results shown in Figures C-3 and C-4 were generated by Manitoba Conservation's numerical model of the Red River Valley ("MIKE-11 hydrodynamic model").

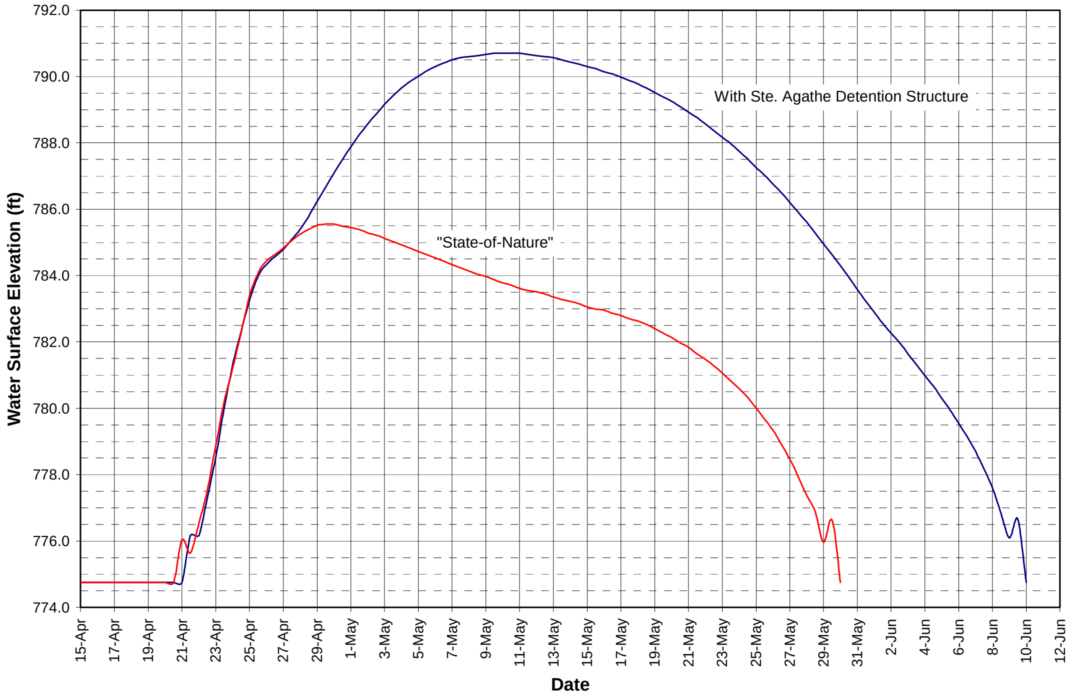


Figure C-3 – Water Level Hydrographs of Red River at Morris – 1 in 1000 Year Flood (With and Without Ste. Agathe Detention Structure)

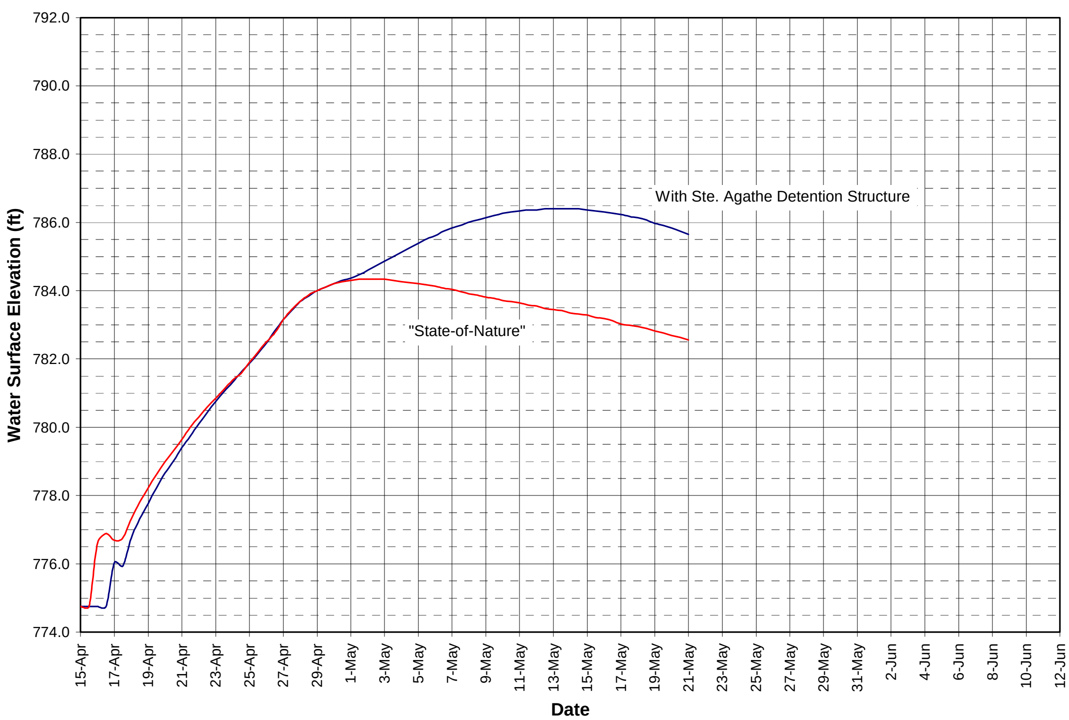


Figure C-4 – Water Level Hydrographs of Red River at Morris – 1 in 300 Year Flood (With and Without Ste. Agathe Detention Structure)

Similar graphs have been prepared for other locations in the Red River Valley, and for other flood conditions (lesser and greater peak flood flow). They are summarized in Annex A. It will be noted that the water levels at Emerson (Canada/U.S. border) exceed the natural levels in the recession limb of the hydrograph for floods exceeding approximately the 1 in 300 year return period. The impact on the U.S. is discussed further in Section C.10. Similar impacts would occur to the Roseau River First Nation.

The results of the flood routing analysis can also be represented on maps that show the maximum water depths and areal extent of the flooding. The following plates show these results, and comparable conditions for the expanded Floodway (for 1 in 700 year flood protection):

Plate C-6 - 100 Year Flood, Existing Floodway, Inundated Area
Plate C-7 - 300 Year Flood, Existing Floodway, Inundated Area
Plate C-8 - 1000 Year Flood, Existing Floodway, Inundated Area
Plate C-9 - 100 Year Flood, Ste. Agathe Detention Structure, Inundated Area
Plate C-10 - 300 Year Flood, Ste. Agathe Detention Structure, Inundated Area
Plate C-11 - 1000 Year Flood, Ste. Agathe Detention Structure, Inundated Area
Plate C-12 - 100 Year Flood, 1 in 700 Year Expanded Floodway, Inundated Area
Plate C-13 - 300 Year Flood, 1 in 700 Year Expanded Floodway, Inundated Area
Plate C-14 - 1000 Year Flood, 1 in 700 Year Expanded Floodway, Inundated Area

C.7 OPTIONAL SCHEMES TO MITIGATE ARTIFICIAL FLOODING

Some communities in the Red River Valley in southern Manitoba are currently protected by ring dikes. Protection is generally adequate for the 1 in 100 year flood water level, with an additional 2 ft. of freeboard for wind effects. A possible means to minimize the impact of operation of the Ste. Agathe Detention Structure gates would be to permanently raise the crest elevation of these ring dikes. That could substantially reduce the estimated flood damages that would be caused in the Valley between the Ste. Agathe Detention Structure and Letellier.

The cost of these increases in ring dike heights was estimated by Manitoba Conservation and are summarized in Table C-1 for a possible range of design levels corresponding to 1 in 200 yr to 1 in 1000 year flood protection. Only communities that have existing dikes or are scheduled to have dikes constructed under the 1997 flood proofing program have been included. Communities such as Emerson, Gretna, and Rosenfeld were not included because the flood levels at those locations are not increased by the Ste. Agathe Detention Structure at the 1 in 1000 year design flood.

Other assumptions in the estimation of costs included:

- All existing and scheduled dikes can be raised (no physical constraints that prevent it).
- Minimum of 2 ft. of freeboard, 12 ft. top width.
- Dike heights under 10 ft. would have 1V:4H side slopes, and greater dike heights would require 1V:6H side slopes.
- A riverbank stabilization cost was included for design floods exceeding the 1 in 500 year magnitude.
- Lump sums were included for right-of-way, pump stations, and drainage facilities.
- 30% for contingencies, and 20% for engineering/site supervision were also included.

The total cost is estimated to be some $55,000,000 for protection against a 1 in 1000 year flood with operation of the Ste. Agathe Detention Structure. Consideration of how this information can be used in assisting the assessment of the Ste. Agathe Detention Structure is described in Section C.13.

TABLE C-1
Estimated Costs to Mitigate Artificial Flooding
Caused by Ste. Agathe Detention Structure

Community	Estimated Dike Costs (Prepared by Manitoba Conservation)				
	100 Yr. Flood	200 Yr. Flood	300 Yr. Flood	650 Yr. Flood	1000 Yr. Flood
Morris	0	3,640,000	4,281,000	7,432,000	11,830,000
St. Jean Baptiste	0	2,821,000	3,033,000	4,975,000	7,462,000
Letellier	0	834,000	925,000	1,016,000	1,517,000
Dominion City	0	728,000	728,000	728,000	1,395,000
Brunkild	0	789,000	912,000	2,275,000	4,156,000
Rosenort	0	1,031,000	4,034,000	5,248,000	10,374,000
Aubigny	0	1,486,000	1,668,000	2,548,000	3,625,000
St. Pierre-Jolys	0	0	1,941,000	2,032,000	4,671,000
Riverside	0	1,668,000	2,154,000	3,246,000	4,247,000
Roseau River FN	0	1,083,000	2,708,000	4,333,000	5,417,000
TOTAL	0	***$14,080,000***	***$22,384,000***	***$33,833,000***	***$54,694,000***

C.8 FLOOD DISCHARGE CAPACITY OF THE STE. AGATHE DETENTION STRUCTURE

C.8.1 FLOOD PROTECTION CAPACITY

The Ste. Agathe Detention Structure has been designed in this preliminary phase to be capable of substantially reducing flood damages for Red River floods between 1 in 100 year and 1 in 1000 year magnitudes. This range was selected with the following rationale:

- It is recognized that additional flood reduction benefits could be accrued if the gates would commence operation at floods in the range of 1 in 30 years to 1 in 100 years. However, the benefits downstream are estimated to be minor, and would be offset to a large extent by the adverse effects of artificially high water levels upstream. The psychological impact that would be associated with operation of the Ste. Agathe Detention Structure gates at floods much more frequent than 1 in 100 years would clearly not be palatable to upstream residents. Furthermore, 1 in 100 year flood protection would correspond roughly to the current level of protection for Winnipeg.

- On the other hand, the flood at which commencement of operation of the Ste. Agathe Detention Structure gates to provide protection downstream could have been selected at 1 in 125 to 1 in 150 year floods so that residents upstream could be comforted by the fact that their properties would have less risk of being adversely affected. This reduced risk would be minor, and it would result in a sharp increase in flood damages between Ste. Agathe and the Floodway Inlet, as well as in Winnipeg. It would result in a significant decrease in the effectiveness of the concept.

- At the upper end of the flood protection range, it is possible that the limit of protection could be at any point between about the 1 in 300 year flood and possibly the 1 in 2000 year flood, with relatively minor impacts on arrangement of structures and cost of the project. Selection within this range would require the engineering of this option to be on a more detailed level, and would require both engineering and socio-economic optimization to be carried out. This is beyond the scope of the current study. For present purposes, a capacity of 1 in 1000 year flood protection was deemed to be representative of the concept. It was not considered appropriate to select a low protection limit of say a 1 in 300 year to 1 in 500 year flood, because it would cost almost the same as the 1 in 1000 year flood protection, and provide substantially less benefits. The advantages over the Floodway Expansion at the diminished protection level would be minimal, and in KGS Group's view, not worth the effort required to resolve the difficult social issues of this project.

C.8.2 STE. AGATHE DETENTION STRUCTURE CAPACITY VIS A VIS UPGRADES TO CITY OF WINNIPEG FLOOD PROTECTION INFRASTRUCTURE

The proposed scheme includes the same upgrades to the City of Winnipeg flood protection infrastructure that is proposed for the Floodway Expansion (see Appendix B, Section B.6.16).

In Section B.6.16.2 of Appendix B, a comparison of the Floodway Expansion with and without the upgrades to the flood protection infrastructure in Winnipeg is described. It is shown that it would be advantageous to include the upgrades, as compared to constructing an incrementally larger Floodway that would be required without the upgrades. A similar comparison with the Ste. Agathe Detention Structure has been done and the cost of the incremental capacity in the Ste. Agathe Detention Structure was found to be less than 50% of the cost of the upgrades in Winnipeg.

On the basis of economics, the upgrades should not theoretically be included in the scheme. However, if the upgrades to Winnipeg's flood protection infrastructure were not made, the Ste. Agathe Detention Structure gates would have to be lowered at flood flows of about 20,000 cfs less than the current criteria, or at about a flood of 1 in 75 year magnitude. Furthermore, it would require increases in flood levels by several feet in the area upstream of the Ste. Agathe Detention Structure. This was judged by KGS Group as being unacceptable, and the upgrades were adopted as part of this scheme. It is a subjective decision, however, and should be reviewed if the Ste. Agathe Detention Structure were to gain favour in the next phase of project evaluation.

C.8.3 MANAGEMENT OF EXTREME FLOODS

The Ste. Agathe Detention Structure will retain a large volume of water during a major flood event. The height of the earth structure at the river is more than 70 ft. Overtopping of this structure, and a subsequent breach formation could create a substantial breach outflow. Even breaches in the lower height dikes east or west of the river could cause a significant rapid release of large flows. Furthermore, release of a large breach outflow could lead to a domino effect at the Floodway West/East Dikes, thereby exacerbating the flood inflow into Winnipeg.

From another perspective, the cost of incorporating sufficient discharge capacity to pass the PMF, and thereby minimize the risk of overtopping/breach formation is relatively small in a new structure of this type.

Consideration of the foregoing facts led KGS Group to select an arrangement of the structures and related channels that would have the hydraulic capacity to pass the PMF in the Red River without undue risk of overtopping any of the structures. The need for this capability, and the most cost effective and environmentally acceptable away to achieve it should be reviewed in future studies of the concept.

C.9 PRECEDENTS OF ARTIFICIAL FLOODING

The concept of incurring a relatively small amount of damage in one area to prevent major damages in another area, or to avoid costly construction works, is controversial. A literature review, and polling of certain key agencies that are responsible for flood control, was undertaken. The following results are available:

- There are numerous precedents of permanent reservoir creation that required expropriation of local residents in a flooded zone. The precedents are world-wide and include Manitoba (Grand Rapids Dam and the Churchill River Diversion are prime examples). However, those are more severe situations where flooding was to be a permanent feature and not an infrequent event as it would be for the Ste. Agathe Detention Structure. The Ste. Agathe Detention Structure could be viewed as a less invasive and milder form of these precedents of permanent reservoir formation.

- There are a few precedents where limited flooding of primarily agricultural land has been caused in order to protect downstream interests. Precedents are the Oder River, Germany, the Po River, Italy, and the Rhine River, Germany. Information on these precedents is difficult to obtain, and verbal description by sources familiar with those situations indicate that the scale is much less than the situation in Manitoba (Roth, 2001, Broderson, 2001, Romaneesen, 2001). Deliberate breaching of dikes has been done on a limited scale, and mostly agricultural properties were affected. One source (Broderson, 2001) suggested that more extensive flooding was not possible because of strong local opposition.

- The upper Rhine basin, shared by Switzerland, France and Germany, has been profoundly altered over the last two centuries for development of navigation and hydropower. River training works and dike construction have encroached on the channel sufficiently to reduce flood protection levels from roughly the 200 year level to the 100 year level in the last 50 years. A current goal is to restore the earlier level of flood protection.

  The problem is being approached in two ways. First, the operating plans for structures on the River are being modified to provide increased flood storage. Secondly is the construction of off-stream storage. The constructed polders are seen as improving ecological values as well.

  Three such polders are being constructed, two in Germany and one in France, which will retain some 50,000 acre-ft. The projects are controversial as people in the affected areas are being asked to make their land available with no benefit to themselves (Plate, 2001).

- Although the Yangtze River starts high in the mountains of Tibet, the navigable lower half of the River has a relatively low slope and is subject to severe flooding caused primarily by the Asian monsoon rains. The residents of the lower portion of the basin have endured floods for eons.

The 1931 central China flood caused some 140,000 fatalities, affected 28 million people and submerged an area larger than the entire Red River basin (not including the Assiniboine) for four months. Protective measures completed after that flood included thousands of miles of dikes (Winchester, 1996), development of two natural lakes for the flood storage, and the Jinjiang Flood Diversion Region of Wuhan. Similar flood control measures have also been developed for the Lower Yellow River.

The Flood Control Region contains dikes and diversion canals aimed at reducing peak water levels by diverting water from the Yangtze River into polders where water can be retained until the mainstem flow recedes. The areas where water is retained are heavily populated and are rebuilt after the system is used. During the 1998 flood some 330,000 people were evacuated from the Region. Generally, evacuation notice is short, a matter of a few hours, and rebuilding at government expense is a lengthly process (Li Yitain, 2001).

C.10 STE. AGATHE DETENTION STRUCTURE – IMPACTS ON USA

The Ste. Agathe Detention Structure will affect water levels in Minnesota and North Dakota. The effect on water levels at the 1 in 1000 year design flood is illustrated in Figure C-5. The water levels at the International boundary are not increased beyond natural levels but the duration of flooding is affected. Flooding would be prolonged by three to four days. Figure C-6 shows that a similar effect takes place at the 1 in 300 year flood, however the flood duration is prolonged by a day or less.

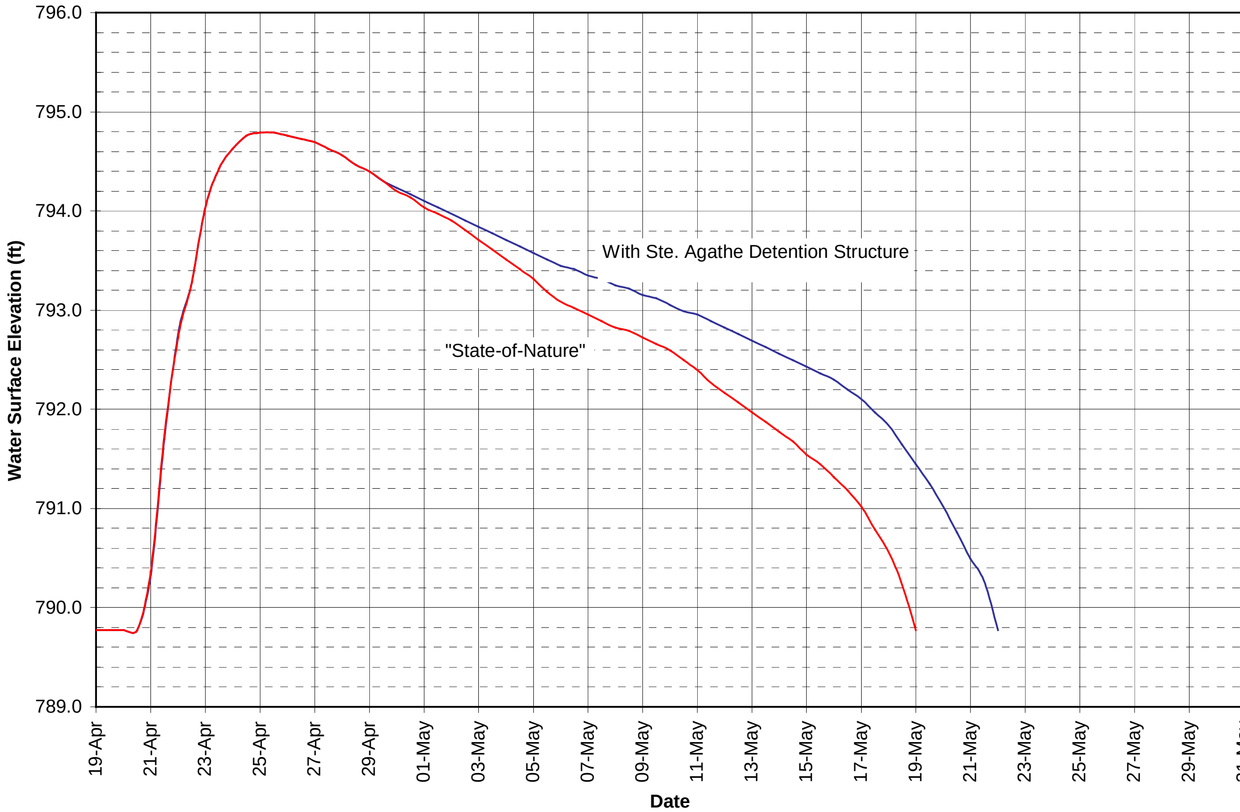


Figure C-5 – Water Level Hydrographs of Red River at Emerson – 1 in 1000 Year Flood (With and Without Ste. Agathe Detention Structures)

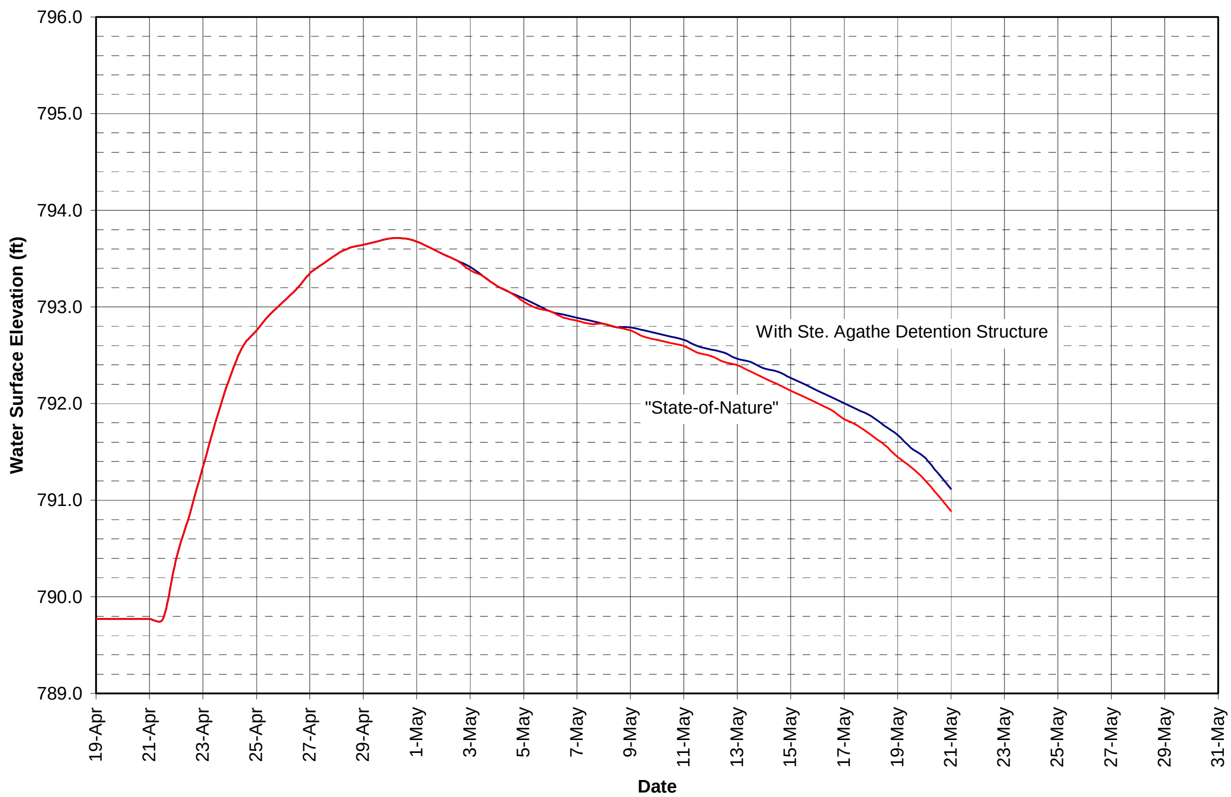


Figure C-6 – Water Level Hydrographs of Red River at Emerson – 1 in 300 Year Flood (With and Without Ste. Agathe Detention Structure)

The operation of the Ste. Agathe Detention Structure would have no effect on urban centres protected by ring dikes or on ring-diked or elevated farmsteads in the United States. (The increased risk of damage due to a few extra days of flooding on any engineered structure would be extremely small.) On the other hand, slightly prolonged flooding of agricultural lands could have an effect on farmers' ability to plant a crop or on crop yields.

Increased damages to agricultural producers in the United States at the design flood, while rare and likely small compared to the damages they would experience in a flood of this magnitude under natural conditions, are possible.

Figure C-7 illustrates the effect of the Ste. Agathe Detention Structure on water levels at the International Border when an extremely large flood takes place. This flood, which approximates the Probable Maximum Flood (PMF), would not cause water levels to be above natural levels, however the duration of flooding would be prolonged by about a day.

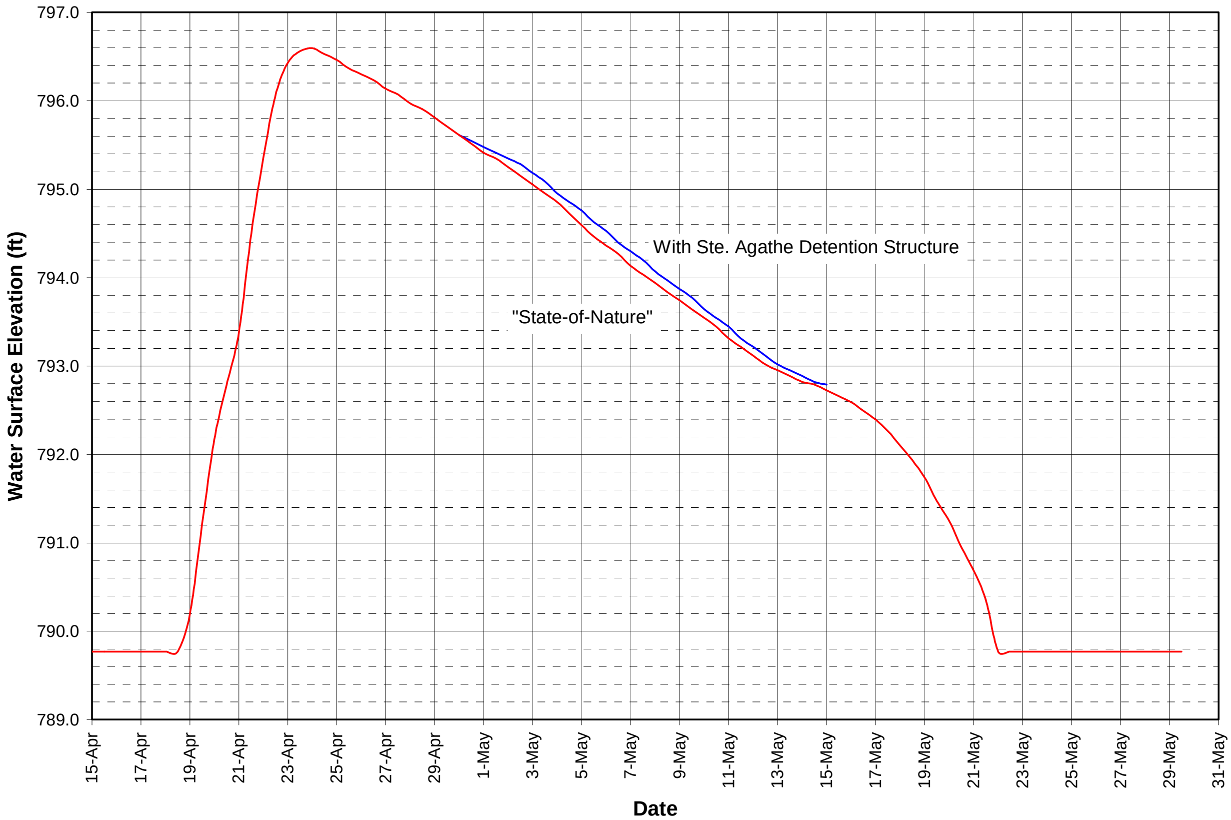


Figure C-7 – Water Level Hydrographs of Red River at Emerson – PMF (With and Without Ste. Agathe Detention Structure)

C.10.1 POTENTIAL INVOLVEMENT OF THE INTERNATIONAL JOINT COMMISSION

The 1909 Boundary Waters Treaty provides the principles and mechanisms to help prevent and resolve disputes, particularly those pertaining to water quantity and quality, pertaining to waters forming the International Boundary (boundary waters) or crossing the boundary.

The International Joint Commission (IJC) is a binational organization established by the Treaty. It consists of three members appointed by Canada and three by the United States headquartered in Ottawa and Washington, respectively. The Commission has two distinct roles. One is to undertake investigation of specific issues or monitor situations based on specific **references** from governments. The work carried out by the International Red River Basin Task Force following the 1997 flood is an example of a reference.

The other is a quasi-judicial function of issuing Orders of Approval in response to **applications** for the use, obstruction or diversion of waters that flow along, and in certain cases across, the international boundary if such uses affect the natural water levels or flows on the other side. Article IV of the Treaty specifically states: *The High Contracting Parties agree that, except in cases provided for by special agreement between them, they will not permit the construction or maintenance on their respective sides of the boundary of any remedial or protective works or any dams or other obstructions in waters flowing from boundary water or in waters at a lower level than the boundary in rivers flowing across the boundary, the effect of which is to raise the natural level of waters on the other side of the boundary unless the construction or maintenance thereof is approved by the aforesaid International Joint Commission.*

Although the Ste. Agathe Detention Structure would, on average, increase natural water levels at the International Boundary less often than once every few hundred years, there is a case to be made that the structure would require an IJC Order of Approval. Rather than dispute the applicability of Article IV, it would probably be preferable to seek an Order of Approval.

The process for issuing an Order of Approval is defined in the IJC's Rules of Procedure. Essentially, a detailed application would be made; notice published in the Canada Gazette, U.S. Federal Register and local media; statements filed; hearings held; witnesses subpoenaed; and a decision rendered. Once an Order has been issued the Commission retains a jurisdiction over the matter and may issue further Orders.

While in theory issuing an Order of Approval could be accomplished in a matter of months, public interest in the Ste. Agathe project could result in a much longer process. An alternative process for constructing the project exists, however, as described in Section C.10.2.

C.10.2 AN INTERNATIONAL AGREEMENT

Article IV, of the Boundary Waters Treaty (quoted above), states that approval is required *except in cases provided for by special agreement between them.* That is, the federal governments of the two countries could execute an agreement that would allow the project to proceed under defined conditions. These conditions would likely involve the design and operation of the project and a commitment to payment of compensation to affected landowners in the U.S. Because of the rarity of the event that would affect U.S. interests, the language covering requirements following operation of the gates during a flood emergency would have to be particularly clear.

The 1987 agreement between the then Canadian Department of External Affairs and the U.S. Department of the Army that permitted the construction of the international section of the Emerson-Noyes dike is one such example. Another is the agreement concerning the Pine Creek Diversion in the Roseau River basin.

The acceptability of this project in the U.S. would be a major factor in the willingness of the U.S. federal government to enter into an agreement to permit its construction. One possible approach would be to include U.S. residents of the affected area in public consultations as one means of gauging public concern. Using existing organizations such as the IJC's Red River Board, the Red River Basin Board, or the Pembina River Advisory Board to host a meeting might be one way of dealing with the potential problem of Canadians doing consultation in the U.S. U.S. concerns could then be incorporated at the front end of the project.

Undoubtedly the U.S. federal lead on any such agreement would be the U.S. Army Corps of Engineers. A process will also be required to engage their professionals, as well as Minnesota and North Dakota professionals, in questions related to the design and operation of the Ste. Agathe Detention Structure.

C.11 MITIGATION OF U.S. IMPACTS FROM STE. AGATHE DETENTION STRUCTURE

Consideration was given to operation modes, to modifications of the Ste. Agathe Detention Structure, and/or to supplementary works that would prevent or minimize the impact on the U.S. that is described in Section C.10.

Each is described below:

Operation Mode

At first glance, it would seem that additional release of flow through the Ste. Agathe Detention Structure would permit rapid drawdown of the "Red Sea" and elimination of the potential backwater effect in the U.S. Practical limitations, however, would make this unworkable:

- The operation at floods exceeding the 1 in 100 year magnitude require constant release of approximately 135,000 cfs through the Ste. Agathe Detention Structure, as described in Section C.4.1. This could be exceeded, but to the detriment of the residents between the Ste. Agathe Detention Structure and the Floodway Inlet, and only up to a condition where there could be substantial risk of flooding in Winnipeg. Whether this can eliminate the effects in the U.S. is uncertain, and requires further study. It is unlikely, however, to prevent the effects in the U.S. for floods in excess of the 1 in 500 year condition.
- Operation to prevent the effects in the U.S. would be difficult and probably impractical to plan "on the fly". It is possible to analyse a flood in a retrospective study and identify a suitable operation mode that would balance the interests in the U.S. and north of the Ste. Agathe Detention Structure. However, analysis during the flood event could not reasonably be expected to generate a reliable projection of outflow at the Ste. Agathe Detention Structure that could prevent effects in the U.S. and not unduly penalize Canadians.

Modifications to Ste. Agathe Detention Structure

Consideration of modification of the structures that comprise the Ste. Agathe Detention Structure did not lead to alternate layouts that could solve the backwater impact in the U.S., and still provide suitable protection in Winnipeg.

Supplementary Works

Floods in excess of the 1 in 100 year flood cause overbank flooding in the Emerson to Letellier area. Although detailed studies were not possible in this initiative, it was considered probable that "out-of-channel" improvements, consisting of excavated channel(s) or similar improvements in appropriate areas could result in lower water levels both at the peak of floods and on the receding limb of the flood hydrograph. The expected cost of such a measure could be substantial but likely not of such magnitude to make the Ste. Agathe Detention Structure unjustifiable. Further study would be required to confirm this.

C.12 ENVIRONMENTAL AND SOCIO-ECONOMIC CONSIDERATIONS

Environmental and socio-economic issues related to both the Ste. Agathe Detention Structure and the Floodway Expansion are described in Appendix F. The reader is referred to that document to supplement the engineering information described herein.

C.13 ESTIMATED COSTS OF STE. AGATHE DETENTION STRUCTURE

The pre-feasibility capital cost for construction of the Ste. Agathe Detention Structure is estimated to be approximately $390,000,000. This is based on adjustments to previous cost estimates by KGS Group (KGS Group, 2000) which are summarized in Table C-2. The overall cost of the project for comparative purposes to the Floodway Expansion is estimated to be $543,000,000, and takes into account upstream flood damages, operation and maintenance, and upgrades to Winnipeg's flood protection infrastructure.

To be consistent with the procedures used previously in flood protection studies for Winnipeg (KGS Group, 2000; Royal Commission on Flood Cost Benefit, 1958) a cost component has been retained which reflects potential damages that the Ste. Agathe Detention Structure would cause upstream during extreme floods.

TABLE C-2
Revision To Pre-Feasibility Cost Estimates of Ste. Agathe Detention Structure
(1 in 1000 Year Design Flood)
(All Costs In Millions of 2001 Dollars)

No.	Item	Previous Cost Estimate[1]	Revision	Revised Pre-Feasibility Cost Estimate
1	Red River Control Structure	$57.25	2 more bays 1 less gate	$53.4
2	Detention Dike	$128	Rat River Structure costed separately	$126.5
3	Rat/Marsh Diversion	$23.75	New Rat River Control Structure	$8.0
4	Marsh River Control Structure	Not Required	New Structure	$26.7
5	Flood Discharge Channel	Not Required	New Channel	$36.8
6	Rat River Control Structure	Not Required	New Structure	$5.3
7	Utilities Impact	$1.0	Additional Impacts	$1.5
8	Indirect Costs, including cost escalation, interest during construction, contingencies, administration, engineering and construction supervision	$105	Adjustment proportional to direct costs	$132
9	Present Value of Incremental Damages Upstream of Ste. Agathe Detention Structure	$21	Refinement in this study	$33
10	Present Value of Operation and Maintenance Cost of Ste. Agathe Detention Structure	$65	Refinement and definition of required O&M costs	$10
11	Upgrade of Flood Protection Infrastructure in Winnipeg	$74	Refinement in this study	$110
	TOTALS	**$475**		**$543**

1. As previously estimated (KGS Group, 2000) in studies for IJC.

Specifically, Table C-2 contains line item #9 that lists the increment in damages that are due to the operation of the gates in the Ste. Agathe Detention Structure. These have been estimated using the flood routing results from Manitoba Conservation's "MIKE-11 hydrodynamic model" numerical model, with damages estimated by KGS Group's numerical model that was prepared in previous studies (KGS Group, 2000). The latter model is GIS-based and contains a massive inventory of over 56,000 residential, agricultural, commercial, and institutional buildings. It uses depth-damage relationships that relate potential flood damage as a percent of assessed value of the property, to the depth of flooding relative to first floor elevation, to estimate the potential structure damages. Damage to crops, and other flood damages are also included. The model compared well to actual damages reported in the 1997 flood. The reader is referred to the previous report for details (KGS Group, 2000).

The damages that have been included are:

- Structural damages to residential, agricultural, commercial, and institutional buildings and damages to their contents.
- Damages to infrastructure such as roads, utilities, drainage ditches, etc.
- Agricultural damages and losses in crop production.
- Emergency response costs.

The results from the model have been increased by 20% to include minor flood-related, compensable damages and a monetary value to reflect intangible damages such as stress and anxiety. Business losses have not been included because this is not recommended by federal criteria.

The average annual damages have been based on the results shown in Figure C-8. The shaded area represents the average annual increment in damages upstream of the Ste. Agathe Detention Structure that are attributable to the operation of the gates in the structure when they are required to protect Winnipeg. The present value of 50 years of average annual incremental damages have been computed using an interest rate of 8%, an inflation rate of 3%, and an assumed annual rate of economic growth in the area of 1%.

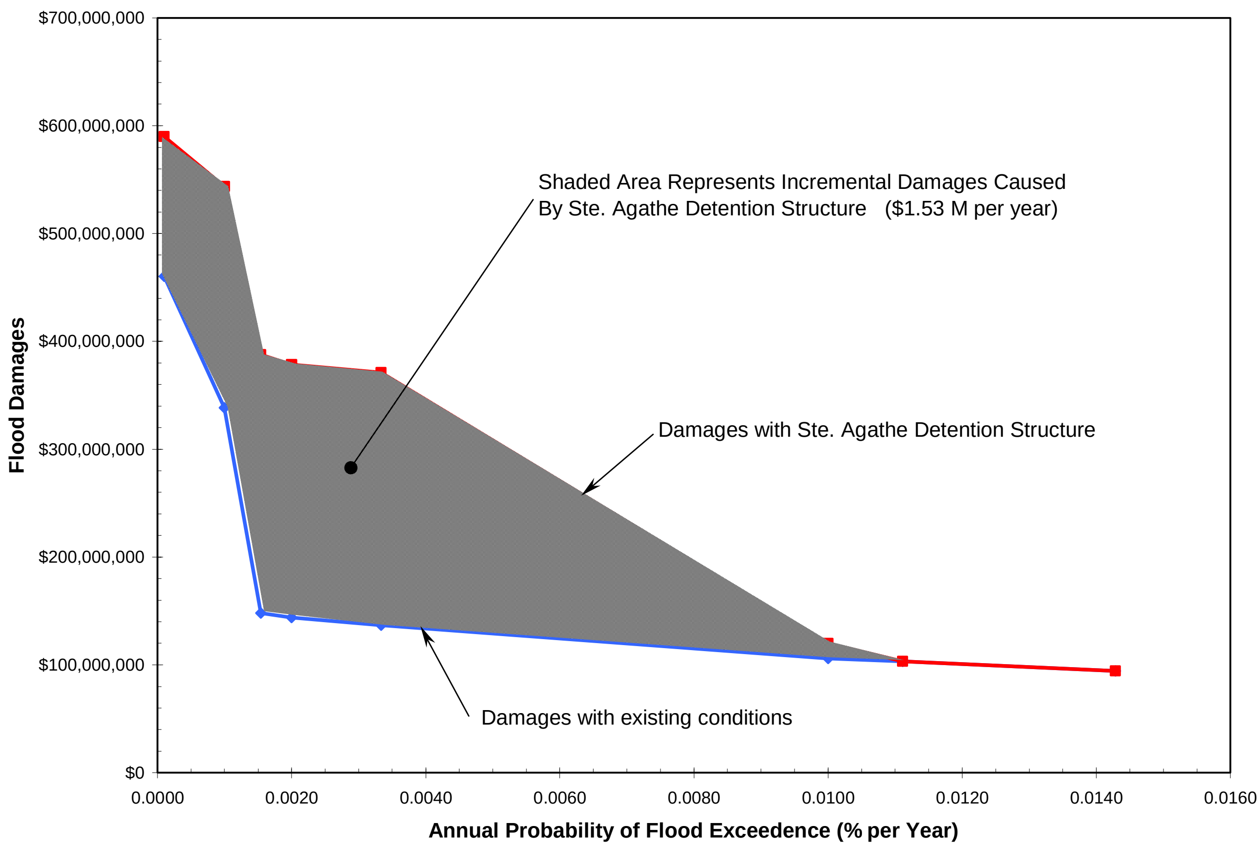


Figure C-8 – Incremental Damages Caused by Ste. Agathe Detention Structure

It could be argued that in this case of artificial flooding upstream of the Ste. Agathe Detention Structure, that more than the increment described above should be applied as a penalty against the concept. The rationale could be that it is very difficult to define the increment after the fact, and the tendency could be towards more generous compensation than the theoretical increment might suggest. That would tend to move towards a cost that would represent the entire area under the upper curve, as shown in Figure C-8. The line item cost associated with damages caused by the Ste. Agathe Detention Structure in Table C-2 would then be approximately $68,000,000. This notion has not been adopted in this study because the true incremental cost to society has been used in all economic comparisons. It has, however, been considered in the comparison of the Floodway and the Ste. Agathe Detention Structure the Main Report.

The costs of mitigation schemes involving enhancements of ring dikes described in Section C.7 have also not been included in the overall cost for the Ste. Agathe Detention Structure. They have been prepared for information and some portion may be added in future comparisons with the Floodway Expansion. It is clear that in any case only a portion of those costs would be appropriate to be included, because if the ring dike enhancements are included in the project, the present value of flood damages (see previous paragraph) would be reduced significantly. Further study would be required to quantify this effect.

Table C-2 also includes an item (#10) that is comprised of the present value of operation and maintenance of the structure and the dikes. This is a valid component that must be included in a fair comparison with the Floodway expansion. The previous preliminary estimate of this component by KGS Group for the IJC was a generous one, and was based on 1% of the capital cost of the project per year over the life of the project. This is in line with experience with hydroelectric structures (Kuiper, 1965, and U.N., 1955). Information on flood control projects was not readily available at the time. The revised estimate in the current study was based on the actual cost of operation and maintenance for the existing Floodway structures/embankment/channels, and on an examination of annual activities that would be required to maintain the Ste. Agathe project in a safe and operable state throughout its life. An estimate of $500,000 per year was prepared, and results in a present value over a period of 50 years of approximately $10,000,000.

Review of the project arrangement as it affects the environment, and in particular, fish, has led to identification of additional possible changes to the design of the project. The additional costs have been roughly estimated to be $12,000,000, and are described in Appendix F. Considerable review and refinement would be required before any of these possible modifications would be adopted in the project. At this time, it is important to note that even if all these potential enhancements for the benefit of the environment were adopted, the project cost would only rise by about 2%. This should not be a significant factor in comparison with the Floodway Expansion.

Other items such as taxes and insurance are relatively minor and have not been included.

C.14 BENEFIT COST ANALYSIS OF STE. AGATHE DETENTION STRUCTURE

Benefits of the Ste. Agathe Detention Structure were previously estimated by KGS Group (KGS Group, 2000). The method used was relatively standard, although it included components that reflected the influence of risk and uncertainty that are now routinely used by the U.S. Army Corps of Engineers. The reader is referred to more detailed explanation of the methodology, assumptions and results in the previous report (KGS Group, 2000).

The further studies of the Ste. Agathe Detention Structure that have been carried out led to modifications that influence the previous benefit/cost analysis. The primary modifications are:

- Revision of cost estimate.
- Refinement of estimated potential damages upstream of Ste. Agathe, and benefits derived between the Ste. Agathe Detention Structure and the Floodway Inlet, and north of Winnipeg.
- Approximation of affected parties outside the primary dikes in Winnipeg, and in the unprotected areas north of the City of Winnipeg.

The revised figures that reflect updates of the issues listed above are provided in Table C-3. The analysis is based on the basic assumptions adopted previously (KGS Group, 2000).

TABLE C-3
Summary Of Economic Analysis Of
Ste. Agathe Detention Structure

Present Value of Costs, Including Operation and Maintenance	$ 517,000,000
Present Value of Damages South of Ste. Agathe Detention Structure	$ 33,000,000
TOTAL	**$ 550,000,000**
Present Value of Benefits • In City of Winnipeg • In area between Floodway Inlet and Ste. Agathe Detention Structure • In area north of Winnipeg	 $ 1,990,000,000 $ 35,000,000 $1,100,000
TOTAL	**$ 2,026,100,000**
Benefit / Cost Ratio	**3.7**
Net Benefits	**$ 1,500,100,000**

They include:

- Economic life used for present value estimation, 50 years. It should be noted that the structures are expected to have functional lives considerably longer than 50 years. However, the difference in present value between 50 years and 100 years is only on additional 14%, and would be additive to each of the options being considered.
- Interest rate 8% per year.
- Inflation rate for operation and maintenance costs, and flood damage costs, 3% per year.
- Allowance for future economic and population growth in the area, 1% per year.

If the project costs were increased to include all of the potential enhancements for environmental reasons, the benefit cost ratio would decrease from 3.7 to 3.6, and the net benefits would reduce from $1,500,000,000 to $1,488,000,000.

C.15 REQUIREMENTS FOR FURTHER STUDY

If the Ste. Agathe Detention Structure continues to be considered as an acceptable project, there are several areas of uncertainty that should be addressed in more detail than was possible in this study:

1. Estimation of the PMF in the Red River.

2. Feasibility level of study of the project to increase the reliability of the cost estimation and confirm the feasibility of the structures proposed. This would have to include subsurface investigations at the proposed site.

3. Further study and resolution of enhancing the level of flood protection at existing ring dikes in the Red River Valley, as well as possible means to provide protection, where practical, to individuals outside the ring dikes. This would be initiatives to mitigate the potential effects of artificial flooding caused by the Ste. Agathe Detention Structure.

4. Refinement of mitigation schemes for environmental enhancements.

5. Additional flood routing studies to address a broader range of potential flood hydrographs so that operational uncertainties can be clarified.

6. Detailed study of effects of structures on river ice to confirm that spring break up will not create unexpected adverse conditions with the structures as currently conceived.

7. Feasibility-level studies of possible channel or “out-of-channel” improvements in the Emerson area that could eliminate the adverse effect of the project on the U.S.

8. Investigate means to mitigate the flood impacts on the Roseau River First Nation.

9. Further refinement of the best combination of upgrades to the flood protection infrastructure in Winnipeg, with the design capacity of the Ste. Agathe Detention Structure.

REFERENCES

REFERENCES

1. *KGS Group, March, 2000, "Flood Protection Studies for Winnipeg", Parts II and III*

2. *KGS Group, January, 2000, "Update to Flood Damage Estimates for Southern Manitoba"*

3. *Canadian Dam Association, 1995, "Dam Safety Guidelines"*

4. *Plate, E.J, 2001. "Management Strategies for the Development of the Upper Rhine," Water International, March 2001, Volume 26, No. 1.*

5. *Winchester, Simon, 1996. "The River at the Center of the World", Henry Holt and Company, New York*

6. *Li Yitain, 2001. Personal communication*

7. *E.Kuiper, 1965, "Water Resources Engineering"*

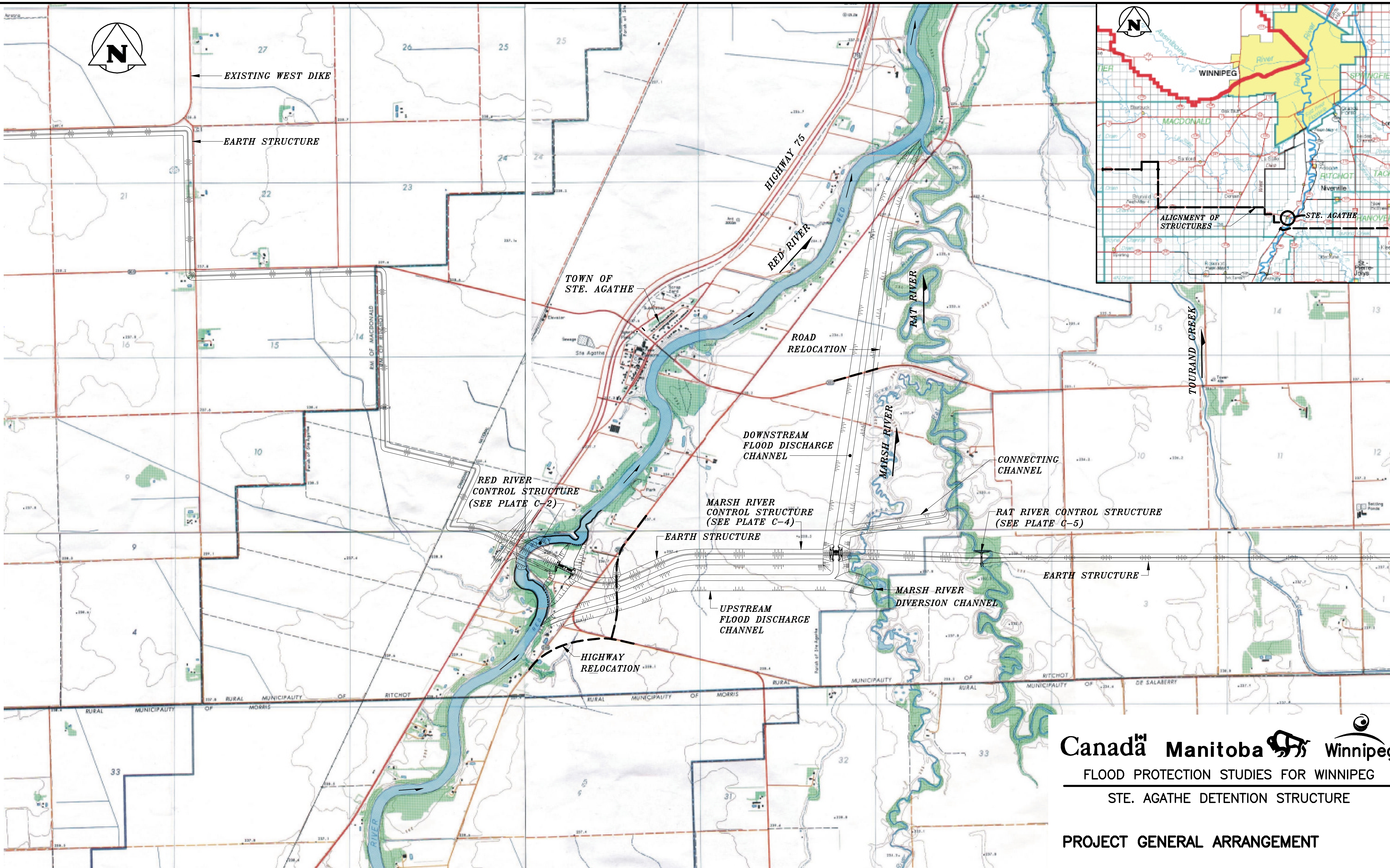
8. *U.N., 1955, "Multi-purpose River Basin Development", Part I: "Manual of River Basin Planning"*

9. *Roth, G., 2001, University of Genoa, Italy, Personal communication*

10. *Broderson, C, 2001, University of Wroclaw, Poland, Personal communication*

11. *Romaneesen, E, 2001, Partner Re-Research and Exposure Control, Zurich, Switzerland, Personal communication*

PLATES



Canada Manitoba Winnipeg

FLOOD PROTECTION STUDIES FOR WINNIPEG

STE. AGATHE DETENTION STRUCTURE

PROJECT GENERAL ARRANGEMENT

LEGEND

235.0 TOPOGRAPHIC CONTOUR (GEODETIC ELEVATION IN METRES)

0 500 1000 1500 2000 2500m

SCALE 1:40000

PLATE C–1

FINAL REPORT–SEPTEMBER 2001

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KGS FILE NO.: P:/00-311-07/ADMIN/ADMINDOCS/FINAL REPORT/APPENDIX C/PLATES/PLATE C-01.DWG
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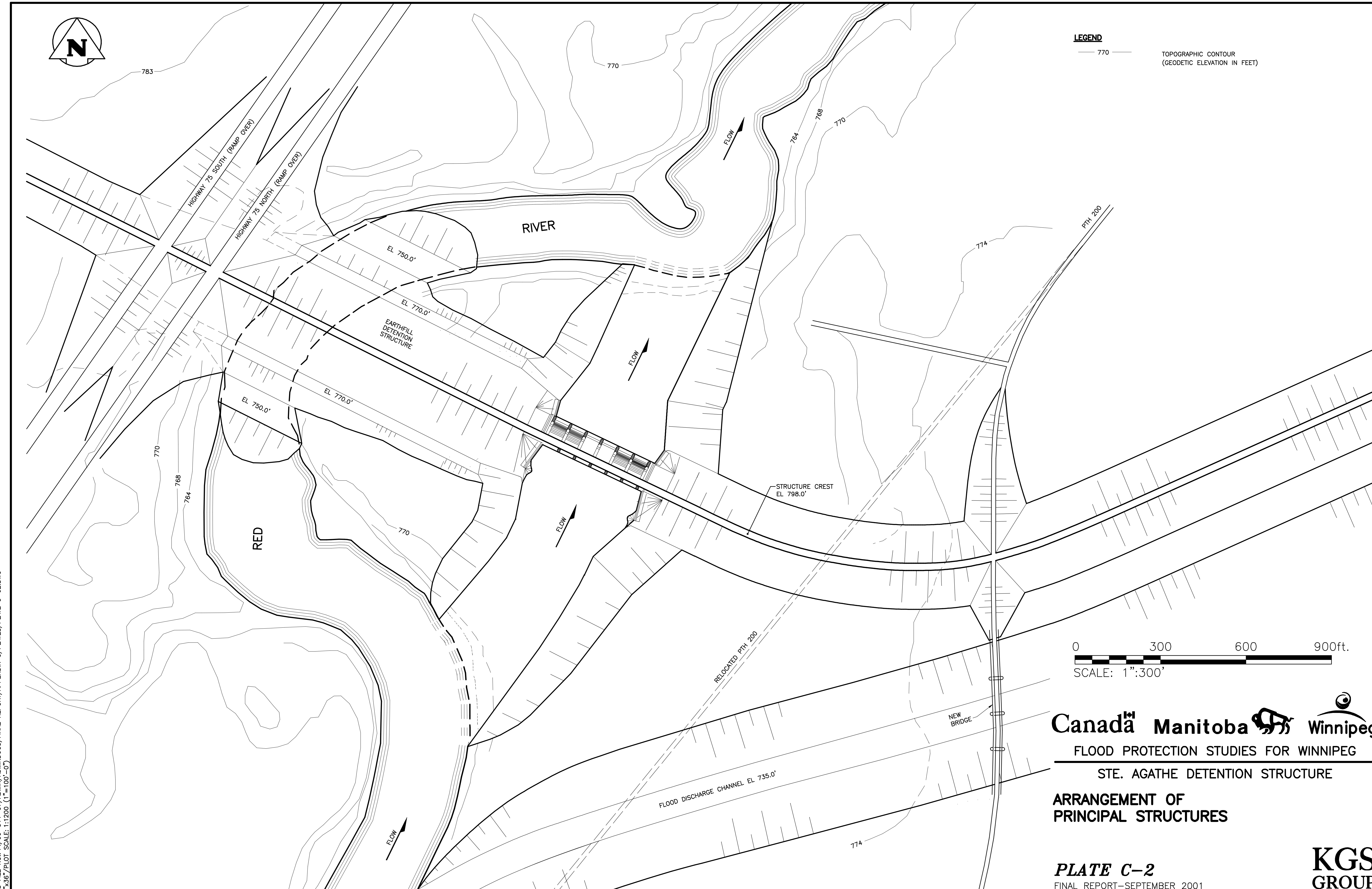

Canada Manitoba Winnipeg

FLOOD PROTECTION STUDIES FOR WINNIPEG

STE. AGATHE DETENTION STRUCTURE

ARRANGEMENT OF PRINCIPAL STRUCTURES

PLATE C–2

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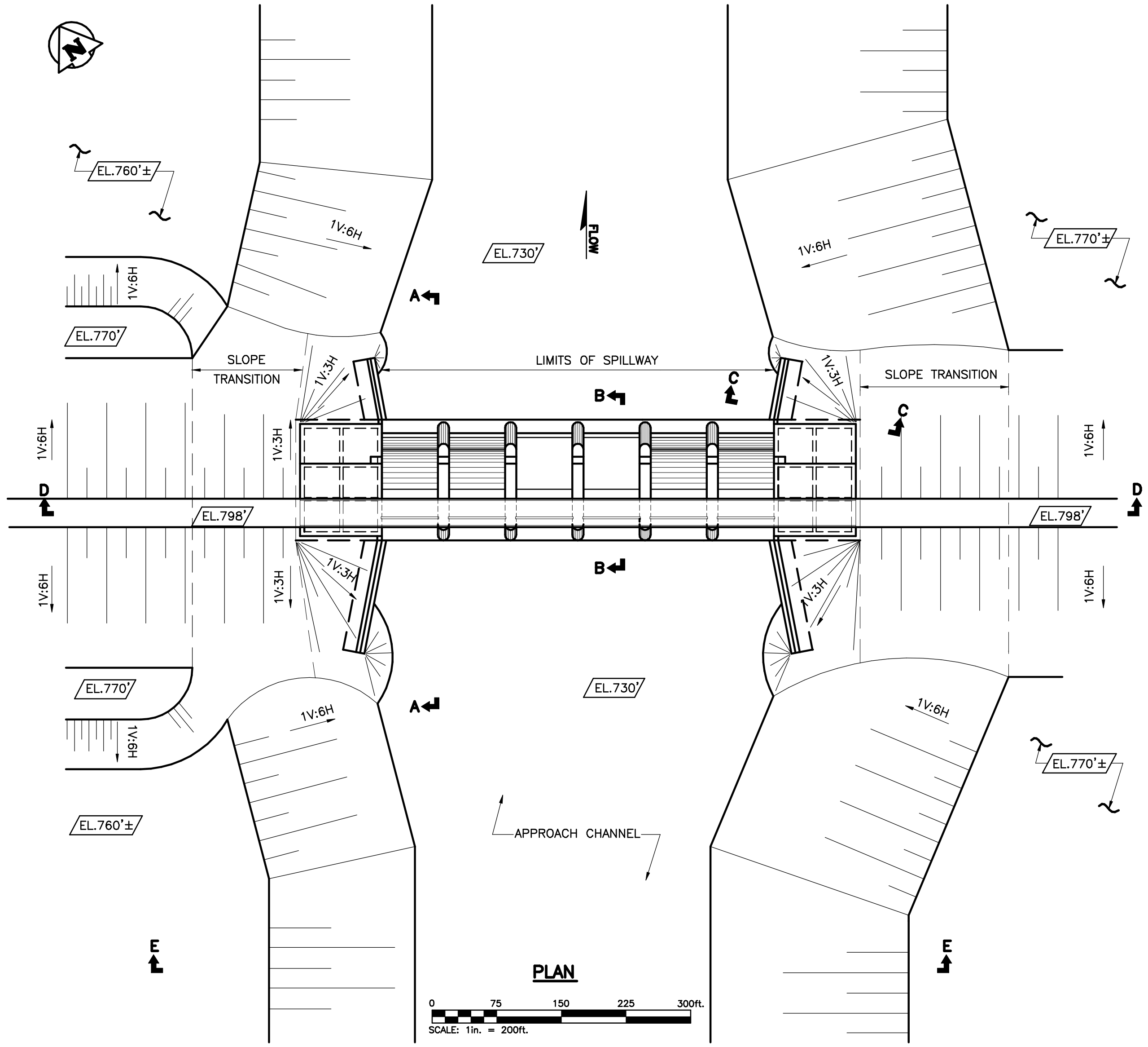
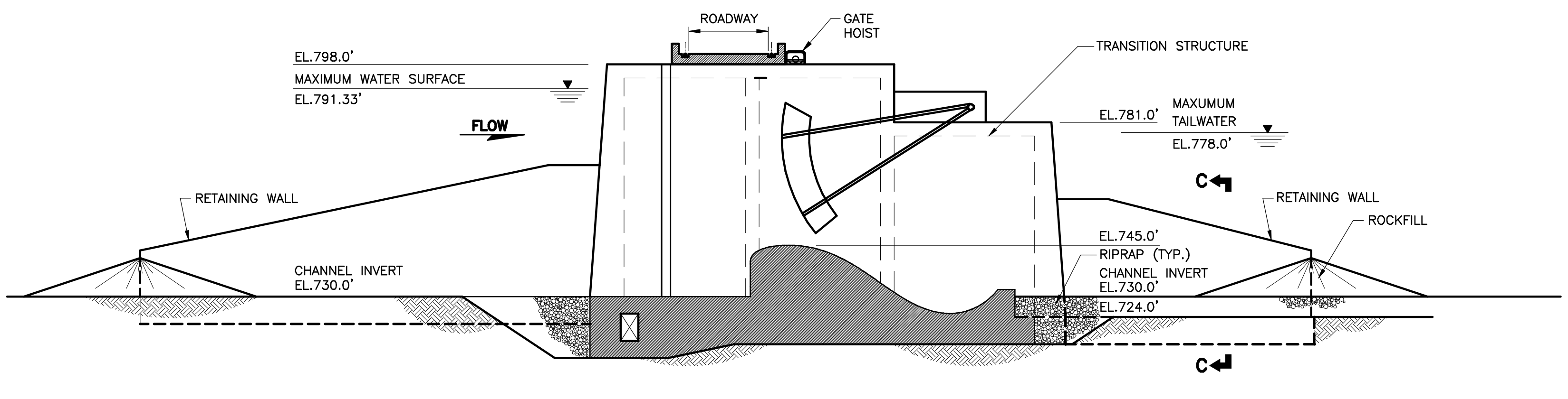


PLAN



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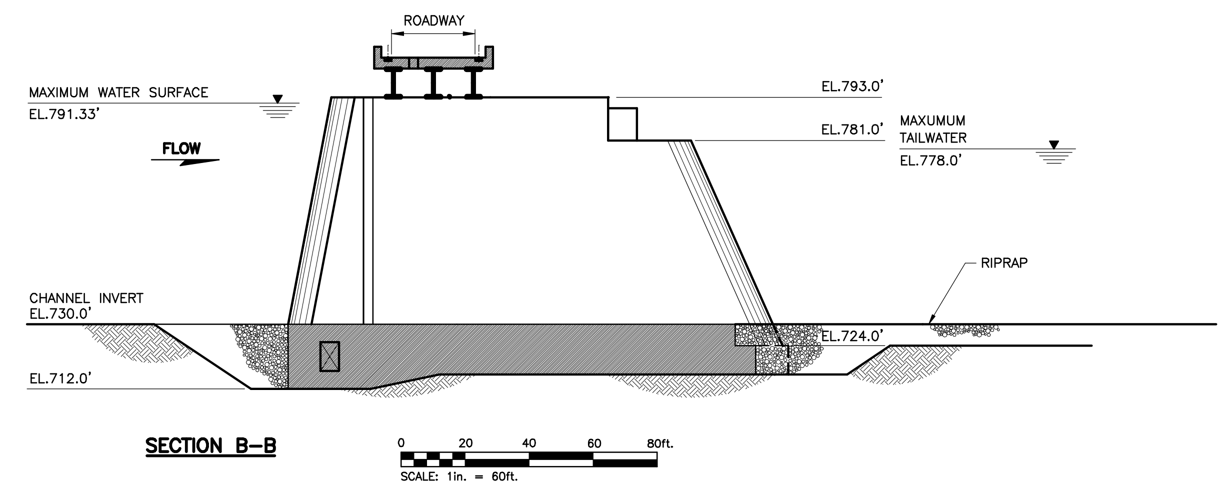

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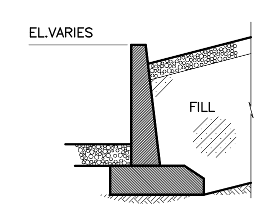

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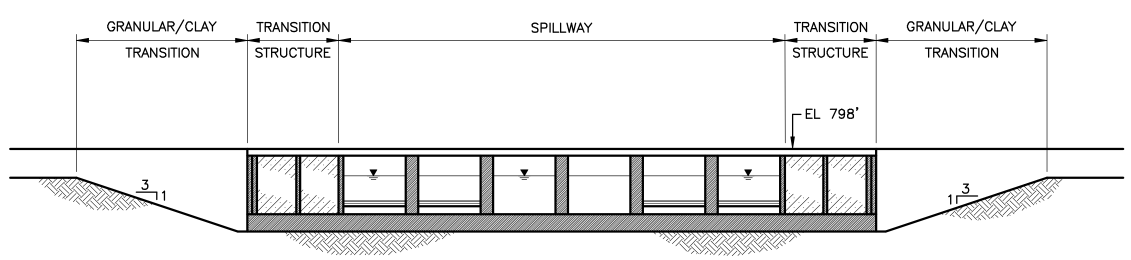

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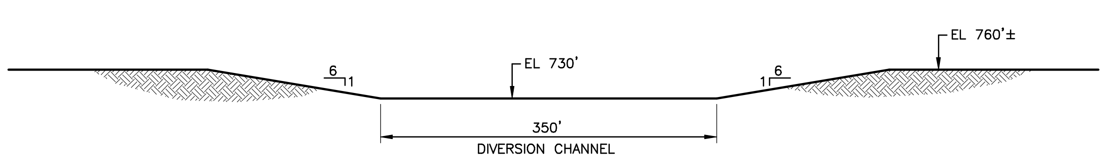

SECTION E–E

Canada Manitoba Winnipeg

FLOOD PROTECTION STUDIES FOR WINNIPEG

STE. AGATHE DETENTION STRUCTURE

RED RIVER CONTROL STRUCTURE

PLATE C–3

FINAL REPORT–SEPTEMBER 2001

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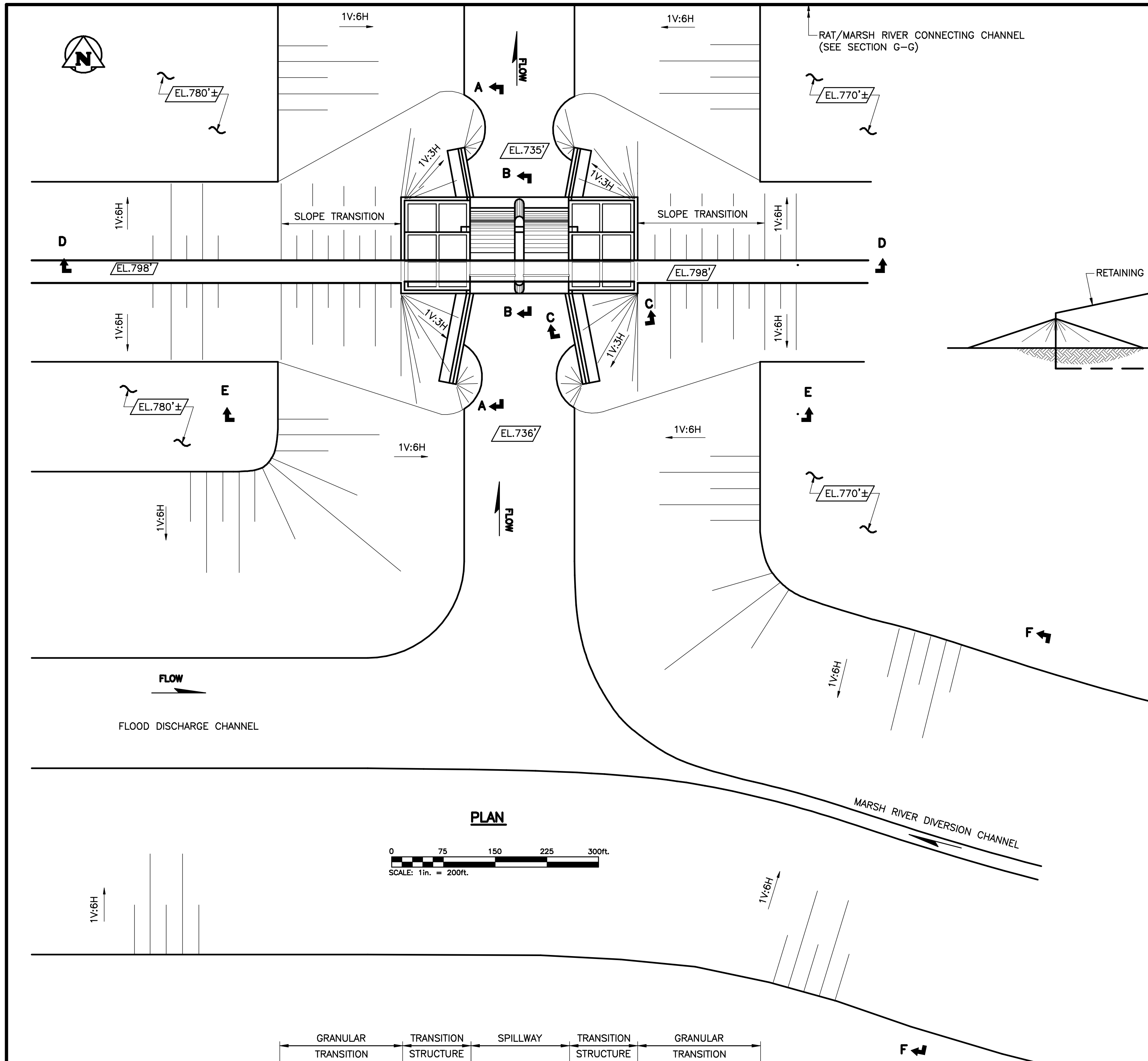

PLAN

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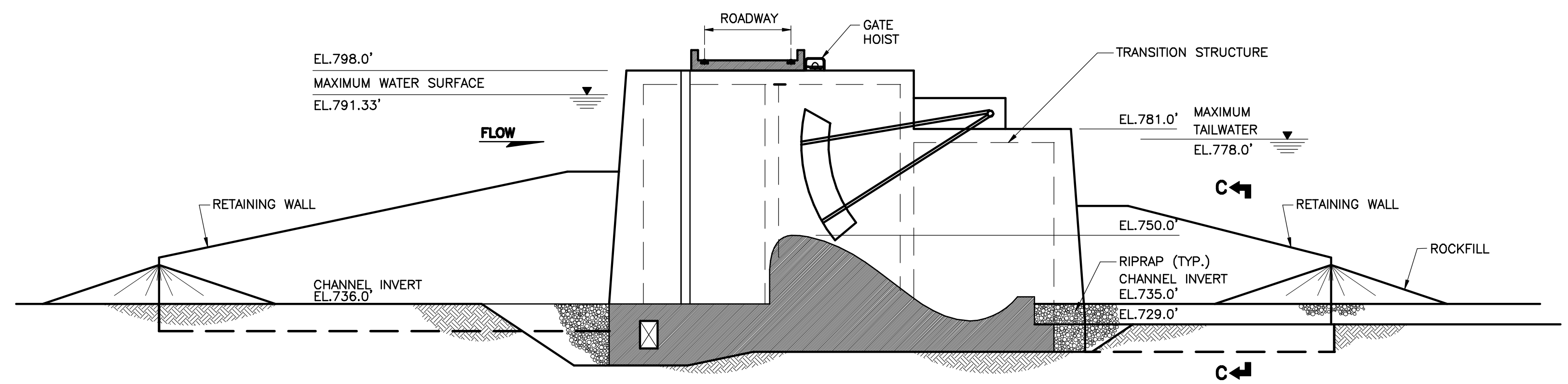

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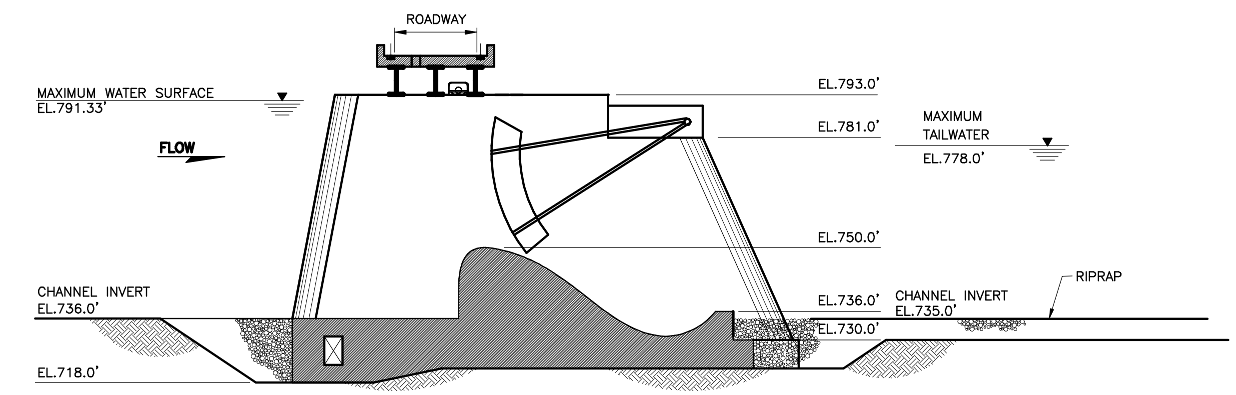

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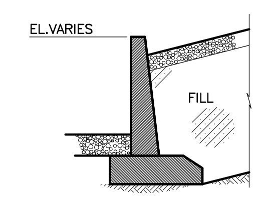

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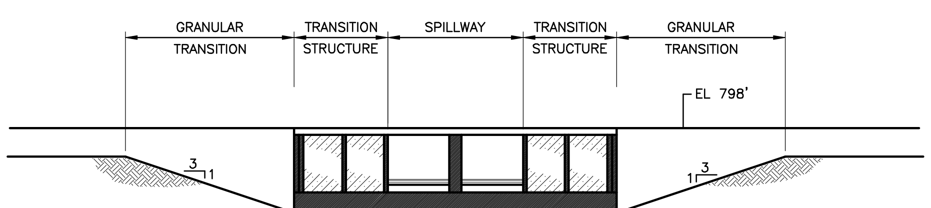

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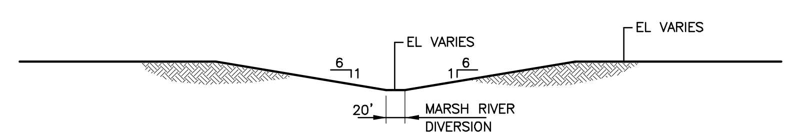

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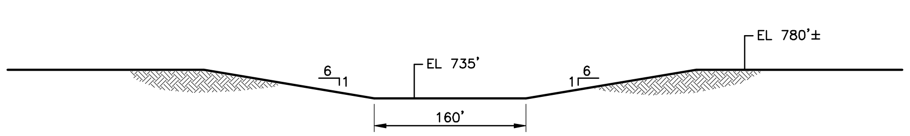

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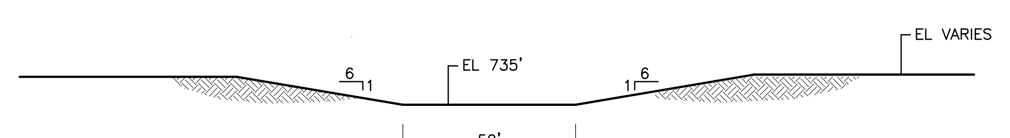

SECTION G-G (RAT/MARSH RIVER CONNECTING CHANNEL)

Canada Manitoba Winnipeg

FLOOD PROTECTION STUDIES FOR WINNIPEG

STE. AGATHE DETENTION STRUCTURE

MARSH RIVER CONTROL STRUCTURE

PLATE C-4

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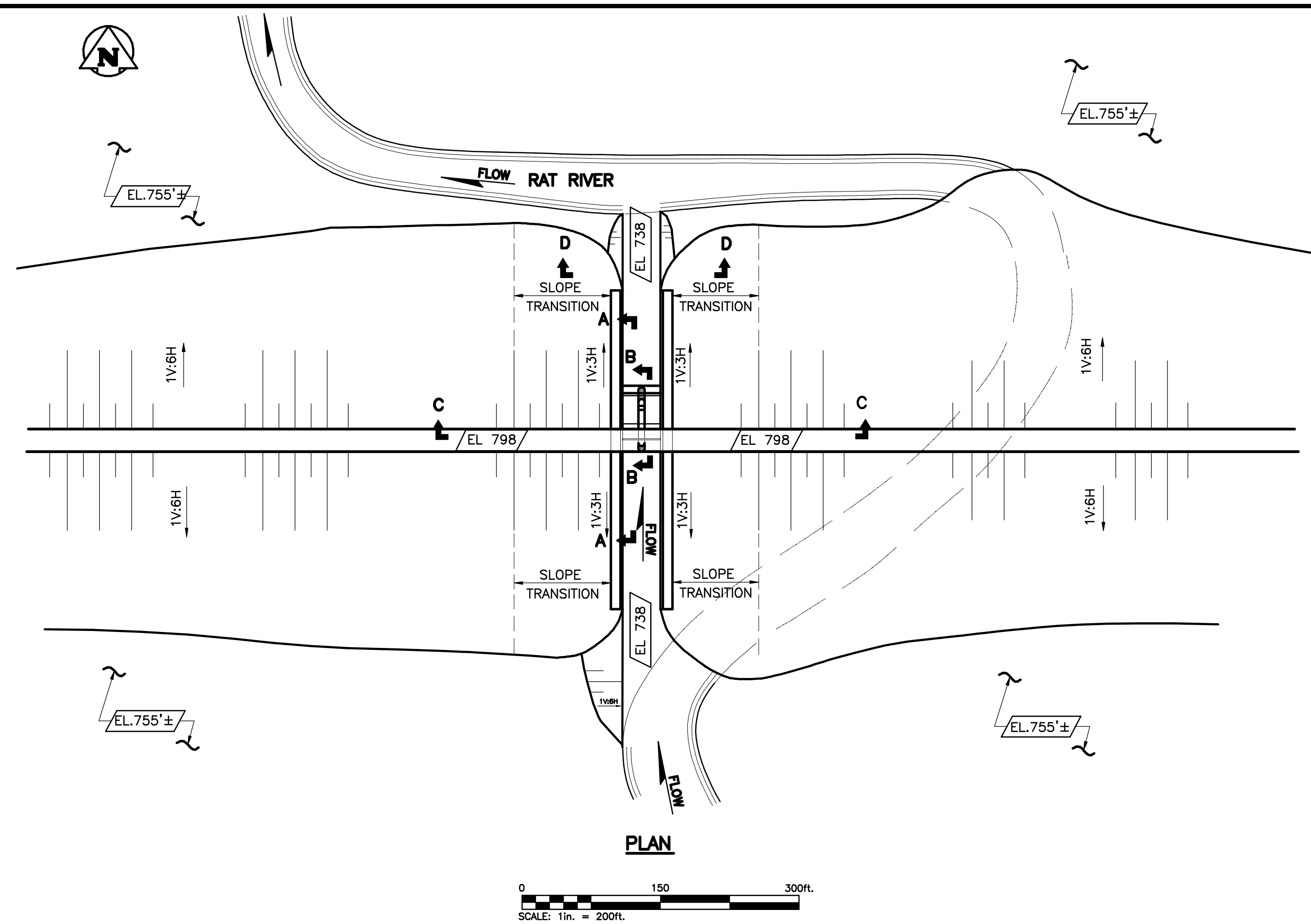
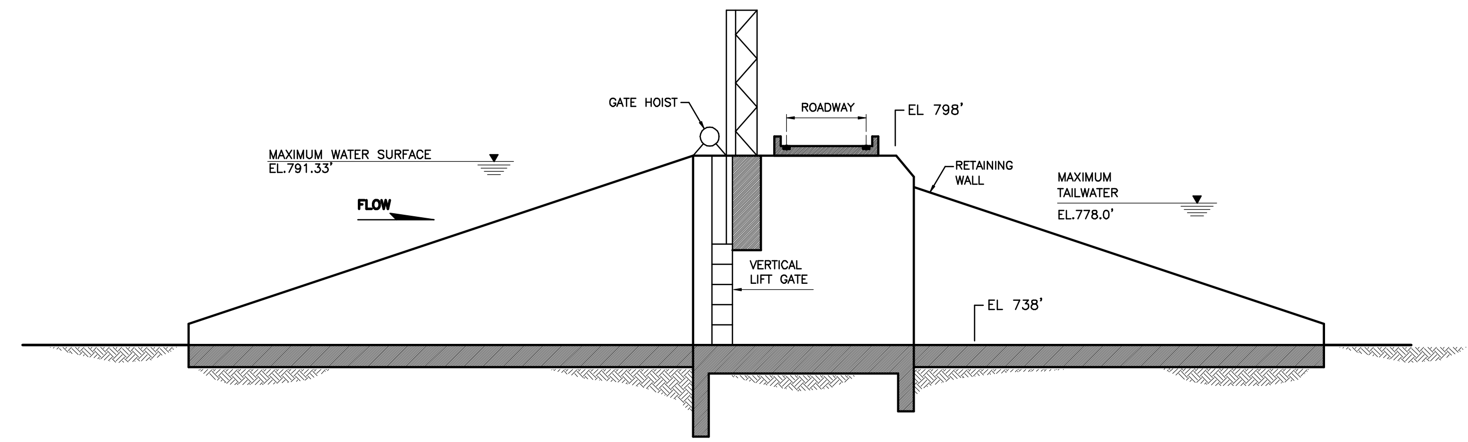


PLAN



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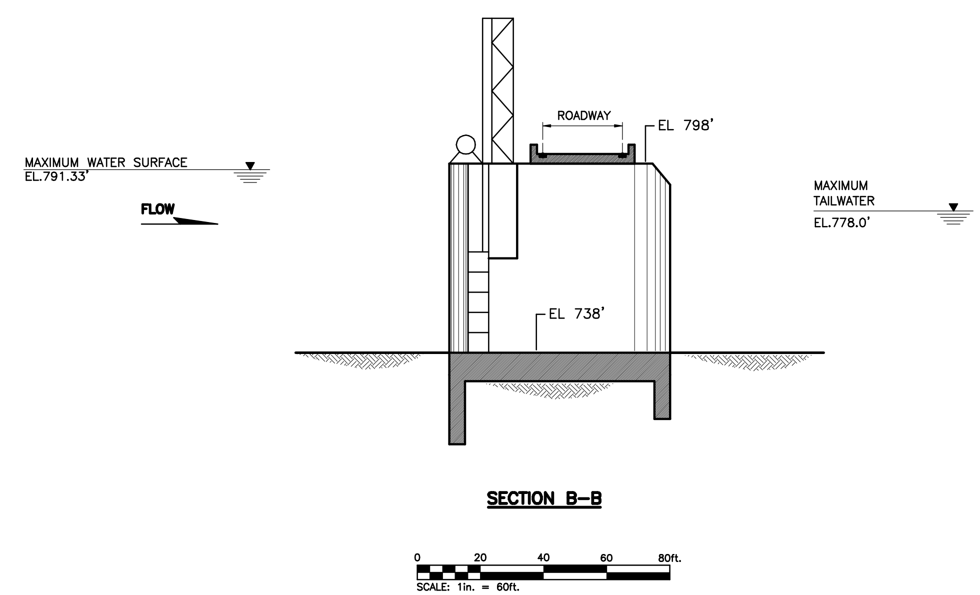

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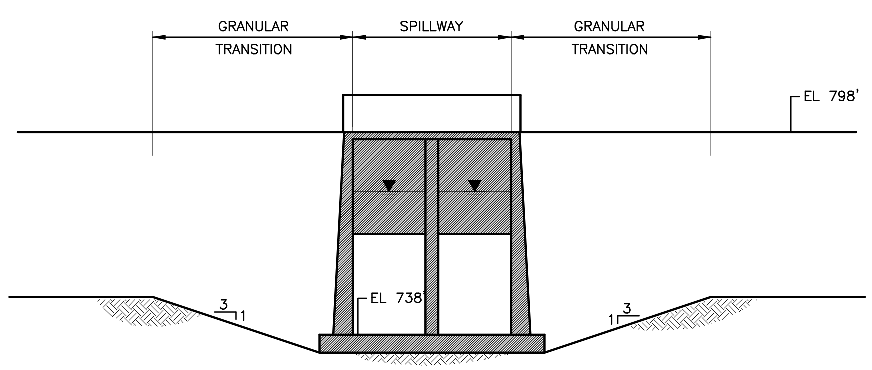

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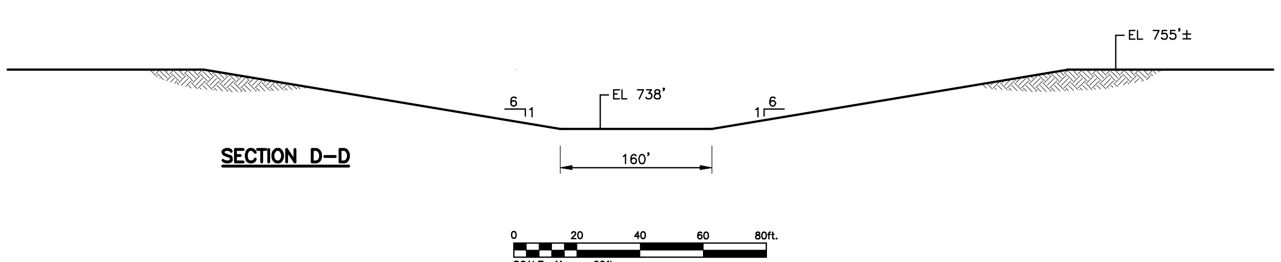

SECTION D–D

Canada Manitoba Winnipeg

FLOOD PROTECTION STUDIES FOR WINNIPEG

STE. AGATHE DETENTION STRUCTURE

RAT RIVER
CONTROL STRUCTURE

PLATE C–5

FINAL REPORT–SEPTEMBER 2001

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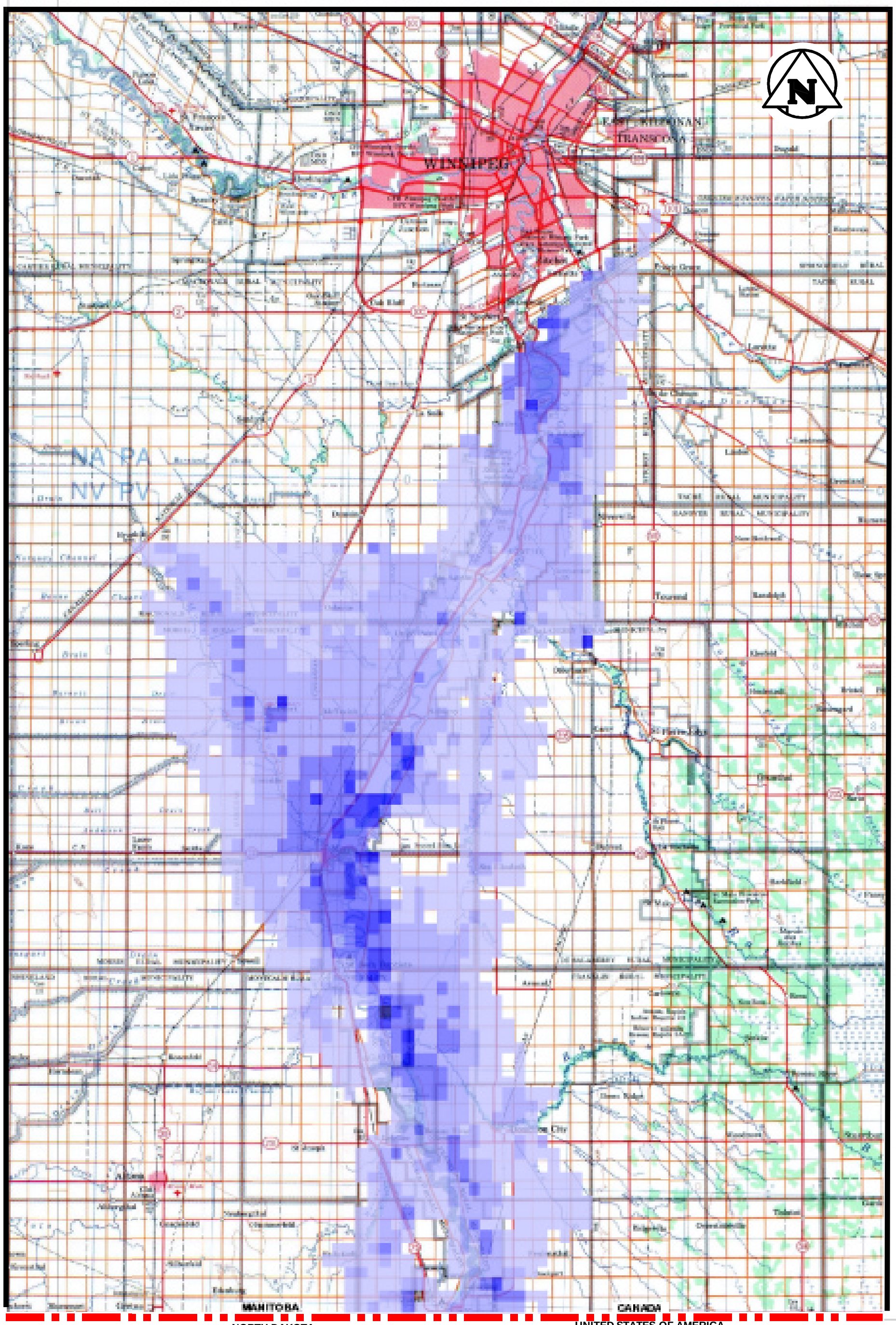

DEPTH OF FLOODING (Ft)

- 1" TO 3'-3"
- 3'-3" TO 6'-6"
- 6'-6" TO 9'-10"
- 9'-10" TO 13'-1"
- 13'-1" TO 16'-4"
- 16'-4" TO 19'-8"
- 19'-8" TO 22'-11"
- 22'-11" TO 26'-2"
- 26'-2" TO 29'-6"

Canada Manitoba Winnipeg

FLOOD PROTECTION STUDIES FOR WINNIPEG

STE. AGATHE DETENTION STRUCTURE

100 YEAR FLOOD EXISTING FLOODWAY INUNDATED AREA

PLATE C-6

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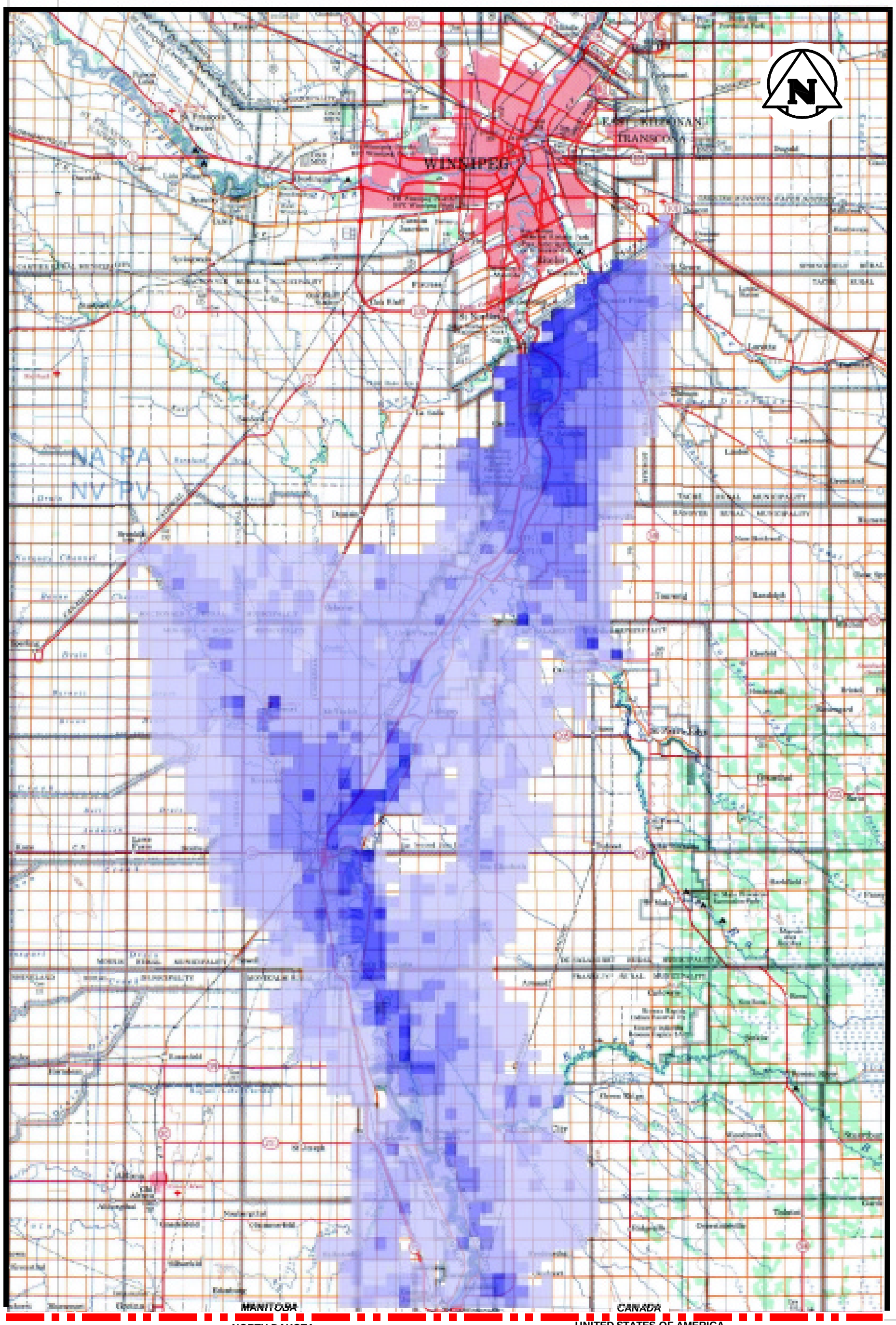

DEPTH OF FLOODING (Ft)

- 1" TO 3'-3"
- 3'-3" TO 6'-6"
- 6'-6" TO 9'-10"
- 9'-10" TO 13'-1"
- 13'-1" TO 16'-4"
- 16'-4" TO 19'-8"
- 19'-8" TO 22'-11"
- 22'-11" TO 26'-2"
- 26'-2" TO 29'-6"

*Flooding in Winnipeg would occur, and is not shown in this figure.

Canada Manitoba Winnipeg

FLOOD PROTECTION STUDIES FOR WINNIPEG

STE. AGATHE DETENTION STRUCTURE

300 YEAR FLOOD
EXISTING FLOODWAY
INUNDATED AREA

PLATE C-7

FINAL REPORT–SEPTEMBER 2001

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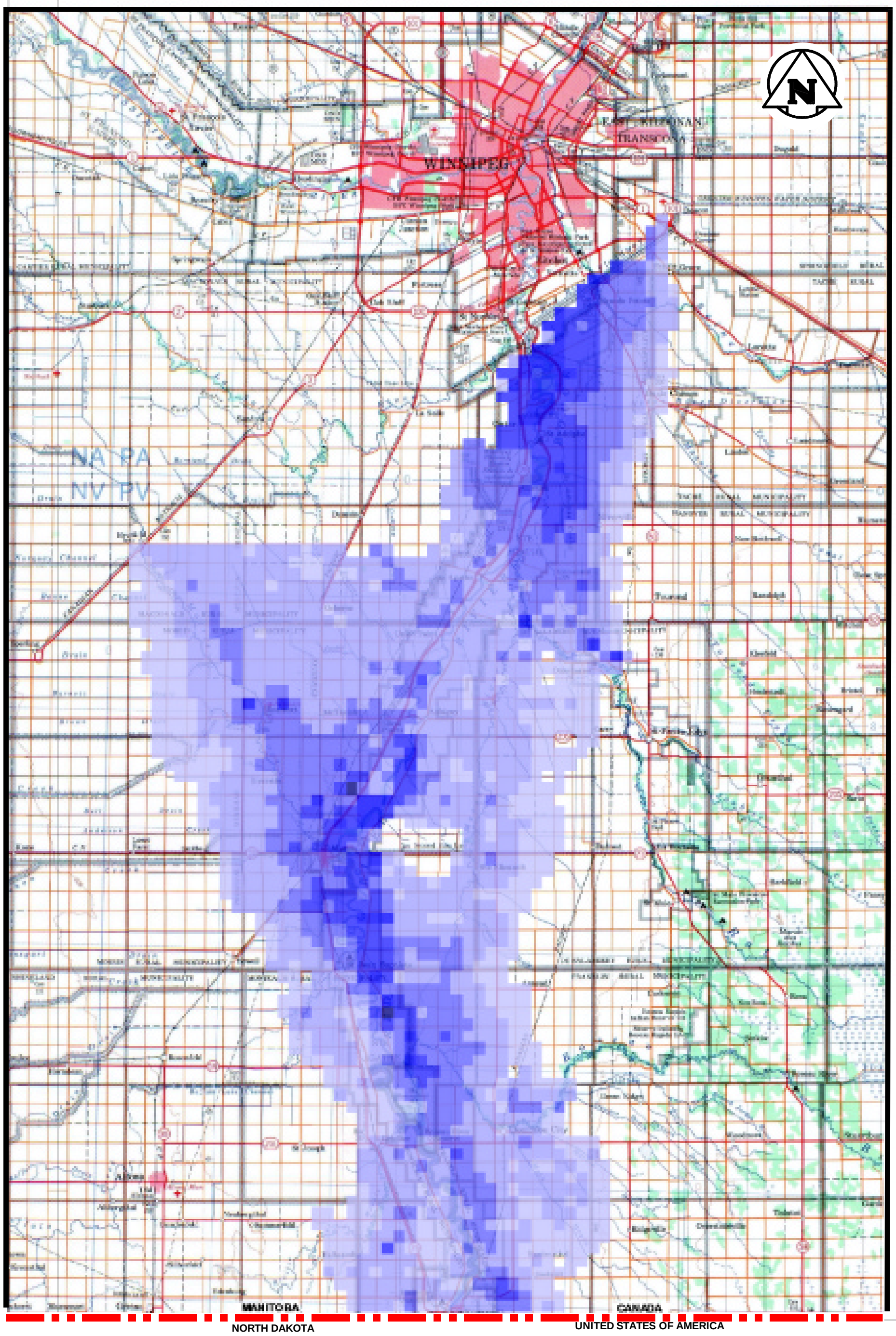

DEPTH OF FLOODING (Ft)

- 1" TO 3'-3"
- 3'-3" TO 6'-6"
- 6'-6" TO 9'-10"
- 9'-10" TO 13'-1"
- 13'-1" TO 16'-4"
- 16'-4" TO 19'-8"
- 19'-8" TO 22'-11"
- 22'-11" TO 26'-2"
- 26'-2" TO 29'-6"

*Flooding in Winnipeg would occur, and is not shown in this figure.

Canada Manitoba Winnipeg

FLOOD PROTECTION STUDIES FOR WINNIPEG

STE. AGATHE DETENTION STRUCTURE

1000 YEAR FLOOD
EXISTING FLOODWAY
INUNDATED AREA

PLATE C–8

FINAL REPORT–SEPTEMBER 2001

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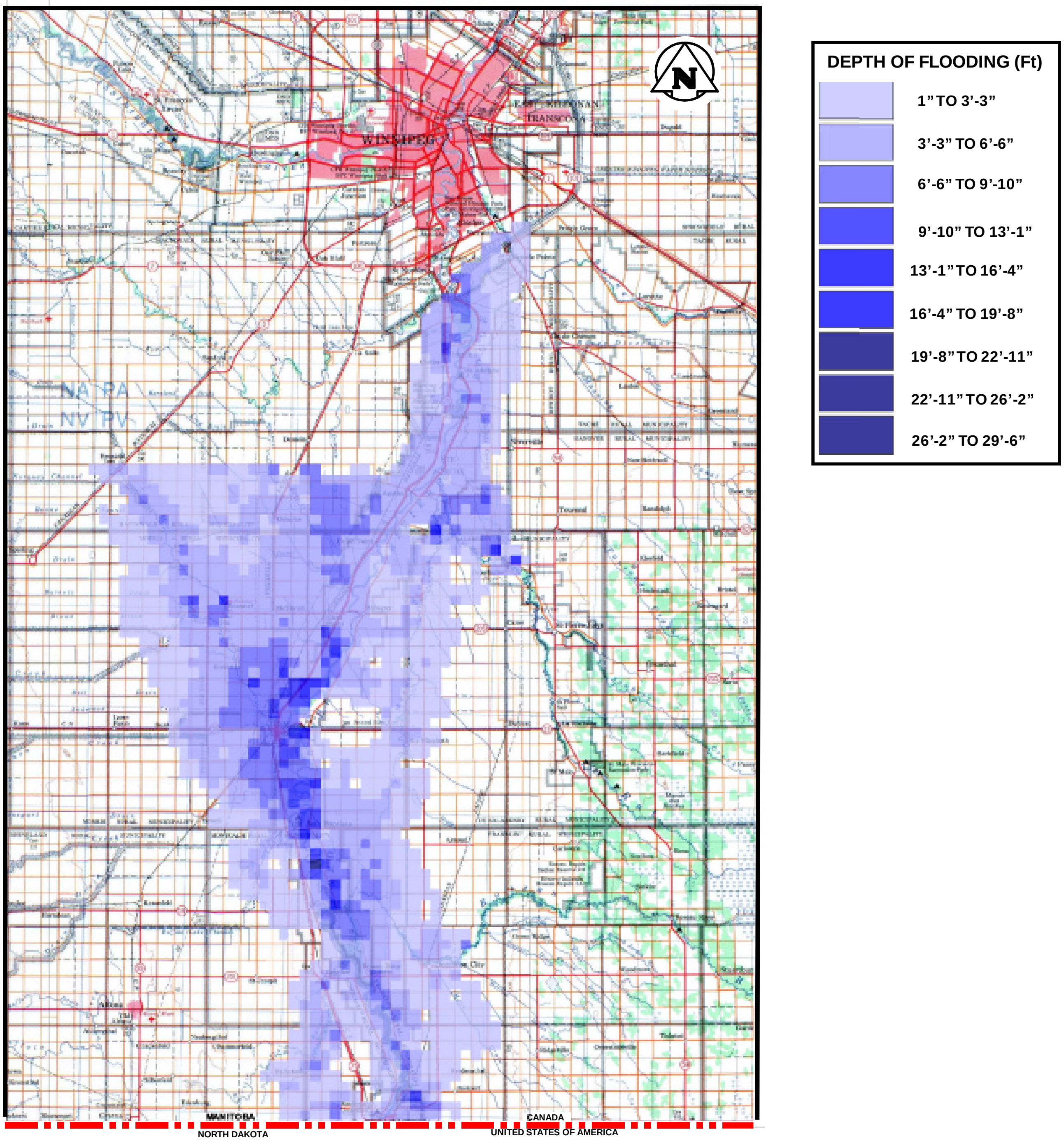

Canada Manitoba Winnipeg

FLOOD PROTECTION STUDIES FOR WINNIPEG

STE. AGATHE DETENTION STRUCTURE

100 YEAR FLOOD
STE. AGATHE DETENTION STRUCTURE
INUNDATED AREA

PLATE C-9

FINAL REPORT – SEPTEMBER

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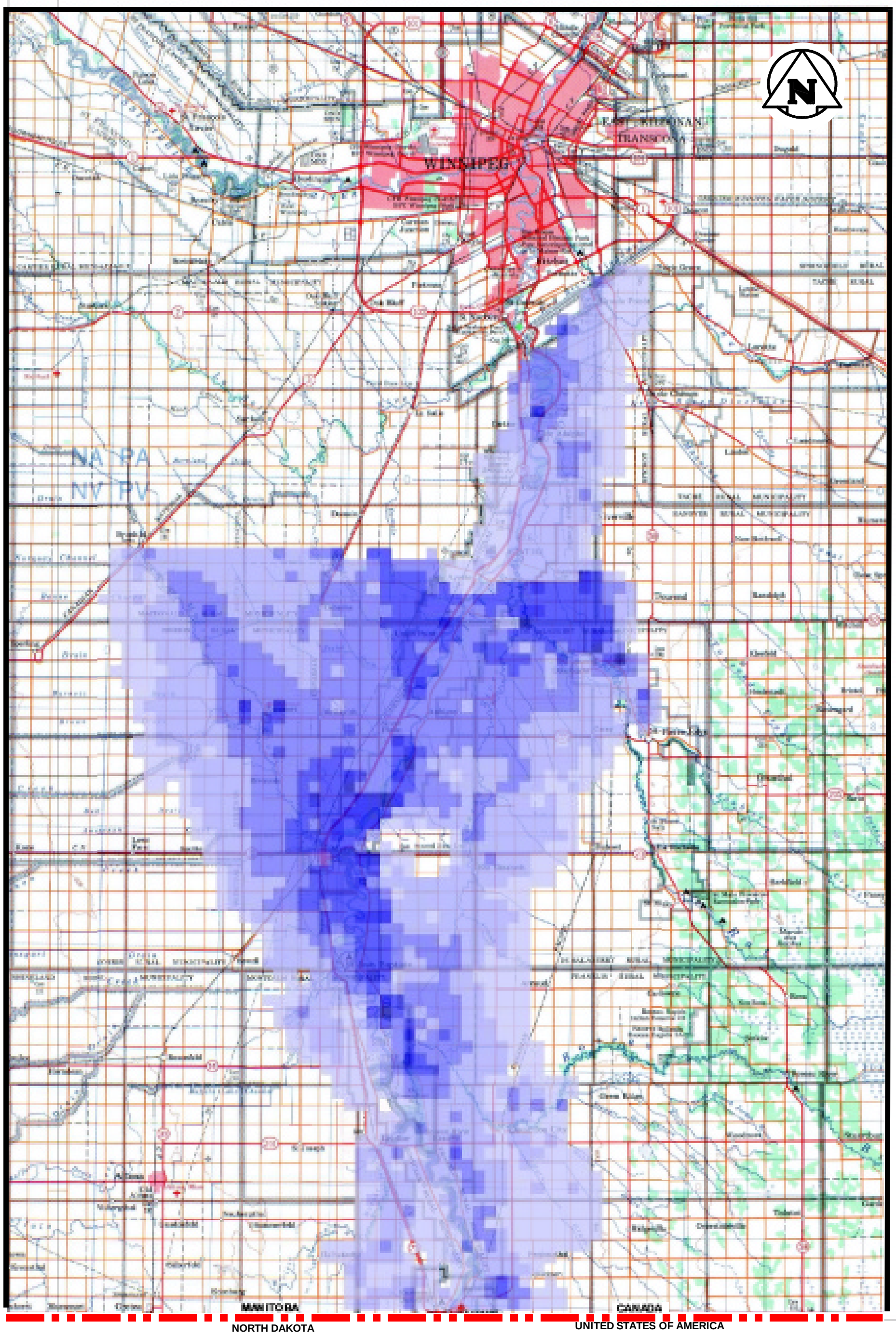

DEPTH OF FLOODING (Ft)

- 1" TO 3'-3"
- 3'-3" TO 6'-6"
- 6'-6" TO 9'-10"
- 9'-10" TO 13'-1"
- 13'-1" TO 16'-4"
- 16'-4" TO 19'-8"
- 19'-8" TO 22'-11"
- 22'-11" TO 26'-2"
- 26'-2" TO 29'-6"

Canada Manitoba Winnipeg

FLOOD PROTECTION STUDIES FOR WINNIPEG

STE. AGATHE DETENTION STRUCTURE

300 YEAR FLOOD
STE. AGATHE DETENTION STRUCTURE
INUNDATED AREA

PLATE C-10

FINAL REPORT – SEPTEMBER

KGS GROUP

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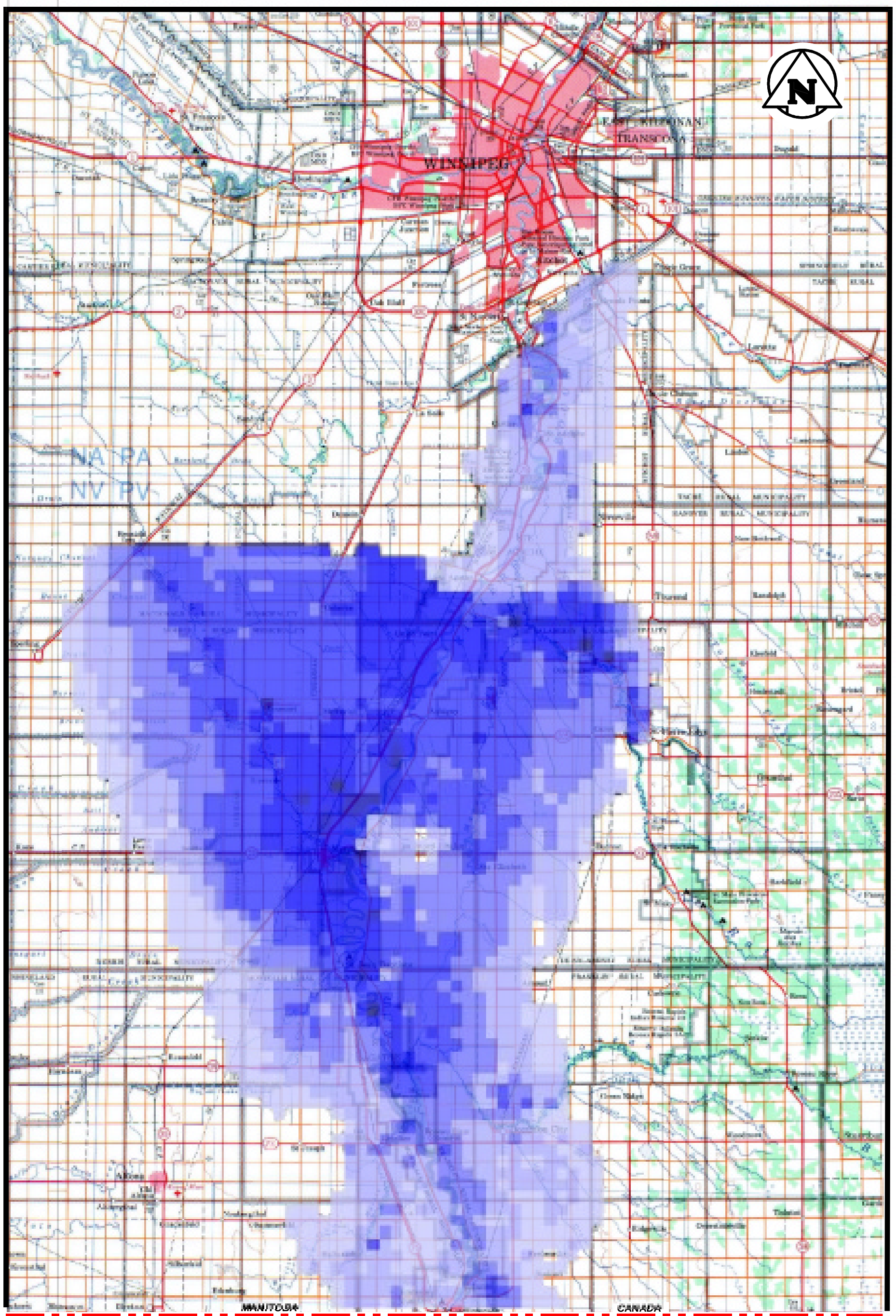

DEPTH OF FLOODING (Ft)

- 1" TO 3'-3"
- 3'-3" TO 6'-6"
- 6'-6" TO 9'-10"
- 9'-10" TO 13'-1"
- 13'-1" TO 16'-4"
- 16'-4" TO 19'-8"
- 19'-8" TO 22'-11"
- 22'-11" TO 26'-2"
- 26'-2" TO 29'-6"

Canada Manitoba Winnipeg

FLOOD PROTECTION STUDIES FOR WINNIPEG

STE. AGATHE DETENTION STRUCTURE

1000 YEAR FLOOD
STE. AGATHE DETENTION STRUCTURE
INUNDATED AREA

PLATE C-11

FINAL REPORT – SEPTEMBER

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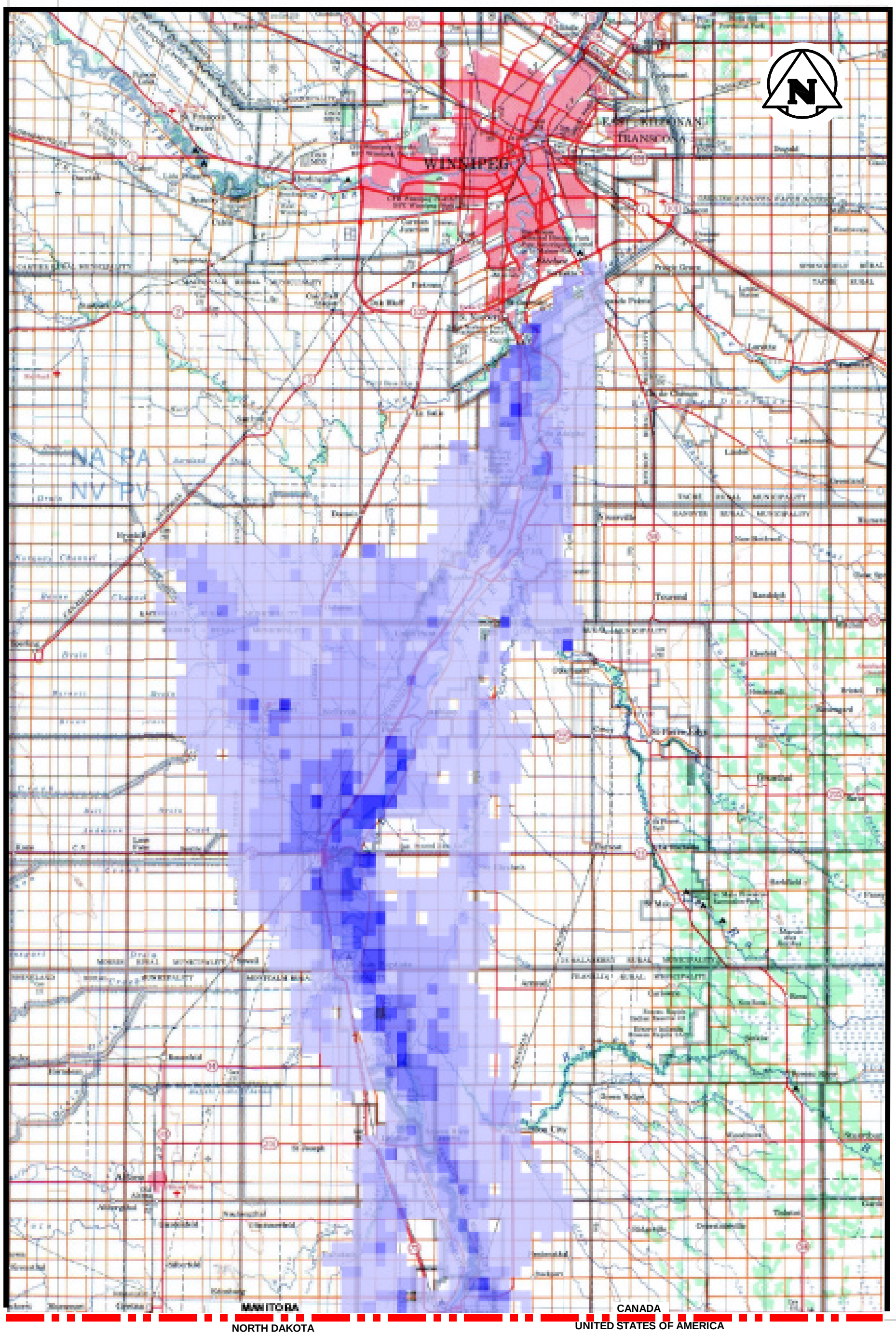

DEPTH OF FLOODING (Ft)

- 1" TO 3'-3"
- 3'-3" TO 6'-6"
- 6'-6" TO 9'-10"
- 9'-10" TO 13'-1"
- 13'-1" TO 16'-4"
- 16'-4" TO 19'-8"
- 19'-8" TO 22'-11"
- 22'-11" TO 26'-2"
- 26'-2" TO 29'-6"

Canada Manitoba Winnipeg

FLOOD PROTECTION STUDIES FOR WINNIPEG

STE. AGATHE DETENTION STRUCTURE

100 YEAR FLOOD
1 IN 700 YEAR EXPANDED FLOODWAY
INUNDATED AREA

PLATE C-12

FINAL REPORT-SEPTEMBER 2001

KGS GROUP

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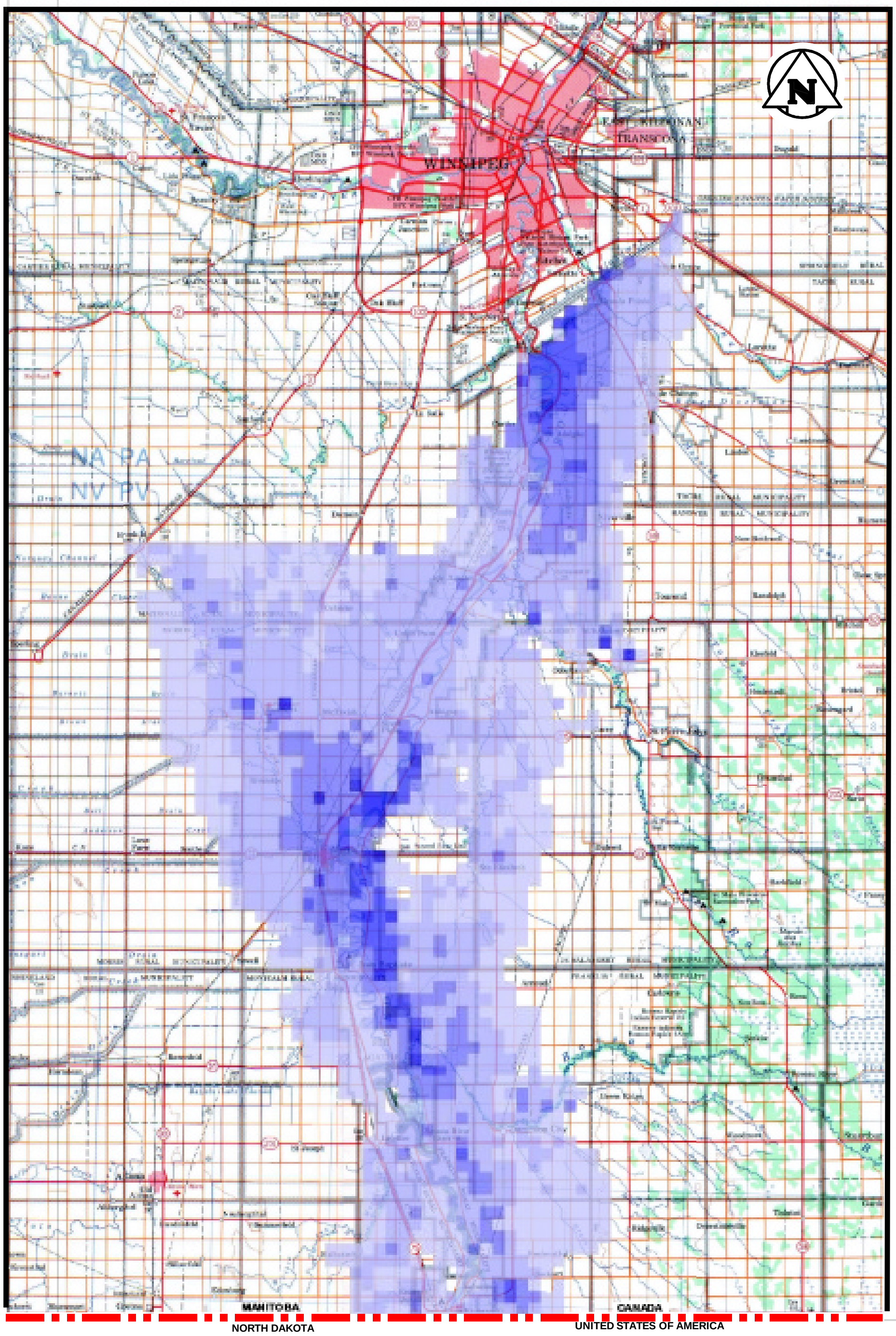


DEPTH OF FLOODING (Ft)

- 1" TO 3'-3"
- 3'-3" TO 6'-6"
- 6'-6" TO 9'-10"
- 9'-10" TO 13'-1"
- 13'-1" TO 16'-4"
- 16'-4" TO 19'-8"
- 19'-8" TO 22'-11"
- 22'-11" TO 26'-2"
- 26'-2" TO 29'-6"

Canada Manitoba Winnipeg

FLOOD PROTECTION STUDIES FOR WINNIPEG

STE. AGATHE DETENTION STRUCTURE

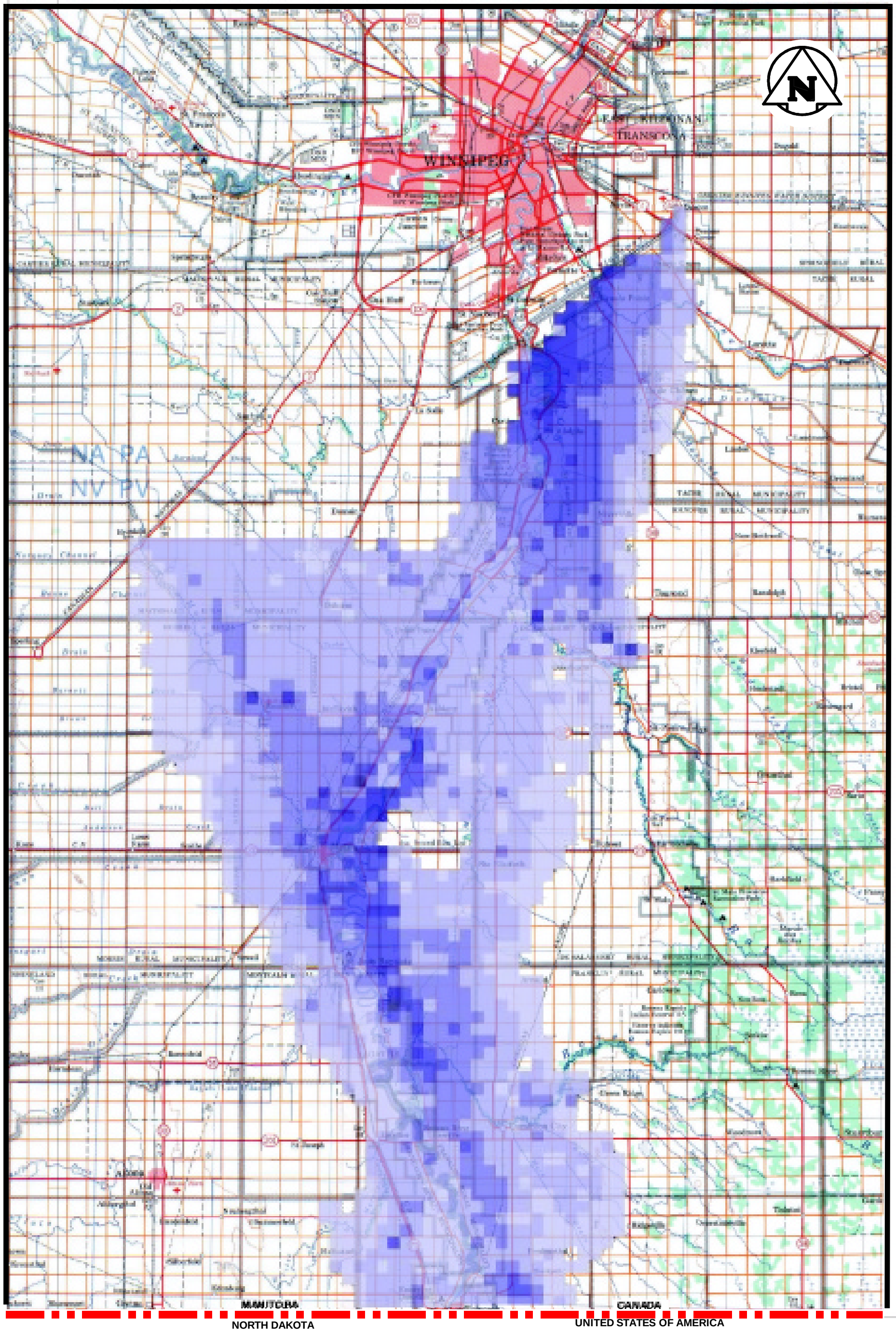
300 YEAR FLOOD
1 IN 700 YEAR EXPANDED FLOODWAY
INUNDATED AREA

PLATE C-13

FINAL REPORT–SEPTEMBER 2001

KGS GROUP

KGS FILE NO.: P:/00-311-07/ADMIN/ADMINDOCS/FINAL REPORT/APPENDIX C/PLATES/PLATE C-06-C14.DWG



DEPTH OF FLOODING (Ft)
1" TO 3'-3"
3'-3" TO 6'-6"
6'-6" TO 9'-10"
9'-10" TO 13'-1"
13'-1" TO 16'-4"
16'-4" TO 19'-8"
19'-8" TO 22'-11"
22'-11" TO 26'-2"
26'-2" TO 29'-6"

*Flooding in Winnipeg would occur, and is not shown in this figure.

Canada Manitoba Winnipeg

FLOOD PROTECTION STUDIES FOR WINNIPEG

STE. AGATHE DETENTION STRUCTURE

1000 YEAR FLOOD
1 IN 700 YEAR EXPANDED FLOODWAY
INUNDATED AREA

PLATE C-14

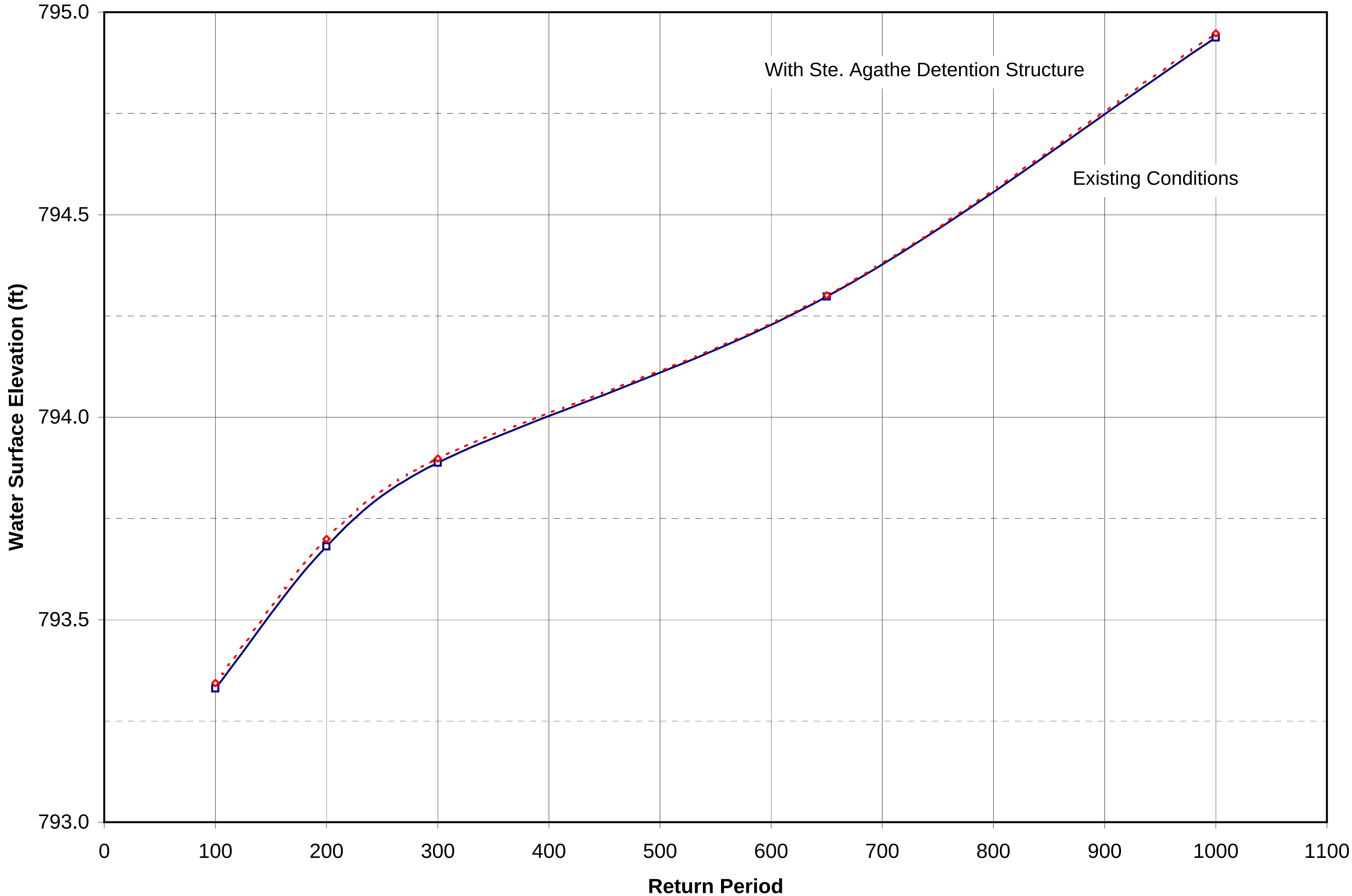
FINAL REPORT–SEPTEMBER 2001

KGS GROUP

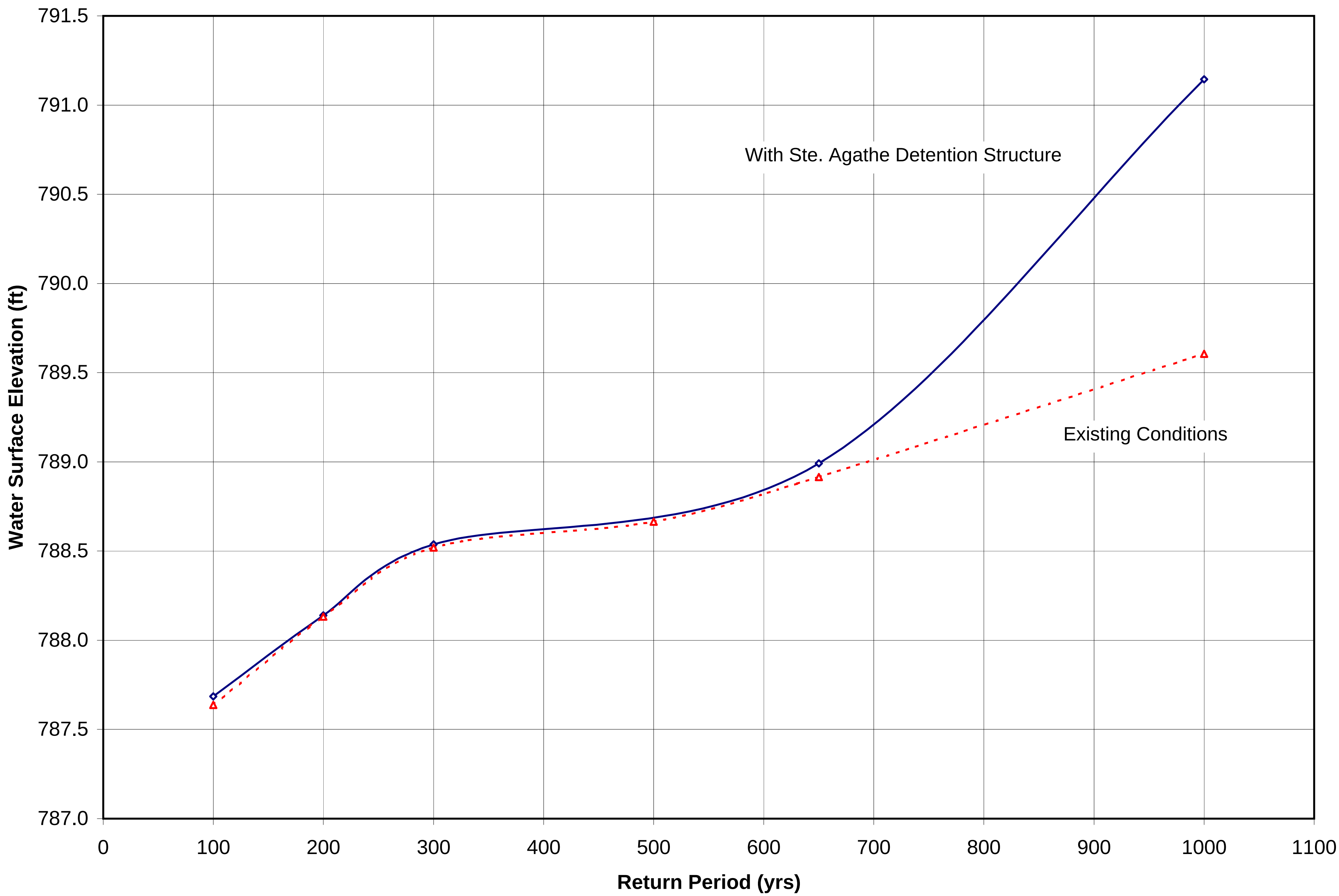
KGS FILE NO.: P:/00-311-07/ADMIN/ADMINDOCS/FINAL REPORT/APPENDIX C/PLATES/PLATE C-06-C14.DWG

ANNEX A

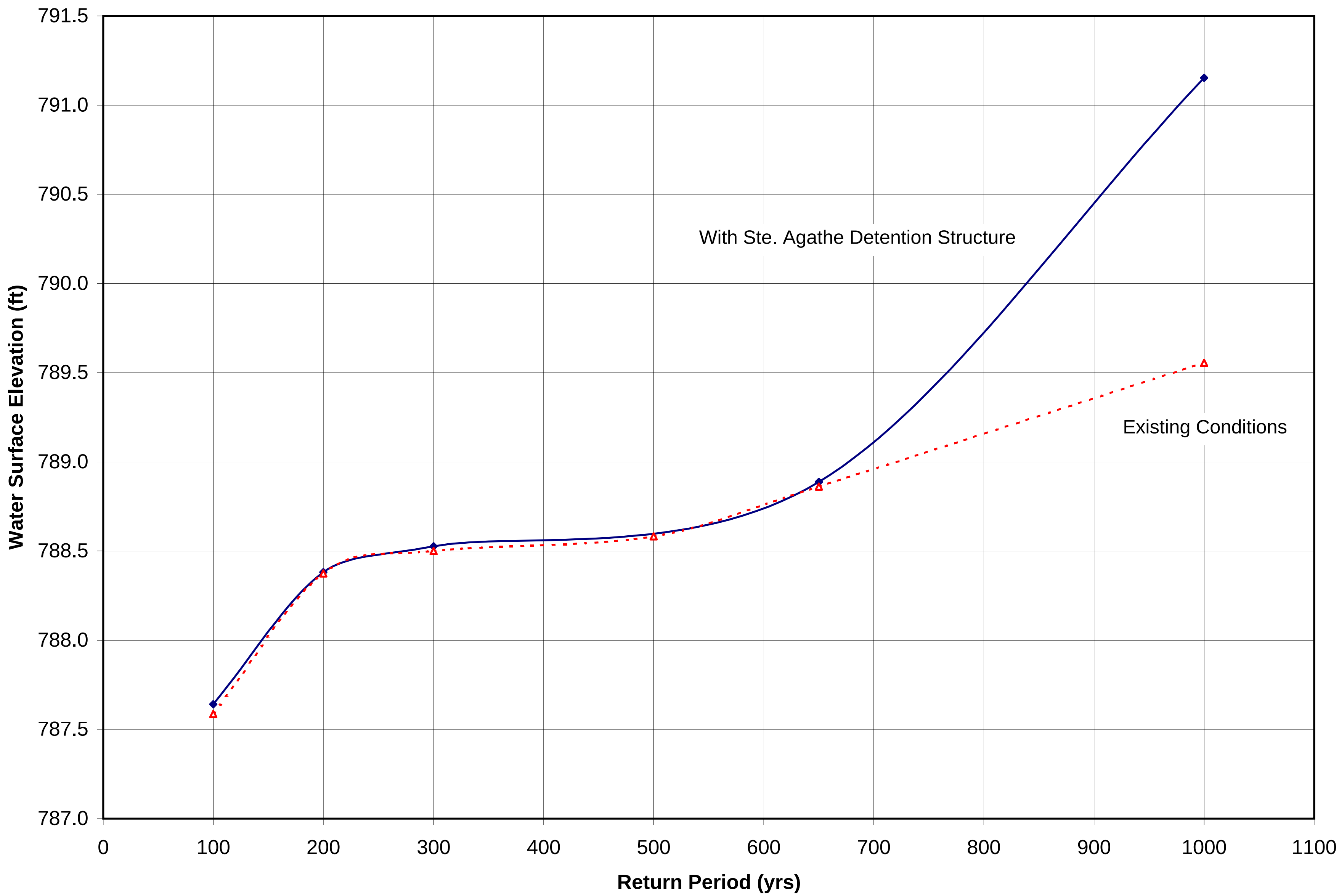
STAGE PROBABILITY CURVES AND FLOOD STAGE HYDROGRAPHS FOR RED RIVER (WITH OR WITHOUT STE. AGATHE DETENTION STRUCTURE)



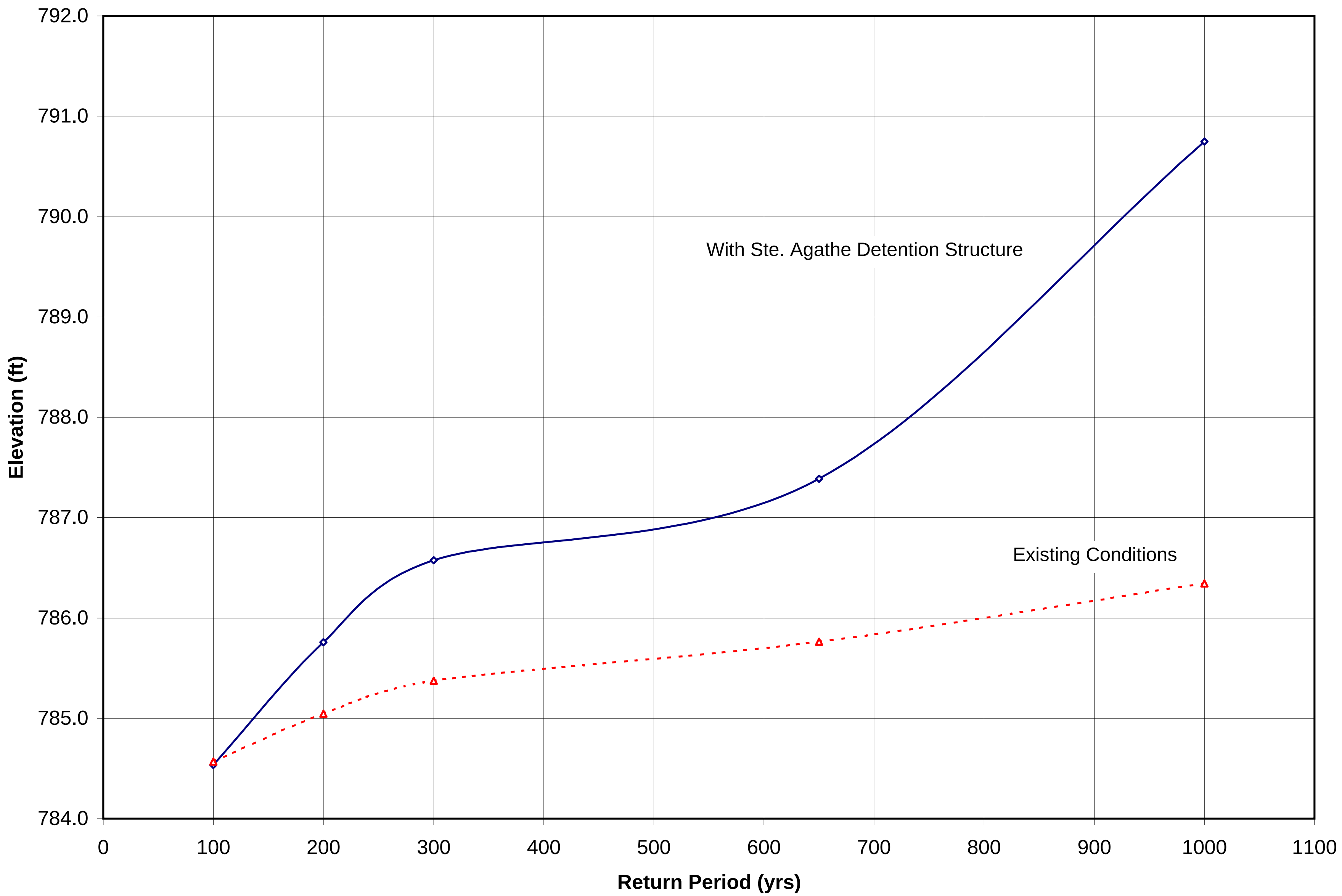
Ste Agathe /Floodway Expansion Study
Stage Probability Curve at Emerson
FIGURE C-A-1



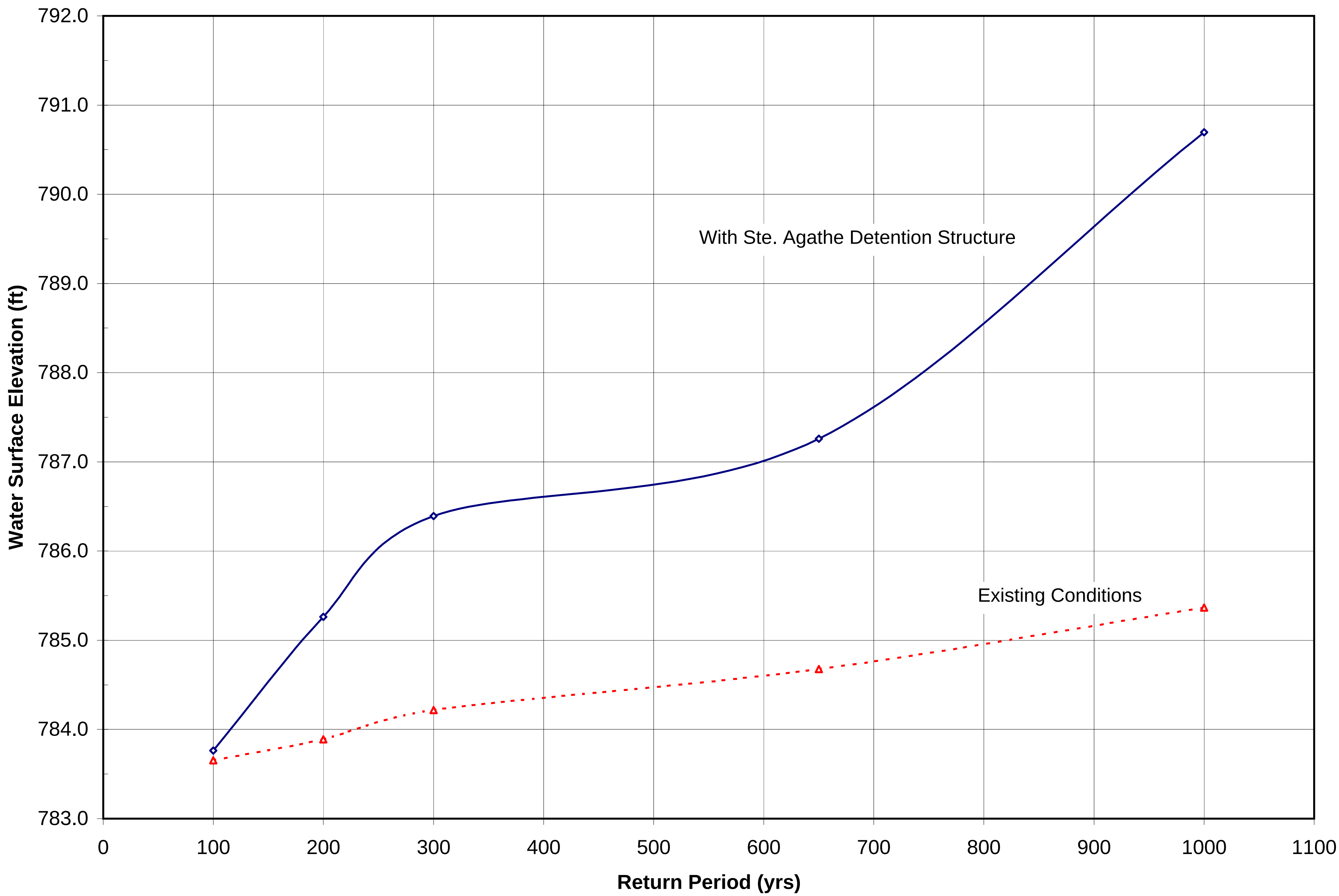
Ste Agathe /Floodway Expansion Study
Stage Probability Curve at Letellier
FIGURE C-A-2



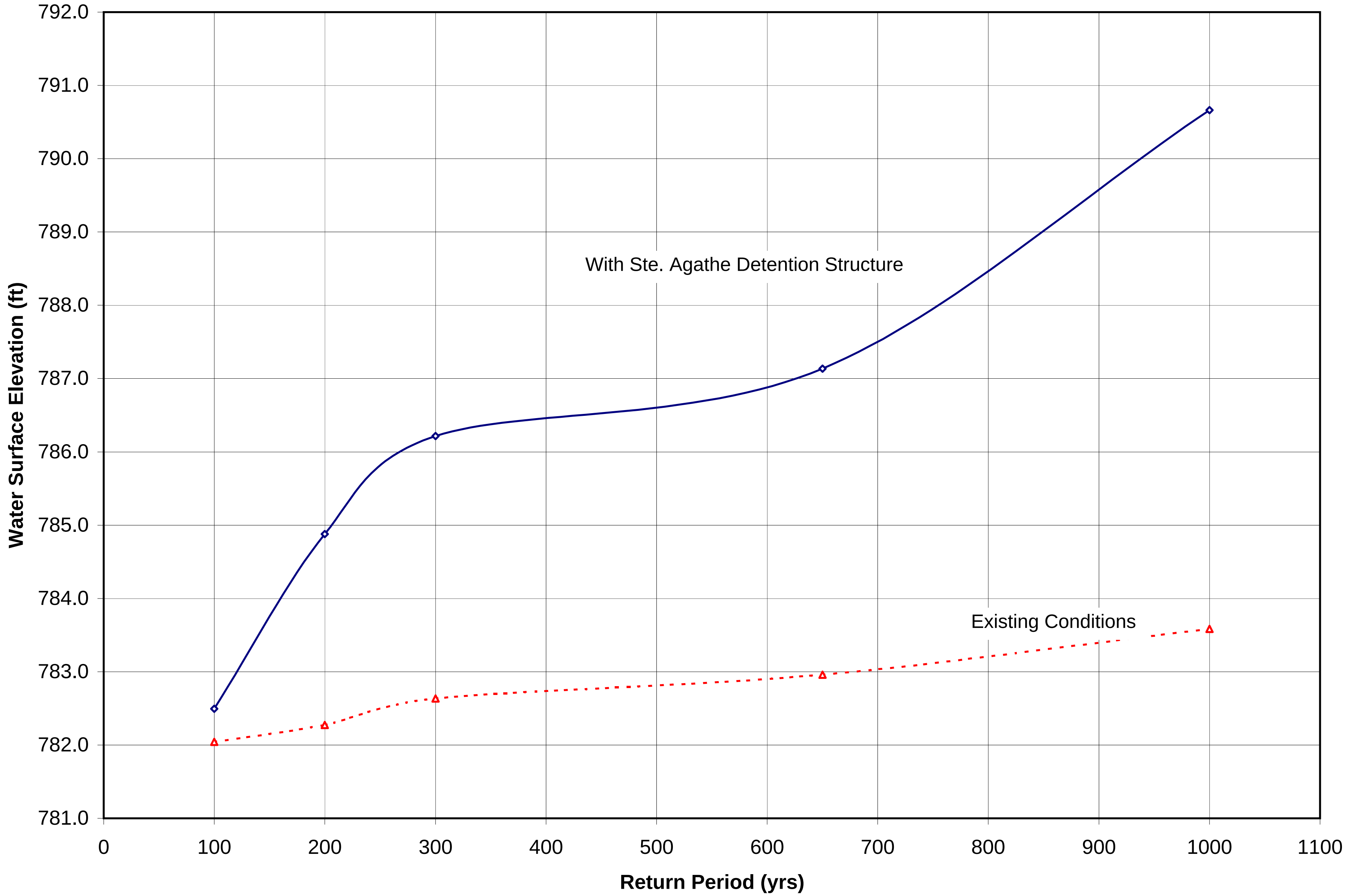
Ste Agathe /Floodway Expansion Study
Stage Probability Curve at Dominion City
FIGURE C-A-3



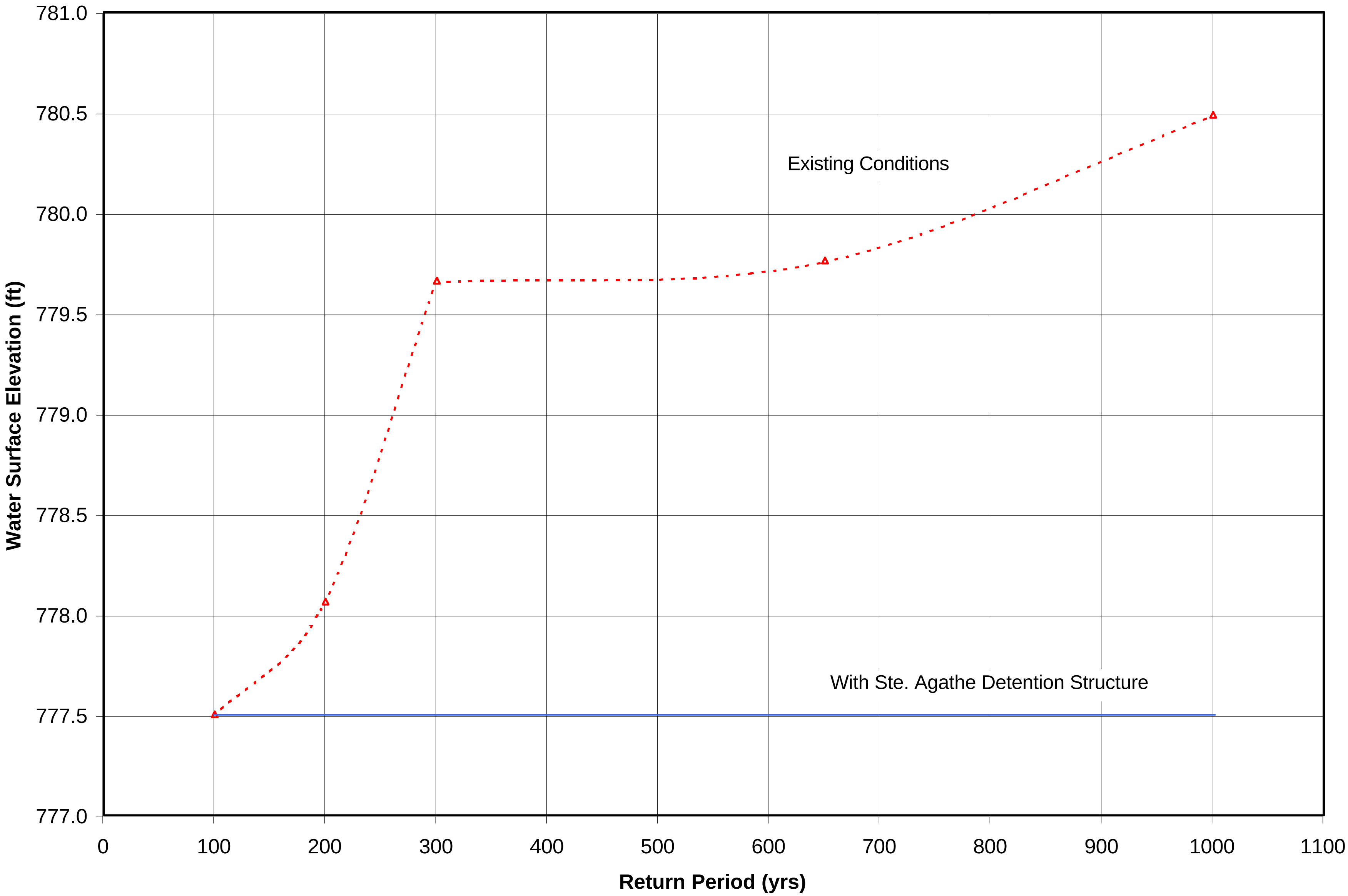
Ste Agathe /Floodway Expansion Study
Stage Probability Curve at St. Jean Baptiste
FIGURE C-A-4



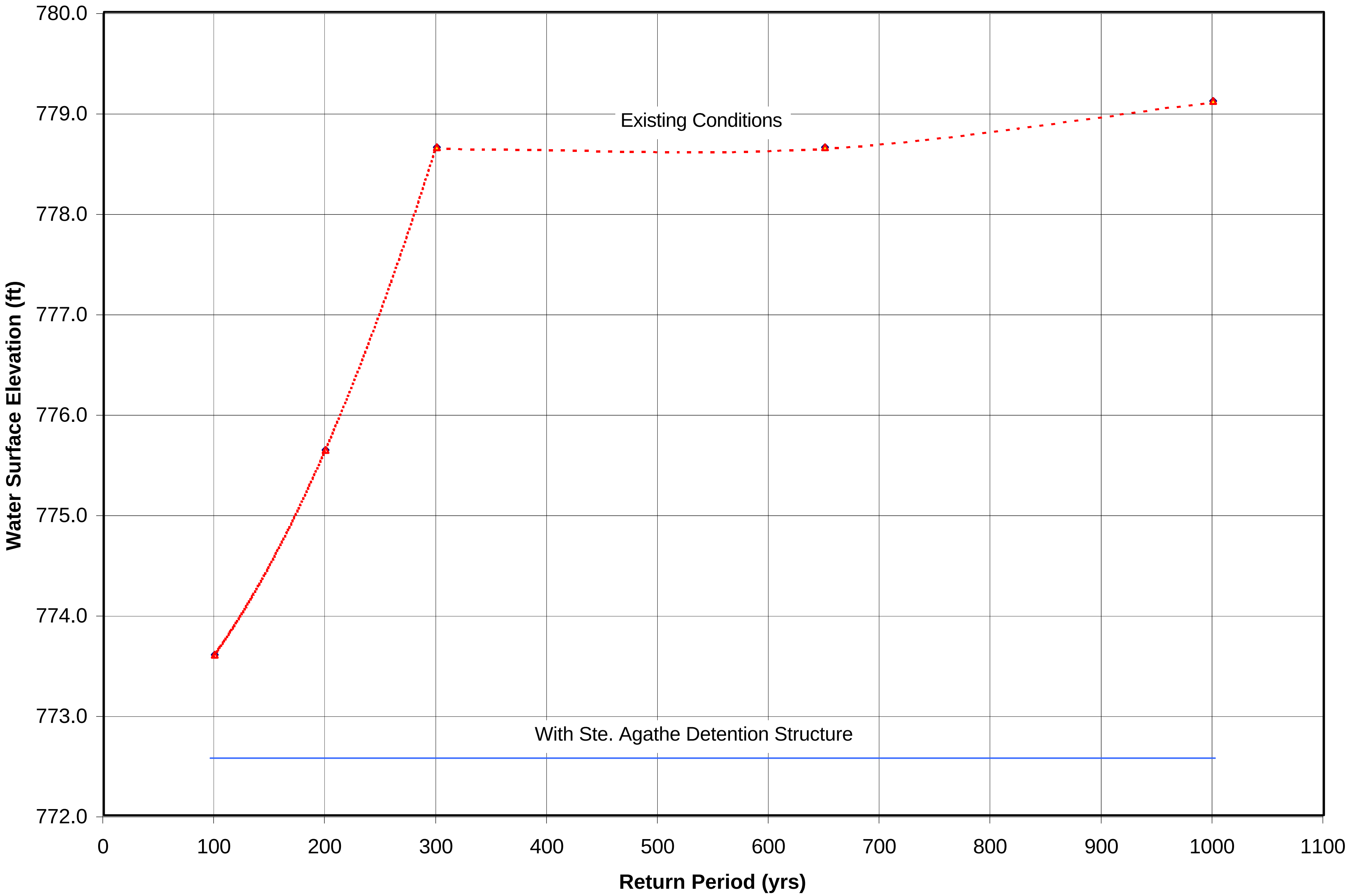
Ste Agathe /Floodway Expansion Study
Stage Probability Curve at Morris
FIGURE C-A-5



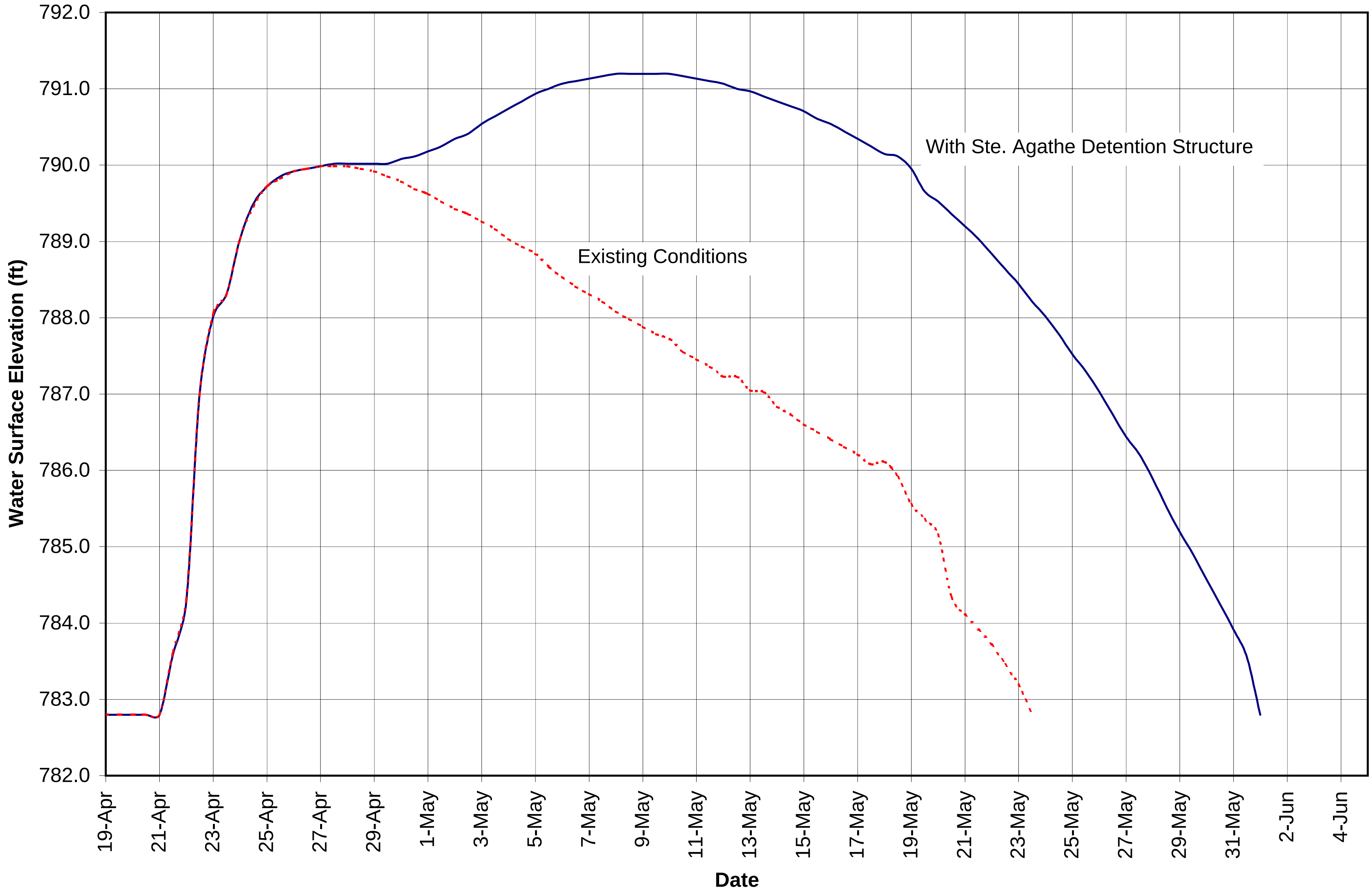
Ste Agathe /Floodway Expansion Study
Stage Probability Curve at Aubigny
FIGURE C-A-6



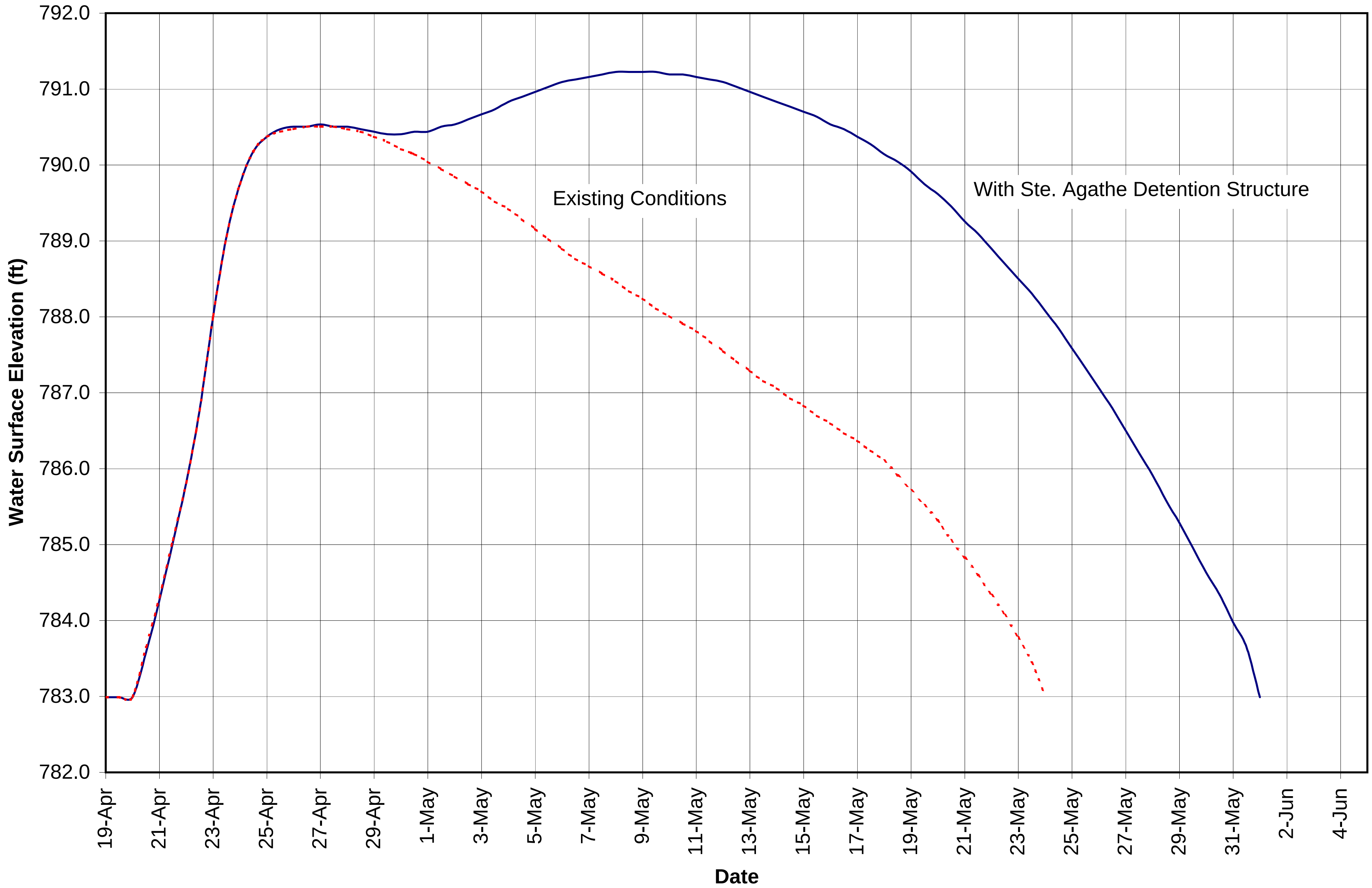
Ste Agathe /Floodway Expansion Study
Stage Probability Curve at Ste. Agathe
FIGURE C-A-7



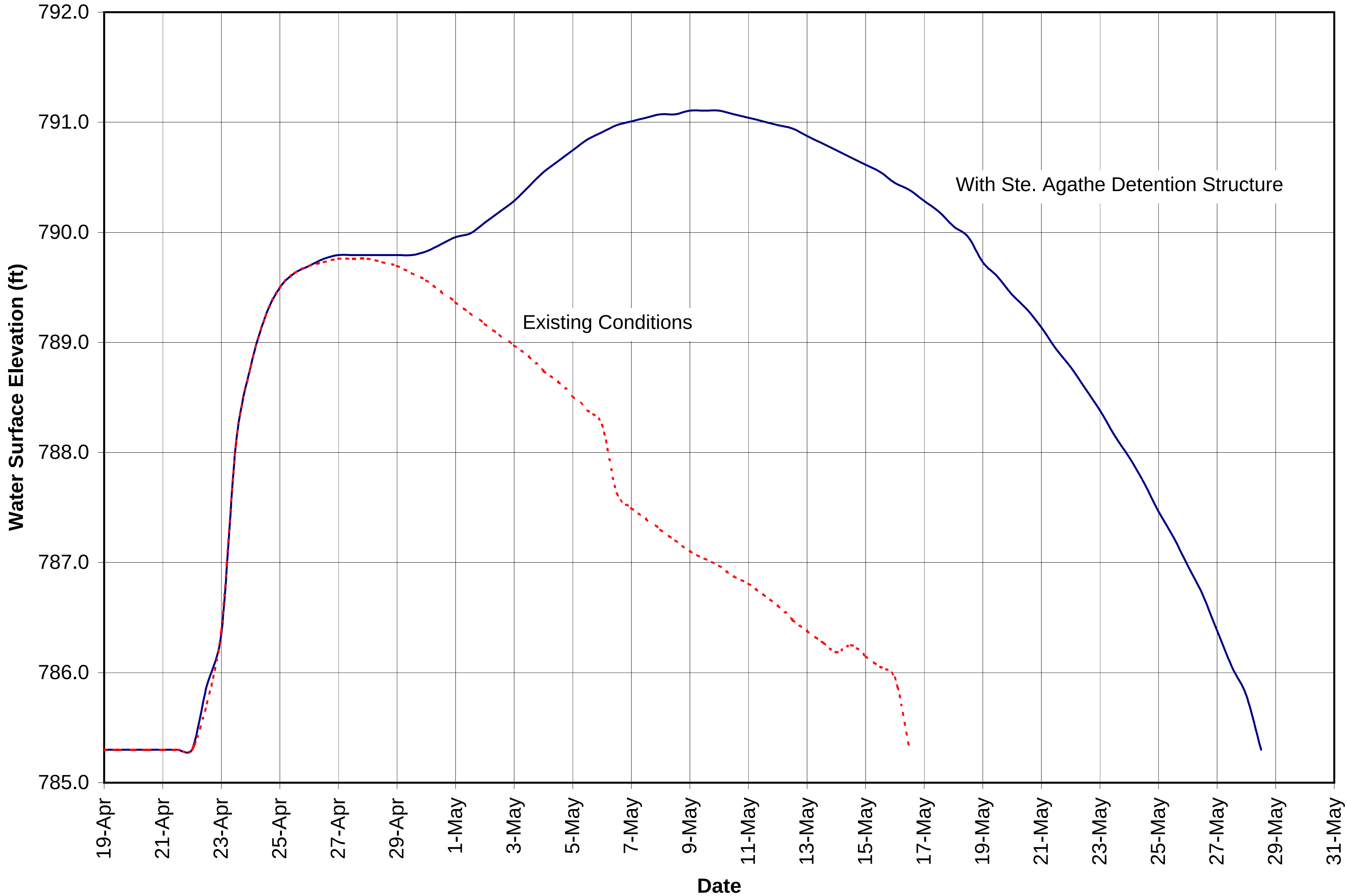
Ste Agathe /Floodway Expansion Study
Stage Probability Curve at St. Adolphe
FIGURE C-A-8



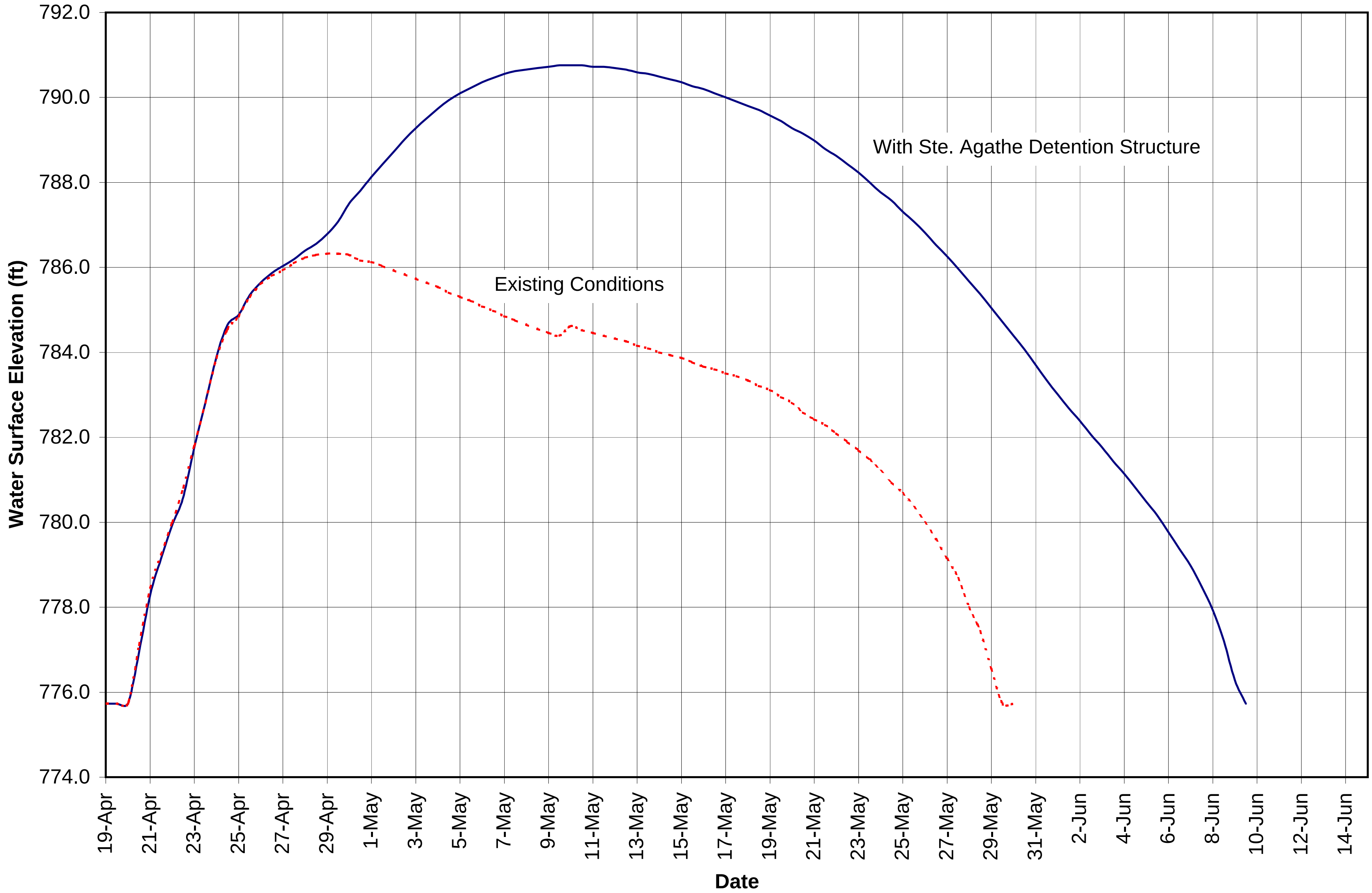
Ste Agathe /Floodway Expansion Study
1000 Year Stage Hydrographs at Letellier
FIGURE C-A-9



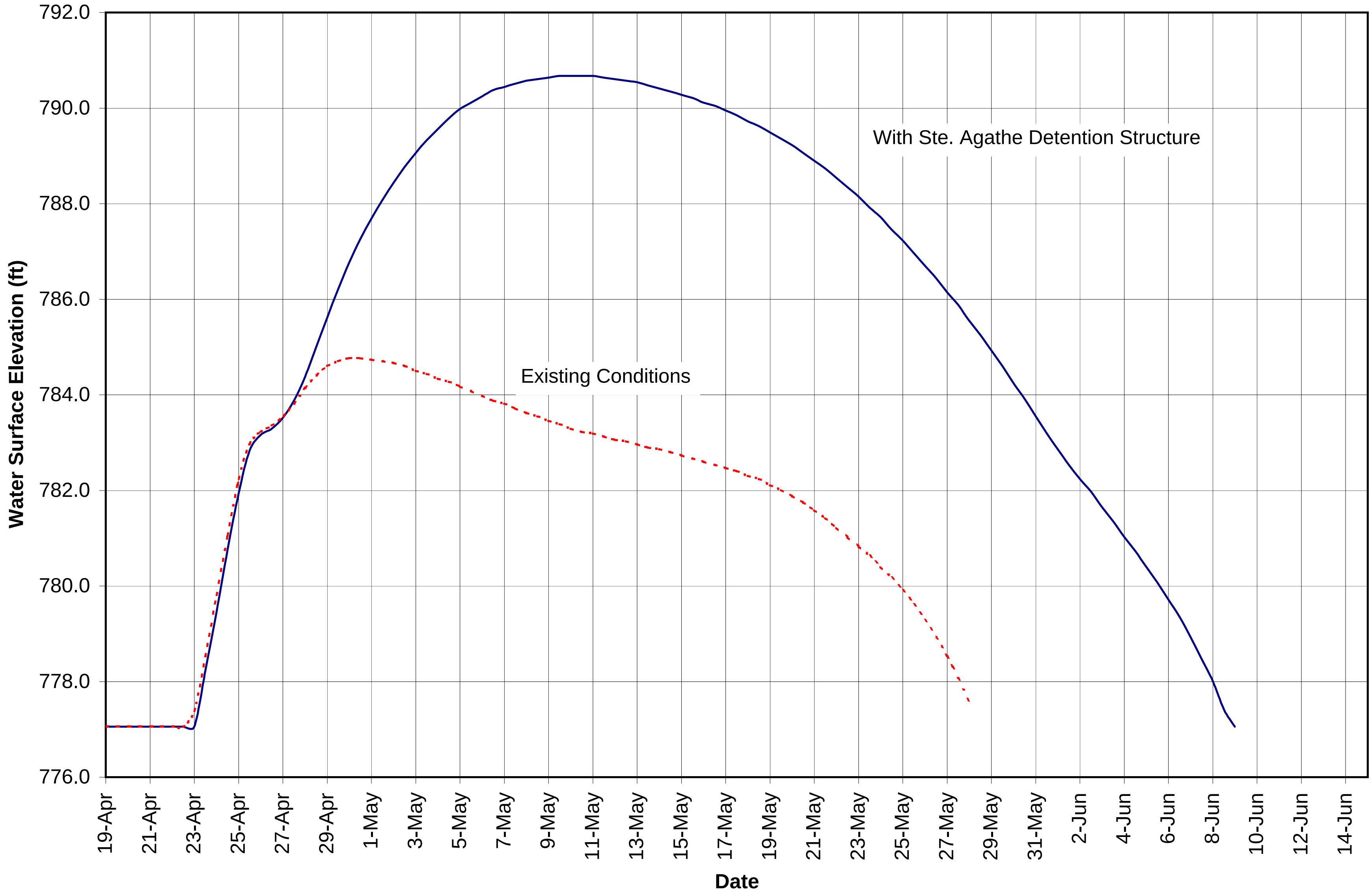
Ste Agathe /Floodway Expansion Study
1000 Year Stage Hydrographs
at Roseau River Indian Reserve
FIGURE C-A-10



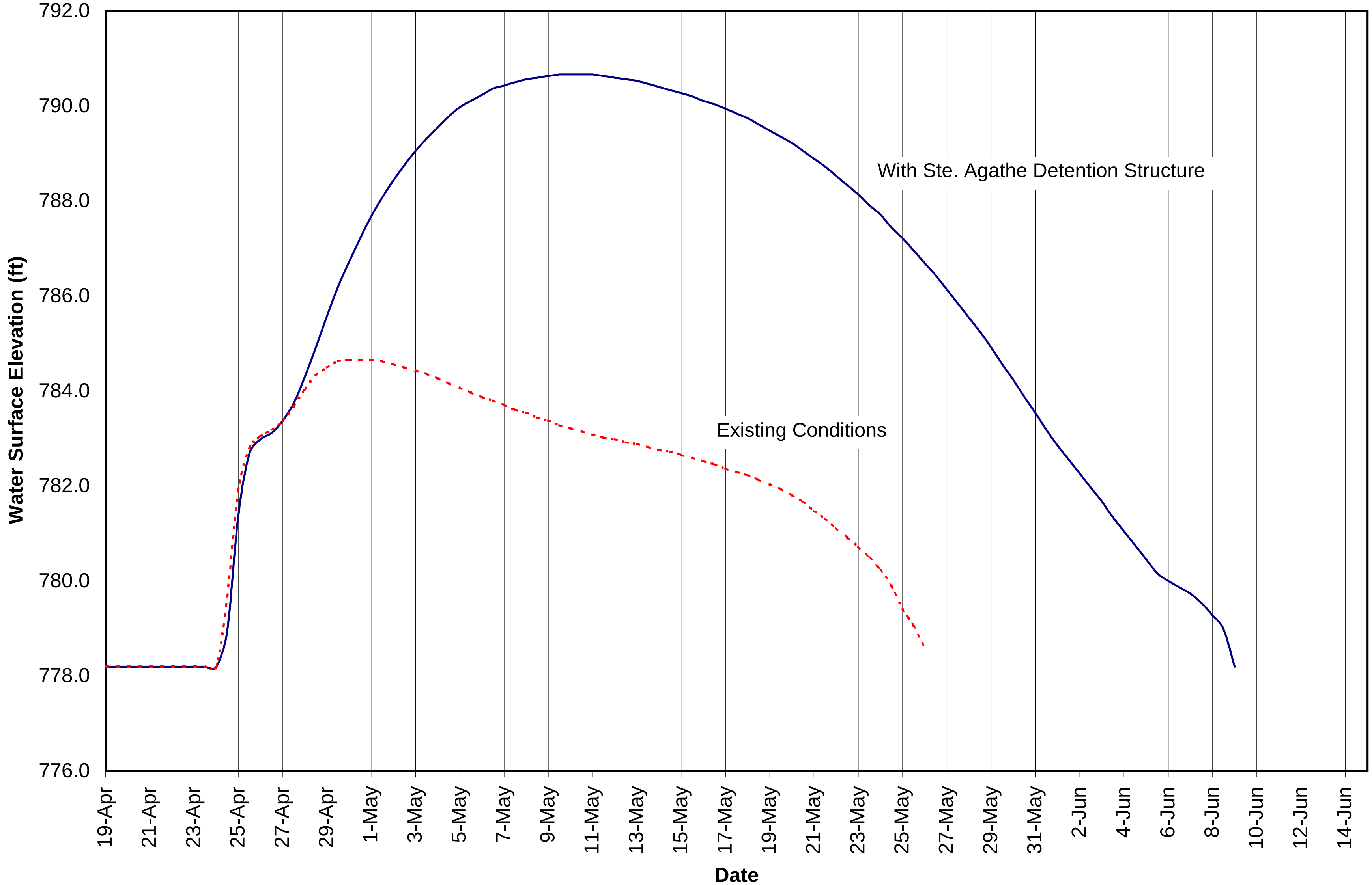
Ste Agathe /Floodway Expansion Study
1000 Year Stage Hydrographs at Dominion City
FIGURE C-A-11



Ste Agathe /Floodway Expansion Study
1000 Year Stage Hydrographs at St Jean Baptiste
FIGURE C-A-12



Ste Agathe /Floodway Expansion Study
1000 Year Stage Hydrographs at Riverside
FIGURE C-A-13



Ste Agathe /Floodway Expansion Study
1000 Year Stage Hydrographs at McTavish
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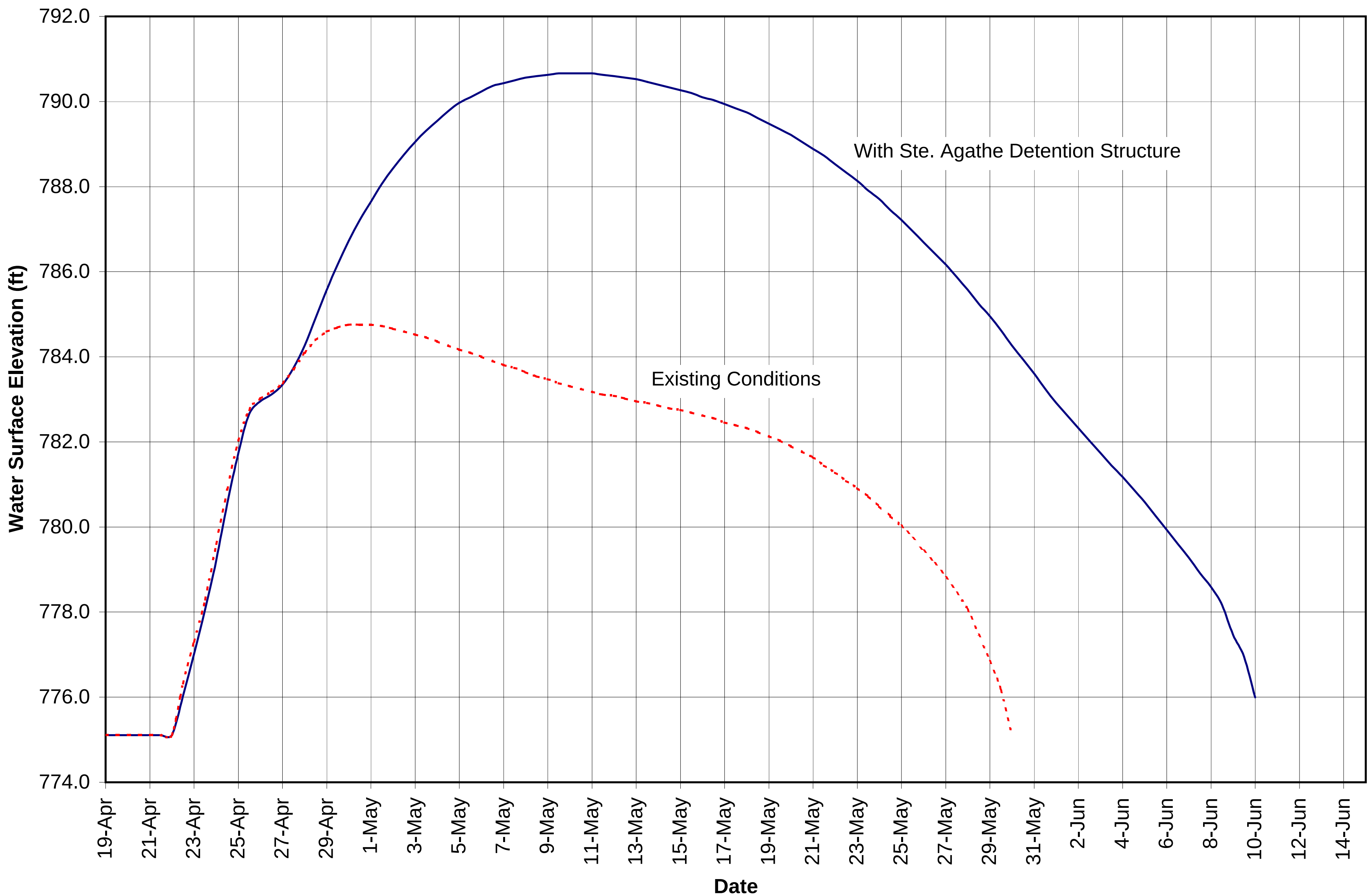
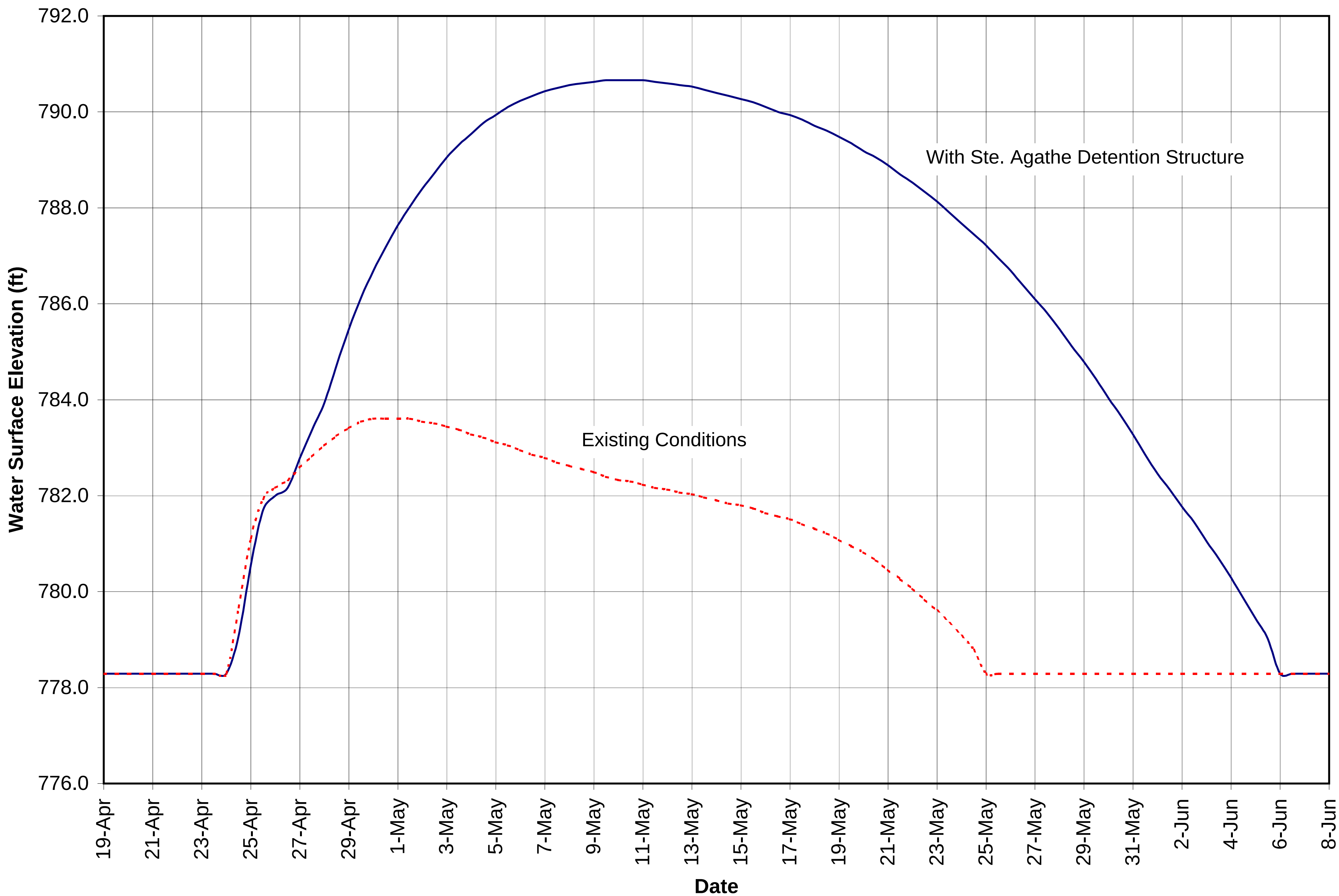


Ste Agathe /Floodway Expansion Study
1000 Year Stage Hydrographs at Rosenort
FIGURE C-A-15



Ste Agathe /Floodway Expansion Study
1000 Year Stage Hydrographs at Aubigny
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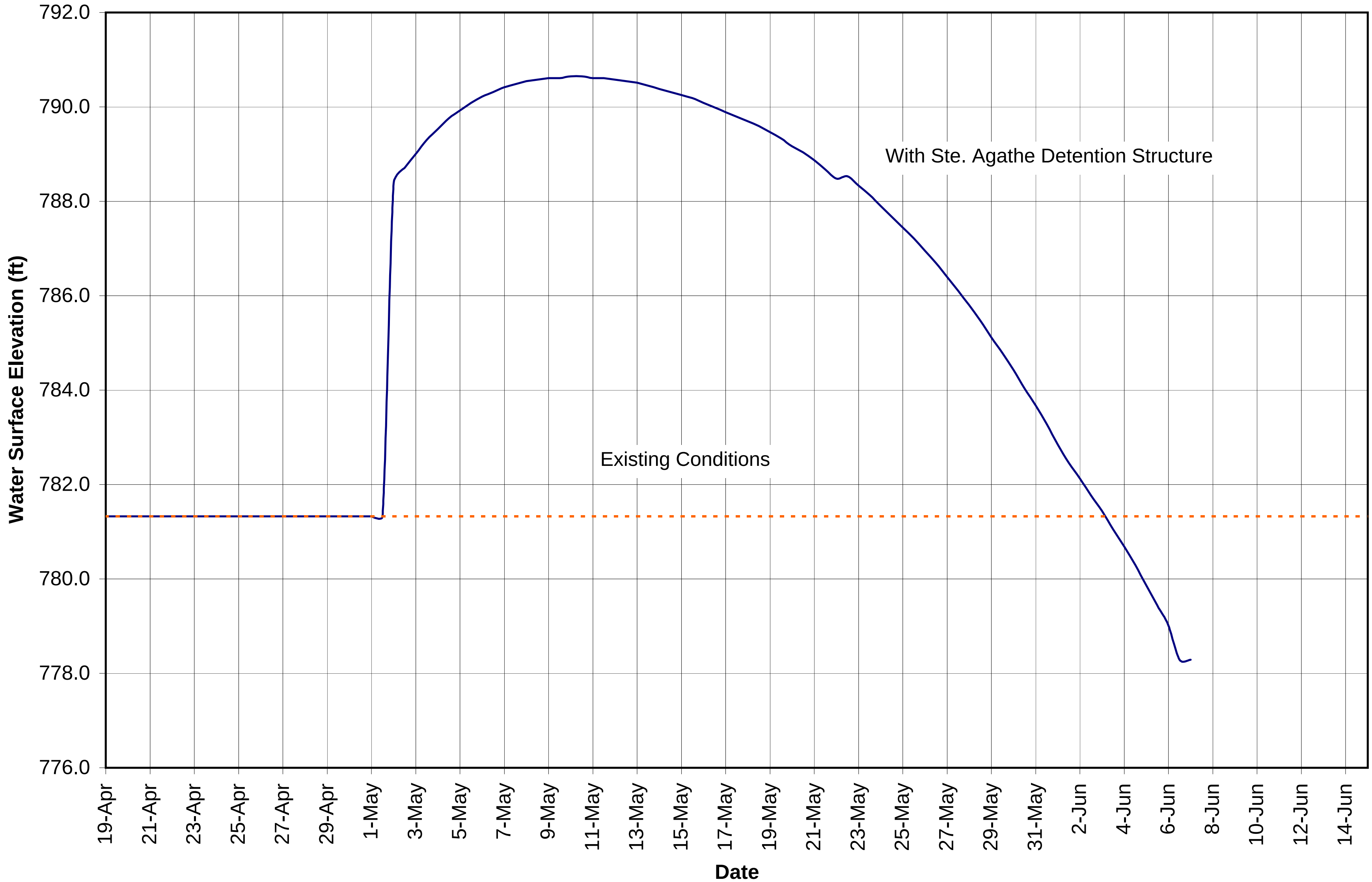

Ste Agathe /Floodway Expansion Study
1000 Year Stage Hydrographs at St Pierre-Jolys
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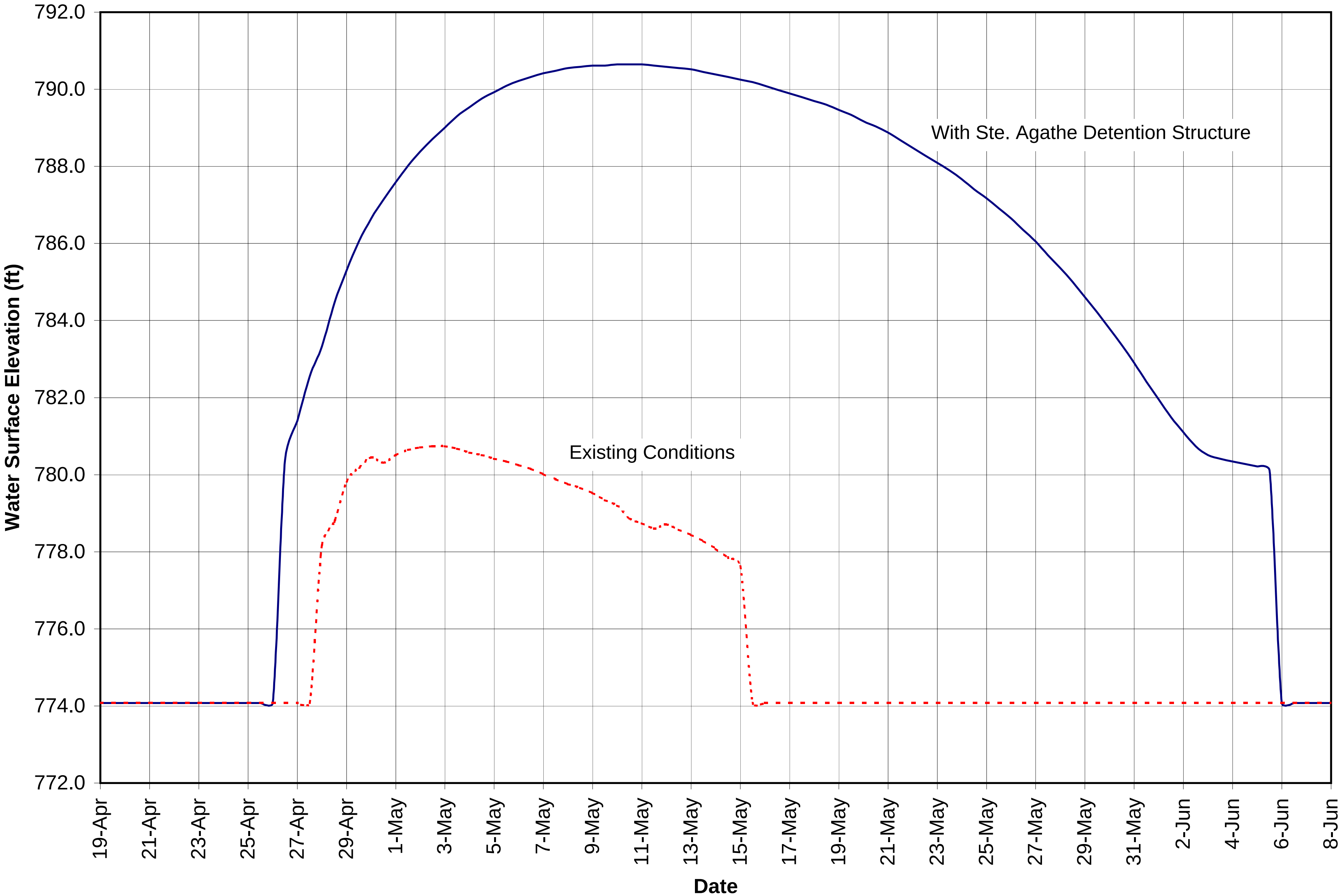
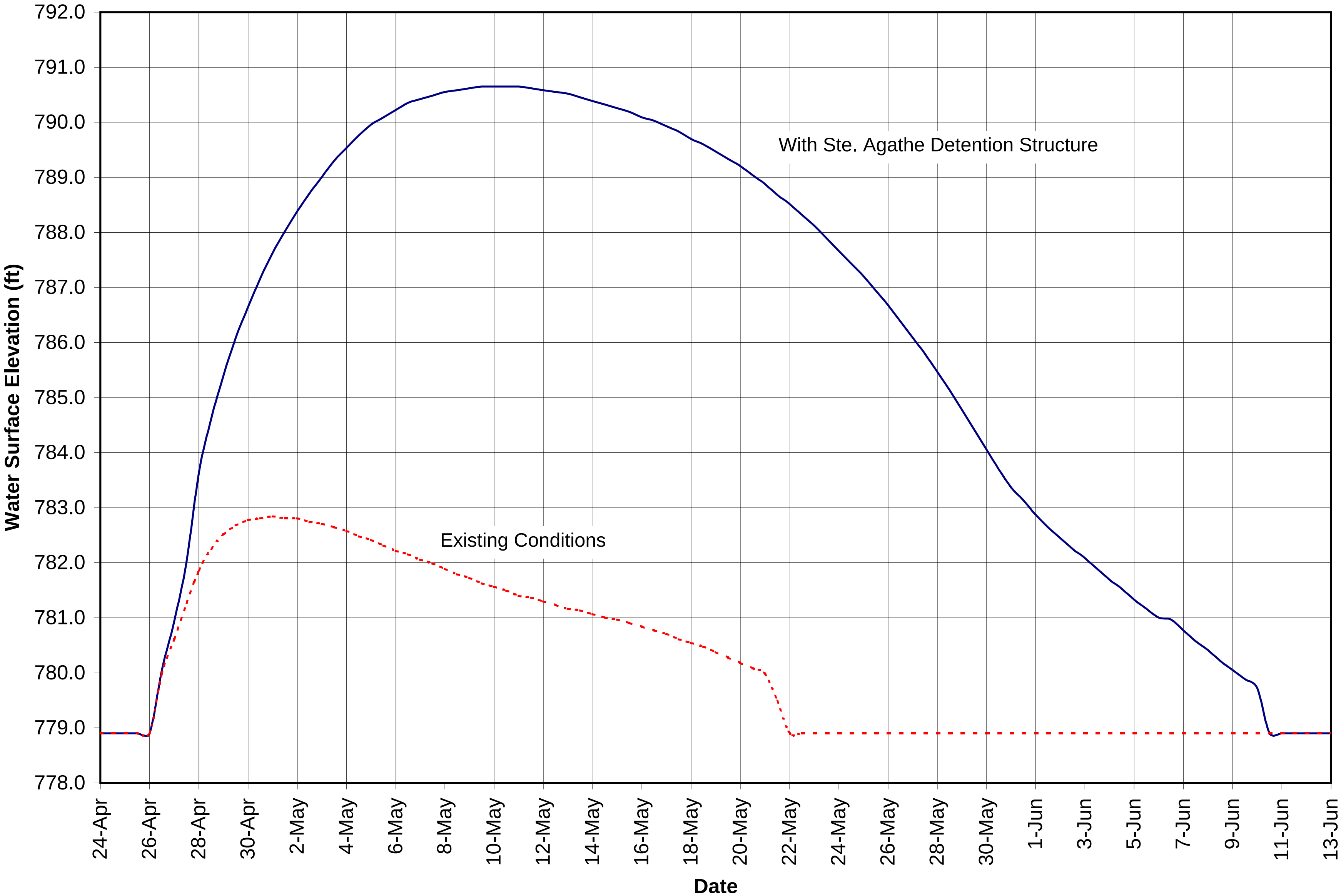
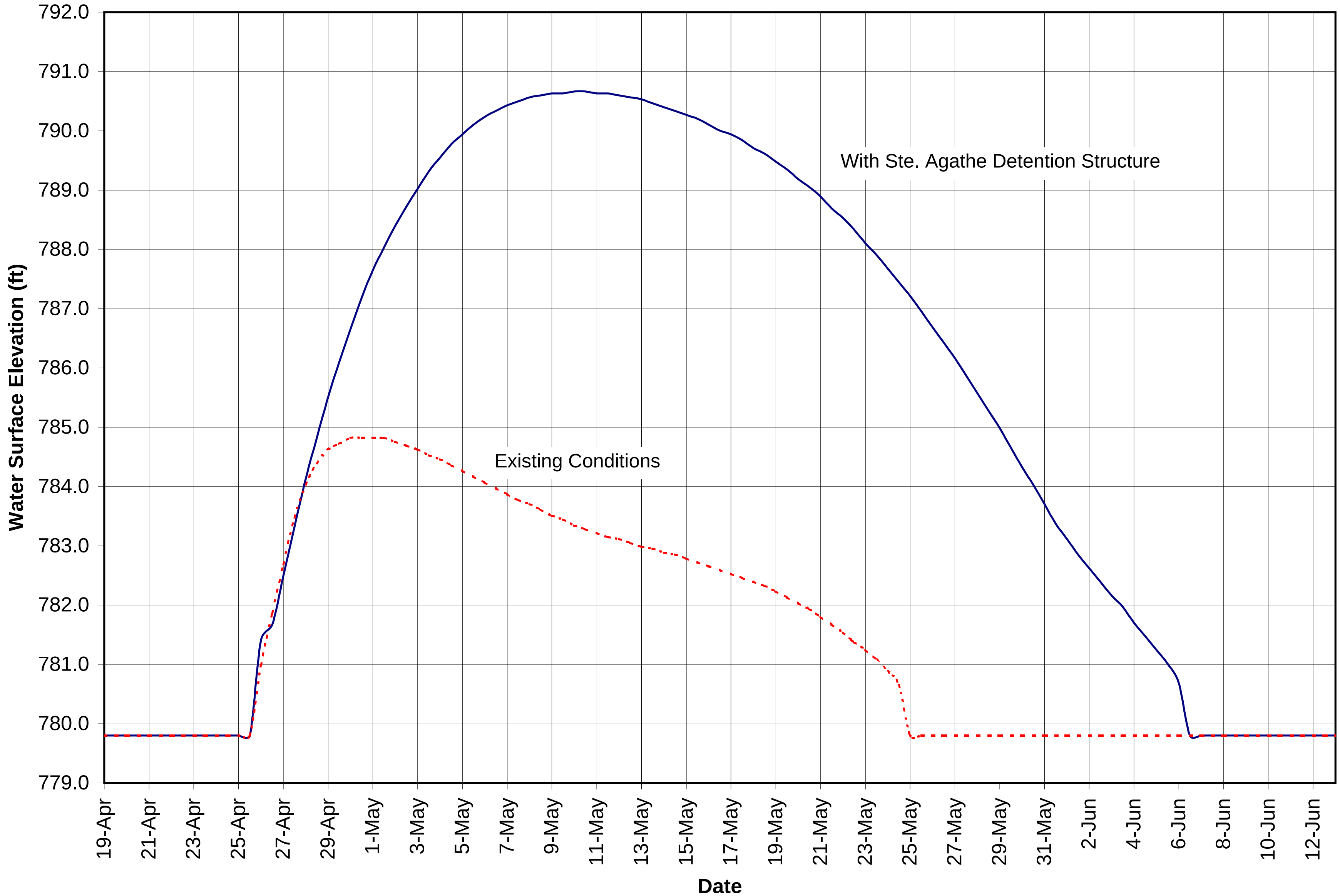


Ste Agathe /Floodway Expansion Study
1000 Year Stage Hydrographs at Otterburne
FIGURE C-A-18



Ste Agathe /Floodway Expansion Study
1000 Year Stage Hydrographs at Osborne
FIGURE C-A-19



Ste Agathe /Floodway Expansion Study
1000 Year Stage Hydrographs at Brunkild
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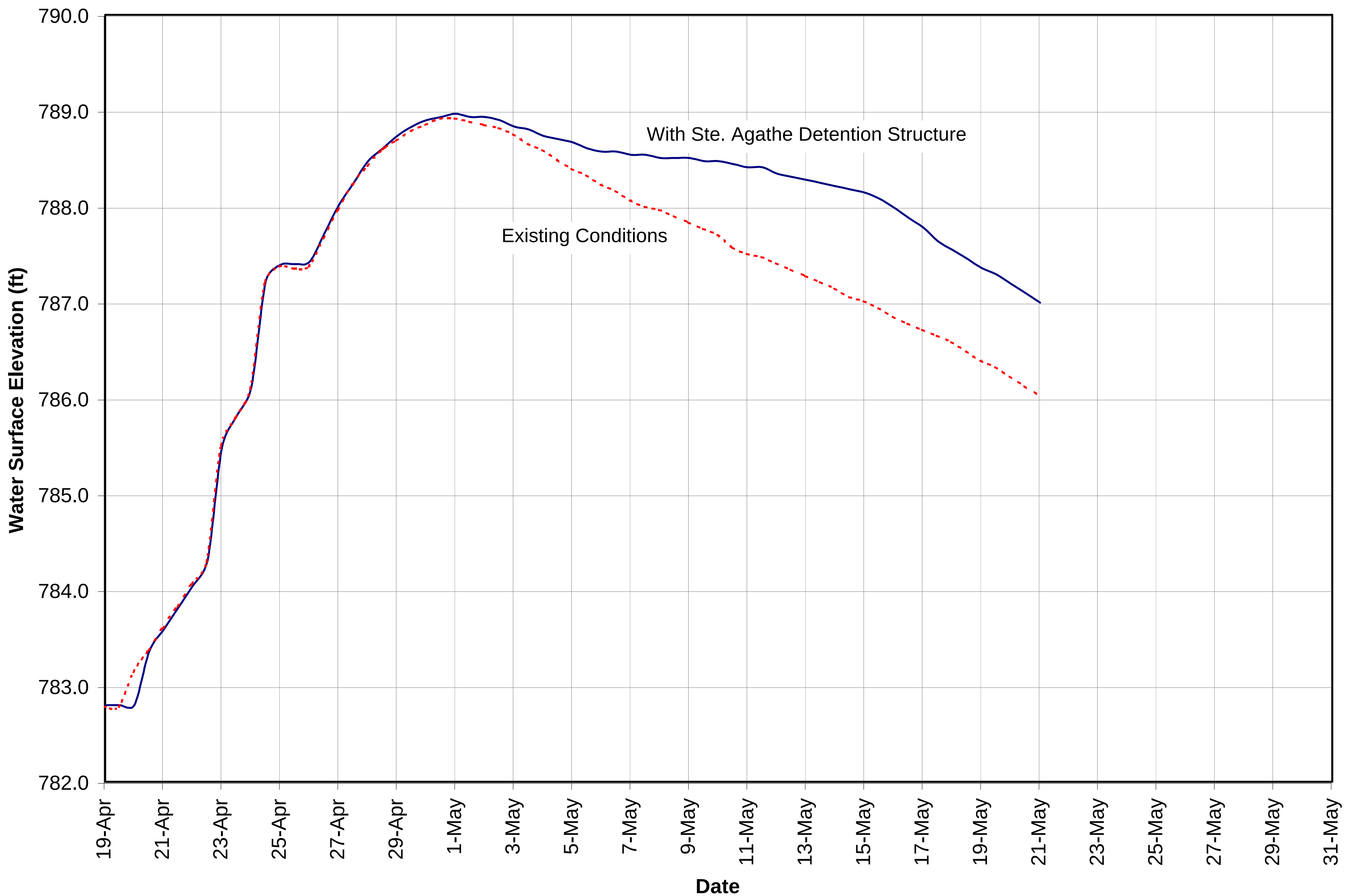

Ste Agathe /Floodway Expansion Study
300 Year Stage Hydrographs at Letellier
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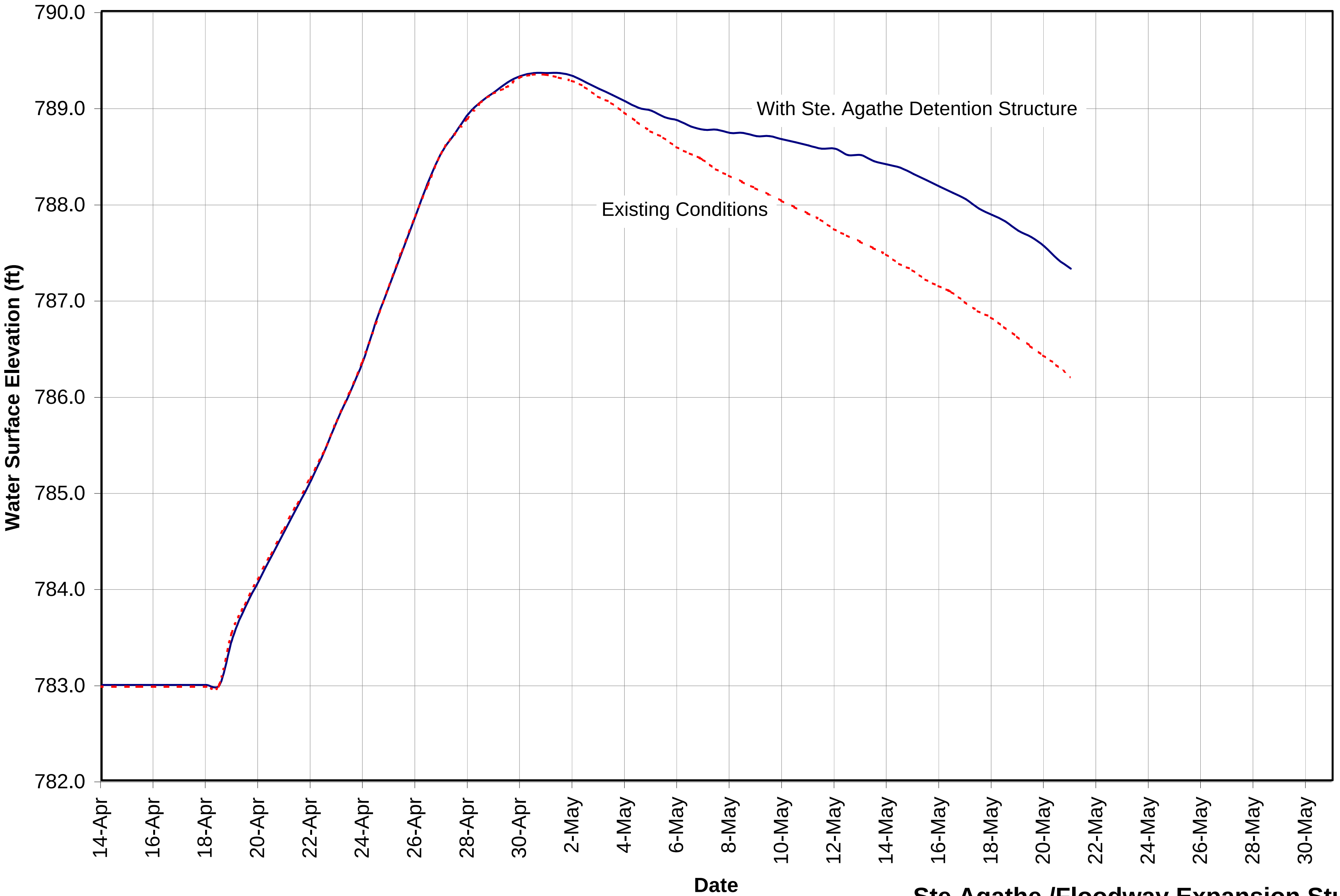

Ste Agathe /Floodway Expansion Study
300 Year Stage Hydrographs
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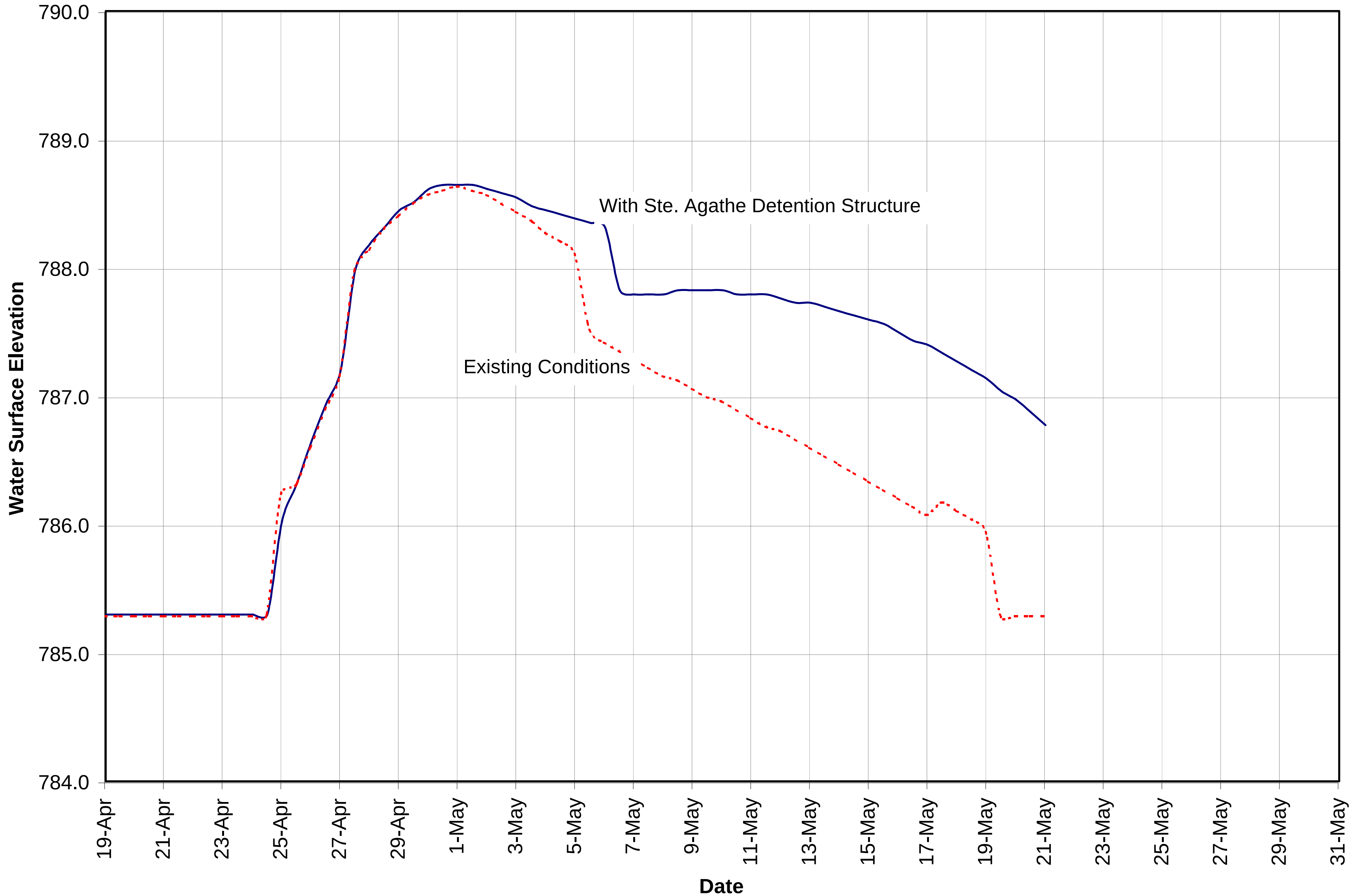
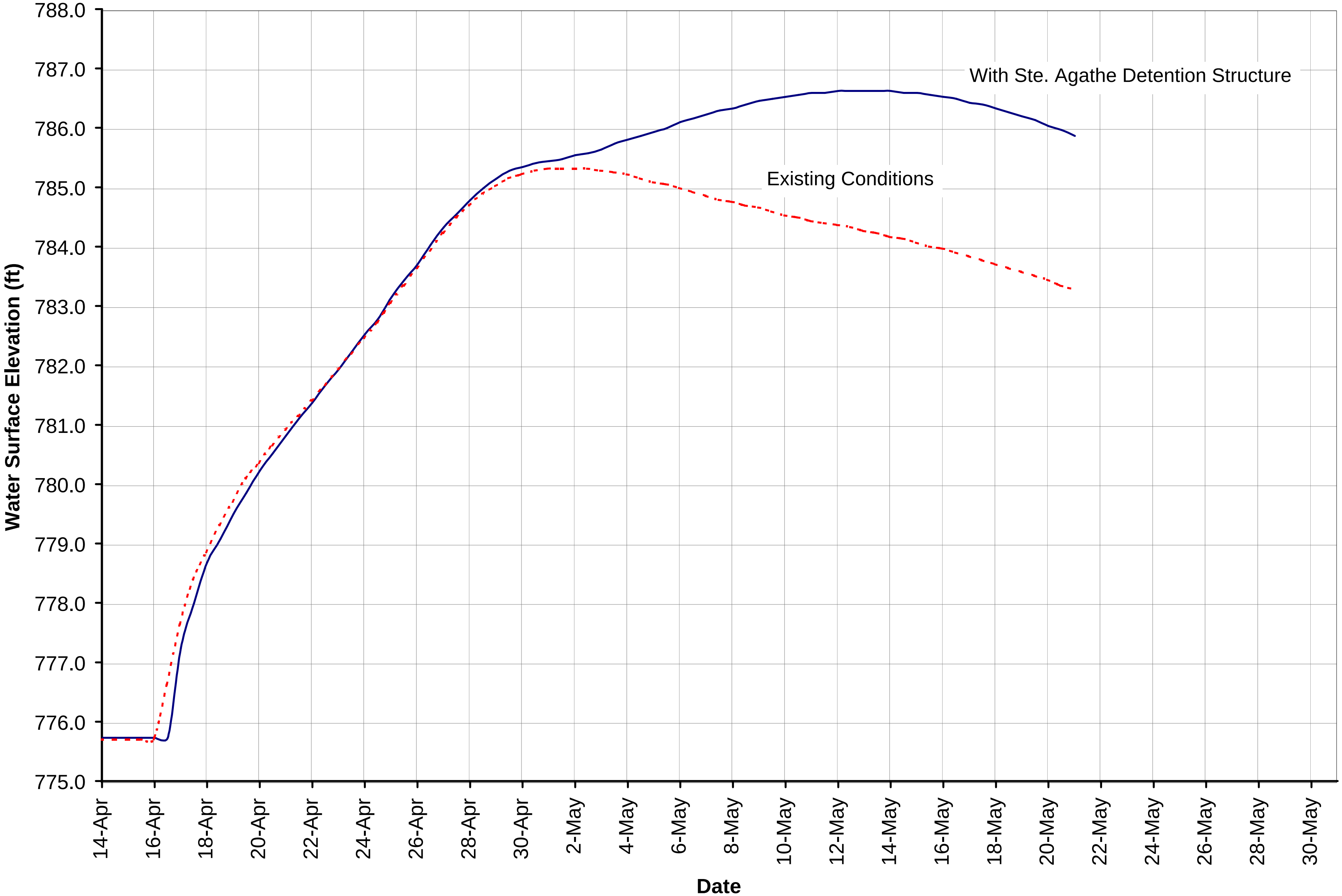
FIGURE C-A-22



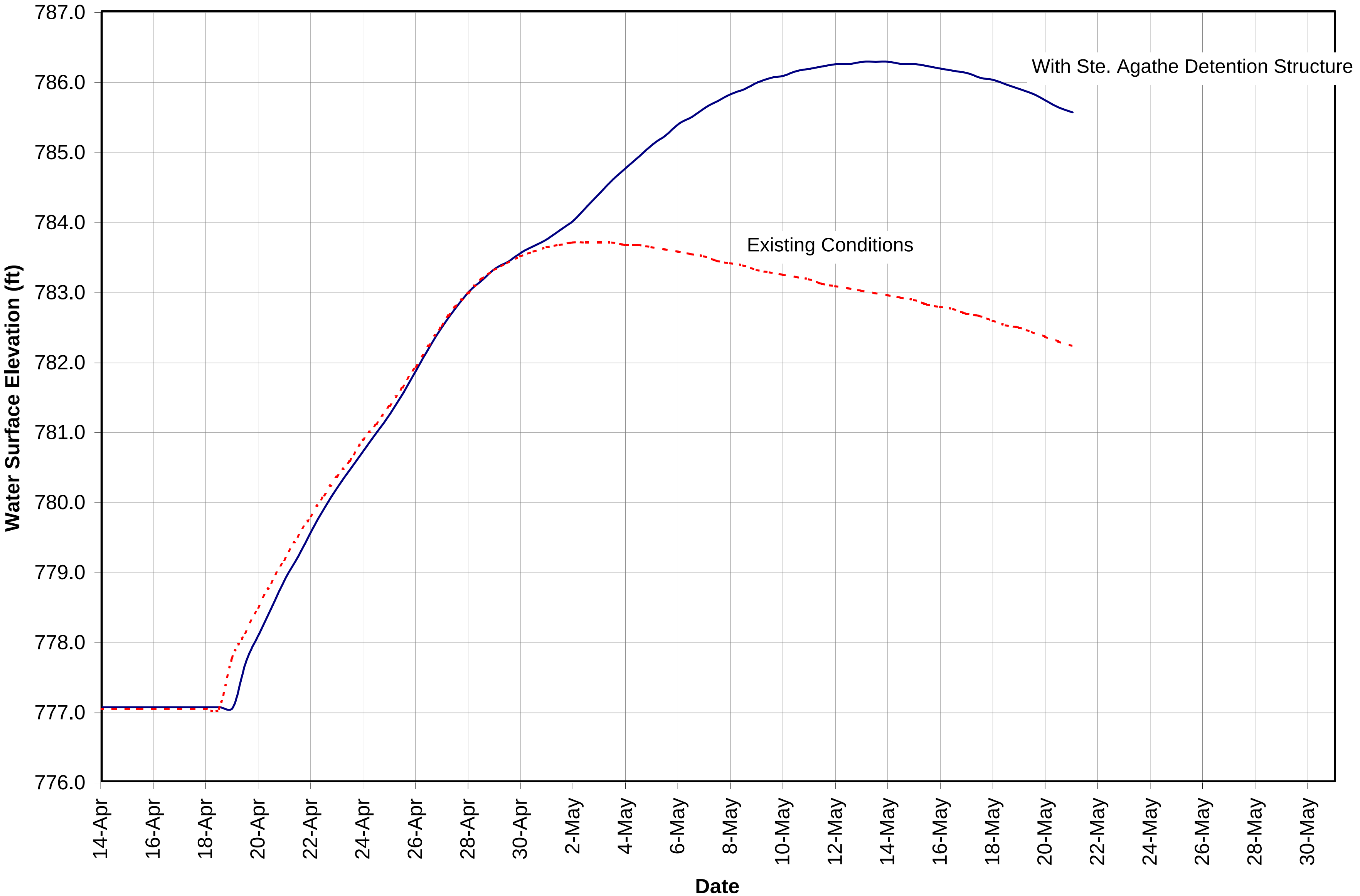
Ste Agathe /Floodway Expansion Study
300 Year Stage Hydrographs at Dominion City
FIGURE C-A-23



Ste Agathe /Floodway Expansion Study

300 Year Stage Hydrographs at St.Jean Baptiste

FIGURE C-A-24



Ste Agathe /Floodway Expansion Study
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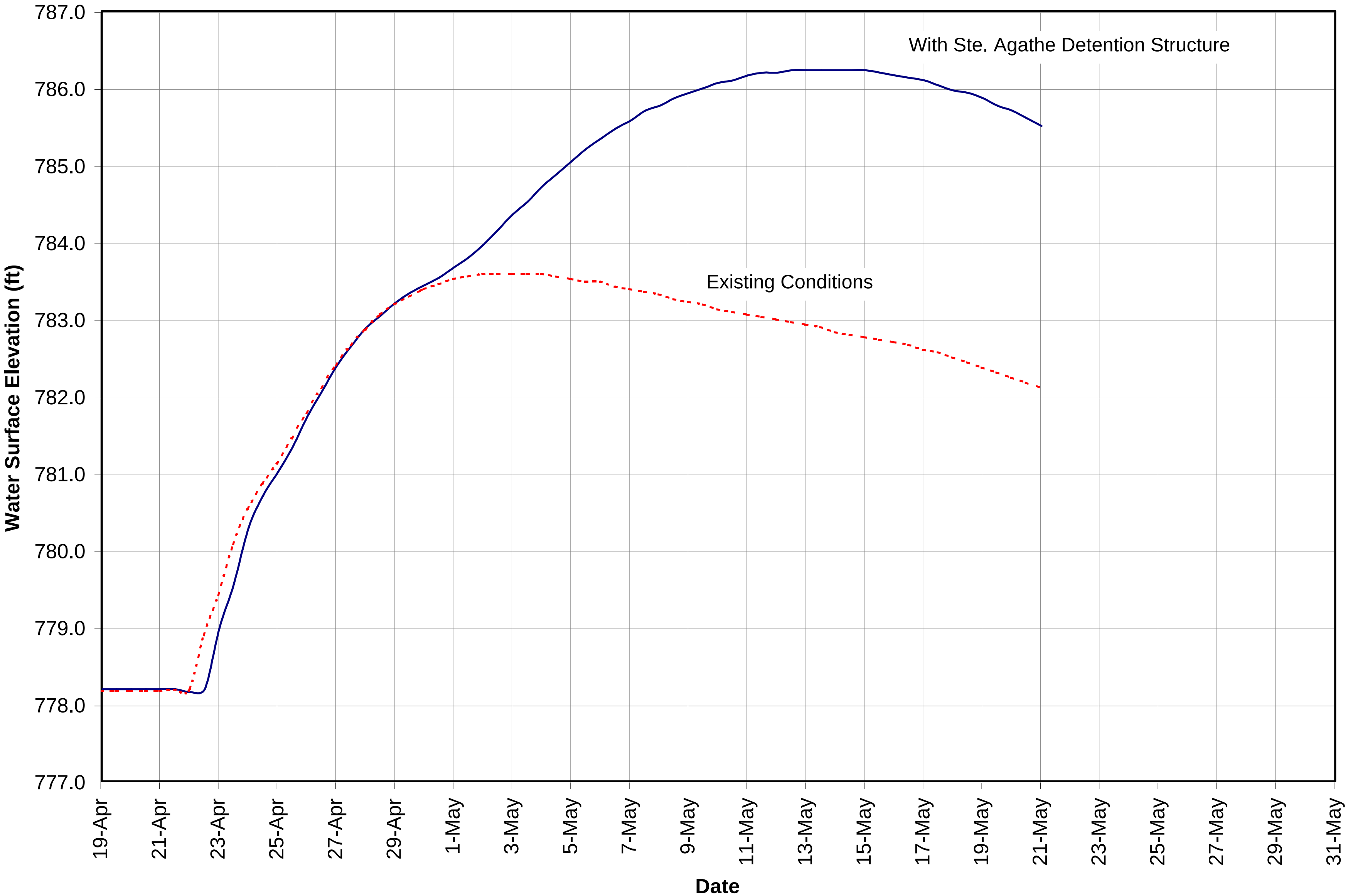

Ste Agathe /Floodway Expansion Study
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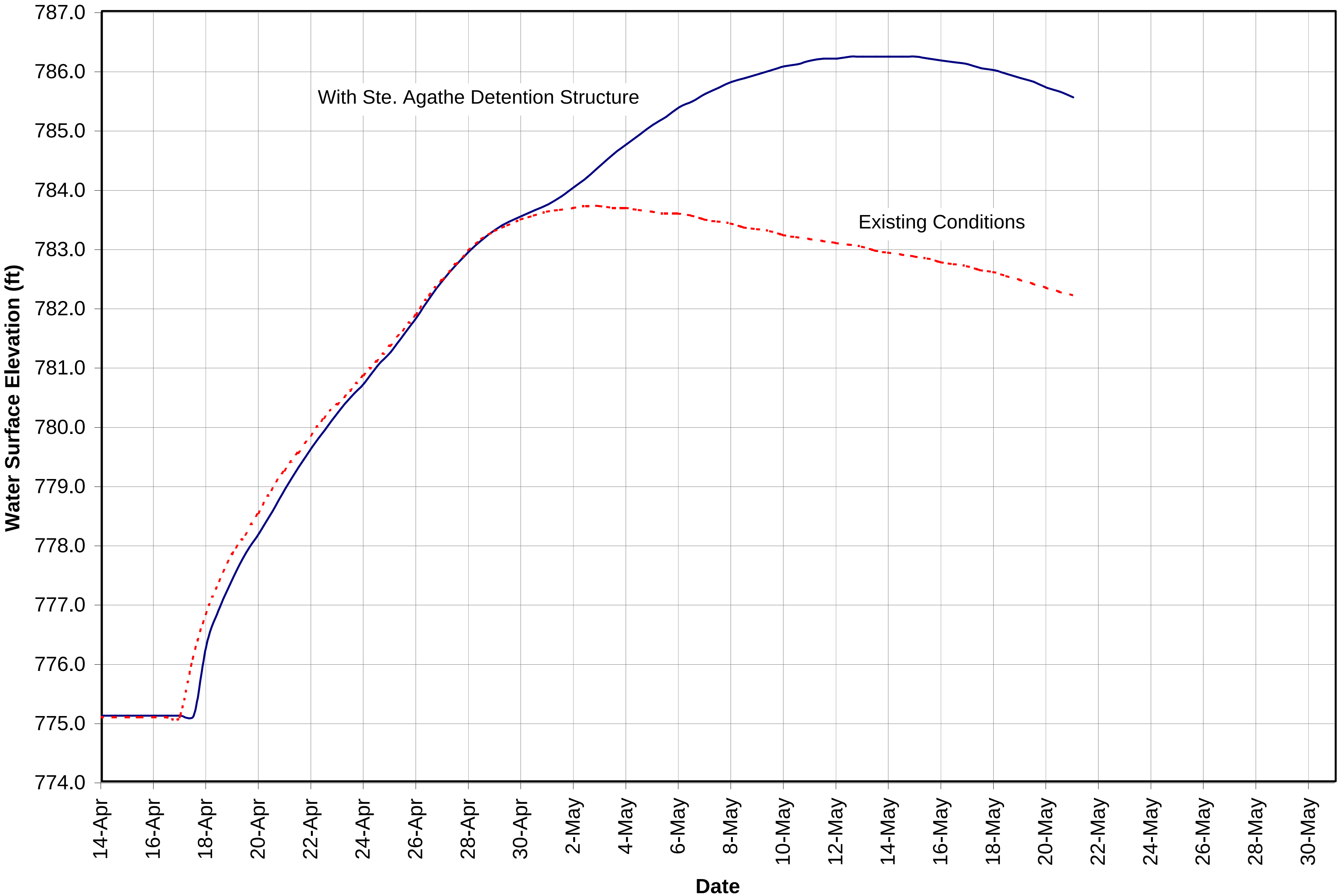
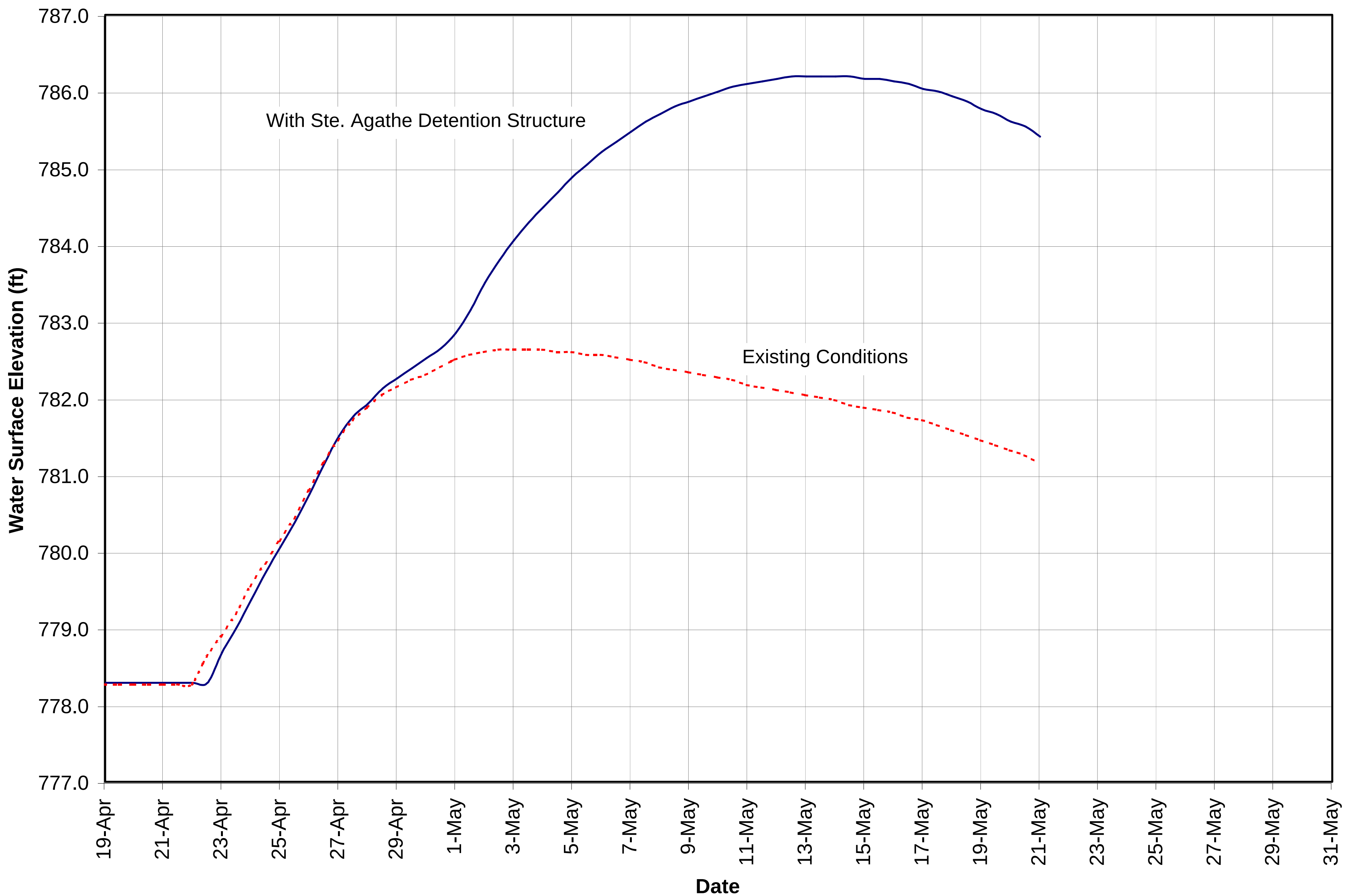
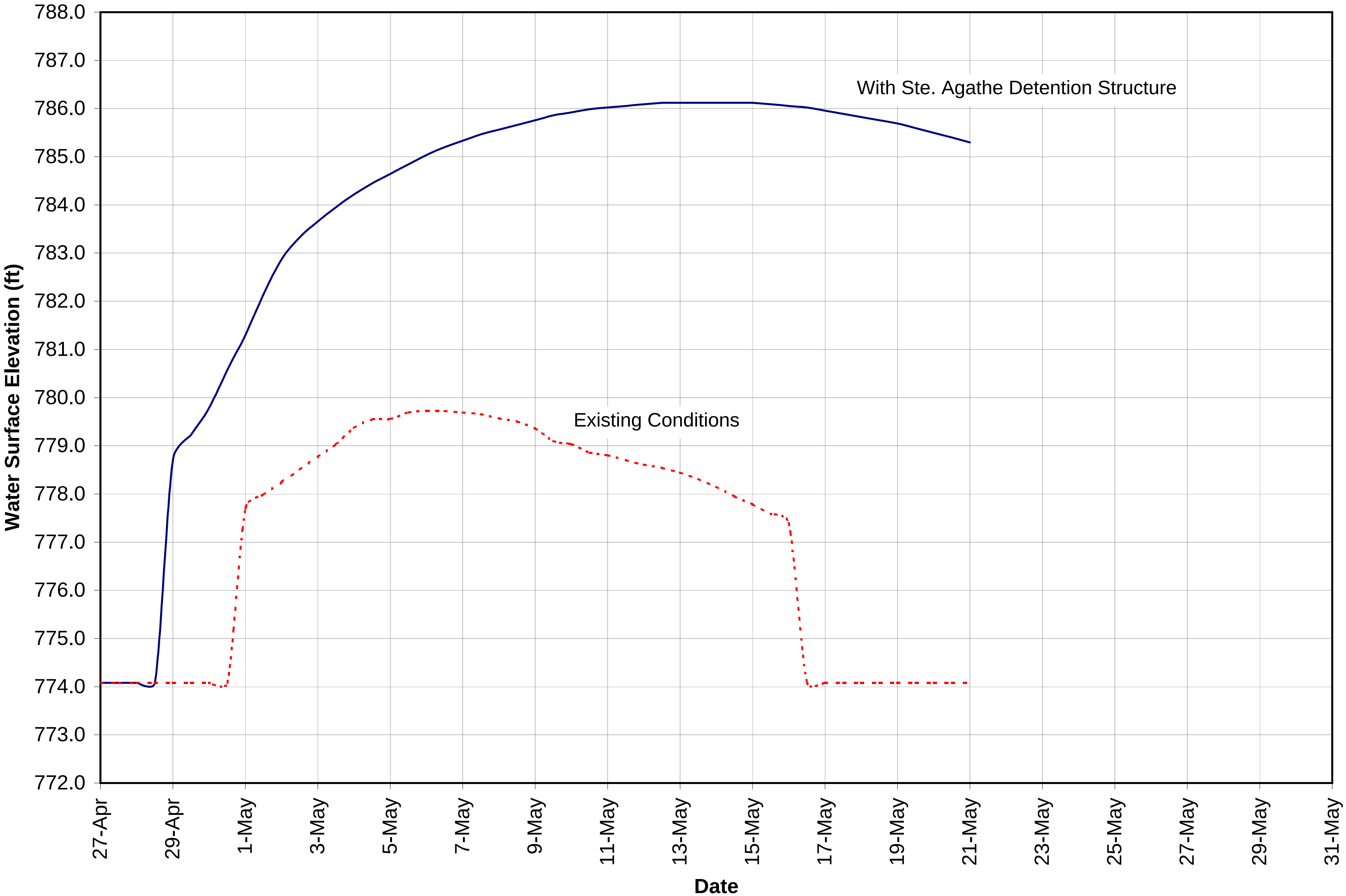


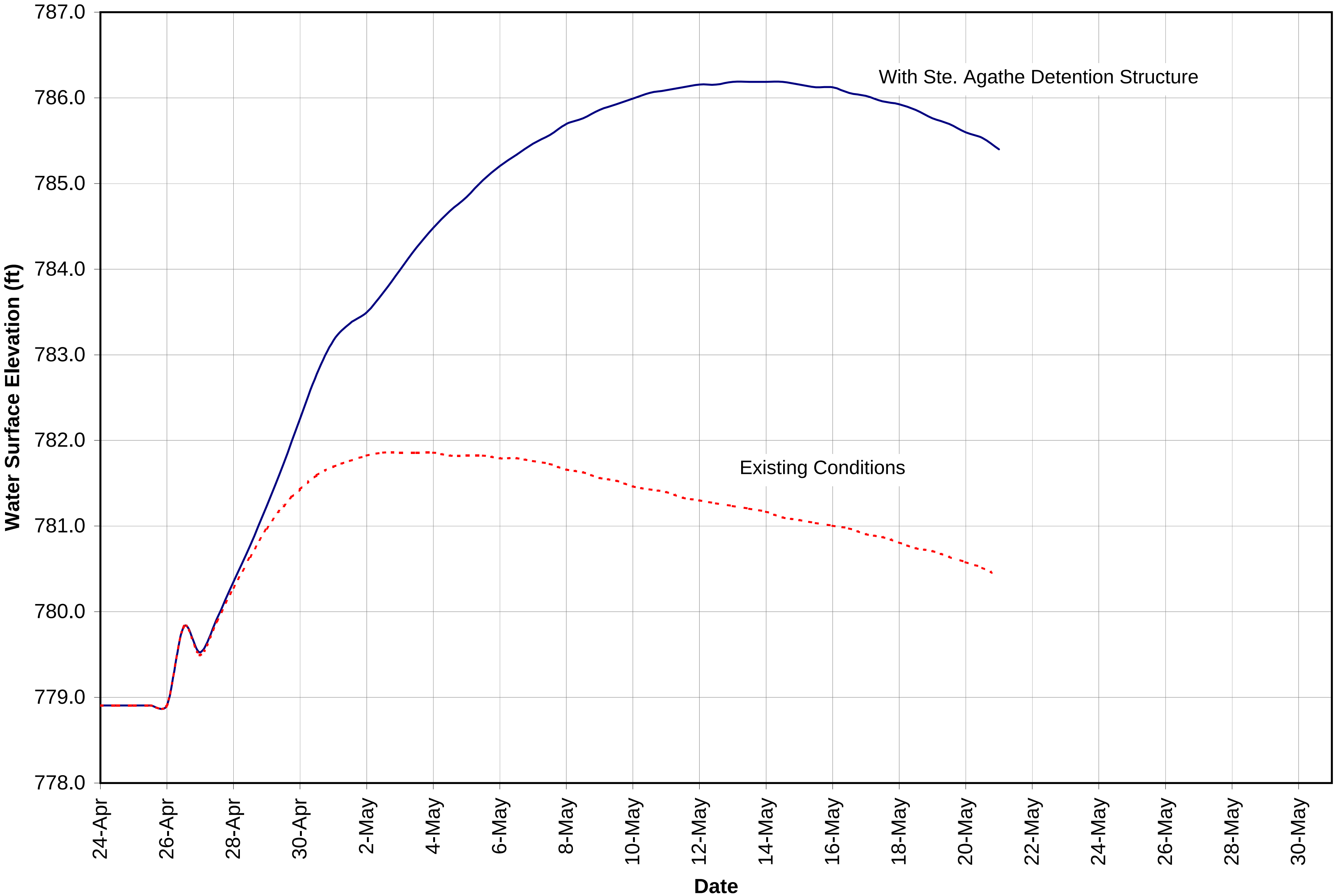
Ste Agathe /Floodway Expansion Study
300 Year Stage Hydrographs at Rosenort
FIGURE C-A-27



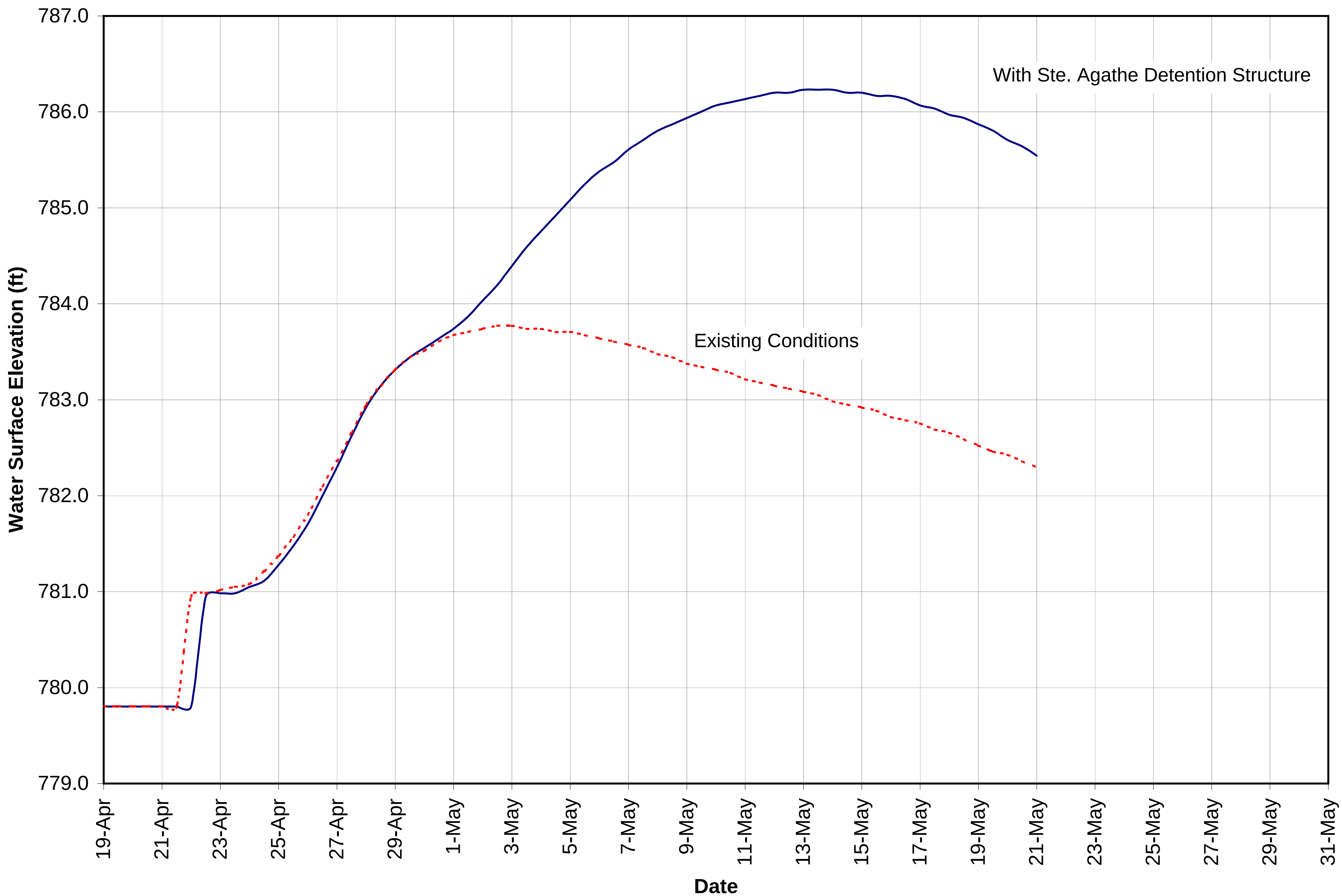
Ste Agathe /Floodway Expansion Study
300 Year Stage Hydrographs at Aubigny
FIGURE C-A-28



Ste Agathe /Floodway Expansion Study
300 Year Stage Hydrographs at Otterburne
FIGURE C-A-29



Ste Agathe /Floodway Expansion Study
300 Year Stage Hydrographs at Osborne
FIGURE C-A-30



Ste Agathe /Floodway Expansion Study
300 Year Stage Hydrographs at Brunkild
FIGURE C-A-31

Canada

Manitoba CONSERVATION

Winnipeg

FLOOD PROTECTION STUDIES FOR WINNIPEG

APPENDIX D
WEST DIKE

NOVEMBER 2001

KGS GROUP

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

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D.1 INTRODUCTION

This appendix is one of six that accompany and supplement the Main Report on Studies of Flood Protection for Winnipeg. It describes the studies and findings regarding the West Dike, and its function as a critical component of the Floodway Expansion scheme.

The 1997 flood demonstrated that the West Dike is an important part of the existing flood protection system for Winnipeg. It protects the City from the entry of floodwaters across the floodplain to the west of the Red River. The overall dike is approximately 44 miles in length, with grassed slopes typically at 1V:6H upstream and 1V:5H downstream. The upgraded portions along highway PR305 and a section to the east have been constructed at 1V:4H sideslopes. The location of the dike is shown in Plate D-1.

The current height of the dike has previously been shown, using approximate analyses, to be capable of protecting against water levels of approximately El. 774 ft. at the Floodway entrance (KGS Group, 2000). Subsequently, more detailed analyses using a finite element model of the Red Sea showed similar results (CHC, 2000).

Consequently, the strategy of protecting Winnipeg in emergency conditions by raising the water level above the “state-of-nature” at the Floodway Inlet would require an increase in the crest level of the West Dike.

Economic analyses (KGS Group, 2000) also showed the merits of such increases in crest levels of the West Dike and West Embankment.

The Work Plan for the current study did not originally include refinements to the estimated cost of raising the West Dike. However, it was deemed necessary that since it was an integral part of the Floodway Expansion scheme it should be reviewed. A modest budget was extracted from the contingency fund for this study, and was possible to provide resources for:

- A site visit by KGS Group representatives, along with a geotechnical engineer from Prairie Farm Rehabilitation Administration (PFRA), Vic Klassen, to view the current status of the dike.

- PFRA (V. Klassen) conducted a limited drilling/sampling program along the existing dike to supplement information on the embankment and foundation conditions.
- A literature review to locate any precedents that have used unconventional and inexpensive means to protect embankments against wave action on reservoirs.
- Review of the hydraulic analysis of wind and wave generation on the "Red Sea", previously undertaken by Canadian Hydraulic Centre (CHC, 2000).
- Review of existing drawings and proposed plans for rehabilitation of the West Dike.
- Preparation of a conceptual design for raising the crest level of the dike.
- Estimation of costs of raising the dike to suit a maximum water level of El. 778 ft. at the Floodway Inlet, for flood flows of 1 in 700 years.
- Identification of possible alternatives that could reduce the cost of the dike raises, but would require considerable further study before an acceptable, feasibility arrangement would be confirmed.

The findings are described herein.

D.2 HYDRAULIC CONSIDERATIONS

Feasibility design of raising the crest levels of the West Dike would require a detailed analysis of wind setup, wave generation and runup on the face of the dike, and selection of design criteria that suitably reflect the combined probabilities of the flood event and an adverse wind that could cause erosive waves. This should be done in a systematic way to address the varying conditions of potential water depth along the dike, and exposure to wave action from the “Red Sea”. Adequate funding to undertake this was not available within the budget of this study, and approximations were required based on the preliminary work by CHC.

The design condition that was addressed involved:

- Peak flood water level of El. 778 ft. at the Floodway Inlet.
- 1 in 700 year flood.
- 1 in 10 year wind from the south, coincident with the peak water levels.

The reasons for the first two conditions are discussed in detail in Appendix B. Details of design wind were prepares by Manitoba Conservation for CHC (CHC, 2000).

Table D-1 summarizes the estimated existing crest level, and the required crest level based on extrapolation of CHC’s results. These figures are recognized to be approximate only and will have to be refined by further analysis. They are considered, however, adequate to advance the cost estimation of upgrading the West Dike, as part of the overall Floodway Expansion.

TABLE D-1
Estimated Crest Levels of Existing West Dike and Increased Crest Levels for Range of Design Conditions

LOCATION[1] (METRES)	ESTIMATED EXISTING CREST LEVELS[2] (GEODETIC, FEET)	ESTIMATED CREST LEVEL REQUIRED[3]
		FOR 1 IN 700 YEAR FLOOD & 1 IN 10 YEAR WIND
Sta. 0 + 00 (Control Structure) to Sta. 156 + 00 (near LaSalle)	El. 780.8	El. 784.0
Sta. 156 + 00 to Sta. 235 + 00	El. 780.8 to El 784.0	El. 784.0 to El. 785.5
Sta. 235 + 00 to Sta. 295 + 00	El. 784.0	El. 785.5 to El. 787.0
Sta. 295 + 00 to Sta. 333 + 00	El. 784.0 to El. 779.0 ±[4]	El. 787.0 to El. 788.0
Sta. 333 + 00 to Approx. Sta. 703 + 00 (West End)	El. 785.0 ± (assumed)	El. 788.0

Notes:
1. See Map in Plate D-1, Stations based on Manitoba Conservation (Department of Natural Resources) 1983 control.
2. Approximate only – require refinement based on site surveys
3. Freeboard based on:
   - 1 in 10 year wind from critical direction
   - 1 in 6 slope of upstream face
   - riprap face on slope
4. Existing dike crest is low (El. 779.0 ± ft.) from approximately Sta. 295 + 00 to Sta. 324 + 00

D.3 PRELIMINARY DESIGN

The following basic criteria have been adopted to estimate the quantity of fill required for increases in crest level of the West Dike and the West Floodway Embankment:

- Side slopes 1V:5H downstream, 1V:6H upstream.
- Crest elevations as listed in Table D-1.
- Riprap layer required for windspeeds with a 1 in 10 year return period.
- No adjustments required to drainage structures (eg. Manness Drain, Domain Drain).
- PFRA site investigation and testing established that the high plasticity clay in the West Dike embankment and the foundation is low in sodium content and is non dispersive and is therefore resistant to erosion.

A typical cross section of the West Dike is shown in Figure D-1.

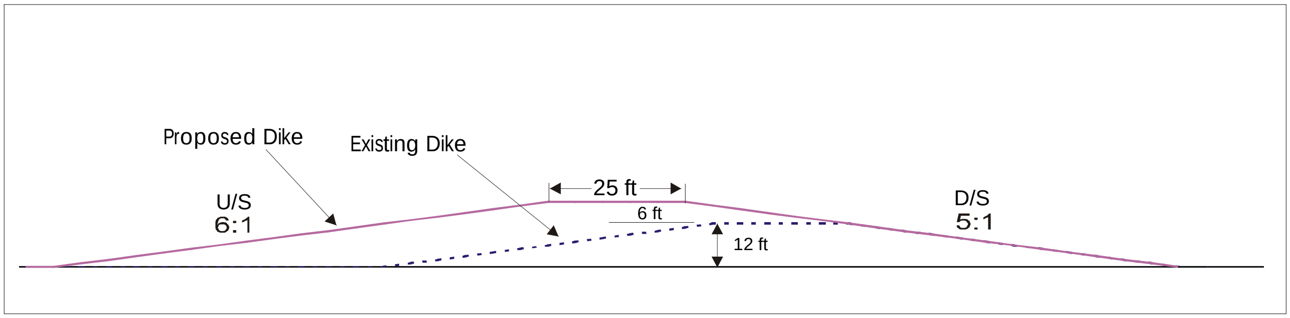


Figure D-1 – Typical Cross Section of West Dike

The estimated quantities of fill for impervious, granular transition, and riprap are summarized in Table D-2. The dike consists of a homogeneous clay section, with a riprap thickness of 1.6 ft. on the upstream slope, underlain by 1.0 ft. of granular transition material. The estimates undertaken in this study were hampered by lack of as-built drawings that document the existing dike configuration. At more advanced design stages there may be opportunities for economy through refinements to the slope geometry and riprap detail. Any further studies of the West Dike should be accompanied by detailed surveys and preparation of suitable engineering drawings.

TABLE D-2
Estimated Quantities of West Dike Fill for 1 in 700 Year Flood

MATERIAL	QUANTITY OF FILL (yd^3)
Impervious Fill	4,000,000
Transition/Filter	350,000
Riprap	700,000

- The estimated quantities are based on the available information on the existing dike structure which included:

STATION (metres)	REFERENCE ON DIKES
• Sta. 0 + 00 to Sta. 186 + 55 and Sta. 295 + 00 to Sta. 333 + 00	DNR, 1983; Red River Floodway, Plan-Profile of West Dike, Construction Drawings 1 to 19, August 1993.
• Sta. 186 + 55 to Sta. 333 + 00	DSLea, 1997; Red River Floodway, Plan-Profile of West Dike, Construction Drawings 1 to 9, September 1997. (Note side slopes are at 1V:4H)
• Sta. 333 + 00 to Sta. 462 + 00	Manitoba Highway and Transportation, Upgrading of PR305 from PR332 to 8 miles east; Sheets 1 to 5, June 1999. (Note side slopes are at 1V:4H)
• Sta. 462 + 00 to Approx. Sta. 703 + 00	Undefined. Ground elevation estimated from 1:50,000 topographic maps.

- The East Dike is anticipated to require a slight increase in crest height (up to 2 ft.), subject to survey confirmation. The quantity is anticipated to be minor, relative to the West Dike, and has not been included in this estimate.

- The quantity estimates are at a prefeasibility level and should be taken as ± 20% accuracy.

- The 8 mile upgraded section of PR305 that also serves as the West Dike must be evaluated for suitability as a water retaining structure.

D.4 COST ESTIMATION

Unit prices for the West Dike/West Embankment have been estimated as follows:

- Impervious fill, $5/cu. Yd.
- Granular filter, $15/cu. Yd.
- Riprap, $20/cu. Yd.

Estimated costs for the quantities of material given in Table D-2, Section D.3 are summarized in Table D-3. The unit price assumed for the impervious fill includes some cost allowance for items such as borrow area development, topsoil removal and replacement, drainage improvements, land acquisition, and weather conditions at the time of construction (eg. a wet year).

TABLE D-3
Estimated Costs for Raising Crest Levels of West Dike/West Embankment

MATERIAL		ESTIMATED COST
Impervious Fill		$20,000,000
Transition/Filter		$5,300,000
Riprap		$14,000,000
Allowance for modifications to existing culverts/drainage structures		$2,000,000
Purchase of Right-of-Way		$1,000,000
SUBTOTAL		**$42,300,000**
Engineering/Construction Supervision	15%	$6,300,000
Interest During Construction	8%	$3,400,000
Contingency	20%	$8,500,000
TOTAL ESTIMATED COST		**$60,500,000**

D.5 ALTERNATIVE WAVE PROTECTION SCHEMES

The cost estimation described above was based on the assumption that riprap would be used to provide protection against waves on the "Red Sea". This is an expensive option, and further study is required to justify it, or identify other options that would be acceptably safe.

It is not clear that riprap is necessary. The following arguments could be raised in favour of excluding riprap from the design:

- Ring dikes in the Red River Valley that have been built in the last 30 years do not have riprap protection, and no erosion has been reported at any locations (further study would be required to determine whether this was by good fortune or whether it was due to the adequacy of the erosion resistance of clay fill with a solid cover of grass).
- The clay dike currently has a substantial coverage of grass (See Photo D-1), indicative that a comparable grass cover on a raised dike section may provide resistance to short term wave attack.

Photo D-1 – Typical Section of West Dike

Further study is required to confirm that armouring of the upstream face of the West Dike is required.

If a thorough study confirms that some form of protection from waves is justified, then there may be less expensive options than the riprap that has been assumed for budgetary purposes in this study. Options that have been considered at this time are:

1. Flattened slopes on the upstream face of the dike, so that the incoming waves will break and dissipate without causing erosion. The cost of the additional fill may be less than the cost of the riprap, although property acquisition and existing features (roads, transmission lines, buried services, ditches, etc.) would add to the cost.

2. Grass coverage on the upstream face. The capacity of this to resist erosion is considered doubtful, but review of conditions at existing ring dikes may suggest that this will provide adequate protection. In-situ tests with a specially constructed wave flume at the site may be justified. Considerable additional work is required to prove that this option is acceptably safe.

3. Grass coverage of the upstream face with a geo-textile to enhance erosion resistance.

4. Provision of a beltway of heavy vegetation such as spruce trees with strong energy absorbent limbs at low heights above the ground to break waves. The effectiveness of this would have to be tested, and the cost of land acquisition, planting and on-going maintenance (mostly replacement of dying plants/trees) would have to be compared to confirm the economy of this option.

5. Interlocking pre-fabricated armouring systems. The overall cost of this including installation would have to be considered.

6. Reliance on temporary measures as were experimented by the Canadian Army on portions of the West Dike in 1997. This may be combined with Option 2 or 3. If suitable precedents can be located, and this can be demonstrated to be an acceptable protection measure over the length of the dike, it would be clearly the most economic approach.

7. Combinations of the above as considered appropriate based on detailed information on each, and locally differing conditions along the dike.

D.6 RECOMMENDATIONS FOR FUTURE PLANNING

- Dike surveys to provide suitable information on the existing structure.
- Dam safety review of existing structures, including inspections, selection of appropriate freeboard criteria, and inflow design flood.
- Pre-design planning to complement the Floodway Expansion if that option is selected. This would include:
    - Additional simulations by CHC's finite element model, or equivalent, to estimate static water level for design flood selected.
    - Hydraulic analysis on a reach by reach basis along the dike to determine wave potential, setup at various water levels, and required crest level that may vary depending on location.
    - Consideration of options described in Section D.5 and selection of preferred option(s).
    - Geotechnical investigations and more refined dike design, integrated with determination of the preferred slope protection option(s).
    - Revised cost estimation at a pre-commitment level of detail.
    - Consideration of insitu tests of the erosion potential of the existing dike with an established grass cover.

REFERENCES

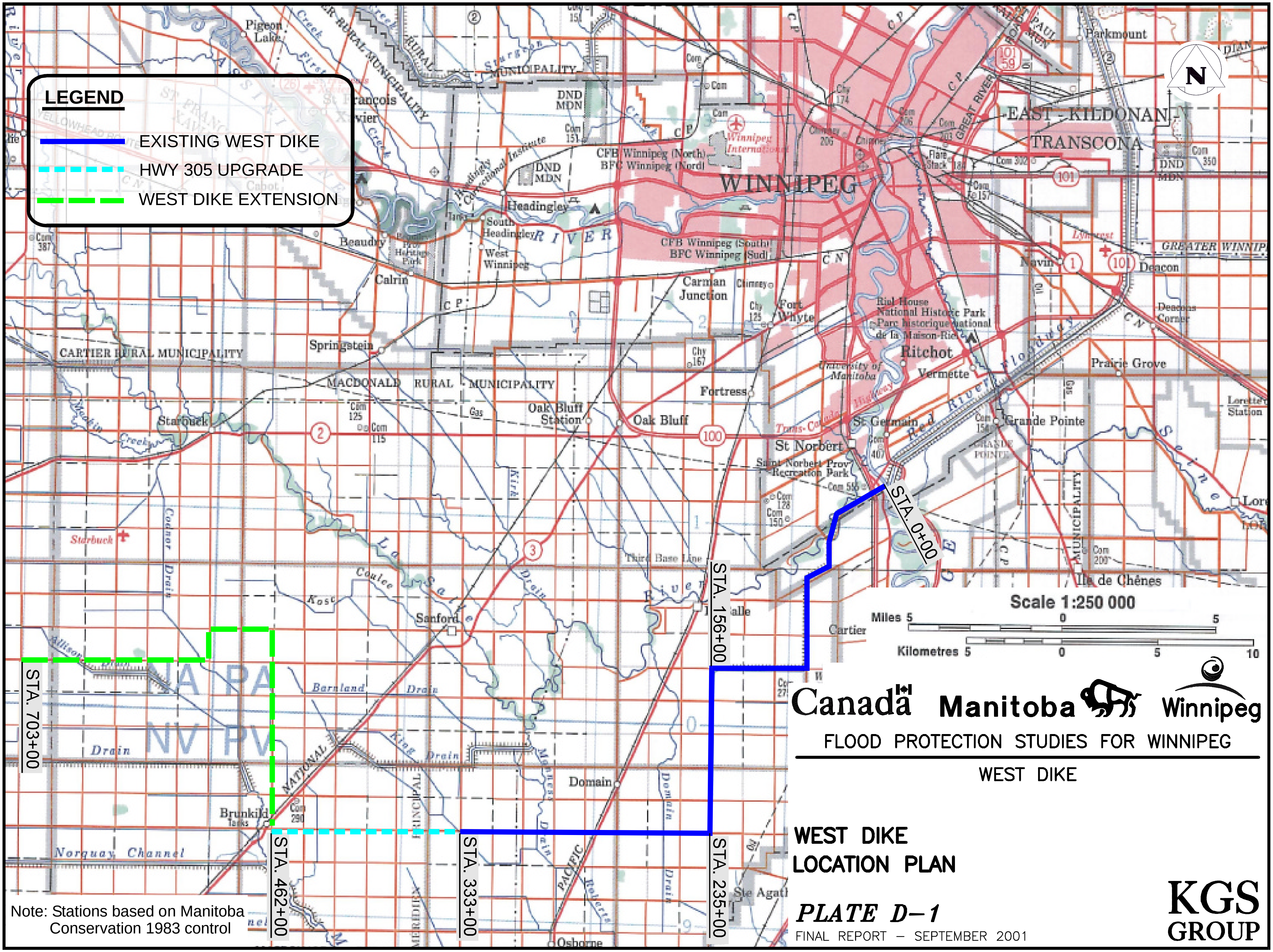
REFERENCES

1. *Canadian Hydraulics Centre, 2000, "Two-Dimensional Model of the Red River Floodway Forebay Area".*

2. *KGS Group, 2000, "Flood Protection Studies for Winnipeg", Part III.*

PLATES

KGS FILE NO.: P:/00-311-07/ADMIN/ADMINDOCS/FINAL REPORT/APPENDIX D/PLATE D-1.CDR



Canada Manitoba Winnipeg

FLOOD PROTECTION STUDIES FOR WINNIPEG

WEST DIKE

WEST DIKE LOCATION PLAN

PLATE D-1

FINAL REPORT – SEPTEMBER 2001

KGS GROUP

FLOOD PROTECTION STUDIES FOR WINNIPEG

APPENDIX E
CONTROL OF SUMMER WATER LEVELS IN WINNIPEG

NOVEMBER 2001

KGS GROUP

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

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This appendix is one of six that accompany and supplement the Main Report on Studies of Flood Protection for Winnipeg. This volume describes findings on studies of the use of the Red River Floodway as a means to control summer water levels in Winnipeg.

Five alternative methods were examined to achieve this control:

- ***Scheme A - EXISTING FLOODWAY with No Additional Excavation -*** Use the existing Floodway channel discharge capacity to divert the required flow. No additional excavation would be required. This scheme would require raising the Floodway Inlet Control Structure gates to pond water level at the Floodway channel inlet to the required level to achieve the desired diversion flow.

- ***Scheme B – EXCAVATED FLOODWAY CHANNEL With "State-of-Nature" Water Levels at Inlet; Existing Floodway -*** The construction of a larger Floodway channel having a discharge capacity large enough to divert the required flow at state of nature flood levels. The excavation for Scheme B would be relative to the existing Floodway channel. This would require a substantial diversion channel approaching the size of the Red River.

- ***Scheme C – EXCAVATED FLOODWAY CHANNEL With Above "State-of-Nature" Water Levels at Inlet; Existing Floodway as Base Condition*** - The construction of a smaller channel than Scheme B, which would require water levels in the Red River during summer floods that would be above the "state-of-nature". Similar to Scheme B, the additional required excavation would also be relative to the existing channel.

- ***Scheme D – EXCAVATED FLOODWAY CHANNEL With "State-of-Nature" Levels at Inlet; 1 in 700 Year Floodway Base Condition -*** The construction of a large Floodway channel with dimensions and capacity of Scheme B, having a discharge capacity large enough to divert the required flow at "state-of-nature" flood levels. The major difference of Scheme D compared to Scheme B is that the excavation of the enlarged Floodway channel would be relative to the 1 in 700 year expanded Floodway.

- ***Scheme E – EXCAVATED FLOODWAY CHANNEL With Above "State-of-Nature" Levels at Inlet; 1 in 700 Year Floodway Base Condition -***The construction of a smaller Floodway channel with dimensions and capacity of Scheme C, which would require some additional backwater over the "state-of-nature" water levels. The major difference of Scheme E compared to Scheme C is that the excavation of the enlarged Floodway channel would be relative to the 1 in 700 year expanded Floodway.

All of these schemes involve the activation and use of the Floodway Inlet Control Structure gates during summer flood events.

E.2 CONTROL ALTERNATIVES

The water level in Winnipeg is controlled during summer by the operation of the control structure at the St. Andrews Lock and Dam (SALD) at Lockport. Public Works Canada operates the gates in the SALD to maintain the desired water level at James Ave. in Winnipeg at El. 734 ft. The operation of the SALD typically commences when the water level recedes to El. 734 ft. following the spring flood and ends at approximately mid-October, when the gates are opened to allow the gradual lowering of the water levels to natural levels for the oncoming winter season.

During the summer control period as flows increase, the gates are progressively opened in order to achieve the summer target elevation. The water levels in Winnipeg can be controlled until the discharge in the Red River downstream of the Assiniboine River reaches a flow of approximately 12,500 cfs, after which the gates in the SALD are fully opened and the water levels in Winnipeg will rise as determined by the capacity of the river. Water levels during the summer period from June 1 to October 15 have been as high as El. 745 ft. and have exceeded the desired control level approximately 10 percent of the time during the summer period from June 1 to October 31 for the period from 1967 to 1998.

This study examined the use of the Floodway as a means to limit the flow through Winnipeg to approximately 12,500 cfs, and thereby control the water level to El. 734 ft. at the Forks. The five alternative methods that were examined that could achieve this control are described below.

Since the objective of the summer water level control is to increase the flow into the Floodway at below present water levels, all Floodway channel improvements would require that the Floodway invert level would have to be lowered below the existing level and that the Floodway entrance plug would have to be removed. All Floodway excavation alternatives examined in this study would therefore require the provision of a gated control structure at the Floodway entrance to restrict the diversion when flows in the Red River are low, and during the spring breakup period to prevent the movement of ice floes into the Floodway channel.

All of the schemes presented below require the use of the Floodway Inlet Control Structure gates to control the water level at or above the “state-of-nature” at the Inlet. Schemes that do not require the use of the Floodway gates, would require substantially more excavation in the

Floodway channel to achieve the goal of controlled water levels. These options would be so much more expensive than any of the following five, that they have not been addressed in any detail.

The modifications to the Floodway that are described below, also increase the flood discharge capacity at higher river levels and in spring flood conditions. Examination of both objectives (summer flood level control in Winnipeg to about el. 8 ft. (JAPSD), and spring flood level control to about el. 25.8 ft.) simultaneously has not been possible. That would require considerably more optimization and adjustments to the channel configuration than has been possible within the time and budget constraints of this study.

Scheme A - EXISTING FLOODWAY with No Additional Excavation

This alternative would use the existing Floodway Inlet Control Structure gates to reduce the discharge through Winnipeg and force the excess flood water through the existing Floodway channel. No additional excavation would be required.

Scheme B - EXCAVATED FLOODWAY CHANNEL With "State-of-Nature" Water Levels at Inlet; Existing Floodway

This alternative involves the construction of an enlarged Floodway channel to convey the required summer discharges at or near "state-of-nature" water levels at the Floodway Inlet. The existing Floodway channel is assumed as the base configuration for the channel design and for the determination of the costs of the alternative.

The required Floodway flow and the corresponding "state-of-nature" water level at the Floodway Inlet were computed for each historic daily flow record (June 1 to October 15 only) for the period from 1967 to 1997, for the condition of maximum Red River flows downstream of the Assiniboine River of 12,500 cfs. As shown on Figure E-1, the corresponding points plot as a scatter plot, with the variation in the plotting positions representing the effect of the varying contribution of Assiniboine River flows.

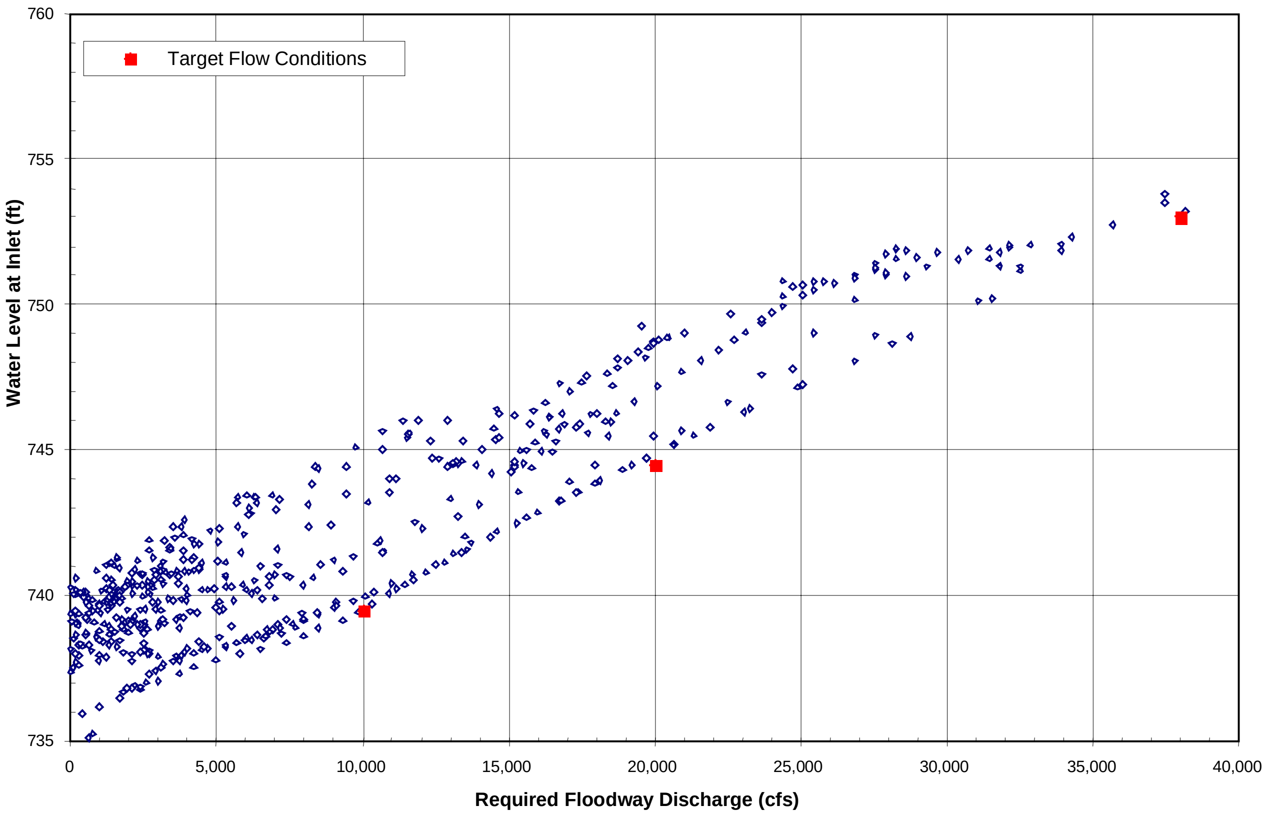


Figure E-1 – "State-of-Nature" Water Levels at the Floodway Inlet

As illustrated on the Figure E-1, the lower envelope curve from this data was used to approximate the design discharges for this scheme. On this basis, the preliminary design discharge was selected as 38,000 cfs at El. 753 ft.; 20,000 cfs at El. 744.5 ft., and 10,000 cfs at El. 739.5 ft.

The existing Floodway channel cross section from Birds Hill to the Floodway Inlet area has a base width of 540 ft., side slopes of 1V:6H, and an invert level sloping from El. 743.37 ft. at the entrance plug to El. 734.91 ft. at Birds Hill. Adjacent dikes or disposal banks range in height from 10 to 20 ft. above the surrounding prairie elevation.

Since the design water surface profile would lie somewhat below the ground surface, the channel design will require deepening of the channel. This design would not require any excavation of the material above the design water level. The unit price of excavation is estimated to increase sharply at channel depths much greater than 10 ft., due to high groundwater conditions. As a result, the maximum depth of excavation below the existing channel base level was selected in this preliminary assessment to be 14 ft. Additional widening of the channel would be required to provide for the design discharge.

Based on these criteria, the following design dimensions were selected for the expanded Floodway from the Floodway Inlet to Birds Hill:

- Invert elevation varies 729.4 ft. to 722.9 ft.
- Maximum depth of excavation 14 ft.
- Side Slopes 1V:6H
- Base Width 500 ft.

The channel downstream from Birds Hill to the Floodway exit would have the following dimensions

- Invert elevation varies 722.9 ft. to 721.2 ft.
- Maximum depth of excavation 9 ft.
- Side Slopes 1V:6H
- Base Width 500 ft.

The channel invert for the lower reach is comprised of a combination of clay and glacial till. The depth of excavation for this reach was limited to approximately 9 ft. in order to minimize the quantity of till to be excavated. The resulting channel bed profiles are shown schematically on Figure E-2 and schematic cross sections for the two reaches are shown on Figures E-3 and E-4, respectively. The Floodway stage-discharge rating curve for Scheme B is shown on Figure E-5.

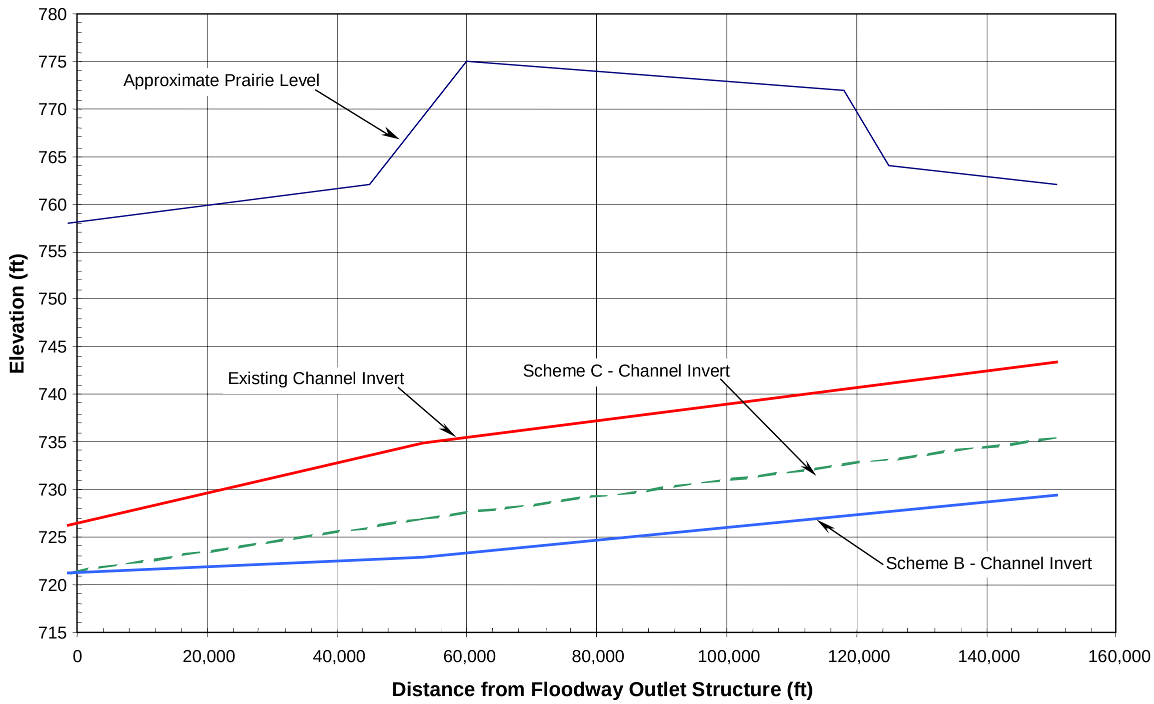


Figure E-2 – Red River Floodway Channel Profiles – Schemes B and C

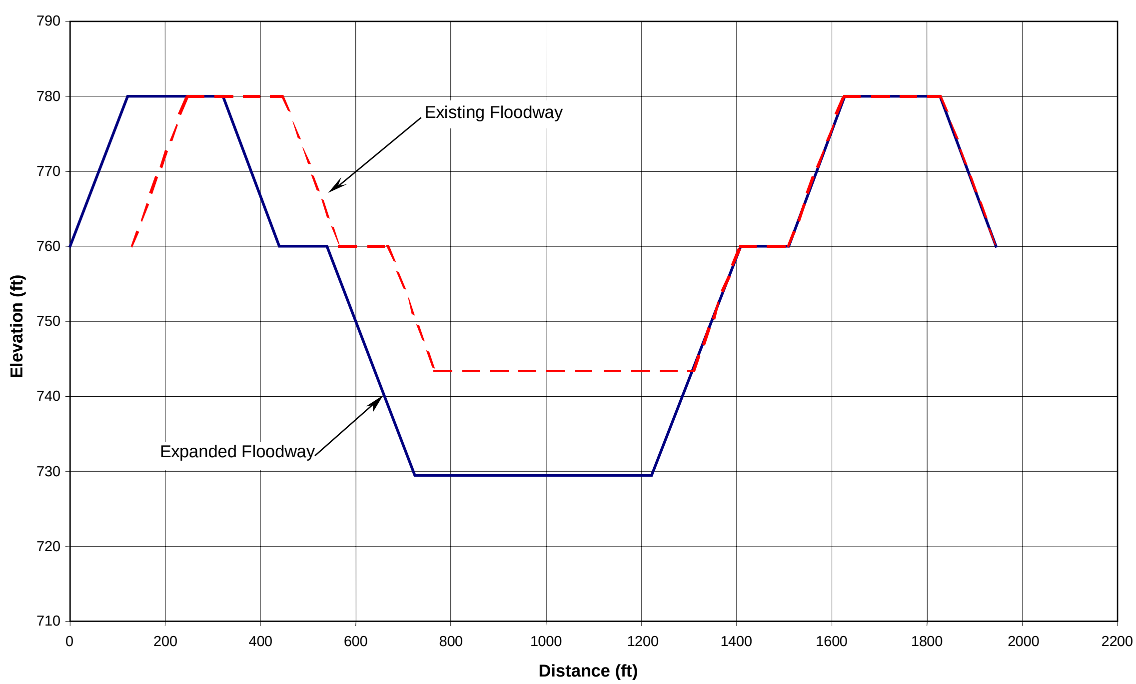


Figure E-3 – Scheme B Schematic Cross Sections (Inlet to Birds Hill)

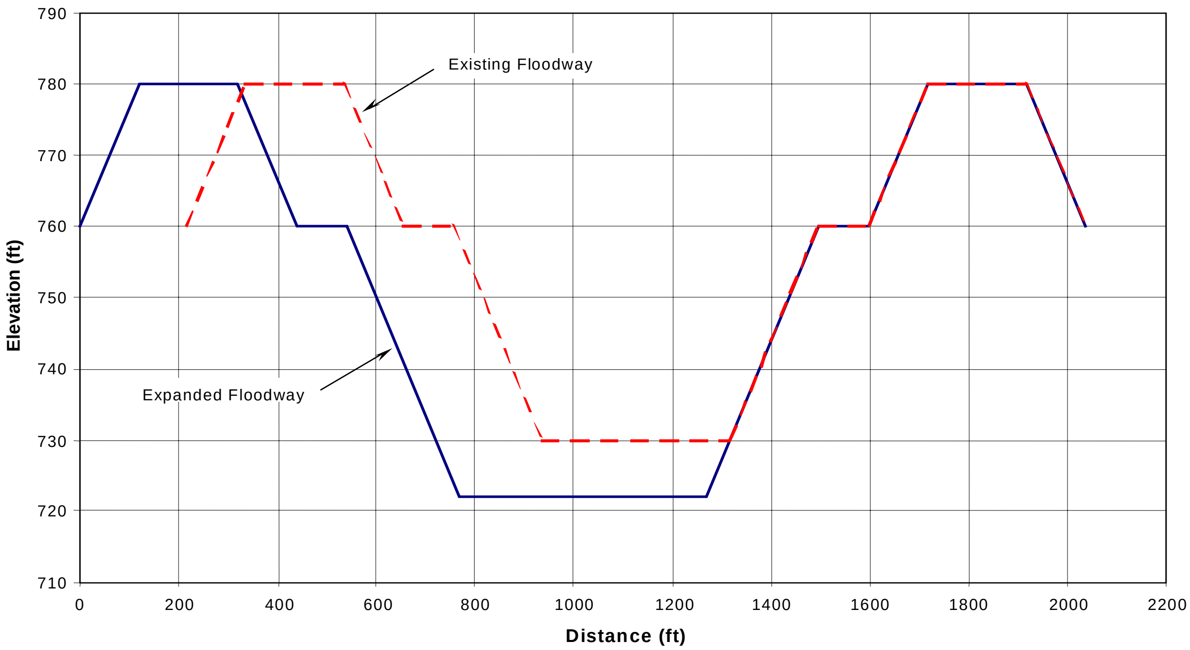


Figure E-4 – Scheme B Schematic Cross Sections (Birds Hill to Lockport)

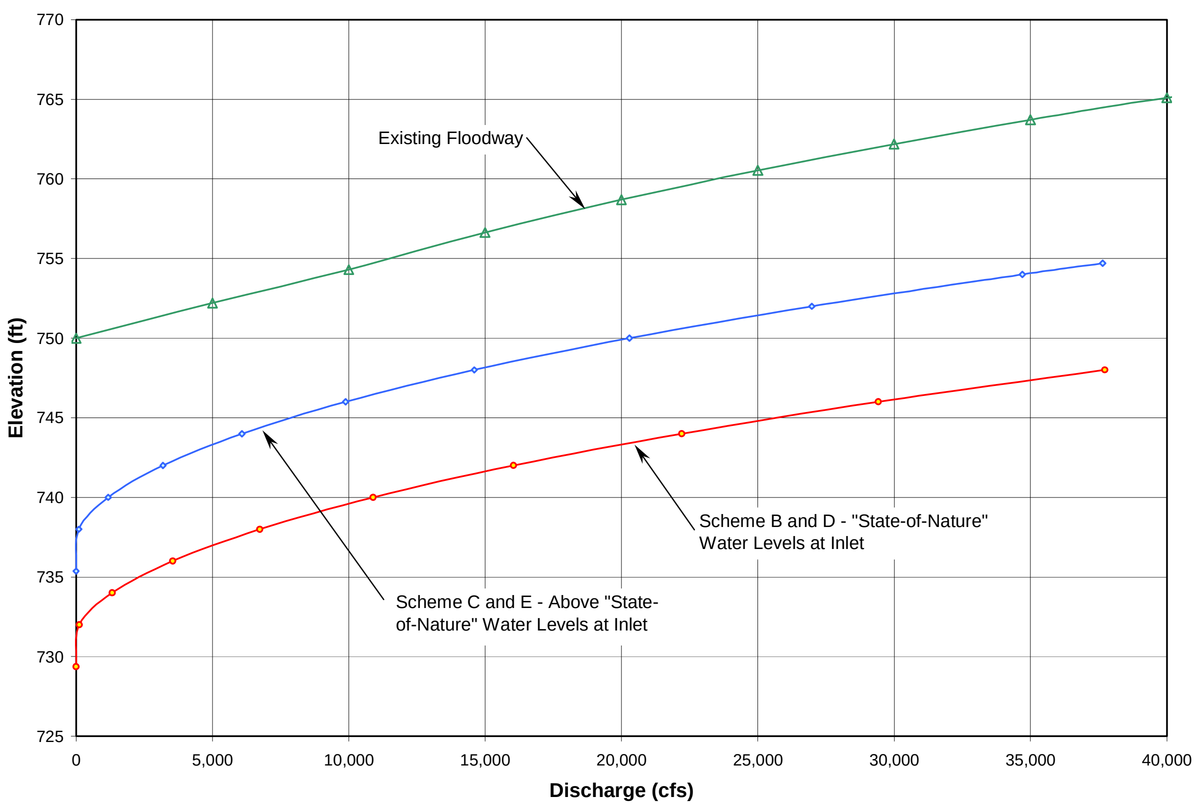


Figure E-5 – Floodway Inlet Stage-Discharge Relationships

For this scheme, consideration was given to increasing the capacity of the Floodway Outlet Structure to locally lower the water level at the downstream end of the channel. This would not, however, provide a substantial benefit for the overall capacity as the local draw down of the water level would be decreased significantly due to the long distance from the Floodway Outlet to the Floodway Inlet, and due to the shallow depths of flow that would occur during summer floods.

The proposed invert of the channel at the Floodway Inlet for this scheme is at El. 729.4 ft., which is only 1.4 ft. above the base slab elevation of the Floodway Inlet Control Structure. A control structure would therefore be required at the entrance of the expanded Floodway channel to restrict flow into the Floodway during the summer when the water level in Winnipeg is controlled to El. 734 ft., and during periods of very low flows. The structure would also be used to prevent the movement of ice into the Floodway channel during the spring breakup period. As discussed in Appendix B, Section B.2.2.4, it would be located at the existing entrance plug, and would replace the plug. The top of structure elevation would be at El. 750 ft., which is the level of the existing channel entrance plug. For this preliminary assessment, a budgetary cost estimate was based on structure configuration that would be comprised of 15 bays each 20 ft. wide, and equipped with stop logs.

While the capacity of the Floodway channel for this scheme is significantly larger than the existing channel, the Floodway Inlet Control Structure would still be required to be used to restrict the movement of floodwaters downstream into Winnipeg. Water would enter the Floodway channel when the water level at the Inlet reaches the invert level of the Floodway channel (El. 729.5 ft.) and without control on either the Floodway channel and/or the Floodway Inlet Control Structure, there would be a natural split of flow into the Floodway and the Red River through Winnipeg.

Based on past discharge meterings and from backwater analyses, the capacity of the Red River at the Floodway entrance is approximately 12,500 cfs at a river water level of approximately El. 741 ft. This flow is the maximum discharge for which the water level at the Forks can be controlled at or below El. 734 ft. This means that unless controlled by the Inlet gates, more than the maximum allowable discharge would be conveyed downstream into Winnipeg whenever the water level at the entrance exceeds El. 741 ft. From the combined rating curve for the expanded

Floodway channel for Scheme B and for the Red River downstream at the inlet shown on Figure E-6, the critical discharge condition would occur whenever the discharge on the Red River at the Inlet exceeds approximately 25,000 cfs. The frequency of this occurrence could be reduced by a much larger capacity Floodway channel, but also at a much greater cost. However, as will be shown later in this study, the project cost for Scheme B is prohibitive in itself, making the larger Floodway channel even less feasible.

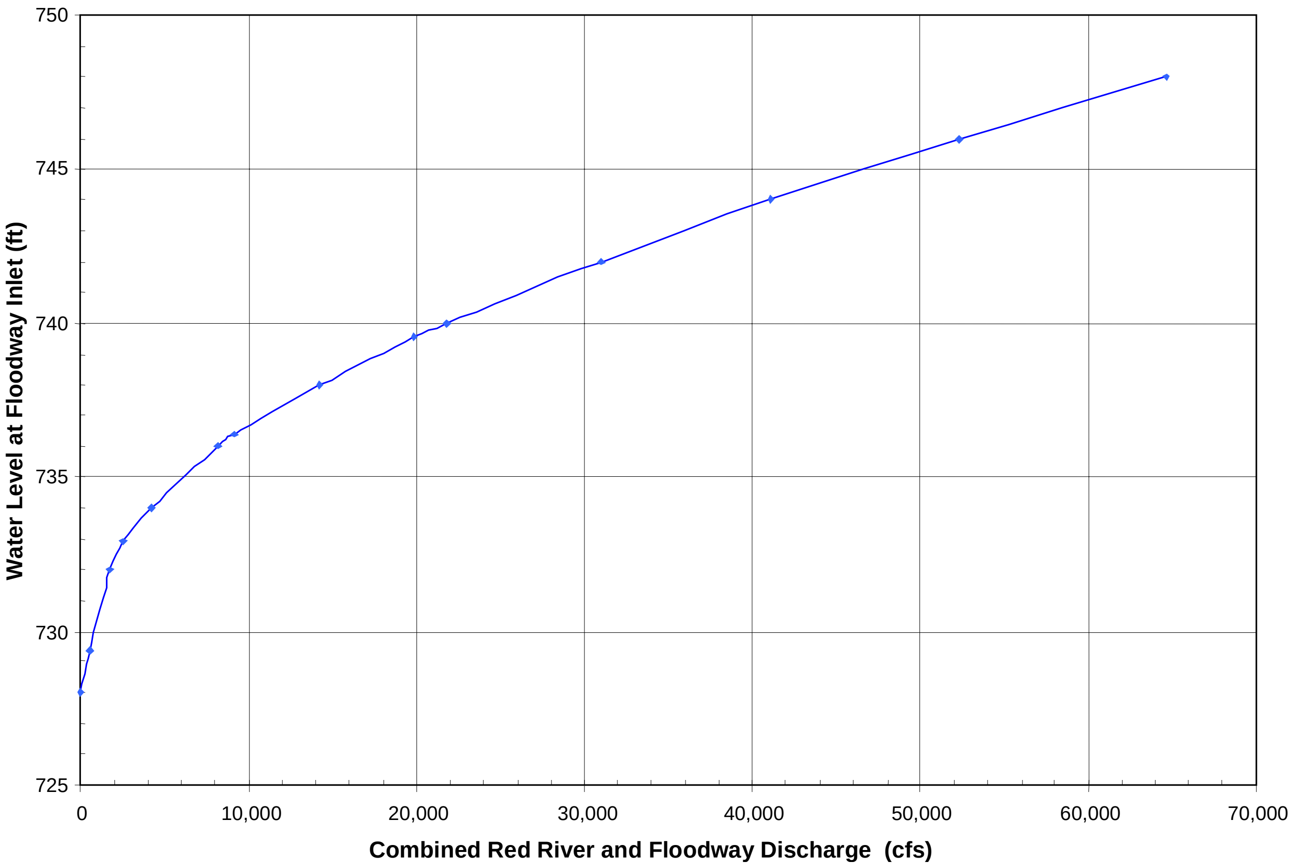


Figure E-6 – Combined Floodway and Red River Channel Stage-Discharge Relationship for Scheme B

Scheme C – EXCAVATED FLOODWAY CHANNEL With Above "State-of-Nature" Water Levels at Inlet; Existing Floodway as Base Condition

This alternative provides some increase in discharge capacity relative to the existing Floodway channel, but it also relies the operation of the Floodway Inlet Control Structure gates to provide some increase in river water level to encourage excess flow to enter the Floodway.

The design requiring the least excavation is one in which most of the excavation is within the existing channel bottom. A number of alternatives with different depths were examined. The intermediate channel having a capacity of 20,000 cfs at El. 750 ft. was selected for this alternative. This channel would have approximately 16,500 cfs additional capacity at El. 750 ft. compared to the existing Floodway (with entrance plug removed), but it would require approximately 6 ft. of water above the "state-of-nature" water level when the Floodway discharge is 20,000 cfs. For the purposes of this study, the channel was deemed representative of the requirements necessary to control levels with moderate backwater effect at the Inlet. Considerably more effort would be required to optimize a channel for this use.

Based on these preliminary assumptions, the following dimensions were used for this option:

• Invert elevation varies	735 ft. to 723 ft.
• Max. depth of excavation	8 ft.
• Side Slopes	1V:6H
• Base Width	420 ft. to 444 ft.

Schematic cross sections for Scheme C are illustrated on Figures E-7 and E-8 for the reaches upstream and downstream of Birds Hill, respectively. The channel bed profile is shown schematically on Figure E-2 and can be compared to the profile for Scheme B. The discharge capacity for Scheme C is also illustrated on Figure E-5.

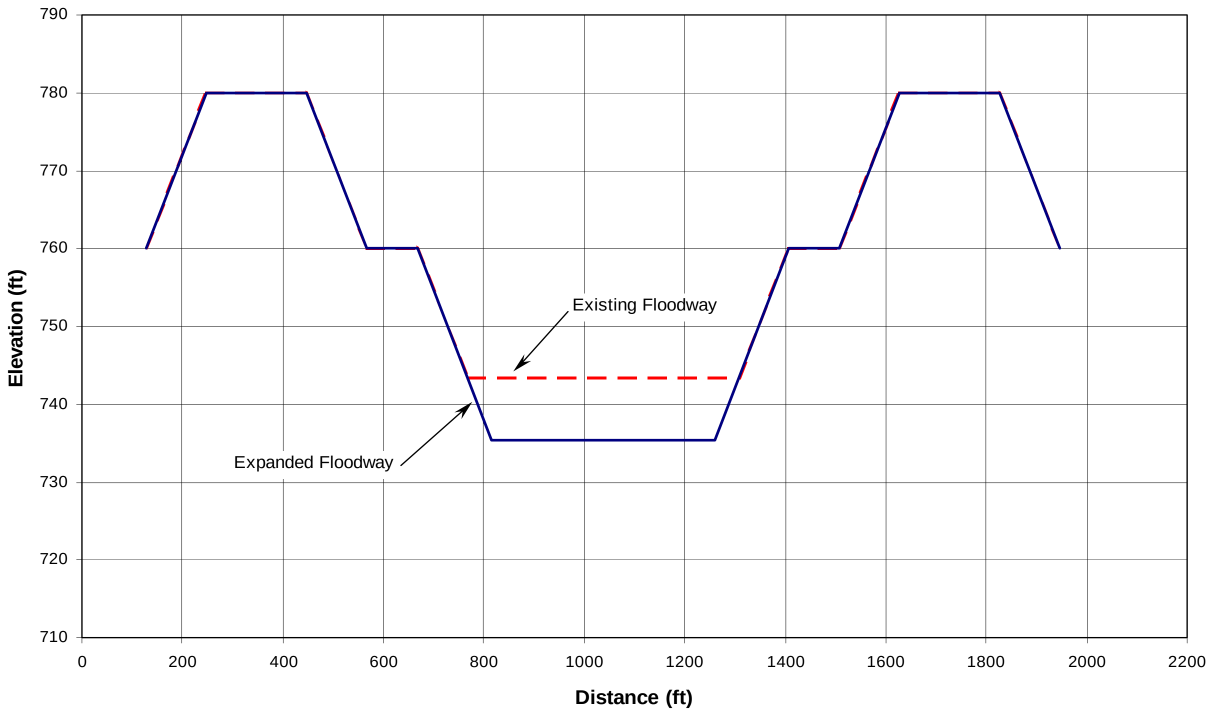


Figure E-7 – Scheme C Schematic Cross Sections (Inlet to Birds Hill)

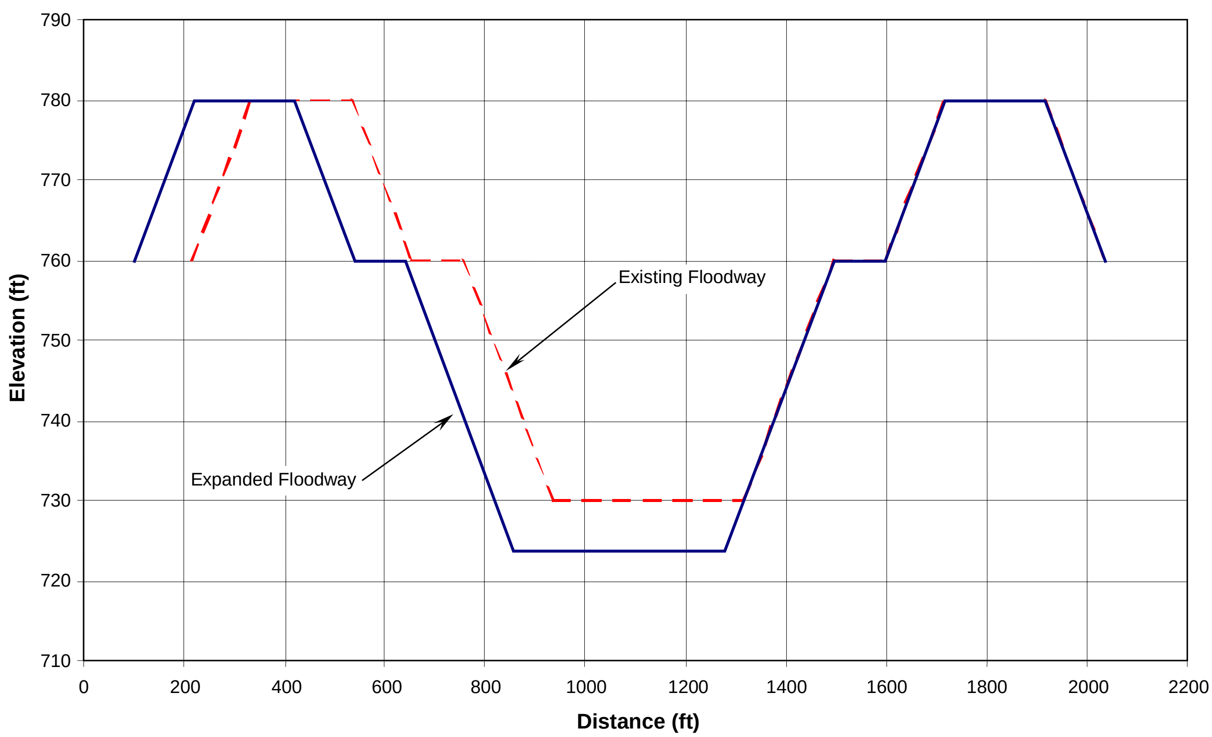


Figure E-8 – Scheme C Schematic Cross Sections (Birds Hill to Lockport)

Since the capacity of the Floodway channel for this alternative is less than that for the "State-of-Nature" Floodway design (Scheme B), the operation of the Floodway Inlet Control structure would be relied upon even more than for Scheme B to achieve the necessary flow control in Winnipeg.

Scheme D – EXCAVATED FLOODWAY CHANNEL With "State-of-Nature" Water Levels at Inlet; 1 in 700 Year Floodway Base Condition

As described in Appendix B, studies have been undertaken to provide additional flood protection for Winnipeg. One option being considered is the expansion of the Floodway channel to increase the flood protection to the 1 in 700 year return period in the Red River in Winnipeg. The "1 in 700 year Floodway channel", however, has been designed to provide the ultimate capacity at the emergency flood level of approximately El. 778 ft. at the Floodway Inlet (see Appendix B for further details). This results in no need for substantial deepening of the channel. Since the invert level for the expanded Floodway channel would still be somewhat above the level required to pass summer discharges, additional excavation would be required.

The invert levels and the base widths at the Floodway Inlet would be similar to the dimensions for Scheme B. The excavation quantities for Scheme D, however, would be somewhat less than for Scheme B since the additional excavation quantities would be relative to the much larger 1 in 700 year Floodway channel compared to the existing Floodway channel considered for Scheme B. Since the channel base width and channel invert levels for Schemes B and D are similar, the hydraulic capacity of the Floodway channel for the Scheme D channel would be essentially the same as for Scheme B. The stage-discharge curve for Scheme D, at the Floodway Inlet, is shown on Figure E-5.

The channel invert elevations are shown schematically on Figure E-9.

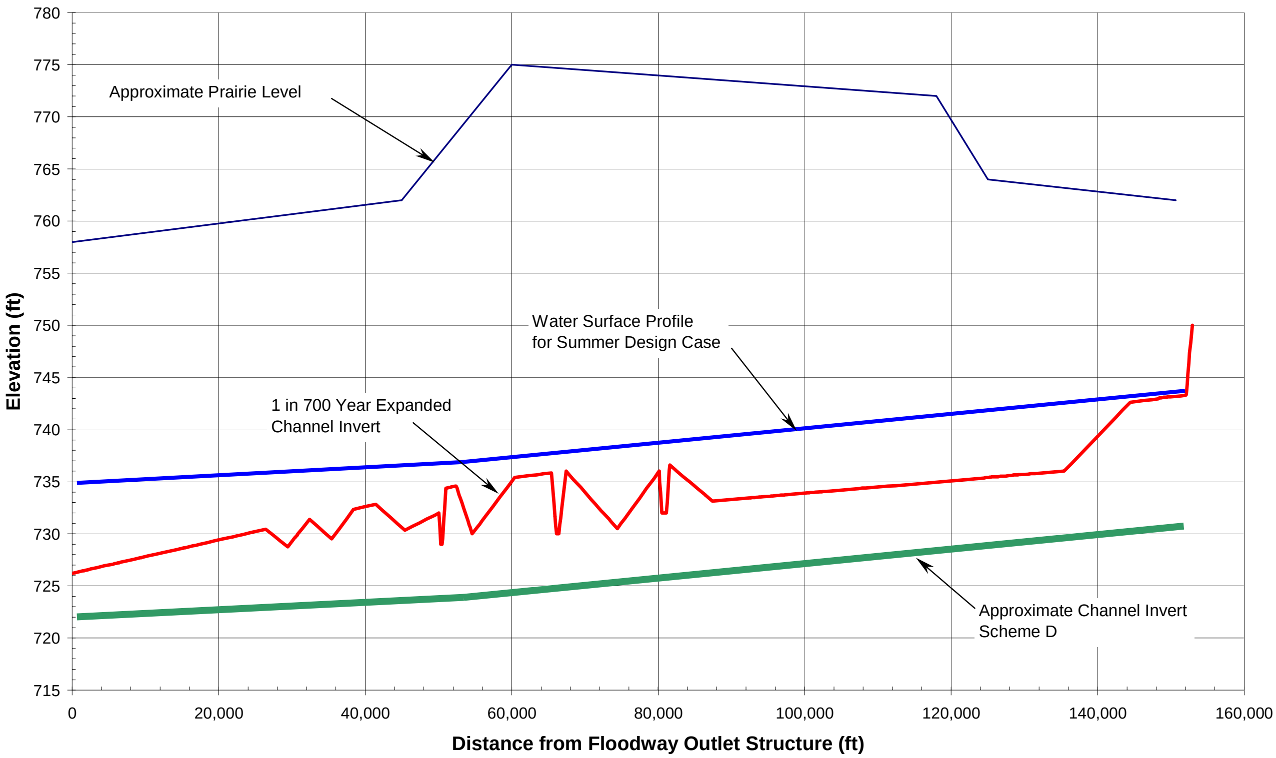


Figure E-9 – Red River Floodway Channel Profiles – Scheme D

Scheme E – EXCAVATED FLOODWAY CHANNEL With Above "State-of-Nature" Levels at Inlet; 1 in 700 Year Floodway Base Condition

The invert levels and the base widths at the Floodway Inlet would be similar to the dimensions for Scheme C. The excavation quantities for Scheme E, however, would be relative to the 1 in 700 year Floodway channel. Since the channel base width and invert level dimensions for Schemes C and E are essentially the same, the hydraulic capacity of the Scheme E channel would be the same as for Scheme C. The stage-discharge rating curve for Scheme E, at the Floodway Inlet, is shown on Figure E-5.

The channel dimensions and invert elevations are shown schematically on Figure E-10.

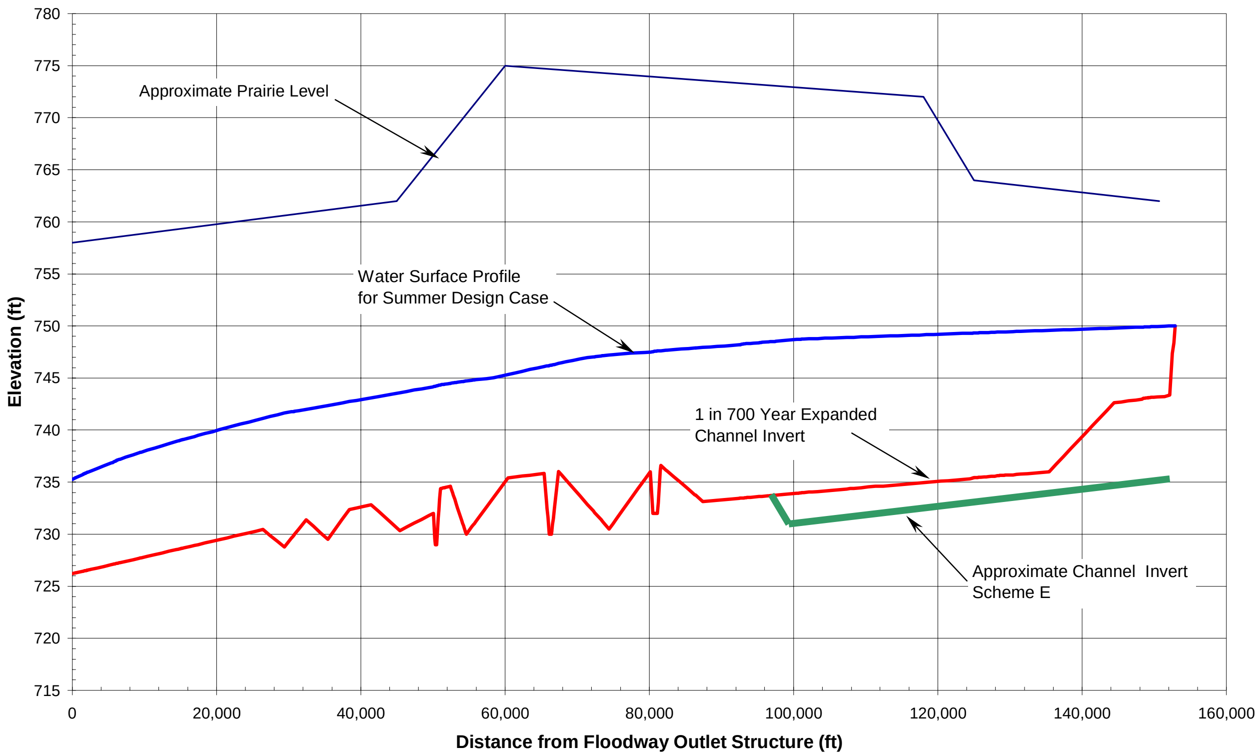


Figure E-10 – Red River Floodway Channel Profiles – Scheme E

E.3 SUMMARY OF WATER LEVELS AND DISCHARGES

Water levels and discharges have been computed for the Red River at the Forks and at the Floodway Inlet for the period from 1967 to 1998 for June 1 to October 15 only. Six conditions were considered, including the existing Floodway channel, assuming no change in the Floodway Inlet gate operation, and for each of the 5 Schemes, assuming that the Floodway gates would be used to restrict flows through Winnipeg.

The computed water levels and discharges are presented in Table E-1. Duration curves have also been computed for each scheme at the locations of the Forks and at the Floodway Inlet. These are shown in Annex A.

Each of the 4 excavation schemes has the capacity to control the water levels at the Forks to El. 734 ft. for nearly 100 percent of the time based on the river flow statistics available since 1967. The exception when this control cannot be achieved is during periods when the Assiniboine River and local flow contributions exceed the 12,500 cfs discharge corresponding to El. 734 ft. at the Forks. These conditions, however, occur only rarely.

As shown in Table E-1, maximum water levels at the Forks are reduced from El. 747.1 ft. under existing conditions, to El. 738.5 ft. under controlled conditions. The percent of time that the water level exceeds El. 734 ft. is reduced from 11.1 percent, for the existing Floodway operation, to approximately 0.6% of the time when the Floodway Inlet control gates are operated to restrict the flow of water in Winnipeg. The maximum water level at the Floodway Inlet varies, however, for each scheme according to the discharge capacity of the respective schemes. Under existing Floodway operating conditions, the computed maximum summer water level at the Floodway Inlet for the historic discharges is approximately El. 753.8 ft. The corresponding maximum summer water level at the Inlet would be increased to approximately El. 764.5 ft., if the gates are operated with the existing Floodway channel. The maximum summer water levels would be El. 748.0 ft. for Schemes B and D, and El. 754.7 ft. for Schemes C and E, to achieve the same level of control.

TABLE E-1
Summary of Water Levels and Flows

Scheme	Forks			Floodway Inlet			Max. Floodway Discharge (cfs)
	Max WL (ft.)	% of Time > 734 ft.	Discharge (cfs)	Max WL (ft.)	% of Time > 746 ft.	% of Time > 758 ft.	
Existing	747.1	11.1	56,150	753.8	0.4	0	9,000
A	738.5	0.6	24,600	764.5	11.4	1.9	37,600
B	738.5	0.6	24,600	748.0	2.0	0	37,600
C	738.5	0.6	24,600	754.7	4.2	0	37,600
D	738.5	0.6	24,600	748.0	2.0	0	37,600
E	738.5	0.6	24,600	754.7	4.2	0	37,600

To illustrate the effects of the water level control, inundation maps of the Red River from the Floodway Inlet to Ste. Agathe have been prepared for water levels at the Floodway Inlet at El. 746.0 ft. and El. 758.0 ft. These levels were chosen to bracket the range of possible controlled upstream water levels and to show the maximum extent of possible flooding. These are shown on Plate E-1, Sheets 1 to 6. A number of photographs were taken between the Floodway Inlet and Ste. Agathe during the Spring 2001 flood to illustrate the level of flooding that would occur at these levels. These photographs, which were taken on May 16 and May 17 when the water level at the Inlet was approximately at El. 754 ft., are in Annex B. The locations of the photographs are referenced on Plate E-1, Sheets 1 to 6.

As shown on Plates E-1, Sheets 1 to 6, at El. 746 ft., flooding would be confined to the river channel with practically no overbank flooding. Conversely, increased areas of overbank flooding are shown at El. 758 ft. Assumed flow in these maps is 30,000 cfs. Water surface profiles for 30,000 cfs are shown in Figure E-11.

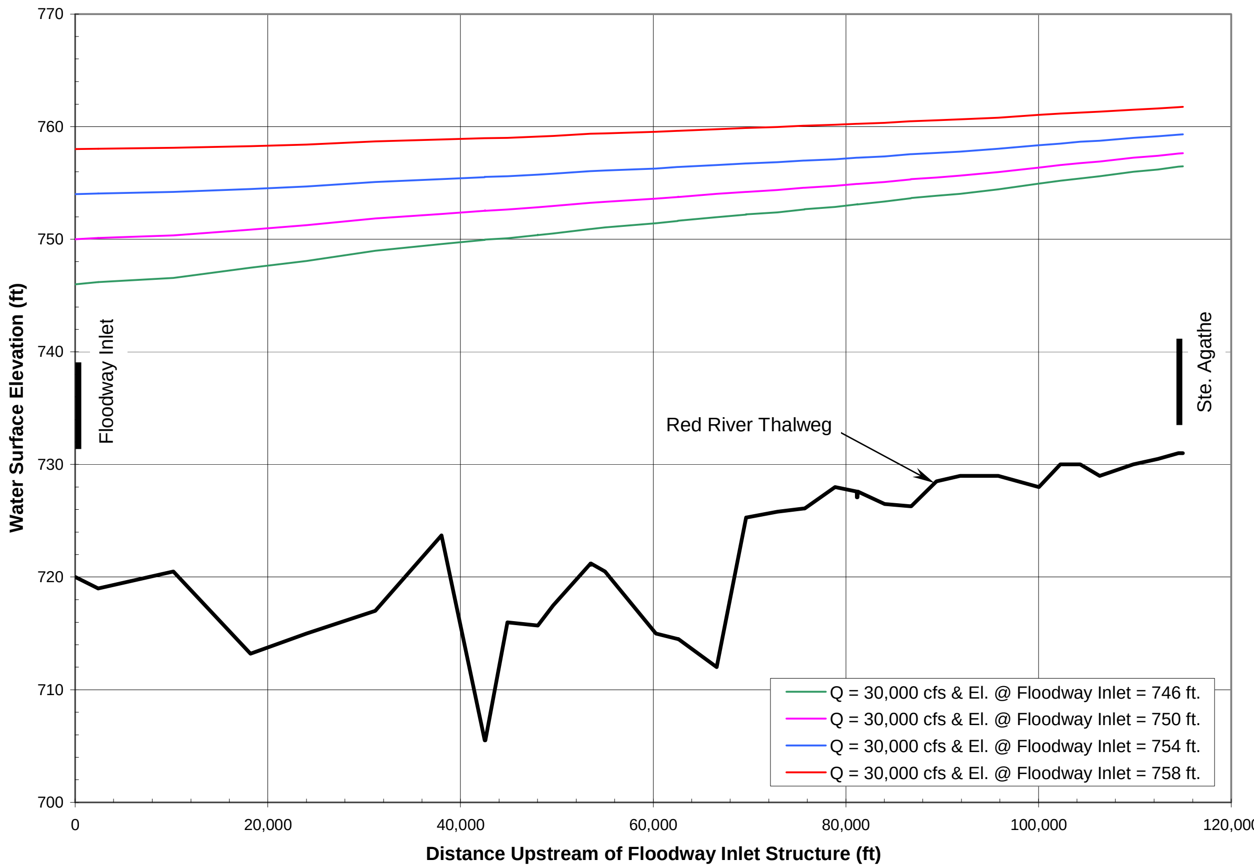


Figure E-11 – Water Surface Profiles for Red River from Ste. Agathe to the Floodway Inlet

Scheme A would require water levels above El. 746 ft. for a considerable time with a maximum water level at El. 764.5 ft. Since this operation would result in considerable flooding it would likely not be acceptable. Schemes C and E would require water levels above “state-of-nature”, but the duration and the maximum water level would be reduced significantly from Scheme A. The maximum water level would be El. 754.7 ft., which is some 10 ft. less than for Scheme A. The duration that the water level would exceed El. 746 ft. is shown to be approximately 2% of the time compared to more than 11% of the time for Scheme A. Schemes B and D, which would produce water levels that are at or below state of nature, would likely be acceptable with respect to the upstream flooding. The cost of these excavation Schemes, however, would be much greater than for the other Schemes.

E.4 COST ESTIMATES

The estimated costs for the four Floodway channel excavation schemes, B to E, are summarized in Tables E-2 to E-5. The basis of the cost estimate uses unit costs similar to those used for the cost estimates for the expanded Floodway described in Appendix B, Section B.6.20. The excavation quantities have been based on relatively few cross sections and should be used only for comparative purposes. Also, no allowances have been included for modifications required to bridge piers to facilitate the channel bed excavation.

As noted in Table E-2 to E-5, the estimated costs for the 4 Schemes ranges from $29 million for Scheme E to more than $447 million for Scheme B with the lower cost associated with channel excavation from the base condition of the 1 in 700 year Expanded Floodway.

TABLE E-2
Scheme B Cost Estimate

Item	Quantity (yd^3)	Unit Cost ($\$/yd^3$)	Cost
Downstream Birds Hill			
Till	5,040,000	$ 15.30	$ 77,110,000
Unclassified	5,040,000	$ 5.95	$ 29,990,000
Unclassified	16,140,000	$ 2.50	$ 40,350,000
Upstream Birds Hill			
Unclassified	29,520,000	$ 5.95	$ 175,640,000
Unclassified	16,820,000	$ 2.50	$ 42,050,000
Total Excavation Costs			$365,140,000
Entrance Control Structure	LS		$ 7,200,000
Sub-total			**$ 372,340,000**
Contingencies (20%)			$ 74,470,000
TOTAL			**$ 446,800,000**

TABLE E-3
Scheme C Cost Estimate

Item	Quantity (yd^3)	Unit Cost ($\$/yd^3$)	Cost
Downstream Birds Hill			
Till	2,280,000	$ 15.30	$ 34,880,000
Unclassified	2,280,000	$ 5.95	$ 13,570,000
Unclassified	8,060,000	$ 2.50	$ 20,150,000
Upstream Birds Hill			
Unclassified	14,200,000	$ 5.35	$ 75,970,000
Total Excavation Costs			$144,570,000
Entrance Control Structure	LS		$ 750,000
Sub-total			**$ 145,320,000**
Contingencies (20%)			$ 29,060,000
TOTAL			**$ 174,400,000**

TABLE E-4
Scheme D Cost Estimate

Item	Quantity (yd^3)	Unit Cost ($\$/yd^3$)	Cost
Downstream Birds Hill			
Till	4,930,000	$ 12.80	$ 63,100,000
Unclassified	4,930,000	$ 3.45	$ 17,010,000
Upstream Birds Hill			
Unclassified	22,160,000	$ 3.45	$ 76,450,000
Total Excavation Costs			$156,560,000
Entrance Control Structure	LS		$ 7,200,000
Sub-total			**$ 163,760,000**
Contingencies (20%)			$ 32,750,000
TOTAL			**$ 196,500,000**

TABLE E-5
Scheme E Cost Estimate

Item	Quantity (yd^3)	Unit Cost ($\$/yd^3$)	Cost
Downstream Birds Hill			
Till	0		
Unclassified	0		
Upstream Birds Hill			
Unclassified	6,760,000	$ 3.45	$ 23,320,000
Total Excavation Costs			$23,320,000
Entrance Control Structure	LS		$ 750,000
Sub-total			**$ 24,070,000**
Contingencies (20%)			$ 4,810,000
TOTAL			**$ 28,900,000**

The cost for Scheme D appears large ($197 million), and probably not justifiable on only the basis of controlling summer water levels. However, what has not been possible in this preliminary study is to couple the Floodway requirements for both spring floods and summer floods. That would result in a blend of the excavation requirements for both objectives, and reduce the increase in cost that could be identified with the control of summer flood levels. Preliminary, approximate analyses suggest that the effective cost of Scheme D (ie. the amount of investment required to achieve control of summer water levels over what would be required without that objective) would be about 50% of the cost quoted in Table E-4. The cost of Scheme E would remain as shown in Table E-5 ($29 Million), since it does not require channel modifications. Further studies would be required to confidently determine the cost of providing improved control of summer water levels.

E.5 DISCUSSION

The Floodway channel improvements to provide additional capacity for summer discharges for the purpose of controlling water levels in Winnipeg will not be a low cost undertaking. Incremental costs to provide summer water level control varied between approximately $29 million to $447 million. The only channel excavation Scheme that may be viewed as cost effective is Scheme E. However, it requires summer water levels to be above the "state-of-nature" at the Floodway Inlet under summer flood conditions, even with the 1 in 700 year expanded Floodway channel as the base condition. Backwater at the Inlet would be significant and would extend upstream beyond Ste. Agathe, although within the river banks for the most part. More importantly, the Floodway Inlet Control Structure gates would be operated during summer floods, whereas in the past this would not have been done. This may lead to costly requirements to provide free movement of fish during these periods. There would also be adverse effects due to increased water levels upstream, including possible detrimental effects on riverbank stability. These are expected to be relatively minor but would require further study to define in more detail.

These channel improvements should be reviewed as part of the next study level of planning for the flood protection works for the City of Winnipeg. ***It must be clearly understood that any scheme to control summer water levels that is adapted to the existing Floodway, or to an expanded Floodway, will have a substantial cost.*** The value to Winnipeg from control of summer water levels must be assessed in detail in order to gauge whether these costs could be justifiable.

E.6 RECOMMENDATIONS FOR FUTURE STUDY

1. Undertake a study of the potential benefits of controlling water levels to the extent described in this appendix, and possibly to a lesser standard. This would permit the economic merits of modifying the Floodway to be compared to the rather large costs identified in this document.

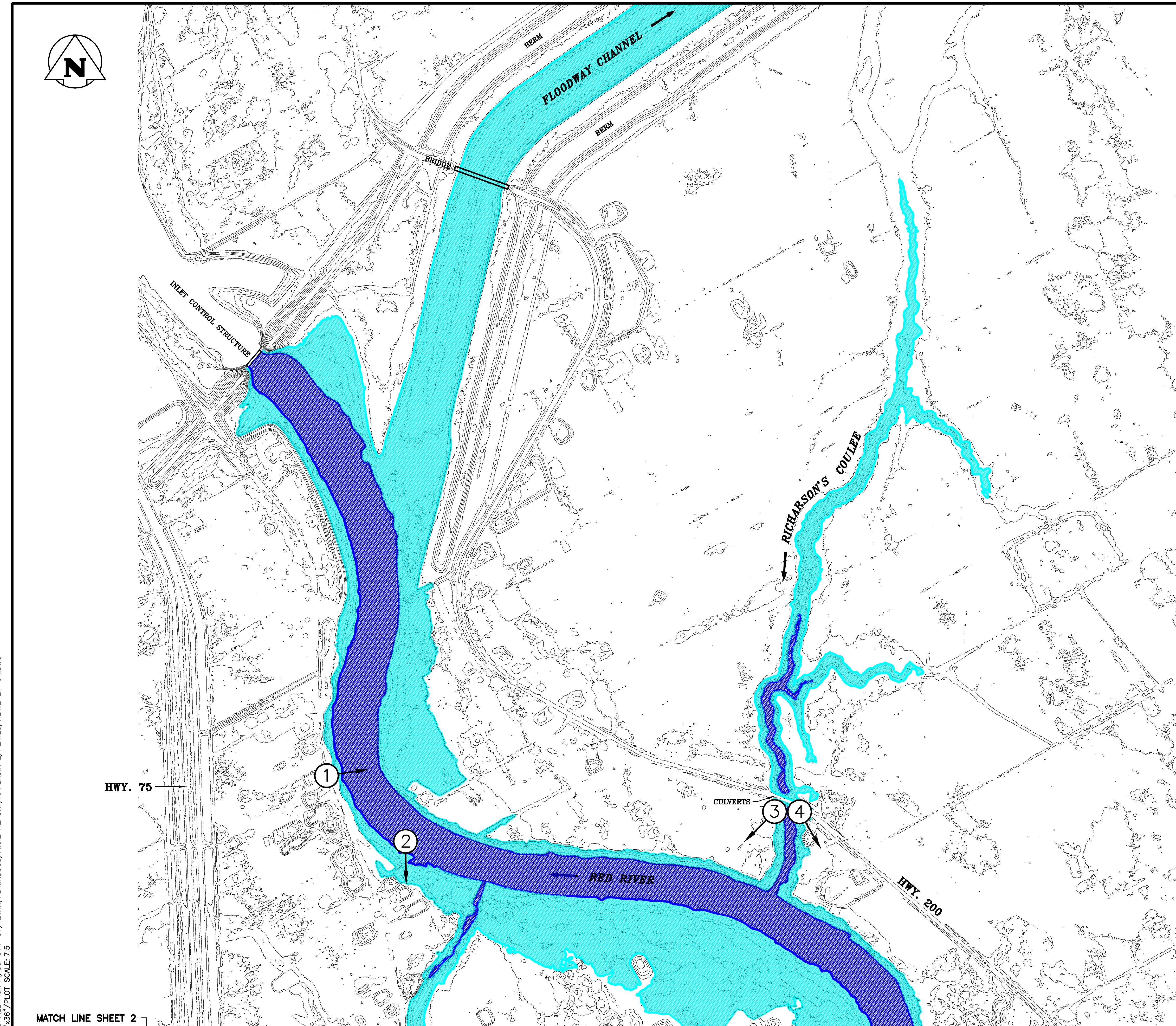
2. After completion of No. 1, undertake a study of adversely affected areas upstream, and after public consultation, arrive at an acceptable limit to the amount that the river level could be raised above the "state-of-nature" condition.

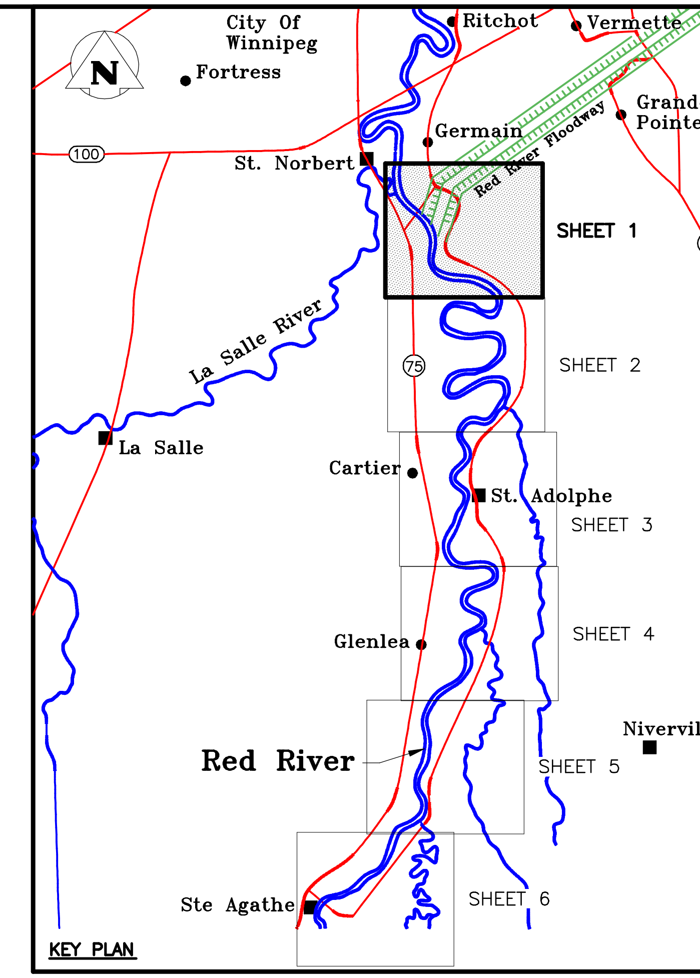
3. If the results of 1 and 2 appear favourable, study the Floodway channel modifications that would be best suited to providing the capability of summer water level control. The modification required for an expanded Floodway should be viewed in parallel with the design objectives for spring floods. This would aim to optimize the channel configuration for both spring and summer floods. This would result in the lowest possible cost of providing the capabilities to control summer water levels in Winnipeg.

4. Assess impacts on fish resources and riverbank stability that would result from using the Floodway gates in summer to control upstream water levels and permit the mobilization of the discharge capacity of the Floodway.

5. If the results of 4 indicate serious and intolerable impacts, then identify and quantify the cost of mitigation measures.

PLATES





LEGEND

FLOODING CORRESPONDING TO EL.746ft. AT FLOODWAY INLET

FLOODWAY CORRESPONDING TO EL.758ft. AT FLOODWAY INLET

(1) PHOTOGRAPH LOCATION AND DIRECTION OF VIEW (TAKEN MAY 16 AND 17, 2001)

NOTE:
1. TOPOGRAPHY BASED ON LIDAR MAPPING (1998) PROVIDED BY MANITOBA CONSERVATION.

0 250 500 750m

SCALE: 1:7500 METRIC 24"x36"
1:15,000 METRIC 11"x17"

Canada Manitoba Winnipeg

FLOOD PROTECTION STUDIES FOR WINNIPEG

CONTROL OF SUMMER WATER LEVELS IN WINNIPEG

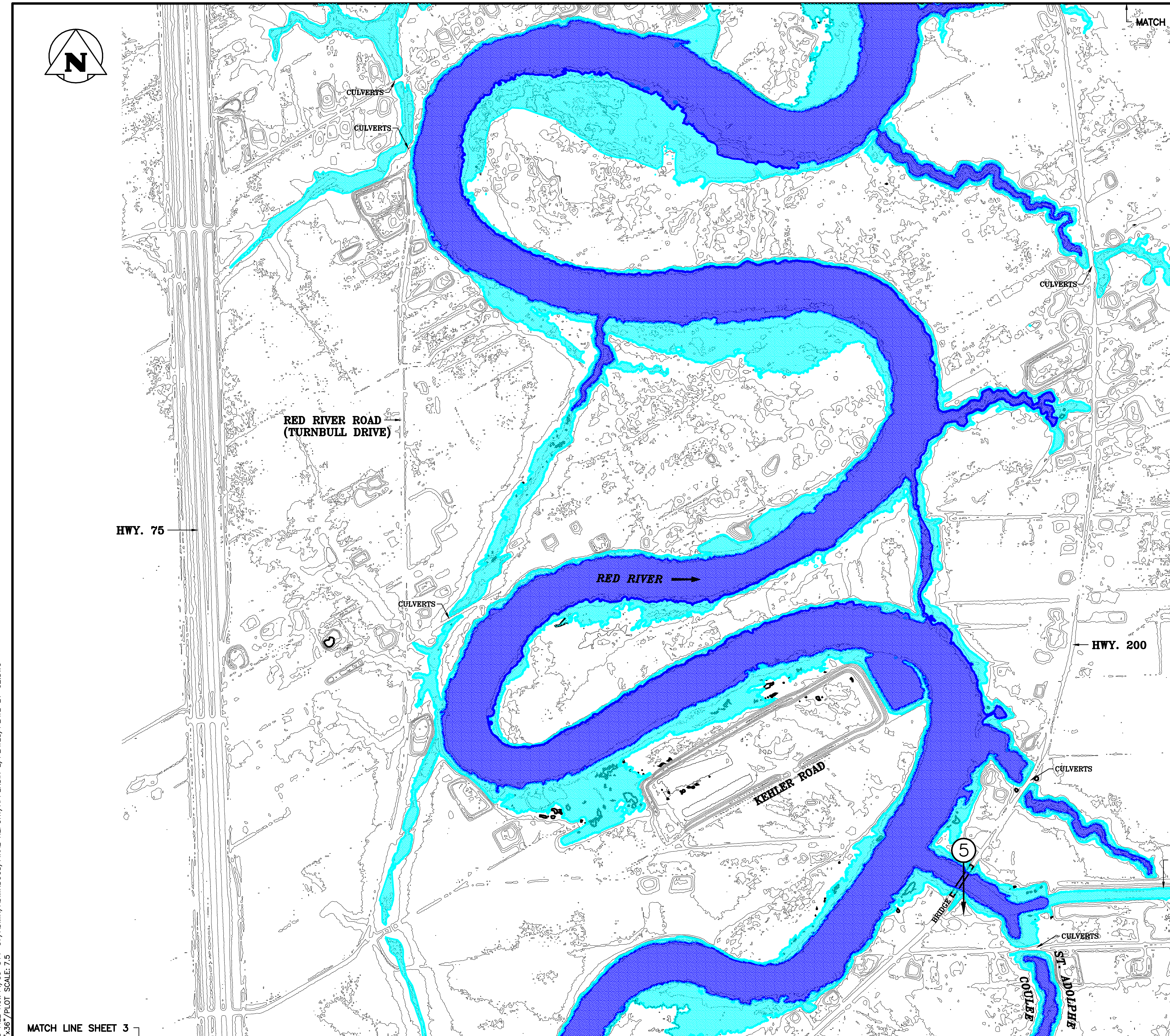
FLOODWAY INLET CONTROL STRUCTURE TO STE. AGATHE – INUNDATION MAPPING

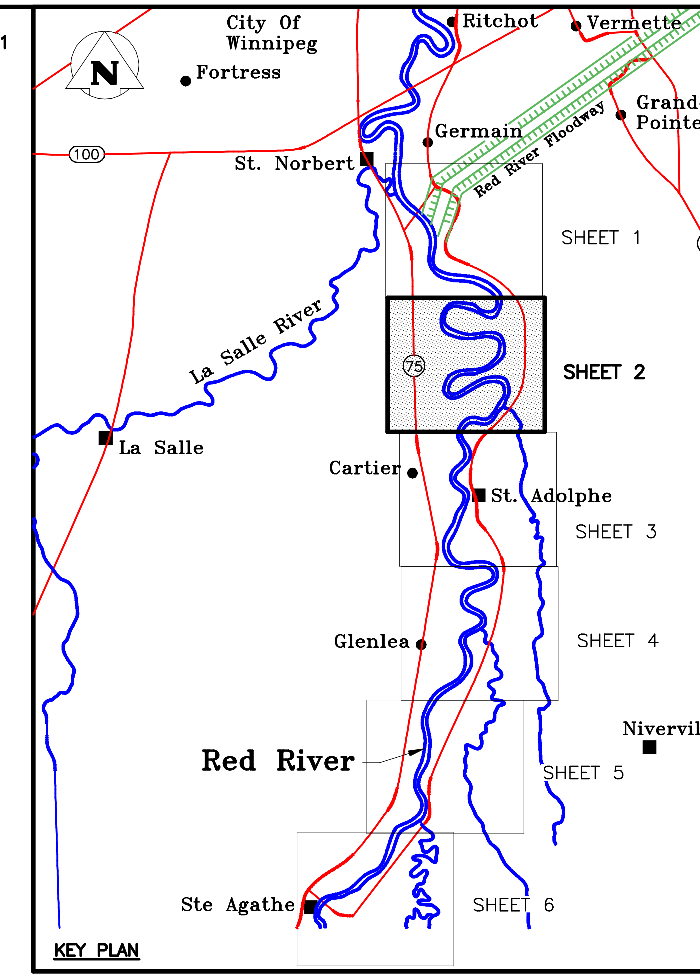
PLATE E–1 (SHEET 1 OF 6)

FINAL REPORT – SEPTEMBER 2001

KGS GROUP

KGS FILE NO: P:/00-311-07/ADMIN/ADMINDOCS/FINAL REPORT/APPENDIX E/PLATES/PLATE E1-01.DWG
24"x36" PLOT SCALE: 7.5





LEGEND

- FLOODING CORRESPONDING TO EL.746ft. AT FLOODWAY INLET
- FLOODWAY CORRESPONDING TO EL.758ft. AT FLOODWAY INLET
- (5) PHOTOGRAPH LOCATION AND DIRECTION OF VIEW (TAKEN MAY 16 AND 17, 2001)

NOTE:

1. TOPOGRAPHY BASED ON LIDAR MAPPING (1998) PROVIDED BY MANITOBA CONSERVATION.

0 250 500 750m

SCALE: 1:7500 METRIC 24"x36"
1:15,000 METRIC 11"x17"

Canada Manitoba Winnipeg

FLOOD PROTECTION STUDIES FOR WINNIPEG

CONTROL OF SUMMER WATER LEVELS IN WINNIPEG

FLOODWAY INLET CONTROL STRUCTURE TO STE. AGATHE – INUNDATION MAPPING

PLATE E–1 ***(SHEET 2 OF 6)***

FINAL REPORT – SEPTEMBER 2001

KGS GROUP

KGS FILE NO: P:/00-311-07/ADMIN/ADMINDOCS/FINAL REPORT/APPENDIX E/PLATES/PLATE E1-02.DWG
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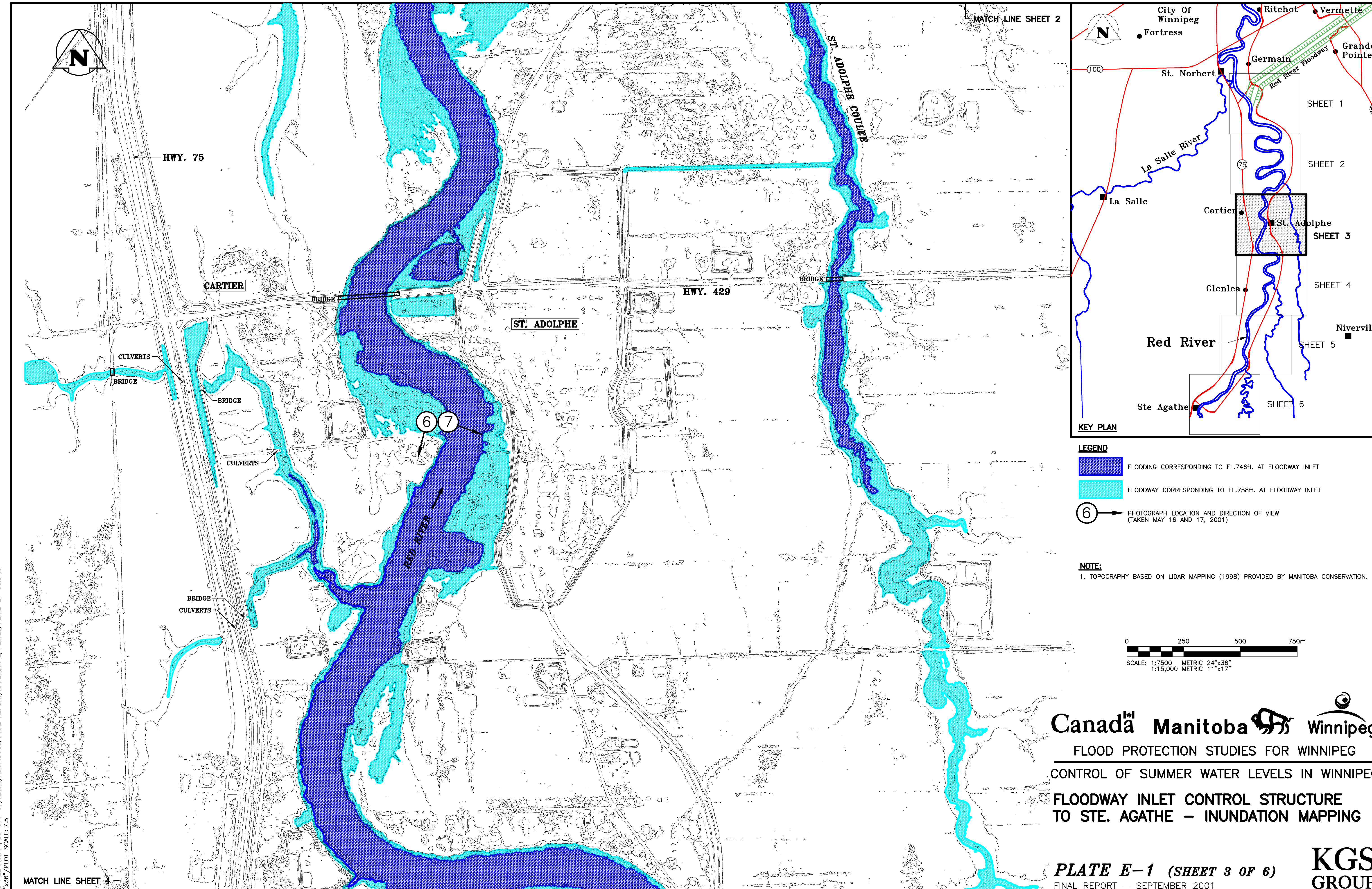

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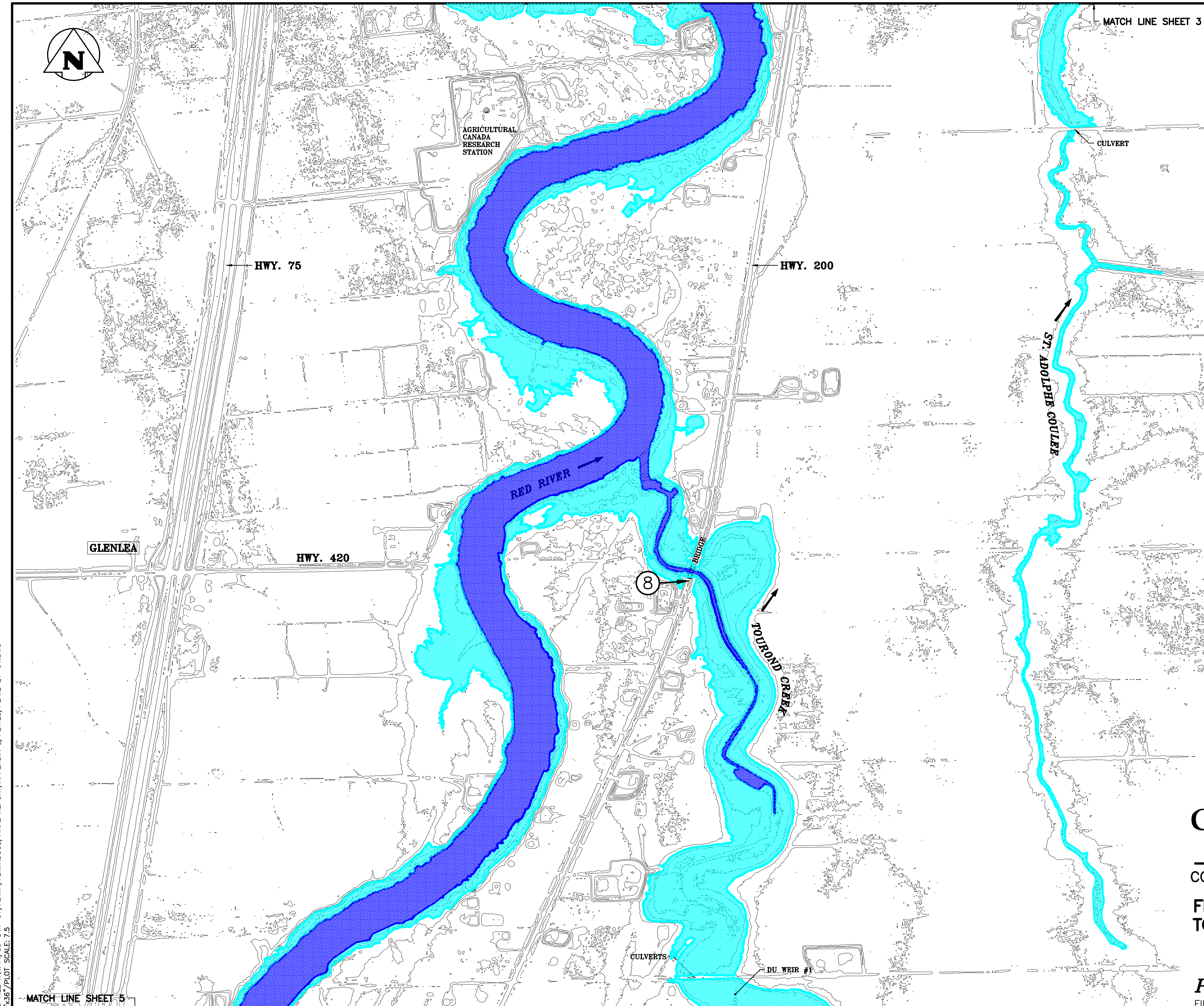

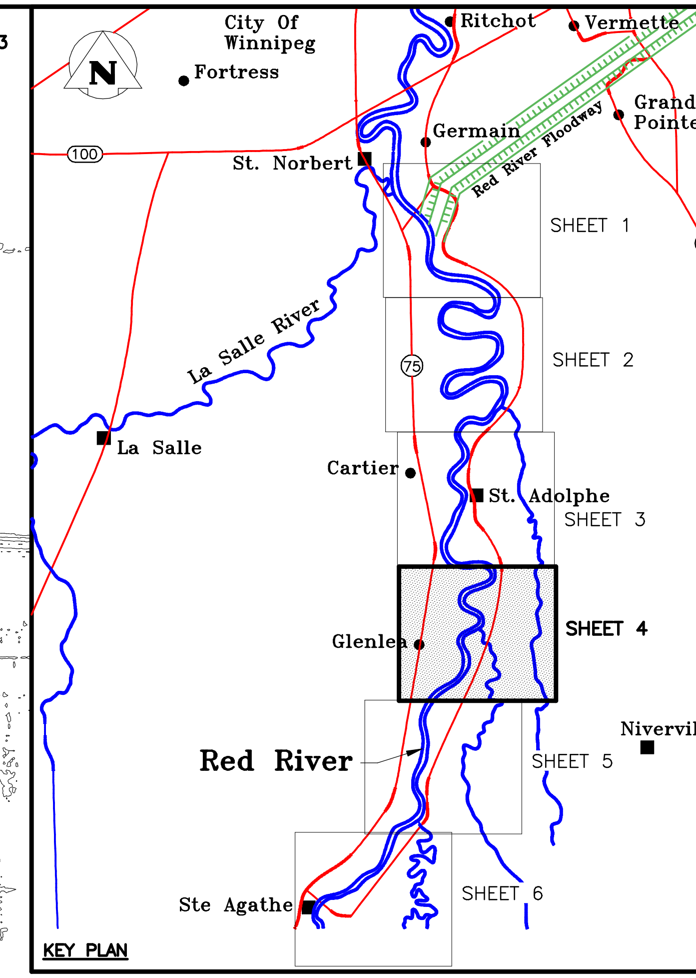

LEGEND

- FLOODING CORRESPONDING TO EL.746ft. AT FLOODWAY INLET
- FLOODWAY CORRESPONDING TO EL.758ft. AT FLOODWAY INLET
- (8) PHOTOGRAPH LOCATION AND DIRECTION OF VIEW (TAKEN MAY 16 AND 17, 2001)

NOTE:

1. TOPOGRAPHY BASED ON LIDAR MAPPING (1998) PROVIDED BY MANITOBA CONSERVATION.

0 250 500 750m

SCALE: 1:7500 METRIC 24"x36"
1:15,000 METRIC 11"x17"

Canada Manitoba Winnipeg

FLOOD PROTECTION STUDIES FOR WINNIPEG

CONTROL OF SUMMER WATER LEVELS IN WINNIPEG

FLOODWAY INLET CONTROL STRUCTURE TO STE. AGATHE – INUNDATION MAPPING

PLATE E–1 (SHEET 4 OF 6)

FINAL REPORT – SEPTEMBER 2001

KGS GROUP

KGS FILE NO: P:/00-311-07/ADMIN/ADMINDOCS/FINAL REPORT/APPENDIX E/PLATES/PLATE E1-04.DWG
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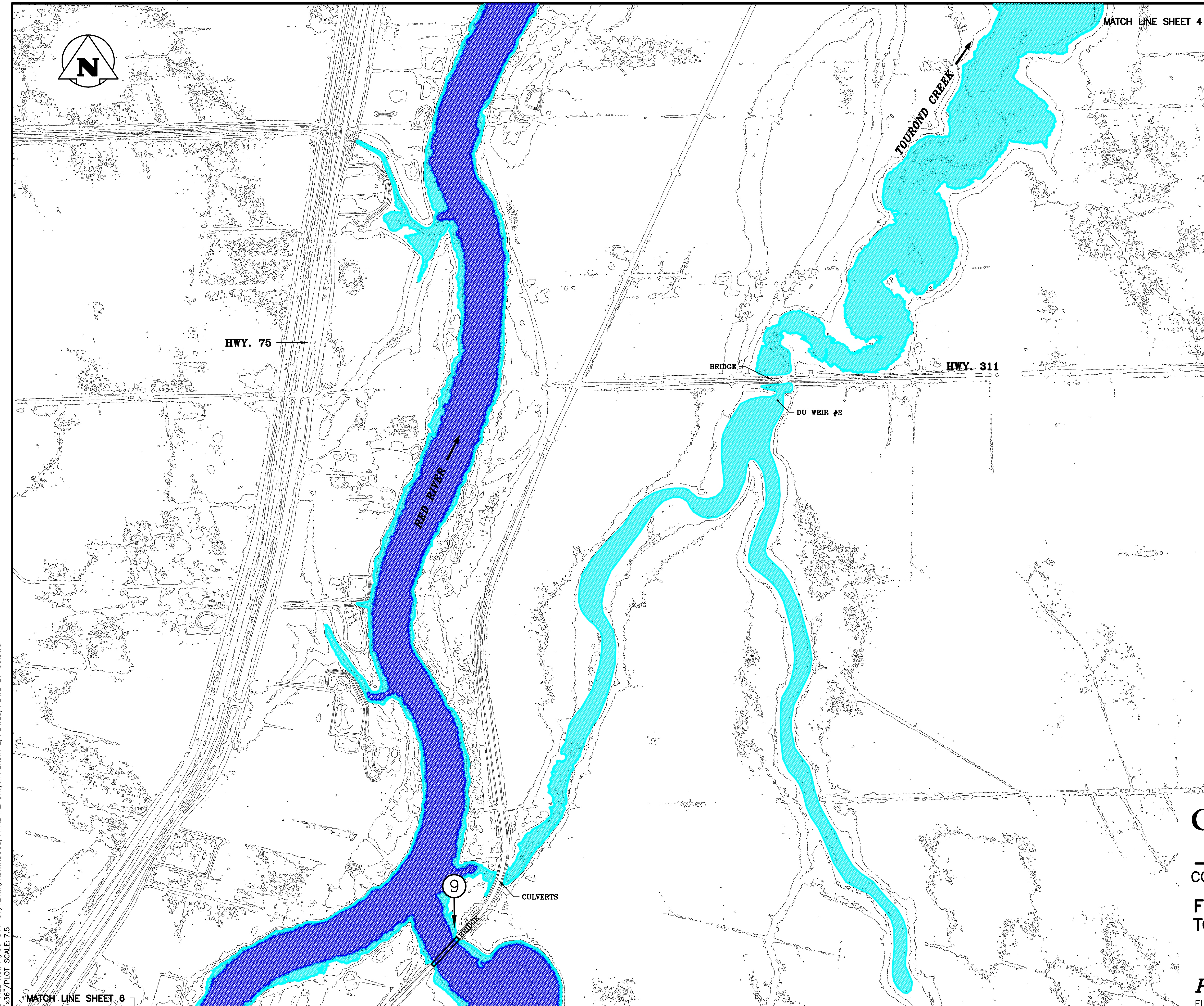

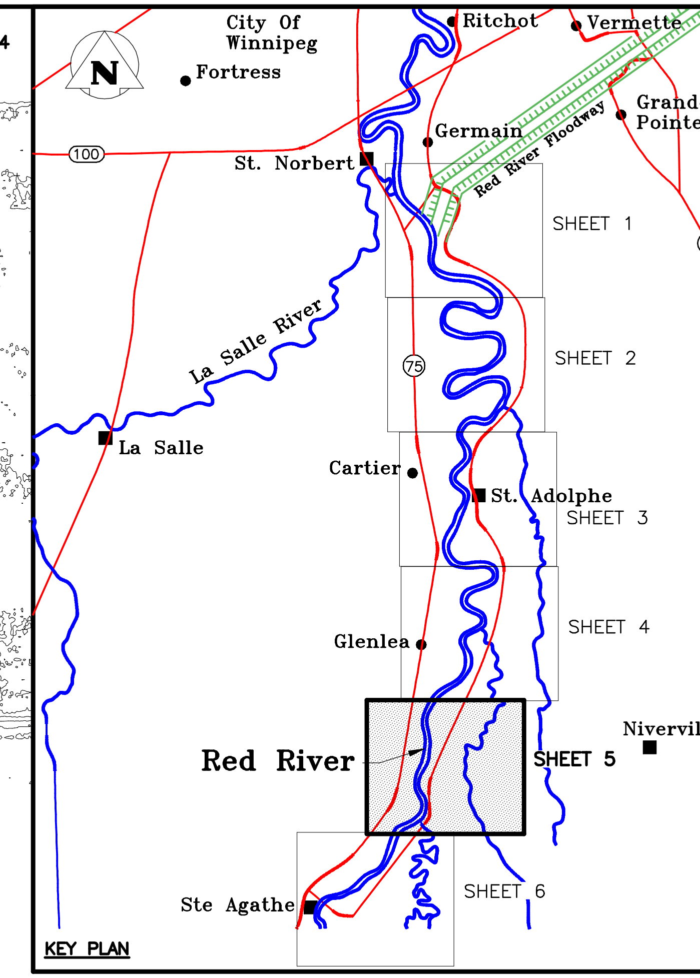

KEY PLAN

LEGEND

FLOODING CORRESPONDING TO EL.746ft. AT FLOODWAY INLET

FLOODWAY CORRESPONDING TO EL.758ft. AT FLOODWAY INLET

(9) → PHOTOGRAPH LOCATION AND DIRECTION OF VIEW (TAKEN MAY 16 AND 17, 2001)

NOTE:

1. TOPOGRAPHY BASED ON LIDAR MAPPING (1998) PROVIDED BY MANITOBA CONSERVATION.

0 250 500 750m

SCALE: 1:7500 METRIC 24"x36"
1:15,000 METRIC 11"x17"

Canada Manitoba Winnipeg

FLOOD PROTECTION STUDIES FOR WINNIPEG

CONTROL OF SUMMER WATER LEVELS IN WINNIPEG

FLOODWAY INLET CONTROL STRUCTURE TO STE. AGATHE – INUNDATION MAPPING

PLATE E-1 (SHEET 5 OF 6)

FINAL REPORT – SEPTEMBER 2001

KGS GROUP

KGS FILE NO: P:/00-311-07/ADMIN/ADMINDOCS/FINAL REPORT/APPENDIX E/PLATES/PLATE E1-05.DWG
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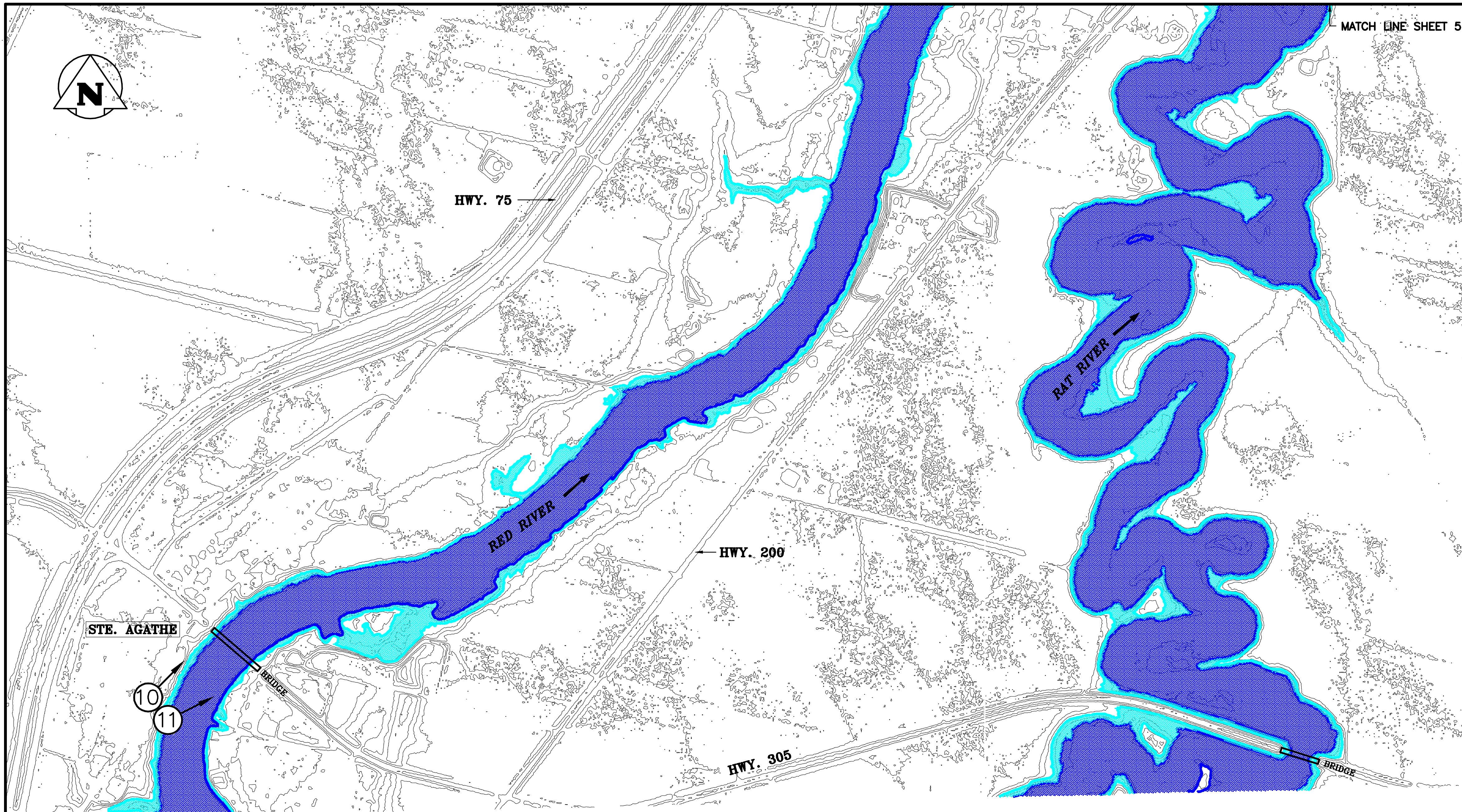
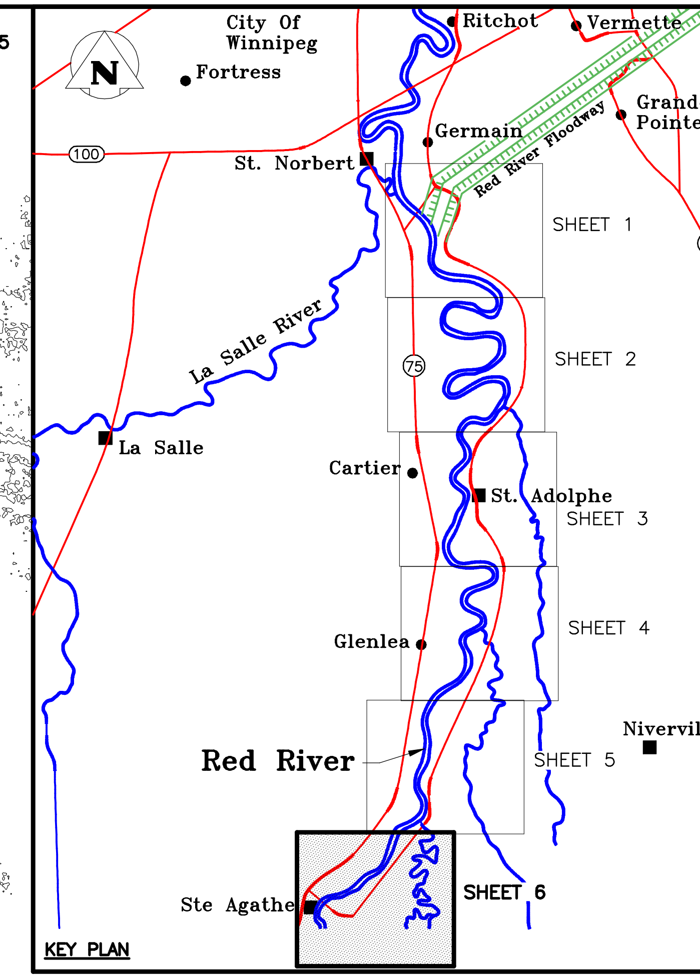




LEGEND

- FLOODING CORRESPONDING TO EL.746ft. AT FLOODWAY INLET
- FLOODWAY CORRESPONDING TO EL.758ft. AT FLOODWAY INLET
- (10) → PHOTOGRAPH LOCATION AND DIRECTION OF VIEW (TAKEN MAY 16 AND 17, 2001)

NOTE:

1. TOPOGRAPHY BASED ON LIDAR MAPPING (1998) PROVIDED BY MANITOBA CONSERVATION.

0 250 500 750m

SCALE: 1:7500 METRIC 24"x36"
1:15,000 METRIC 11"x17"

Canada Manitoba Winnipeg

FLOOD PROTECTION STUDIES FOR WINNIPEG

CONTROL OF SUMMER WATER LEVELS IN WINNIPEG

FLOODWAY INLET CONTROL STRUCTURE TO STE. AGATHE – INUNDATION MAPPING

PLATE E-1 (SHEET 6 OF 6)

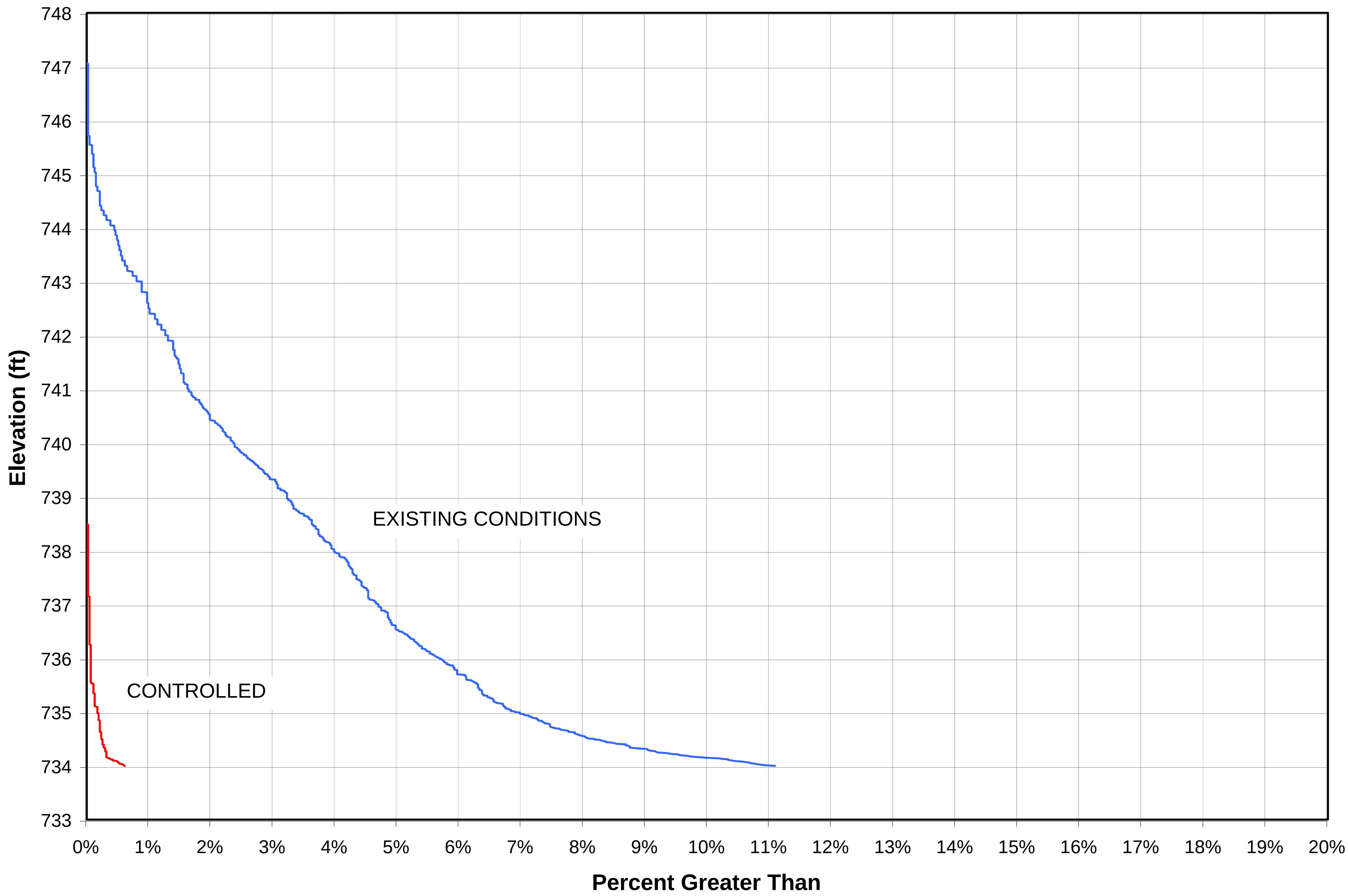
FINAL REPORT – SEPTEMBER 2001

KGS GROUP

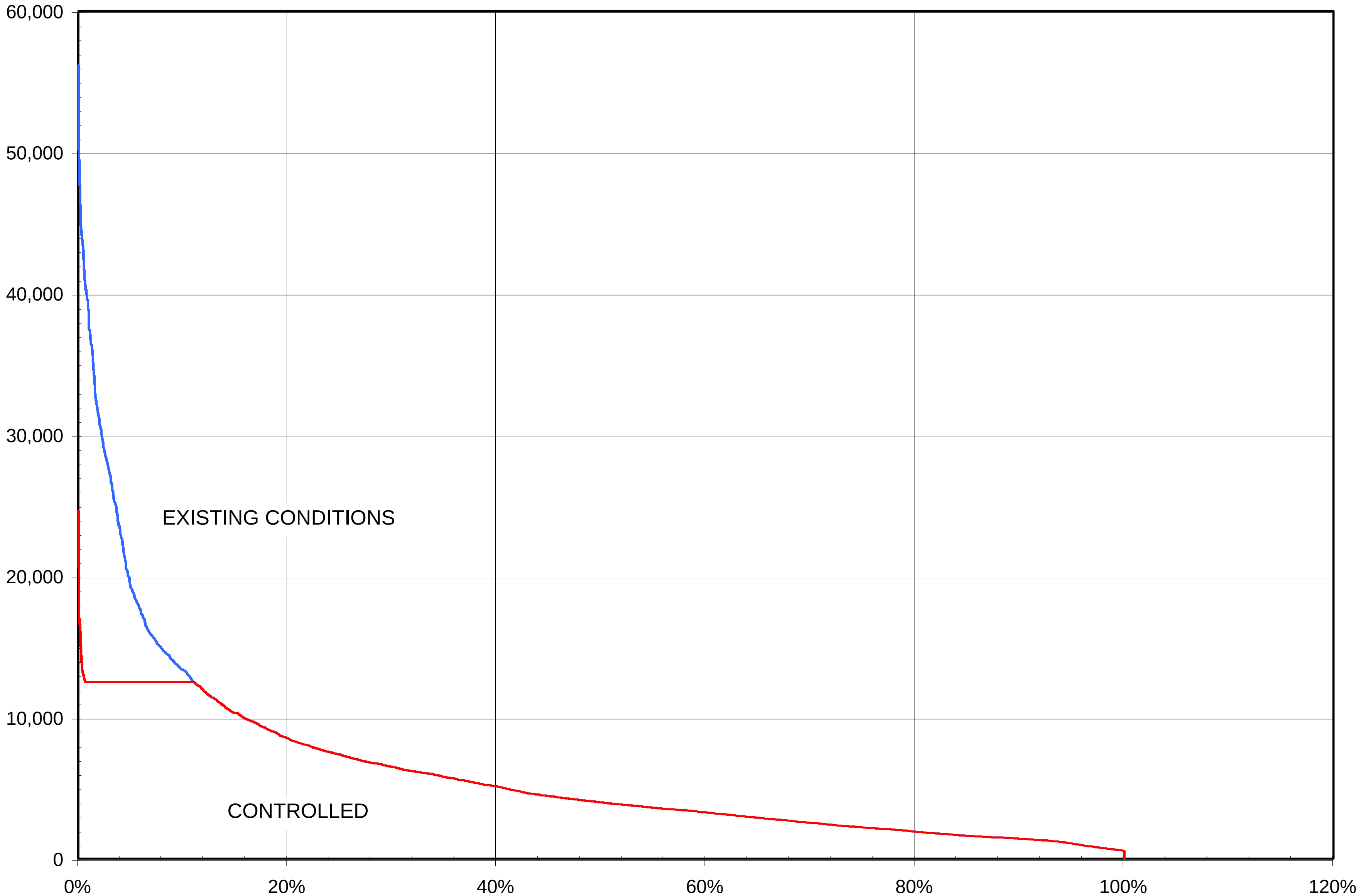
KGS FILE NO: P:/00-311-07/ADMIN/ADMINDOCS/FINAL REPORT/APPENDIX E/PLATES/PLATE E1-06.DWG
24"x36"/PLOT SCALE: 7.5

ANNEX A

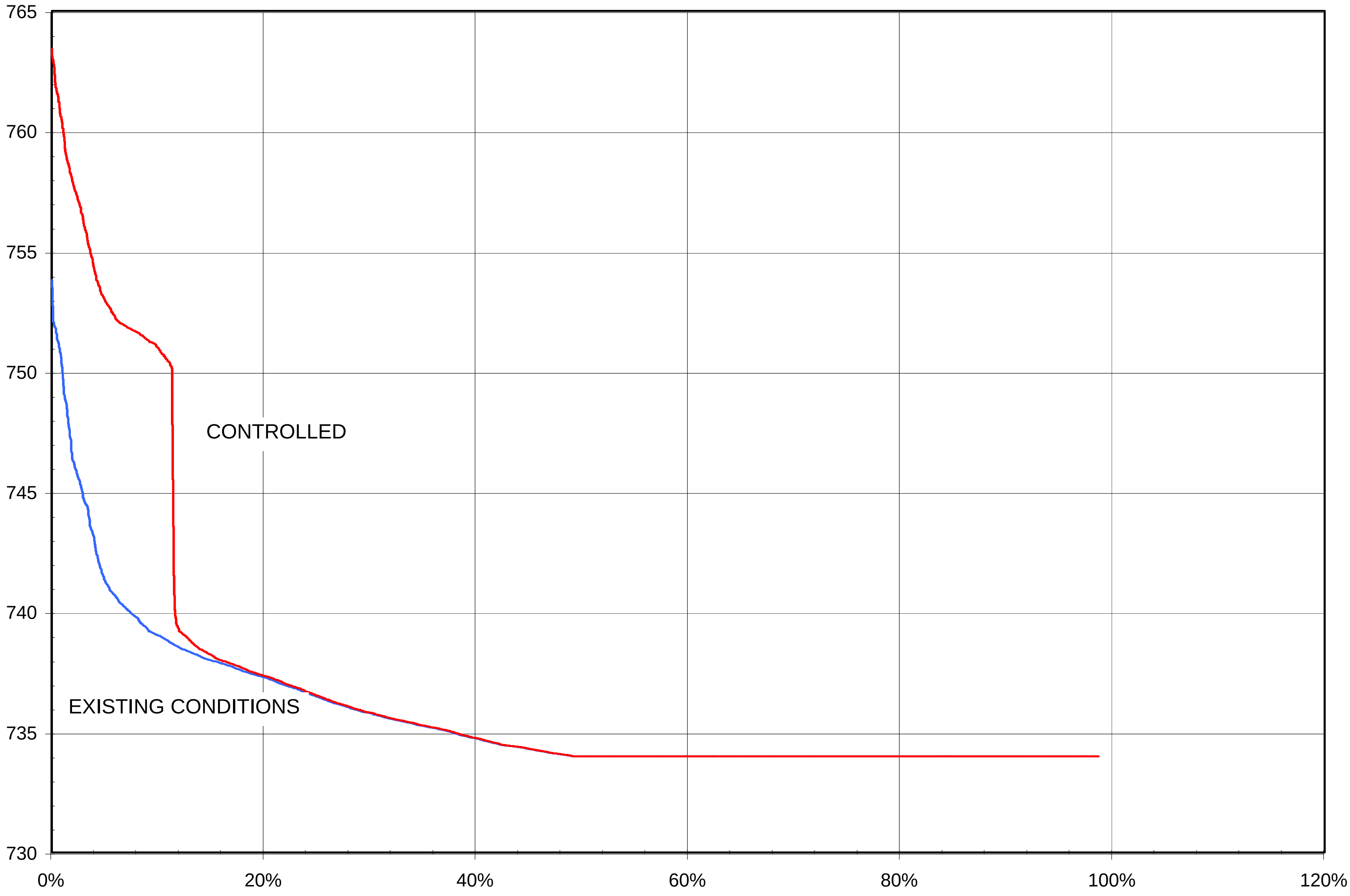
DURATION CURVES



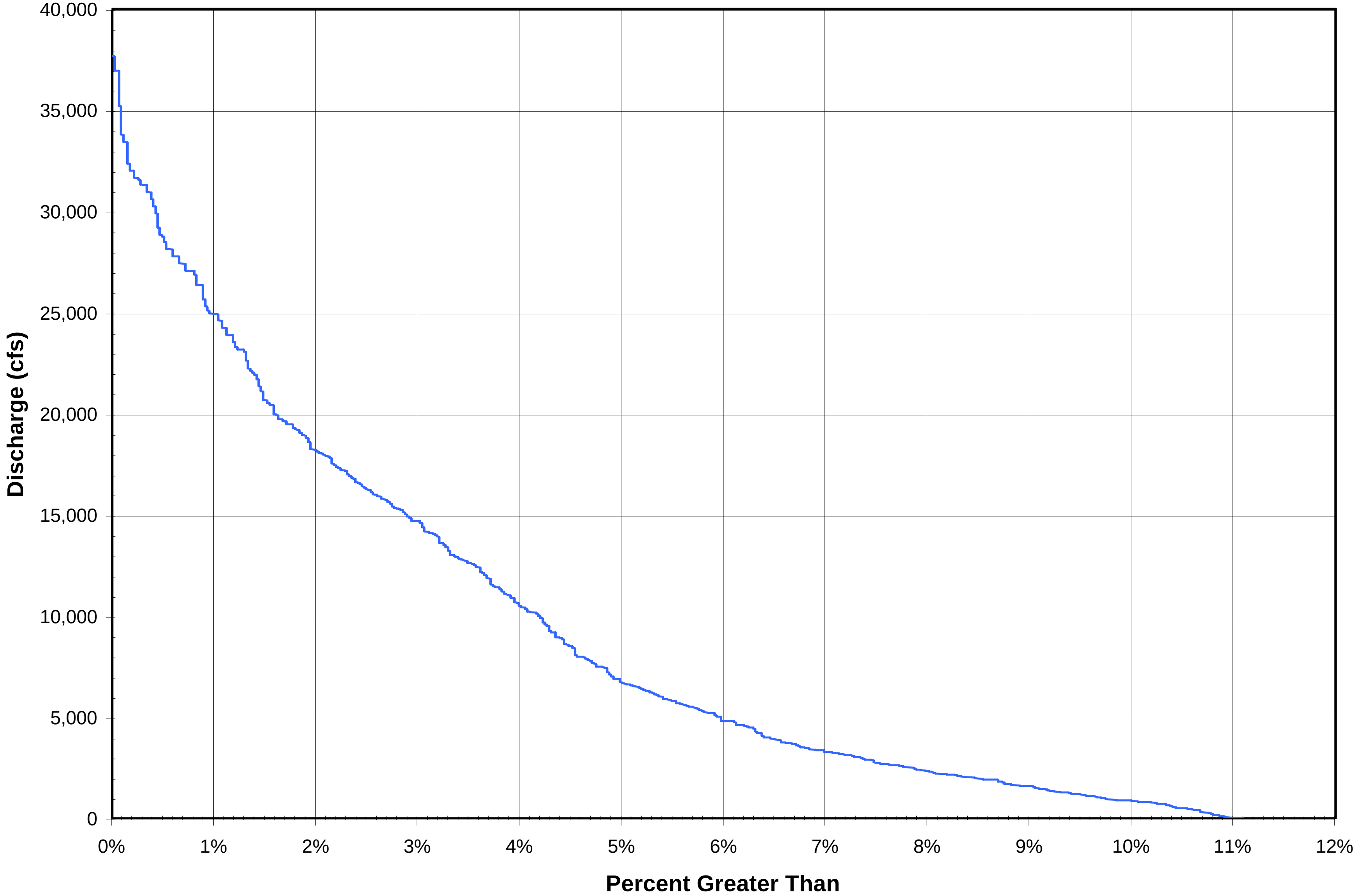
SCHEME A
SUMMER STAGE DURATION CURVE AT THE FORKS
FIGURE E-A-1



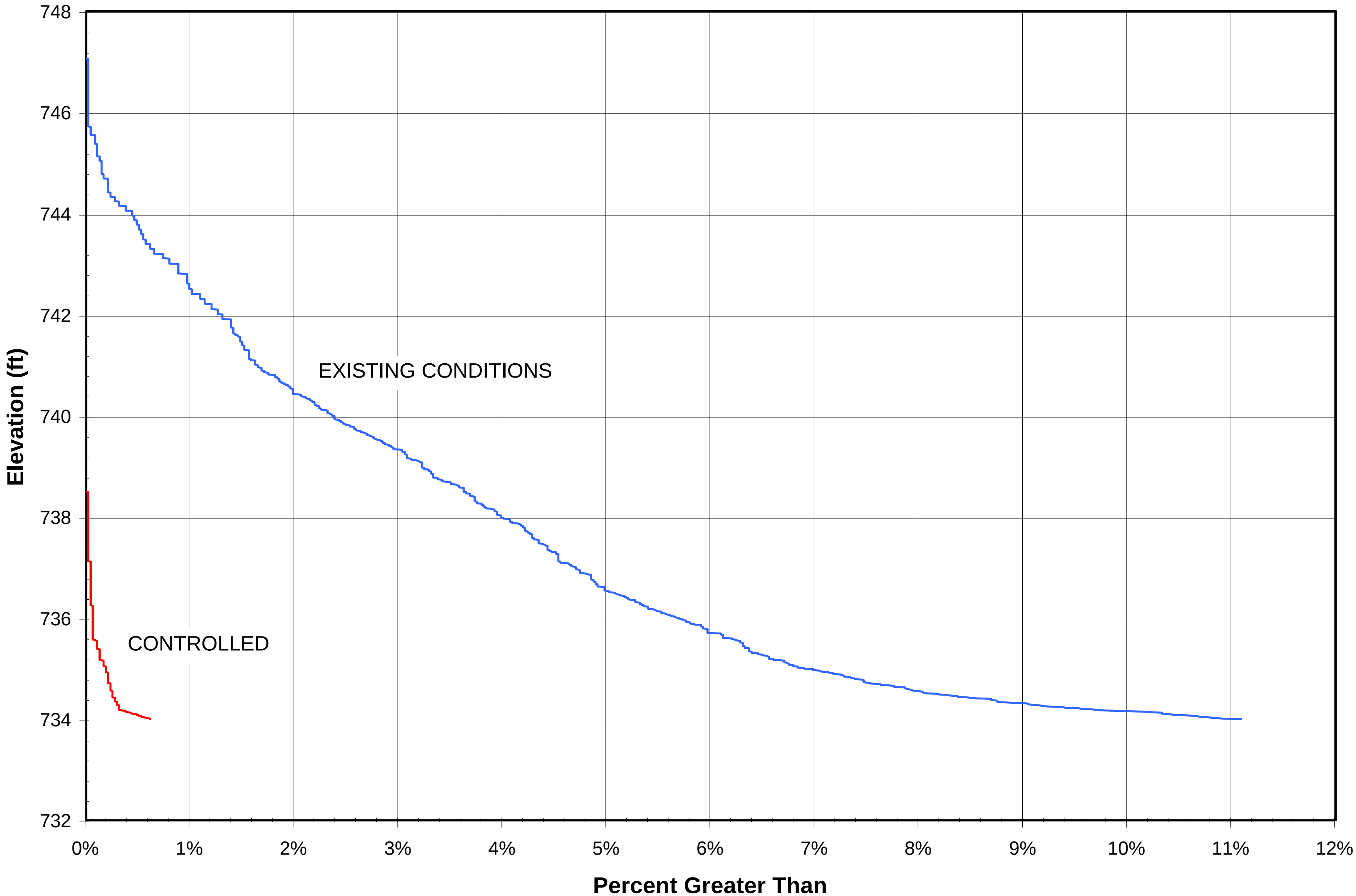
SCHEME A
SUMMER FLOW DURATION CURVE AT THE FORKS
FIGURE E-A-2



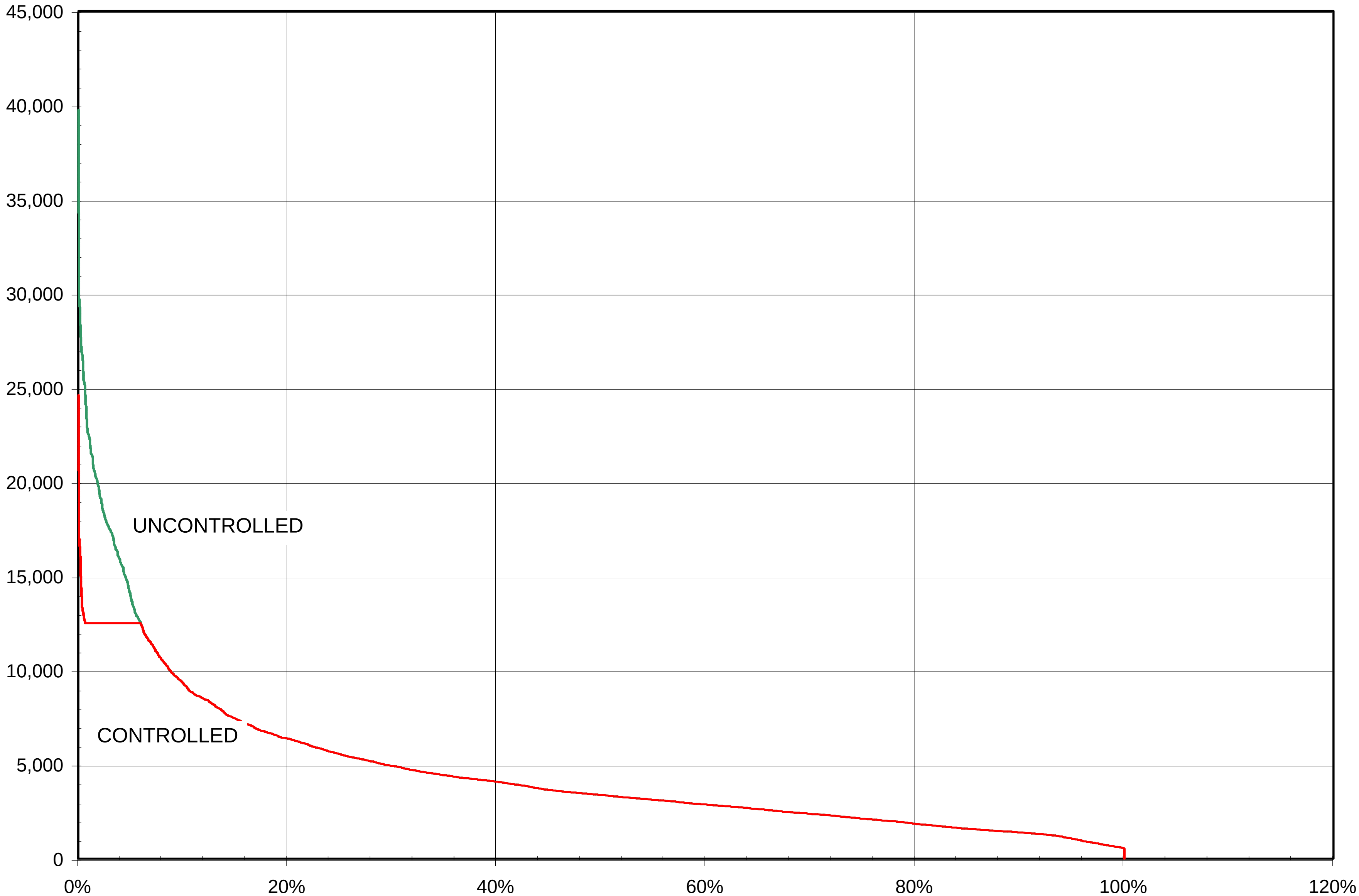
SCHEME A
SUMMER STAGE DURATION CURVE AT INLET
FIGURE E-A-3



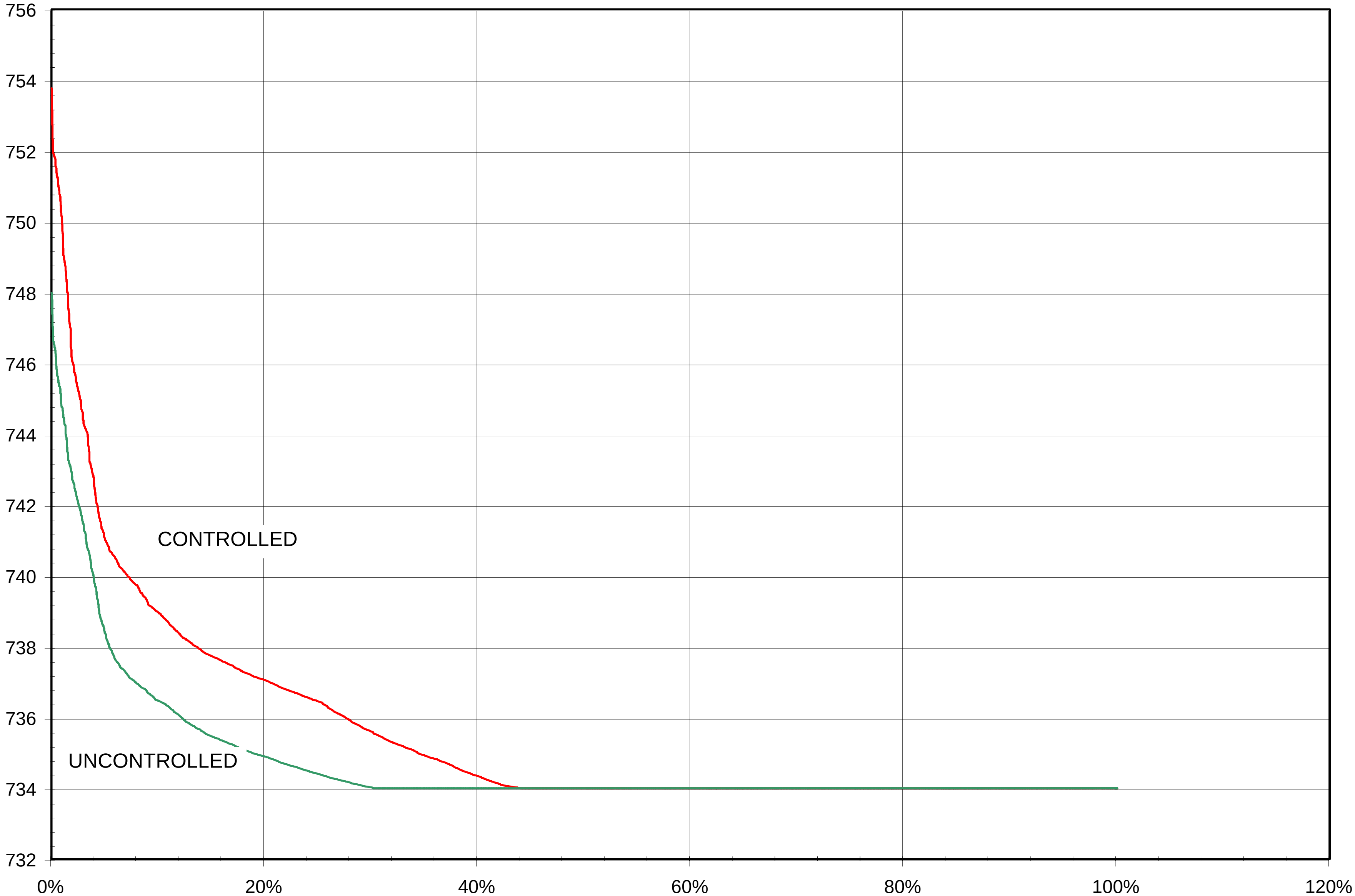
SCHEME A
SUMMER FLOODWAY FLOW DURATION CURVE
FIGURE E-A-4



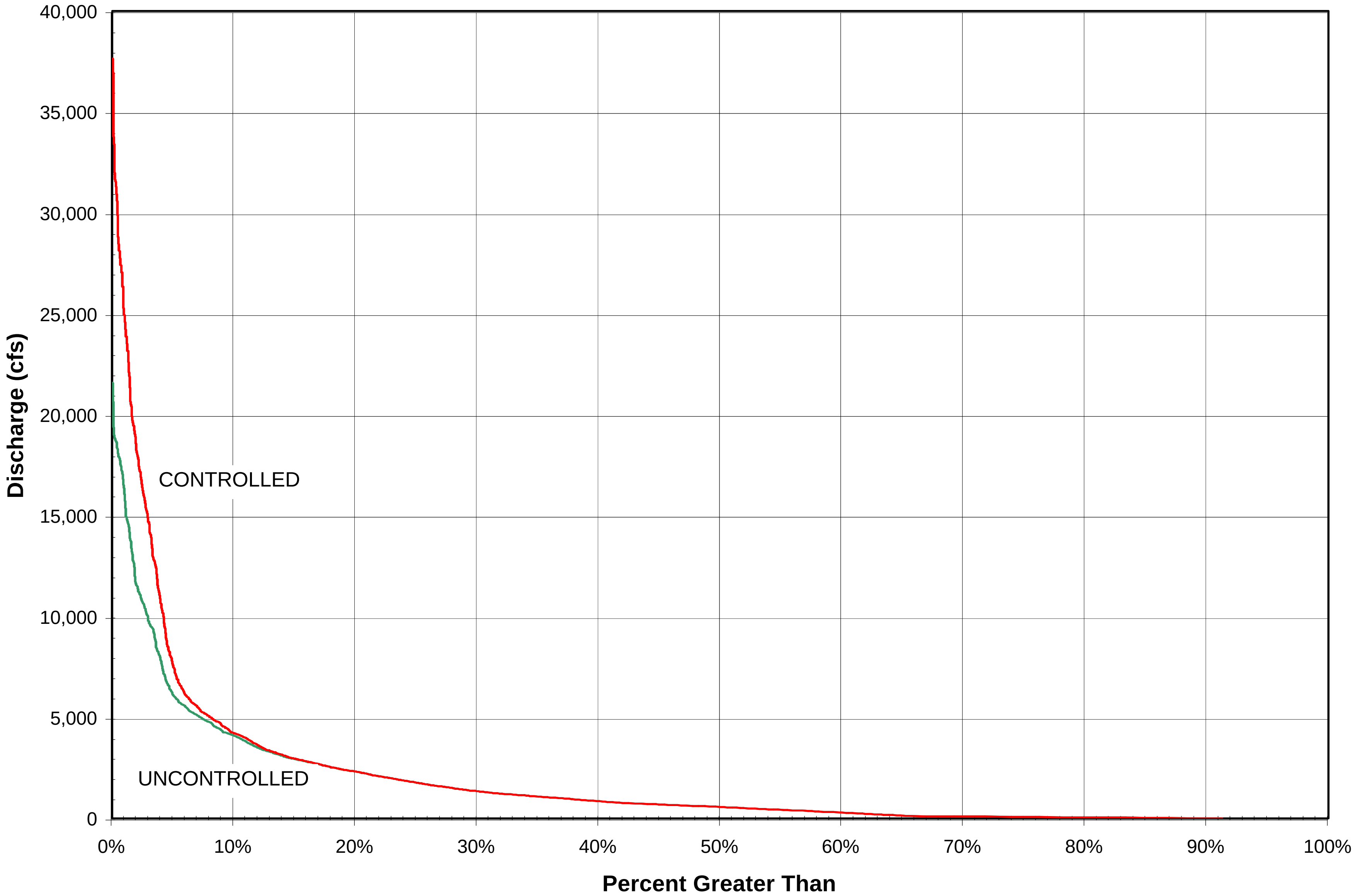
SCHEMES B AND D
SUMMER STAGE DURATION CURVE AT THE FORKS
FIGURE E-A-5



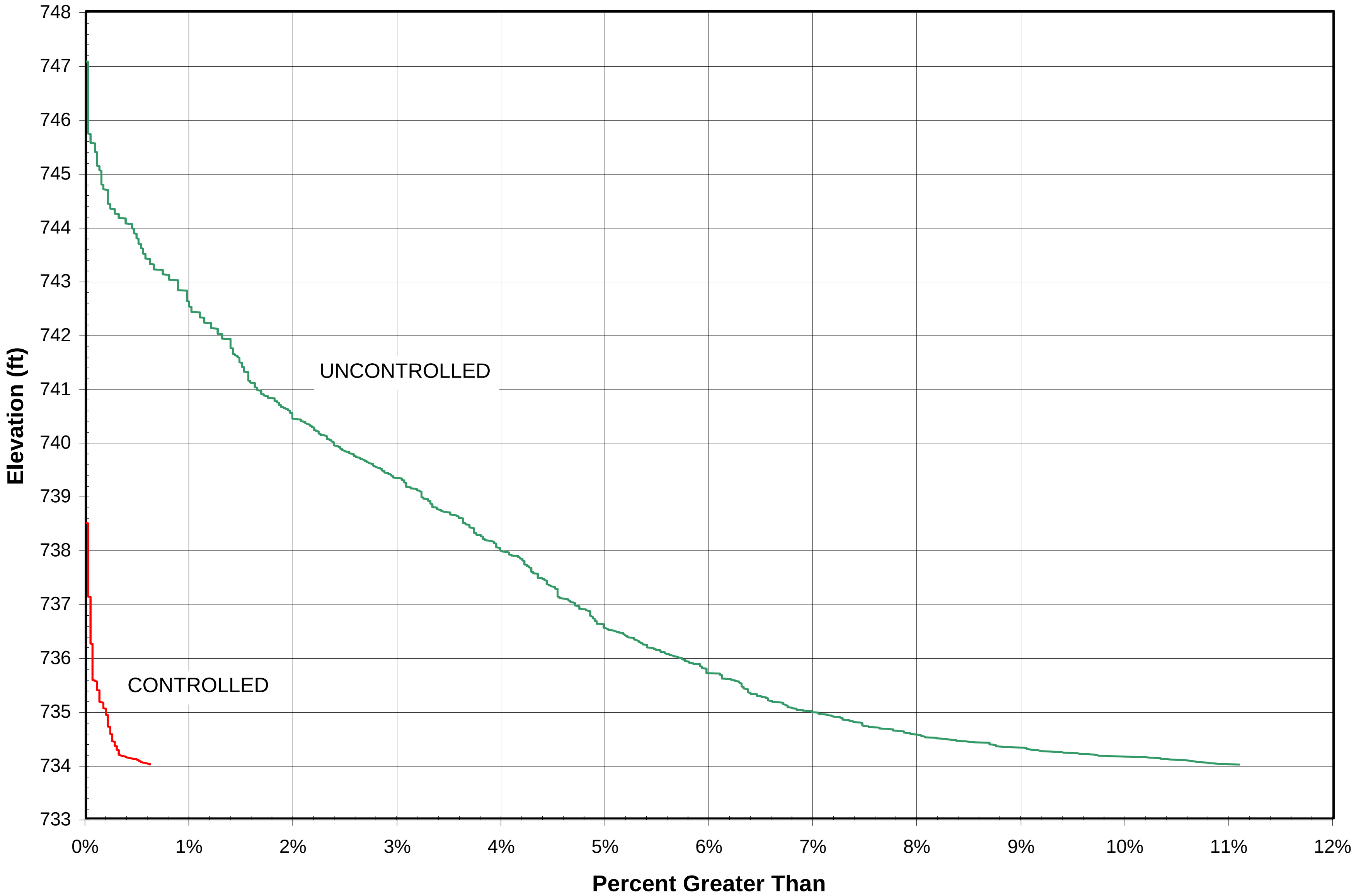
SCHEMES B AND D
SUMMER FLOW DURATION CURVE AT THE FORKS
FIGURE E-A-6



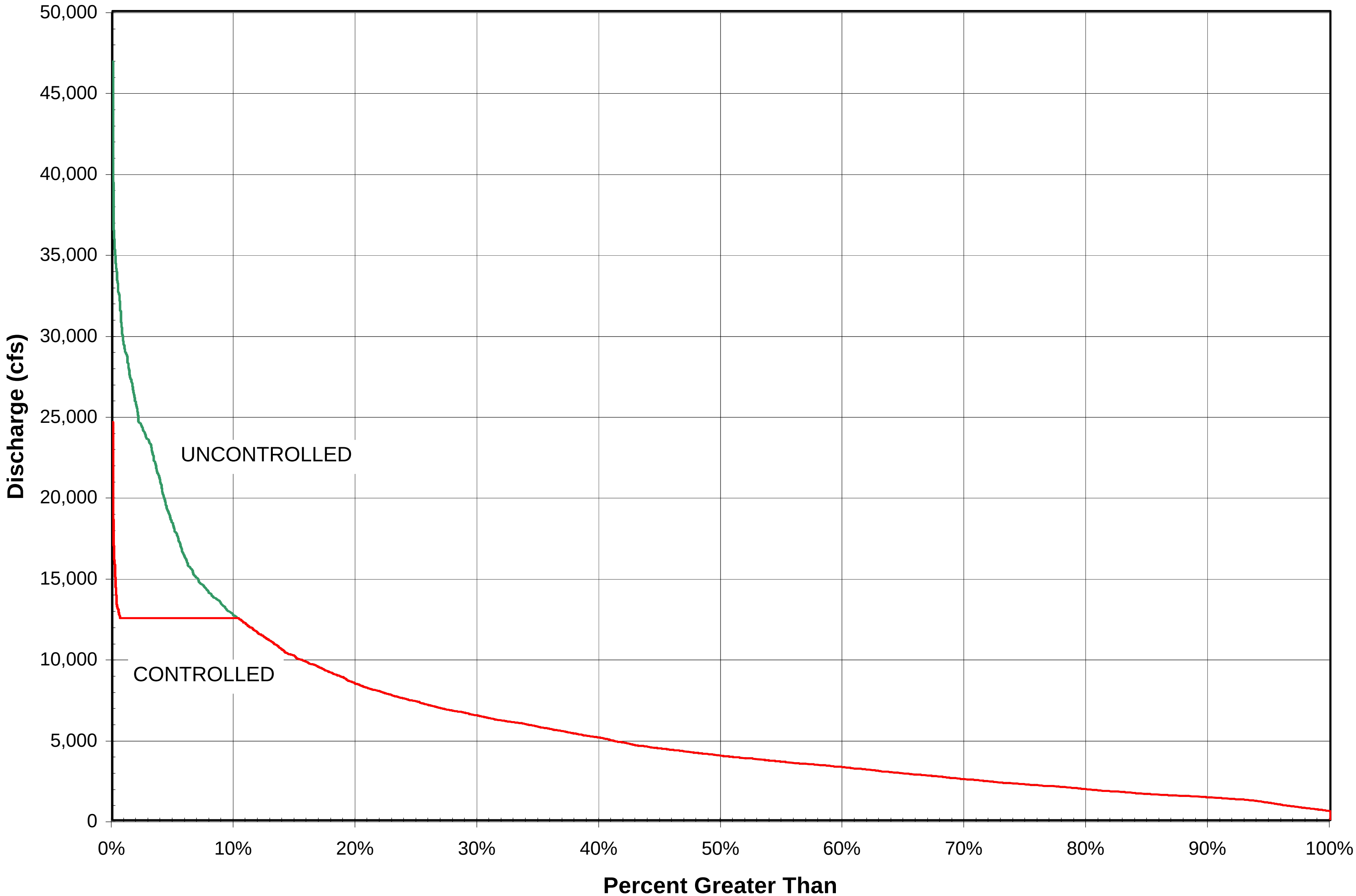
SCHEMES B AND D
SUMMER STAGE DURATION CURVE AT THE INLET
FIGURE E-A-7



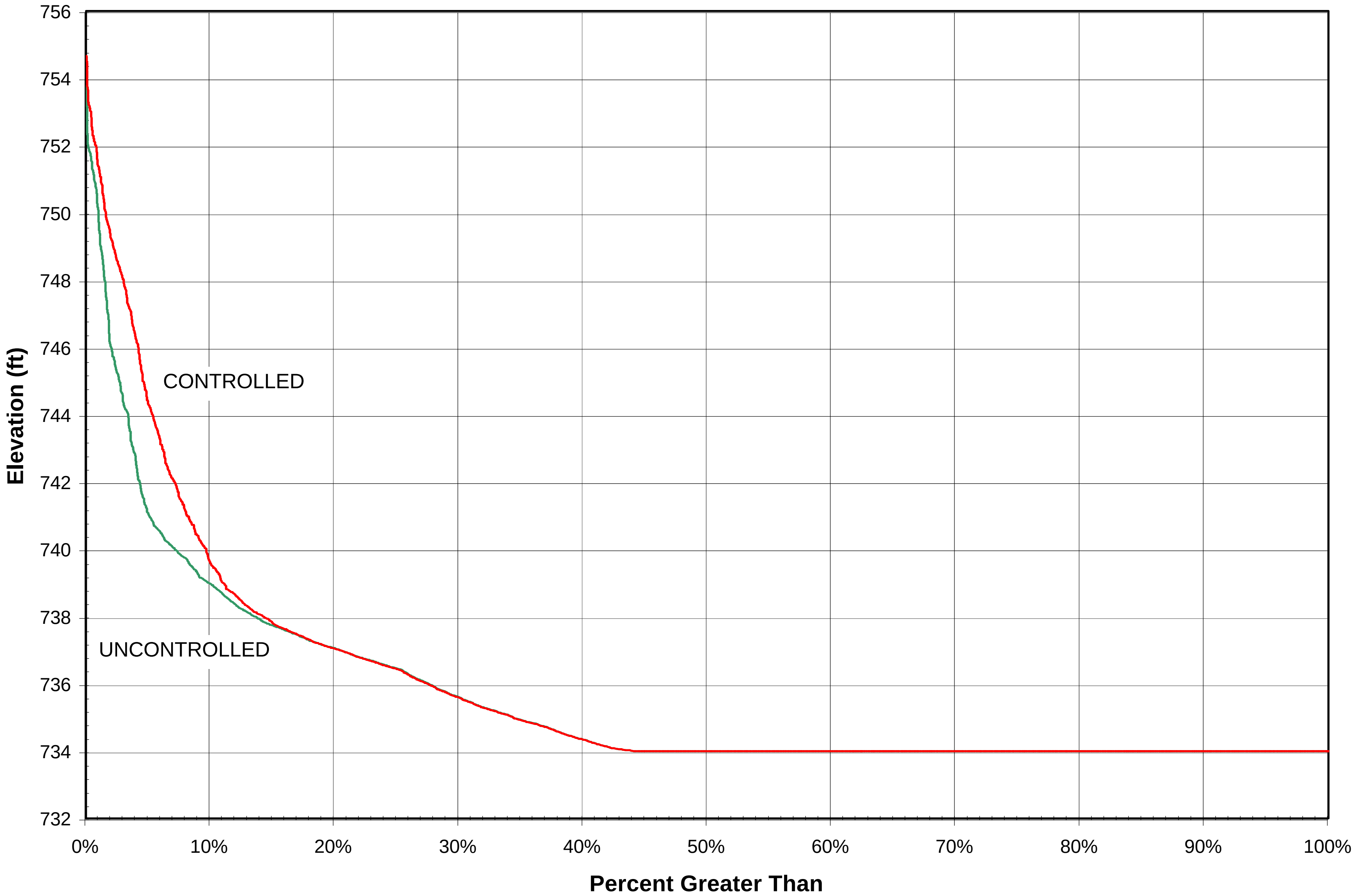
SCHEMES B AND D
SUMMER FLOODWAY FLOW DURATION CURVE
FIGURE E-A-8



SCHEME C AND E
SUMMER STAGE DURATION CURVE AT THE FORKS
FIGURE E-A-9



SCHEME C AND E
SUMMER FLOW DURATION CURVE AT THE FORKS
FIGURE E-A-10



SCHEME C AND E
SUMMER STAGE DURATION CURVE AT THE INLET
FIGURE E-A-11

ANNEX B

PHOTOS

Note: Flow Conditions for Dates of Photos are as Follows:

- May 16, 2001 Flow at Ste. Agathe = 39,800 cfs
  Elevation at Floodway Inlet = 754.49 ft
- May 17, 2001 Flow at Ste. Agathe = 37,600 cfs
  Elevation at Floodway Inlet = 753.71 ft

PHOTO E-1: WEST BANK AT #828 RED RIVER DRIVE LOOKING EAST AT EAST BANK BEHIND #4176 ST. MARYS ROAD (May 16, 2001)

PHOTO E-2: NORTH EAST CORNER OF RING DIKE AT #905 RED RIVER DRIVE (WEST BANK) LOOKING SOUTH EAST (May 16, 2001)

PHOTO E-3: #850 ST. MARYS ROAD LOOKING SW (DOWNSTREAM) FROM NORTHBOUND SHOULDER (May 16, 2001)

PHOTO E-4: #850 ST. MARYS ROAD LOOKING SE ALONG SOUTHBOUND SHOULDER (May 16, 2001)

PHOTO E-5: SOUTH ABUTMENT OF SEINE RIVER DIVERSION BRIDGE (ST. MARYS ROAD) LOOKING NW (DOWNSTREAM) (May 16, 2001)

PHOTO E-6: EAST END CAMPEAU ROAD LOOKING SOUTH (WEST BANK) ALONG TOE OF RING DIKE (May 17, 2001)

PHOTO E-7: EAST END OF CAMPEAU ROAD LOOKING EAST AT EAST BANK (WEST END OF TACHE AVENUE AT STE. ADOLPHE) (May 17, 2001)

PHOTO E-8: APPROXIMATELY 30 M WEST OF ST. MARYS ROAD LOOKING EAST (U/S) AT BRIDGE OVER TOURAND CREEK (May 17, 2001)

PHOTO E-9: RAT RIVER BRIDGE (ST. MARYS ROAD) NORTH ABUTMENT LOOKING SOUTH (D/S PIER NOSES) (May 17, 2001)

PHOTO E-10: SOUTH OF PR #305 BRIDGE ON WEST BANK LOOKING NORTH (May 17, 2001)

PHOTO E-11: PR #305 BRIDGE LOOKING NORTH AT EAST BANK (May 17, 2001)

Canada

Manitoba CONSERVATION

Winnipeg

FLOOD PROTECTION STUDIES FOR WINNIPEG

APPENDIX F
ENVIRONMENTAL CONSIDERATIONS

NOVEMBER 2001

KGS GROUP

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

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F.1 INTRODUCTION

This appendix is one of six that accompany and supplement the Main Report on Studies of Flood Protection for Winnipeg. This volume describes the environmental considerations associated with two preferred alternatives for flood control - the Red River Floodway Expansion and the Ste. Agathe Detention Structure. Both options are still in the pre-feasibility stage, and form the basis of discussion for this section.

An overview of the engineering aspects of the Red River Floodway Expansion and Ste. Agathe Detention Structure is provided in Appendix B and C , respectively. Although the alternatives are still at the development stage of planning, sufficient design has been conducted to identify the potential environmental effects associated with each alternative and to describe the environmental assessment process anticipated to be required to obtain environmental approvals. As defined in the Canadian Environmental Assessment Act, an environmental effect is any change in the environment caused by the project and any change in project caused by the environment. Although the term ‘ effect’ and ‘ impact’ are often used synonymously, ‘ effects’ differ from ‘ impacts’ in that an environmental impact refers to the overall or total change in the environment cause by the project (i.e. the sum of the ‘ effects’). Environmental effects of Floodway Expansion and the Ste. Agathe Detention Structure are considered separately in this appendix.

The intent of this section is to outline the anticipated regulatory framework associated with the Federal and Provincial approval processes and to provide a description of the socioeconomic and biophysical effects associated with each alternative. Measures to mitigate potential environmental effects have been incorporated into the preliminary design phase and further measures are defined here. A preliminary schedule for obtaining environmental approvals and anticipated requirements for the next level of study are provided.

F.2 REGULATORY REQUIREMENTS

F.2.1 REGULATORY FRAMEWORK

Under the Environment Act (Manitoba), all developments listed on the Classes of Development Regulation 164/88 require an environmental license before construction and/or operation. According to this regulation, Flood Control Projects affecting an area greater than 38.6 Sq. miles are categorized as Class 3 Developments and will require a Manitoba Environment Act License. To satisfy the requirements of the assessment and licensing process for this class of project, an Environment Impact Assessment Report (EIAR) will be required to determine the type and significance of environmental effects of the project.

The project could in all likelihood require a Federal assessment under the Canadian Environmental Assessment Act (CEAA). A comprehensive Study environmental assessment will likely be required for the project to comply with the Act (Section 3, Part III, Comprehensive Study List Regulations).

Accordingly, it is anticipated that one Cooperative Environmental Assessment (CEA) will be conducted under the Canada-Manitoba Agreement on Environmental Assessment Cooperation to satisfy both the federal and provincial environmental assessment processes. Conducting the federal and provincial process cooperatively will be the most efficient means of completing the assessment from a schedule perspective. A “Lead Party” (federal or provincial) will be selected to oversee the process and ensure that it is completed.

Following an assessment of a number of alternatives, two preferred options are currently under consideration to provide flood protection for the City of Winnipeg – The Floodway Expansion and the Ste. Agathe Detention Structure projects (see Appendix B and C , respectively). Although it is anticipated that the selection for one of the preferred alternatives will not be completed until early 2002, it is necessary to begin gathering pertinent information for both alternatives and assess their environmental effects early in the process to facilitate a timely completion of the selected project. The project master-planning schedule is provided in Section 9.0 of the Main Report. The schedule shows the key planning, design and environmental tasks required to complete the construction of the preferred alternative.

The process to complete the requirements of the EIAR and to satisfy the regulatory authorities concerned with the flood protection project is summarized below.

- **Scoping**

For reporting purposes, the scope of the project, including the project boundaries, will be clearly identified at the outset to ensure that confusion does not arise on the part of the proponent, the public, or the decision makers. In determining the scope of the project, the physical works that fall within the scope of the project, and undertakings in relation to those physical works will be considered.

Once the scope of the project has been determined, the scope of the assessment must be considered. The scope of the EIAR includes a determination of the environmental effects to be addressed, the scope of the environmental effects to be assessed, and the effects to be considered in making decisions regarding the project. Ultimately, determining the scope of the project and assessment (i.e., the things that will need to be considered in the EIAR) is the sole responsibility of the "Lead Party". However, the lead party will accommodate and consider the needs of the other regulator in the determination of the project scope. Assuming the lead party is the Province, they would work cooperatively with the federal party in determining the scope of the EIAR to ensure that the CEAA requirements are also met.

The scope of the project and assessment define the boundaries within which to complete the baseline studies.

- **Baseline Studies**

The gathering of background information outlining the condition of the existing environment is a necessary component of the EIAR. Baseline studies are important as environmental effects are stated as changes to the baseline environment caused by the project, and future inventories will be tied back to the baseline conditions. Baseline studies should commence as soon as possible for both preferred options to allow for more than one ' field season' to assess the existing environmental conditions. As regulatory authorities such as DFO generally expect several field seasons to assess aquatic conditions, failure to commence the baseline studies until after the alternative selection could ultimately delay the project while sufficient data are collected to satisfy the requirements of the regulatory bodies. It is therefore more time and cost effective to conduct baseline studies for both alternatives as early in the process as possible. Information requirements of the baseline studies are outlined in Section F.4.5.

A minimum of two years of baseline studies of environmental indicators and measurable environmental parameters will likely be necessary. Existing environmental information should be reviewed to allow for the identification of data gaps and deficiencies at the outset. Data gaps and deficiencies determined to be essential to the EIAR should be included in the baseline studies. The cost and timeline of baseline studies will depend upon the level of information that is required by the "Leading Agency" in consultation with federal and provincial departments including the Department of Fisheries and Oceans.

- **Public Participation Planning – Alternative Projects**

The original terms of reference for this study called for design of a public participation process that could assist in evaluating alternate flood control projects. The May 2001 Progress Report describes initial findings from this work, including a review of alternative scopes, approaches and key consideration for such a process. Among other things, this initial assessment found that the scope of flood protection alternatives covered would have a significant impact on the level of public participation required. Two scenarios were considered:

> ***Scenario 1 - Formal consideration of both a Ste. Agathe project and an expansion of the Floodway:*** This presumes that the preferred alternative is not clear-cut at the conclusion of this phase and a more formal public participation process, beyond the inputs received to date would be necessary before the selection could be made. Annex A describes a comprehensive and independent public participation process that could be applied to either scenario. Such a process would include public education, workshops for examining mitigation compensation options, and public hearings by an independent commission. The cost, time required and complexity of public participation would be significant. To be effective, a combination of public education, local stakeholder workshops to examine mitigation / compensation and project alternatives, and independent public hearings would be required. There would need to be strong engagement of residents from throughout the Red River flood zone, from the International Boundary to the outlet of the Red River at Lake Winnipeg.

Scenario 2* - *Formal consideration of more than one Floodway Expansion Option: This presumes that the results of the technical studies and the extent of public opinions and inputs received to this point in the planning process are adequate to allow the decision-makers to select the preferred alternative without undertaking a formal round of public consultations. Presumably, this would be the Floodway Expansion Alternative and only those issues associated with the scope and nature of the Floodway Expansion would need further resolution through a public participation process. The cost, time required and complexity of public participation would also be significant, but not as great as for Scenario 1. Impacts being considered would be less diverse than Scenario 1 reducing the amount of effort required.

Implementing a comprehensive and independent Public Participation Program, would include public education, workshops for examining mitigation / compensation options and public hearings by an independent commission. Such a process, which could be applied to either scenario, would require at least 12 to 14 months. A decision on a preferred project and scale of development would have to wait until this process would be completed. The associated delay would lengthen the period in which the city is exposed to risk of major flooding. In the interests of public safety, the Province of Manitoba is concerned that a public participation process focused on evaluating alternative projects would be overly time consuming and would delay expeditious planning, decision making and development of the Flood Protection Project. They have indicated that it is important to select a preferred alternative and scale as soon as possible, to expedite Project development.

Even without a Public Participation Program focused on evaluating alternatives, there will still be significant opportunity for public participation about the project during the environmental licensing process, as described in this Appendix. Interested parties will be able to comment and offer input on any aspect of project planning and impacts during the licensing public participation process. The environmental process will likely have to be longer and more elaborate, than would have been the case, if the issues of alternatives and scale had been addressed in a public participation process prior to the start of licensing.

- **Joint Panel Review**

In the event that there is significant public concern that cannot be mitigated reasonably through the public consultation process developed by the socioeconomic consultant, or if there is uncertainty as to whether significant adverse environmental effects will occur, a public hearing process could become necessary. Under the Canada-Manitoba Agreement on Environmental Assessment Cooperation a Joint Panel would be convened. The preliminary project schedule at this time assumes that a Joint Panel Review will not be necessary. Should a hearing become a requirement it may add at least six months to one year to the project schedule shown in Section 9.0 of the Main Report.

- **Environmental Impact Assessment Report**

Cooperation of the federal and provincial environmental processes will allow for the preparation of a Cooperative Environmental Assessment and a joint assessment and review process. A Project Administration Team (PAT) will be established to coordinate matters between the federal and provincial governments. The PAT will select a lead agency to oversee the assessment and set up a Technical Advisory Committee that will issue EIAR guidelines for the project. The EIAR Guidelines will incorporate the CEAA and Manitoba Conservation requirements for a Comprehensive Study such that federal and provincial processes are satisfied simultaneously. By initiating the process prior to an alternative being selected, it is anticipated that the EIAR Guidelines issued by TAC will encompass the scope of both alternatives. This will allow for early commencement to baseline studies and the EIAR such that the report can be completed and submitted for approval and licensing in a timely manner once the final project alternative has been selected.

- **Environmental Impact Assessment Preparation and Review**

The EIAR will be prepared and submitted to the proponent for review and comment. The report will also be subject to public review. If additional information is required it will be incorporated into the EIAR prior to submission for environmental licensing and approval.

- **License Application/Approval**

The completed EIAR for the selected alternative will be submitted to Manitoba Conservation for approval. Manitoba Conservation will also provide the EIAR to the Canadian Environmental Assessment Agency for transmission to the Lead Responsible Authority and approval by the Minister of Environment.

- **Additional Issues**

Potential environmental issues have also been identified associated with the Ste. Agathe Detention Structure flood control option that could add significant time to the approval process. Potential exists for elevated water levels in the Roseau River, possibly affecting individuals on the Roseau River First Nation. Potential also exists for an extended duration of flooding south of the U.S. border. Although the potential for these issues has been identified, resolution of the issues has not been considered as part of the preliminary project schedule at this time.

However, the responsible authorities determining the scope of the project and assessment to meet the requirements of CEAA at the outset may include these issues as CEAA requires the assessment of international and transboundary effects.

- **Preliminary Schedule**

The preliminary project master-planning schedule is described Section 9.0 in the Main Report. The anticipated schedule to complete the regulatory process for the City of Winnipeg Flood Protection Project assumes that the environmental approvals will follow funding approval and is outlined below.

Baseline Studies	Fall 2001 to February 2005
Project Selection	January 2002
Funding Approval	October 2002
Preparation of EIAR	October 2002 to July 2003
License Application/Approval	July 2003 to April 2004
Project Commitment	April 2004

F.2.2 GENERAL REQUIREMENTS OF THE ENVIRONMENTAL IMPACT ASSESSMENT REPORT

Manitoba Conservation has prepared general draft guidelines for the preparation of an Environmental Impact Assessment Report (EIAR) for flood control projects. Although specific guidelines for the EIAR will not be issued until an application for environmental approval has been submitted, at a minimum, it is anticipated that all components described below will be included in the EIAR. Requirements of the comprehensive study will also be incorporated into the EIAR to fulfil the federal environmental assessment requirements.

F.2.2.1 Project Description

The EIAR will describe the selected alternative in as much detail as possible and identify any potential effects on the environment that may result from project activities.

The project description will include, but not be limited to, a description of the following:

- Extent of clearing and earthworks for the flood control project and related developments;
- Methods used to clear the sites and dispose of the cleared vegetation and earth fill;
- Size of the reservoir(s) and volume of water to be stored;
- Volume of water to be diverted or held back and frequency of occurrence of diversion or retention;
- Proposed operation and maintenance procedures at the site(s);
- Location and type of access roads and related infrastructure;
- A timetable with respect to all developments and a plan for decommissioning the proposed facility.

The project description will also identify potential sources of effects on the environment. A list of potential sources of environmental effects associated with flood control projects includes:

- Any remaining exploration and planning activities related to the project;
- General influx of workers, equipment and materials;
- Clearing and site preparation required;
- Any maintenance or operational activities that potentially may affect the environment;
- Quarrying for materials to be used for construction purposes;

- The transportation, handling and disposal of any dangerous goods and hazardous materials;
- Construction of the physical components of the development; and
- Decommissioning of any or all of the project components.

F.2.2.2 Environmental Setting

The EIAR will provide an overview description of the existing biophysical and socioeconomic environment to demonstrate an understanding of the baseline conditions within which the development will occur.

Bio-physical Environment

The existing conditions of the biophysical environment will be described for the following environmental components:

- Air quality;
- Climate, topography and landforms;
- Surface or near surface geology, including mineral deposits;
- Soil types and depths;
- Distribution of vegetation types and any unique, rare or endangered plant species or plant communities;
- Location and classification of all surface waters;
- Groundwater regimes;
- Wildlife (including all invertebrate, reptile, amphibian, fish, bird and mammal populations, habitat and seasonal migration patterns, and rare or endangered species and their habitat);
- Aquatic resources (including fish and fish habitat; lower trophic levels; and streams, rivers, lakes, floodplains and their water quality and classification, if applicable);
- Human demographics and settlement patterns.

To the extent possible, environmental indicators will be identified and measurable parameters will be described quantitatively.

Socioeconomic Environment

The following existing conditions of the socioeconomic environment will be described:

- Industrial, resource extraction, agricultural and commercial activities;
- Rural, urban or recreational development (including property ownership and location of residences);
- Aboriginal lands and resource use;
- Recreational and aesthetic resources;
- Heritage resources (including sites or objects of archaeological, paleontological, historical or architectural value);
- Parks and ecological reserves, recreational or aesthetic resources and wildlife management areas;
- Roads, airstrips and railroads; and
- Local economies, infrastructure (including existing health care services) and community values.

F.2.2.3 Pre-Development Planning Review

Several measures for increased flood control capacity were investigated as part of the Flood Protection for Winnipeg study prepared for the International Joint Commission as follows:

- Raise Floodway bridges
- Remove East Embankment of Red River Floodway at Inlet
- Expand Red River Floodway
- Raise West Dike/Raise Red River Floodway Bridges
- Construct Ste. Agathe Detention Structure

- Improve City of Winnipeg Flood Protection Infrastructure
- Raise Primary Dikes
- Improve river channel downstream of Winnipeg
- Construct pump station at Floodway Inlet
- Construct Eastern Tributaries Diversion

From this study, the two preferred flood control alternatives - the Red River Floodway expansion and the Ste. Agathe Detention Structure - were identified as primary measures for further consideration.

The pre-development planning review will describe the extent of consideration and the weighting given to environmental issues during the deliberations over options for providing the desired level of flood control. The study area considered, the criteria used to select potential sites within the study area and any alternatives given consideration will be discussed.

F.2.2.4 Environmental Effects Assessment

Potential environmental effects will be identified and assessed to determine the potential impact of the project on the environment. Information on all of the environmental effects (both positive and negative) associated with the flood control project will be described. Potential adverse effects will be categorized as significant or insignificant, direct or indirect, and short or long term. The time frames within which the effects may occur and the magnitude and duration of the effects will also be described. The environmental effects will be related to and assessed with respect to all biophysical and socioeconomic components identified in the environmental setting.

The cumulative environmental effects of the project will also be assessed. This assessment will also consider the effects of other existing projects and projects planned in the study area.

F.2.2.5 Effects Mitigation

CEAA requires that mitigation measures be developed to address significant adverse effects. CEAA defines mitigation as the "elimination, reduction, or control of a project's adverse environmental effects, including restitution for any damage caused to the environment by such effects through replacement, restoration, compensation, or other means". As a Fisheries Act Authorization will likely be required for either flood control option, it should be noted that mitigation is defined differently under the Fisheries Act. Under the Fisheries Act, mitigation is meant to include measures that are undertaken to maintain fish habitat or to prevent residual damage to fish habitat at the project site or which occurs as a direct result of the project. Compensation is not considered to be mitigation under the Fisheries Act.

F.2.2.6 Residual Effects

In the event that potential effects are identified that cannot be prevented, eliminated or completely mitigated and no mitigation is contemplated, an explanation will be provided.

Anticipated residual effects will be described and categorized as significant or insignificant, direct or indirect, and short or long term. Compensation may be proposed where mitigation measures are not feasible.

F.2.2.7 Follow up

A follow-up program will be implemented to verify the accuracy of the environmental assessment (including measurable effects on environmental indicators and measurable parameters from the baseline study), and to determine the effectiveness of measures taken to mitigate the adverse effects of the project.

F.2.2.8 Public Input

The public involvement program will be described in detail. The results of completed public consultation programs for the project will be provided, and any plans for future public involvement, if applicable, will be identified.

F.2.2.9 Technical References

All conclusions of the EIAR will be backed up by credible technical information. The information will include:

- The credentials of the experts contributing to the EIAR and comprising the project's study team;
- Technical studies of similar facilities and processes which are operating elsewhere;
- Original studies performed by qualified engineers or scientists, commissioned by the proponent specific to the proposed development;
- Identification of facility design documents as prepared by qualified engineers as they become available; and
- Scientific reports and papers on topics relevant to the proposed development.

All null conclusions will be supported by credible analysis and documentation.

F.2.3 PRELIMINARY SCOPING

A preliminary scoping exercise was carried out for each flood control option to identify potential adverse and/or positive environmental effects that may occur as a result of each alternative and to identify areas that will require further investigation at the next level of study. A more detailed and rigorous scoping exercise will be conducted at the next stage of study. Simplified Project-Environment Interaction Matrices for each alternative, identifying potential environmental effects at different levels of study, are provided in Tables F-1 and F-2 and were used to identify the most significant environmental issues.

TABLE F-1
Preliminary Project-Environment Interaction Matrix
Proposed Floodway Expansion

ENVIRONMENTAL COMPONENTS AND POTENTIAL EFFECTS	STAGE OF PROJECT	
	CONSTRUCTION	OPERATION
Physical and Chemical Effects		
Water		
Modified groundwater flows and watertable	●	●
Surface flow variation	●	●
Water quality changes	●	●
Streams (physical and chemical changes)	●	●
Modifications to ice regime		●
Soil		
Decreased soil stability and increased erosion	●	
Disturbance of unique physical features	●	
Changes to relief and topographic character	●	
Air		
Increased noise	●	
Increased air emissions	●	
Biological Effects		
Alteration of terrestrial habitats	●	●
Disturbance to terrestrial wildlife	●	●
Disturbance to riparian wildlife	●	
Loss of fish/aquatic habitats	●	
Disturbance to fish/aquatic wildlife	●	●
Disturbance to protected species (vegetation predominantly)	●	

TABLE F-1 (CONTINUED)
Preliminary Project-Environment Interaction Matrix
Proposed Floodway Expansion

ENVIRONMENTAL COMPONENTS AND POTENTIAL EFFECTS	STAGE OF PROJECT	
	CONSTRUCTION	OPERATION
Social, Economic and Cultural Effects		
Loss of agricultural and commercial resource use		
Alterations to domestic resource use	●	●
Disturbance to outdoor recreation/tourism	●	❍
Risk to community health and safety	●	❍
Benefits to local economic well being		❍
Benefits to local social well being		❍
Alteration of aesthetics	●	
Disturbance to archeaological/historic resources	●	

Legend:

● potential adverse effect

❍ potential positive effect

Note: Socioeconomic effects will be considered either positive or negative depending upon where an individual lives. The potential effects are considered for individuals within four separate ‘ zones’ as discussed separately in Section F-3.

Planning/design effects will be associated with necessary geotechnical site investigaiton that will preceed the construction.

TABLE F-2
Preliminary Project-Environment Interaction Matrix
Ste. Agathe Detention Structure

ENVIRONMENTAL COMPONENTS AND POTENTIAL EFFECTS	STAGE OF PROJECT	
	CONSTRUCTION	OPERATION
Physical and Chemical Effects		
Water		
Decreased groundwater flows and watertable		
Surface flow variation	●	●
Water quality changes	●	●
Streams (physical and chemical changes)	●	●
Modifications to ice regime		●
Soil		
Decreased soil stability and increased erosion	●	●
Disturbance of unique physical features	●	●
Changes to relief and topographic character	●	●
Air		
Increased noise	●	
Increased air emissions	●	
Biological Effects		
Alteration of terrestrial habitats	●	
Disturbance to terrestrial wildlife	●	●
Disturbance to riparian wildlife	●	●
Loss of fish/aquatic habitats	●	●
Disturbance to fish/aquatic wildlife	●	●
Disturbance to protected species (vegetation predominantly)	●	●

TABLE F-2 (CONTINUED)
Preliminary Project-Environment Interaction Matrix
Ste. Agathe Detention Structure

ENVIRONMENTAL COMPONENTS AND POTENTIAL EFFECTS	STAGE OF PROJECT	
	CONSTRUCTION	OPERATION
Social, Economic and Cultural Effects		
Loss of agricultural and commercial resource use		●
Alterations to domestic resource use		
Disturbance to outdoor recreation/tourism	●	●
Risk to community health and safety	●	● ❍
Benefits to local economic well being		● ❍
Benefits to local social well being		●
Alteration to aesthetic values	●	●
Disturbance to archeaological/historic Resources	●	

Legend:

● potential adverse effect

❍ potential positive effect

Note: Socioeconomic effects will be considered either positive or negative depending upon where an individual lives. The potential effects are considered for individuals within four separate ‘ zones’ as discussed separately in Section F-3.

Planning/design effects will be associated with necessary geotechnical site investigaiton that will preceed the construction.

Potential adverse or positive physical, biological and socio-economic effects were identified that will require further investigation. As preliminary investigations to date indicate that public concern and socio-economic effects will play a large role in the overall project selection, they are discussed separately in Section F.3.

Although many biophysical components of the environment were identified that may potentially be affected by either alternative's activities, potential effects that were judged as warranting additional attention at this early development stage are described below.

- As a large number of residents utilize groundwater for domestic supply, the potential effects of modified groundwater flows and water table elevation are an important consideration for the floodway expansion alternative.
- It is also likely that a Fisheries Act Authorization will be required for either flood protection option. As a great level of effort can be necessary to meet the Department of Fisheries and Oceans information needs, it is important to identify project activities that could result in a harmful alteration, disturbance or destruction of fish habitat as early in the project development as possible.

The potential effects of the project activities on groundwater flows and elevations, and aquatic habitat are discussed in Section F.4. All potential effects will be identified and evaluated further in the next level of study.

F.2.4 APPLICABLE LEGISLATION

The following Acts and Regulations may apply to both project alternatives:

Federal

- The Canadian Environmental Assessment Act and Regulations
- Fisheries Act
- Transportation of Dangerous Goods Act and Regulations
- Navigable Waters Protection Act and Regulation
- International Rivers Improvement Act and Regulation (Roseau River)

Provincial

- The Dangerous Goods Handling and Transportation Act and Regulations
- The Endangered Species Act
- The Environment Act
- The Fire Prevention Act
- The Manitoba Heritage Resources Act
- The Manitoba Noxious Weeds Act
- The Manitoba Nuisance Act
- The Public Health Act
- The Workplace Safety and Health Act

The extent that the above Acts are applicable to both project alternatives will be assessed in the next level of study.

F.3 SOCIO-ECONOMIC CONSIDERATIONS

This section examines the socio-economic implications of the Floodway Expansion and the Ste. Agathe Detention Structure for the Red River Flood Zone. The purpose of this analysis is to provide insight into the magnitude and distribution of socio-economic effects of flood protection and project induced flooding produced by the alternatives. The analysis is organized into the following sub-sections:

- **F.3.1 Study Area Characterization**: Details the municipalities included in the study area and provides an overview of their socio-economic characteristics.
- **F.3.2 Methods and Presentation Framework For Evaluating Socio-Economic Effects:** Provides a discussion of the quantitative and qualitative methods and indicators used to evaluate the socio-economic effects of flooding.
- **F.3.3 Overview of Socio-Economic Effects of Alternatives:** Establishes the Existing Floodway as a baseline for the comparison of the alternatives and reviews the different scenarios used to evaluate the effects of flooding.
- **F.3.4 Socio-Economic Effects of the Floodway Expansion:** Presents the results of the analysis of the socio-economic effects of the Floodway Expansion compared to the Existing Floodway.
- **F.3.5 Socio-Economic Effects of the Ste. Agathe Detention Structure:** Discusses the analysis of the socio-economic effects of the Ste. Agathe Detention Structure compared to the Existing Floodway. Because of the concern about project induced flooding, this section also includes a discussion of possible mitigation measures, compensation mechanisms and legal issues associated with the Ste. Agathe Detention Structure.
- **F.3.6 Additional Perspectives on Socio-Economic Effects of Flooding:** Presents additional information on the effects of flooding noted during the course of the study.

F.3.1 STUDY AREA CHARACTERIZATION

The socio-economic study area extends on both sides of the Red River from the Canada-U.S. border north to Lake Winnipeg. The impact of the alternatives on people varies in different areas of the flood zone. These differences have an important bearing on the comparative socio-economic impacts of the alternatives and their acceptability to people in different parts of the flood zone. In order to recognize and illustrate these differences, the study area has been broken into the following four impact zones:

- **Zone 1**: Upstream of Ste. Agathe Detention Structure;
- **Zone 2**: Ste. Agathe Detention Structure to Floodway Inlet;
- **Zone 3**: Winnipeg and Surroundings;
- **Zone 4**: Downstream of Floodway Outlet.

Plate F-1 shows the general location of the four zones. For convenience, the zones are referenced by their number rather than their description on this map and also in the remainder of this section. Table F-3 lists the municipalities included in each zone. The table also presents a summary of some basic socio-economic characteristics of each zone. Some R.M.'s have been split between Zone 1 and Zone 2 to account for the fact that portions of the municipality lie upstream of the proposed Ste. Agathe Detention Structure while other portions lie downstream. The total area of all the potentially impacted R.M.'s has been included because flood event response affects the entire municipality. While some lands not physically impacted by flooding in any flood scenario are included in the socio-economic study area, they are not included in the quantification of flood impacts presented.

TABLE F-3
Study Area Socio-Economic Characteristics – 1996

ZONES	AFFECTED COMMUNITIES	POPULATION		NUMBER OF PRIVATE OCCUPIED RESIDENCES	AVERAGE VALUE OF OWNED OCCUPIED RESIDENCES	NUMBER OF CENSUS FARMS
		1991 CENSUS	1996 CENSUS	1996 CENSUS	1996 CENSUS	1996 CENSUS
Zone 4	100% R.M. of St. Clements 100% R.M. of St. Andrews 100% Town of Selkirk	27,109	28,541	10,195	$106,234	579
Zone 3	100% City of Winnipeg 100% R.M. of E. St. Paul 100% R.M. of W. St. Paul	624,693	628,634	249,395	$96,884	193
Zone 2	100% R.M.of Springfield 100% R.M. of Tache 90% R.M. of Ritchot 60% R.M. of MacDonald 10% R.M. of Hanover 100% Town of Niverville	28,130	30,801	9,671	$111,881	1,220
Zone 1	100% R.M. of Rhineland 100% R.M. of Montcalm 100% R.M. of Franklin 100% R.M. of DeSalaberry 100% R.M. of Morris 90% R.M. of Hanover 40% R.M. of MacDonald 10% R.M. of Ritchot 100% Town of Morris 100% Town of Emerson 100% Village of St. Pierre-Jolys 100% Roseau River #2 First Nation	26,609	28,498	8,673	$93,507	2,174

Source: InterGroup Consultants Ltd. from Statistics Canada, 1991 and Statistics Canada, 1996.

F.3.2 METHODS AND PRESENTATION FRAMEWORK FOR EVALUATING SOCIO-ECONOMIC EFFECTS

The extent of flooding and flood protection afforded by a flood control structure directly affects the socio-economic effects associated with that structure. The traditional damage-dollar estimates presented in Appendix B and Appendix C provide a useful initial impression of the severity of potential flood damage for different flood events and flood control structures, but are not the most effective way of demonstrating how the structures affect people. Considerable effort was directed towards developing a framework for presenting the findings of the socio-economic analysis. The framework that is used in the study incorporates the following factors deemed to be important in understanding and comparing the effects of the alternatives:

- **Existing flood protection as a baseline**. The level of protection and degree of flooding that occur under the existing flood condition are the appropriate starting point for determining the effects of the proposed alternatives. Operation of the proposed alternatives will add to the degree of protection and reduce the level of flooding relative to the Existing Floodway and dike system. There may also be backwater effects that add to upstream flooding. The contributions of the proposed control measures are best understood by comparing their protection and flooding levels with those of the existing flood control system.

- **Flood event differences**. The severity of the flood event will have a significant bearing on the degree of protection and flooding associated with each alternative. More importantly, it will influence the comparison of the alternatives. This comparison is made for four flood events to assess how differences in severity of flooding affects each alternative and its performance. The flood events examined are:

    - the 1 in 90 year flood, similar to the 1997 flood;
    - the 1 in 300 year flood, similar to what has been commonly associated with the 1826 flood;
    - the 1 in 500 year flood;
    - the 1 in 1000 year flood, representing an event that has a reasonably small probability of being exceeded in the next 50 to 100 years.

- **Impact zone differences**. The effects of the alternatives can be substantially different within and between the four impact zones. This has a key influence on the comparative socio-economic effects of the alternatives.

- **Comparison of proposed alternatives**. Each alternative offers different levels of protection and flooding. Understanding the similarities and differences of effects provides the basis for comparing the alternatives.

Once the framework for the comparison of the alternatives was established, attention was directed toward understanding the socio-economic effects of flooding. In order to provide an understanding of the socio-economic effects of each alternative, three analyses were undertaken:

- **Quantitative Indicator Analysis:** The degree of flood protection and project induced flooding resulting from the operation of each structure was estimated for four key socio-economic indicators. While other indicators known to be of potential relevance could not be analyzed because of study constraints, the four presented provide a useful picture of the primary socio-economic implications of the control structure.

- **Qualitative Indicator Analysis:** The study identified less easily measured, but often more important, economic and social effects of flooding, the alternative structures, and measures to manage flood impacts on property owners and residents before, during and after a flood event. A ‘ key person’ interview program was conducted, interviewing people from a variety of backgrounds, communities and organizations within the study area with experience and knowledge in dealing with Red River flood issues. Information received from these key persons has been used to identify areas of public concern and methods for improving the benefits of the projects while mitigating the costs.

- **Legal Analysis:** Legal implications of land requirements for the structures and project induced flooding on private and First Nation lands were identified through legal analysis provided by Manitoba Justice and an independent legal opinion produced specifically for this study.

The methods used in the quantitative analysis of key socio-economic indicators and in qualitative indicator analysis, including the key person interview program, are described below.

F.3.2.1 Quantitative Indicator Analysis – Key Socio-Economic Indicators

KGS Group previously developed a depth-damage model to estimate structural, agricultural and infrastructure damages (KGS Group, 2000) for the region from the Canada-U.S. border to the Floodway Inlet (Zones 1 and 2). In addition to providing a dollar damage estimate, the model could also be queried to provide estimates of other indicators of socio-economic impacts. Assessment of impacts for Zone 3 (Winnipeg and surrounding area) included a similar depth-damage model assessment, although not with the same degree of detail as the analysis prepared for Zones 1 and 2. A Zone 4 damage analysis was influenced by the quality of the topographical data. Appendix A, Section A.3 describes the process for determining impacts on properties downstream of Winnipeg.

Residences Affected

The depth-damage model was queried to return the number of single unit and multi-unit residential buildings in each rural municipality (R.M.) or incorporated municipality. Cottages and guesthouses were excluded from the query. The results were compared to the number of occupied residential structures reported in the 1996 Census of Canada for each incorporated municipality. The estimates were found to correspond within a tolerable range of the Census figures.

The model was then queried to provide the number of flood-damaged residences for each municipality. Residences were tracked according to three classes of flood depths:

- Basement flooding only;
- First floor flooded up to 2 ft.;
- First floor flooded to greater than 2 ft.

These flood depth classes were chosen because they represent significant points on the depth-damage curve. The number of flood damaged residences in each incorporated community was aggregated to provide estimates of flood damaged residences in each zone. For three R.M.'s, Hanover, MacDonald and Ritchot, residences were separated into Zone 1 and Zone 2 based upon their geographic location within the zone. An approximate location of the proposed Ste. Agathe Detention Structure was determined for each of these R.M.'s. Residences located north of this point were presumed to be located in Zone 2 and residences south of this point were presumed to be located in Zone 1.

Impacted residences for Zones 3 and 4 were estimated from a manual review of topographic maps, aerial photographs, tax assessment data for affected areas and other sources of data (See Appendix A, Section A.3). For these zones, it was not possible to estimate the depth of flooding for each impacted residence because the accuracy of existing topographic mapping of the area is not adequate to permit a reasonable approximation of this information. The affected number of residences in the Winnipeg to Lockport reach of the river is not available. It is believed, however, to be similar in magnitude to that shown for the area north of Lockport.

Residents Affected

Estimates of the number of residences affected served as the basis for estimating the number of impacted residents. For Zones 1, 2 and 4, population estimates from the 1996 Census of Canada were compared to the 1999 Manitoba Health Population Report and found to be similar for most incorporated communities. The 1996 Census statistics were used to derive an average population per private inhabited dwelling for each community. These figures were used to convert the number of single unit residences affected into number of residents (people living in residences) affected. A modified figure was used for multi-unit residences. Multi-unit residences accounted for only a small (less than 3%) proportion of the impacted residences in these zones.

In Zone 3, multi-unit residences accounted for a much larger proportion of the total number of residences affected. For the City of Winnipeg, impact population estimates were developed using 1996 Census data to determine total population by City of Winnipeg Ward district. As the depth-damage model provides an indication of buildings that are affected by flooding, estimates of the number and size of multi-unit residential dwellings (apartments, condominiums) were developed using 1996 Census data, City of Winnipeg tax assessment data, Canada Housing and Mortgage Corporation information, and direct communication with the Professional Property Managers Association. This resulted in an average number of suites per unit within Winnipeg and an average number of residents per suite. The inundation depth-damage model estimates were overlaid with this multi-unit dwelling information and Census data to determine the number of residences affected. People who are affected by flooding of these residences were then derived based on average number of residents per household/suite. While more detailed information and analysis would have enhanced the accuracy of the estimate of the total number of residents affected, it is not believed that this would have significantly impacted the results of the comparison of the alternatives.

Agricultural Area Affected

Flooding affects many farming operations in the Red River Valley and large areas of farmland cannot be protected by flood control measures. The depth-damage model was queried to return the total parcel area flooded for each scenario. In some instances, interpolations based on Existing Floodway information were used to estimate impacted agricultural land areas for the Ste. Agathe Detention Structure and Expanded Floodway scenarios. Total parcel area flooded in Zones 1 and 2 is used as an indicator of the severity of the agricultural impacts for each scenario. It is important to note that this analysis considers distribution of flooding (increased water levels) but not increased duration of flooding, which has direct relevance to agricultural activities.

Roads Affected

The loss of access caused by flooded roads is another key indicator of the socio-economic impacts of flooding. Many communities and businesses that do not experience direct flooding are impacted by road closures. The length of roads flooded in Zones 1 and 2 for each scenario is used as an indicator of these impacts. Because of the limited amount of detailed information available, development of similar indices for Zones 3 and 4 was not possible. It would be expected that road infrastructure impacts on Winnipeg would be orders of magnitude greater than those determined in Zones 1 and Zone 2.

All of these indicators are based upon engineering models of the distribution, depth and duration of flooding. Assumptions and limitations associated with the engineering models will also apply to the socio-economic indicator estimates. The estimates presented in this report are not intended as statistically robust predictions of actual flood effects under any scenario. Rather, they are used to identify potential areas of impact and as a comparison of the severity of those impacts under a variety of flood water levels and flood protection scenarios.

F.3.2.2 Qualitative Indicator Analysis

In addition to having physically related consequences, flood damage and the threat of flood damage are sources of stress and anxiety for property owners and residents. Stress and anxiety are important impacts and often serve as indicators of the severity of a flood event. A review of the literature on this topic reveals that, for residents and property owners, primary sources of stress from a flood event are the potential and actual damages to people and property. The frequency of flooding and socio-economic characteristics such as the financial resources, physical health, gender, age and type of property owned by residents can influence the amount of stress and anxiety associated with a given flood event. People engaged in event response and fighting the rising waters are also subject to stress and anxiety. Decision-makers and emergency service providers such as municipal officials, provincial agency representatives, federal agency representatives and the staff of non-profit organizations experience stress from the demands of their duties during flood events. A list of literature reviewed is included in the References section at the end of this Appendix.

Stress and anxiety are not as readily measured as damages to people and property. In order to build a consideration of these more qualitative flood effects into the comparison of the alternatives, a key person interview (KPI) program was undertaken as part of the study. The purpose of the study and the methodology are discussed below.

Key Person Interviews

A Key Person Interview (KPI) program was conducted in June and July of 2001 to obtain perspectives and insights from experienced and knowledgeable local persons about topics of relevance to this study. Twenty-six community representatives and leaders from government, business and community service organizations from all four impact zones were interviewed using a structured interview instrument. Interviewees were asked a series of questions about their experiences with the 1997 flood and their understanding or perception of impacts that may be associated with the two proposed flood control alternatives. Participants were asked to identify positive and negative socio-economic impacts and to comment on possible mitigation measures. Interview notes were summarized and compiled into a summary report. The objectives, method, interview guide and findings of the KPI program are described in detail in Annex B: Key Person Interviews Program Working Paper.

The key person interviews yielded valuable information about local concerns and sensitivities related to flood impacts, management of flood impacts, implications of the flood control alternatives, mitigation measures, compensation mechanisms and public participation in project-related decisions. Comments and concerns noted during the interviews have been incorporated into the analysis of flood effects presented later in this section. These comments are presented to demonstrate the range of perspectives that residents in the socio-economic study area have about the flood protection alternatives and may not necessarily be consistent with analysis presented in other sections of this report.

F.3.3 OVERVIEW OF SOCIO-ECONOMIC EFFECTS OF ALTERNATIVES

Socio-economic effects flow directly from the degree of flood protection and project induced flooding resulting from the operation of the two proposed structures. This section summarizes what is known to date about the two alternatives. Table F-4 presents a qualitative overview of flood protection and project induced flooding associated with the operation of each alternative:

- in comparison to the Existing Floodway,
- for the four impact zones, and
- for the four flood events examined in this study.

A qualitative description of the effects of the Floodway Expansion and the Ste. Agathe Detention Structure compared to the Existing Floodway is included below.

TABLE F-4
Ste. Agathe and Floodway Expansion Options Compared to the Existing Floodway

		Existing Floodway	Ste. Agathe Detention Structure		Floodway Expansion	
	Flood Frequency	Comments	Comparison	Comments	Comparison	Comments
Upstream of Canada-US Border	1 in 90	Protected to Design Level	=		=	
	1 in 300	Design Level protection breached	☒	**Backwater Effect**[1]	=	
	1 in 500	Design Level protection breached	☒	**Backwater Effect**	=	
	1 in 1000	Design Level protection breached	☒	**Backwater Effect**	=	
Zone 1 Upstream of Ste. Agathe Detention Structure	1 in 90	Protected to Design Level	=		=	
	1 in 300	Design Level protection breached	☒	**Backwater Effect**[1], ↑ duration	=	
	1 in 500	Design Level protection breached	☒	**Backwater Effect** ↑ duration	=	
	1 in 1000	Design Level protection breached	☒	**Backwater Effect** ↑ duration	=	
Zone 2 Ste. Agathe Detention Structure to Floodway Inlet	1 in 90	Protected to Design Level	=		= ☑	If changes to operating rules made
	1 in 300	Design Level protection breached	☑	↑ duration, levels at Existing Floodway 1:90	☑	Eliminates Backwater Effect
	1 in 500	Design Level protection breached	☑	↑ duration, levels at Existing Floodway 1:90	☑	Eliminates Backwater Effect
	1 in 1000	Design Level protection breached	☑	↑ duration, levels at Existing Floodway 1:90	=	Reduced Backwater Effect
Zone 3 Winnipeg and Surroundings	1 in 90	Protected to Design Level	=		=	
	1 in 300	Design Level protection breached	☑	↑ duration, levels at Existing Floodway 1:90	☑	
	1 in 500	Design Level protection breached	☑	↑ duration, levels at Existing Floodway 1:90	☑	
	1 in 1000	Design Level protection breached	☑	↑ duration, levels at Existing Floodway 1:90	=	
Zone 4 Downstream of Floodway Outlet	1 in 90	Protected to Design Level	=		=	
	1 in 300	Design Level protection breached	☑	↑ duration, levels at Existing Floodway 1:90	=	
	1 in 500	Design Level protection breached	☑	↑ duration, levels at Existing Floodway 1:90	=	
	1 in 1000	Design Level protection breached	☑	↑ duration, levels at Existing Floodway 1:90	=	

Legend: ☑ better than
= equal to
☒ worse than

Notes: (1) Backwater effect related to the Ste. Agathe Detention Structure could result in the requirement for incremental mitigation, permits, and/or damage compensation
Depth: depth of flooding
Duration: length of time of flooding
Distribution: lateral extent of flooding

Source: InterGroup Consultants Ltd. From KGS flood data. 2001

<u>Overview of Floodway Expansion</u>

Zone 1: Upstream of Ste. Agathe Detention Structure

- Under existing conditions, this zone is substantially protected to approximately the 1 in 90 year flood.
- The Floodway Expansion would result in the same flood conditions as with the Existing Floodway in this zone for all flood events.

Zone 2: Ste. Agathe Detention Structure to Floodway Inlet

- Under existing conditions, this zone is substantially protected to approximately the 1 in 90 year flood.
- Parts of this zone can experience backwater effects with the operation of the Existing Floodway.
- The Floodway Expansion significantly reduces the backwater effect associated with the Existing Floodway for all flood scenarios considered in the socio-economic section of this study resulting in additional protection to residents in this Zone.
- The Floodway Expansion provides the same or better level of protection as the Existing Floodway for all floods up to the 1 in 1000 year flood.

Zone 3: Winnipeg and Surrounding Areas

- Under existing conditions, this zone is substantially protected to approximately the 1 in 90 year flood.
- The Floodway Expansion provides a greater level of protection to this zone for all floods greater than approximately the 1 in 90 year flood.

Zone 4: Downstream of Floodway Outlet

- It is likely that flood events greater than the 1 in 90 year level would result in some flooding in this zone.
- The Floodway Expansion would slightly increase the water levels for floods greater than 1 in 90 years. Further explanation of this is provided in Appendix A.

Overview of Ste. Agathe Detention Structure

Zone 1: Upstream of Ste. Agathe Detention Structure

- At the 1 in 90 year flood level, flooding levels would be the same in this zone for both the Ste. Agathe Detention Structure and the Existing Floodway. A backwater effect is not present under the 1 in 90 year flood.
- The Ste. Agathe Detention Structure creates backwater effects and project induced incremental flooding in this zone for flood events exceeding the 1 in 90 year level.
- The Ste. Agathe Detention Structure increases the depth and duration of flooding in this zone for flood events greater than the 1 in 90 year flood.

Zone 2: Ste. Agathe Detention Structure to Floodway Inlet

- In the event of floods larger than the 1 in 90 year flood, the Ste. Agathe Detention Structure would be operated to maintain flood depth and distribution at approximately the 1 in 90 year level. This results in additional flood protection throughout the zone over existing conditions.
- The Ste. Agathe Detention Structure maintains water levels at the 1 in 90 year level in this zone for all floods up to the 1 in 1000 year level.
- The duration of flooding is increased in this zone compared to the Existing Floodway.

Zone 3: Winnipeg and Surrounding Areas

- The Ste. Agathe Detention Structure provides improved protection compared to the Existing Floodway beginning at approximately the 1 in 90 year flood level.
- The Ste. Agathe Detention Structure maintains water levels at the 1 in 90 year level for all flood events up to the 1 in 1000 year level. The duration of flooding is increased compared to the Existing Floodway.

Zone 4: Downstream of Floodway Outlet

- The Ste. Agathe Detention Structure provides additional flood protection to this zone compared to the Existing Floodway beginning at the 1 in 90 year flood level.
- The duration of flooding is increased in this zone compared to the Existing Floodway.

Comparison of Floodway Expansion and Ste. Agathe Detention Structure

Table F-5 compares the effects of the Ste. Agathe Detention Structure to the effects of the Floodway Expansion for each zone. Key points of these comparisons are presented below. For reference, Plates C-6 to C-14 in Appendix C show the distribution of flooding for each alternative under various flood events.

Zone 1: Upstream of Ste. Agathe Detention Structure

- Beginning at approximately the 1 in 90 year flood event, the Ste. Agathe Detention Structure increases both the depth and duration of flooding for this zone compared to the Floodway Expansion.

Zone 2: Ste. Agathe Detention Structure to Floodway Inlet

- Both the Floodway Expansion and the Ste. Agathe Detention Structure provide increased protection to this Zone compared to the Existing Floodway.
- However, the Ste. Agathe Detention Structure results in a higher degree of protection, both in terms of preventing flood damage and reducing the level of damage, than the Floodway Expansion for this Zone.
- The Ste. Agathe Detention Structure increases the duration of flooding compared to the Expanded Floodway.

Zone 3: Winnipeg and Surrounding Areas

- For the 1 in 90 year to the 1 in 700 year flood levels, the Ste. Agathe Detention Structure and Floodway Expansion provide approximately the same level of flood protection up to the 1 in 700 year level for Floodway Expansion compared to the 1 in 1000 year level for the Ste. Agathe Detention Structure.
- The Ste. Agathe Detention Structure results in increased flood duration in this zone for all flood events greater than 1 in 90 year and up to the 1 in 1000 year design flood compared to Floodway Expansion.

Table F-5
Ste. Agathe and Floodway Expansion Options Compared to Each Other

	Flood Frequency	Ste. Agathe Detention Structure		Floodway Expansion	
		Comparison	Comments	Comparison	Comments
Upstream of Canada-US Border	1 in 90	=		=	
	1 in 300	☒	↑ duration, **Backwater Effect** [1]	☑	
	1 in 500	☒	↑ duration, **Backwater Effect**	☑	
	1 in 1000	☒	↑ duration, **Backwater Effect**	☑	
Zone 1 Upstream of Ste. Agathe Detention Structure	1 in 90	=		=	
	1 in 300	☒	↑ duration, distribution, depth, **Backwater Effect** [1]	☑	
	1 in 500	☒	↑ duration, distribution, depth, **Backwater Effect**	☑	
	1 in 1000	☒	↑ duration, distribution, depth, **Backwater Effect**	☑	
Zone 2 Ste. Agathe Detention Structure to Floodway Inlet	1 in 90	=		= ☑	Changes to Operating Rules required
	1 in 300	☑	↑ duration	☒	
	1 in 500	☑	↑ duration	☒	
	1 in 1000	☑	↑ duration	☒	
Zone 3 Winnipeg and Surroundings	1 in 90	=		=	Possible Benefits if Operating Rules Changed
	1 in 300	=	↑ duration	=	
	1 in 500	=	↑ duration	=	
	1 in 1000	☑	↑ duration	☒	
Zone 4 Downstream of Floodway Outlet	1 in 90	=		=	
	1 in 300	☑	↑ duration	☒	
	1 in 500	☑	↑ duration	☒	
	1 in 1000	☑	↑ duration	☒	

Legend: ☑ better than
= equal to
☒ worse than

Notes: (1) Backwater effect related to the Ste. Agathe Detention Structure could result in the requirement for incremental mitigation, permits, and/or damage compensation
Depth: depth of flooding
Duration: length of time of flooding
Distribution: lateral extent of flooding

Source: InterGroup Consultants Ltd. From KGS flood data. 2001

Zone 4: Downstream of Floodway Outlet

- For floods greater than the 1 in 90 year level, the Ste. Agathe Detention Structure would maintain flood depth and distribution at the 1 in 90 year level. The Floodway Expansion results in higher water levels in this zone for all floods up to the 1 in 1000 year flood.
- The Ste. Agathe Detention Structure increases the duration of flooding in this zone for all flood events larger than the 1 in 90 year flood and up to the 1 in 1000 year design flood, compared to Floodway Expansion.

A more detailed discussion of the quantitative and qualitative socio-economic effects of flooding is contained in the following sections. Section F.3.4 discusses the socio-economic effects of the Floodway Expansion compared to the Existing Floodway for the four flood events and four impact zones. Section F.3.5 includes a similar discussion on the effects of the Ste. Agathe Detention Structure. Because considerable concern related to project induced flooding associated with the Ste. Agathe Detention Structure has been noted, Section F.3.5 also includes a discussion of mitigation and compensation options. Section F.3.6 provides additional perspectives on socio-economic effects of flooding noted during the review of the literature and the key person interviews. A comparison of the socio-economic effects of the Floodway Expansion and the Ste. Agathe Detention Structure is contained in the Main Report.

F.3.4 SOCIO-ECONOMIC EFFECTS OF THE FLOODWAY EXPANSION

This section reviews the socio-economic effects of the Floodway Expansion. It compares the extent of flooding that occurs with the Floodway Expansion with the Existing Floodway for the four key socio-economic variables. It also provides estimates of incremental or additional protection afforded by the Floodway Expansion using the Existing Floodway as a baseline. Specifically this section covers:

Residences Affected: Total number of residences flooded are summarised in Table F-6 and depicted in Figures F-1 to F-4 for the four flood scenarios (1 in 90 year, 1 in 300 year, 1 in 500 year and 1 in 1000 year) and the four zones.

Residents Affected: Table F-7 and Figures F-5 to F-8 display the estimated number of residents who experience some degree of flooding.

Agricultural Area Affected: Figure F-9 shows the amount of agricultural land flooded in Zones 1 and 2.

Roads Affected: The length of flooded roads for Zones 1 and 2 is shown in Figure F-10.

Zone by Zone Impacts: This section presents highlights from the tabular and graphical material and key person interviews for each zone, including key information related to:

- the extent of flooding;
- the analysis of the key socio-economic indicators; and
- additional protection afforded by the Floodway Expansion beyond the Existing Floodway.

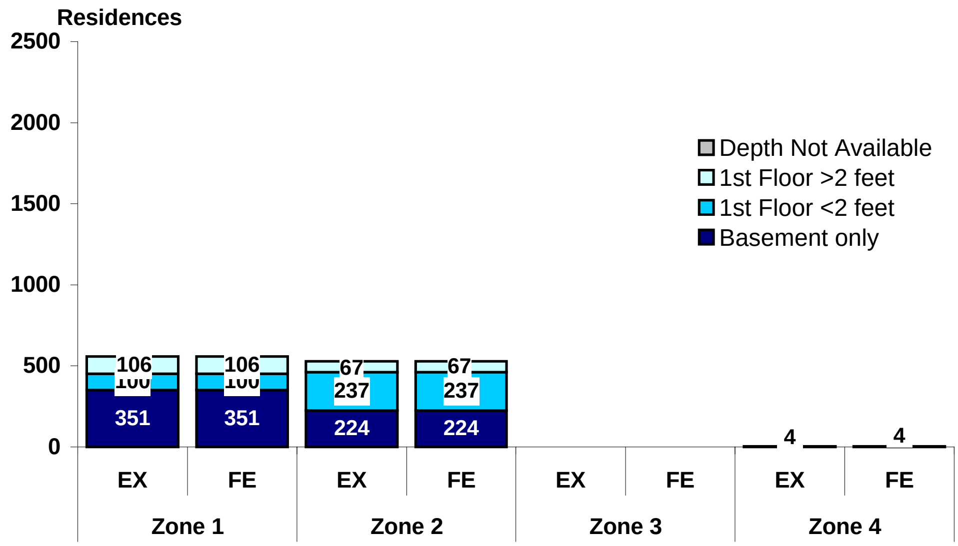
Where effects on the City of Winnipeg are presented graphically, two graphs are used, one with an exact scale to indicate the relative magnitude of the impacts on each zone and another with an altered scale to illustrate in more detail the impacts on Zones 1 and 2.

TABLE F-6
Estimated Number of Flooded Residences by Zone
Existing Floodway and the Floodway Expansion

Zones	1 in 90 Year Flood		1 in 300 Year Flood	
	Existing Floodway	Floodway Expansion	Existing Floodway	Floodway Expansion
Zone 1: Upstream of Ste. Agathe	557	557	732	732
Zone 2: Ste. Agathe to Floodway Inlet	528	528	2,228	1,623
Zone 3: City of Winnipeg and Surrounding Area	-	-	102,000	-
Zone 4: Downstream of Floodway Outlet	4	4	46	46
Total	**1,089**	**1,089**	**105,006**	**2,401**

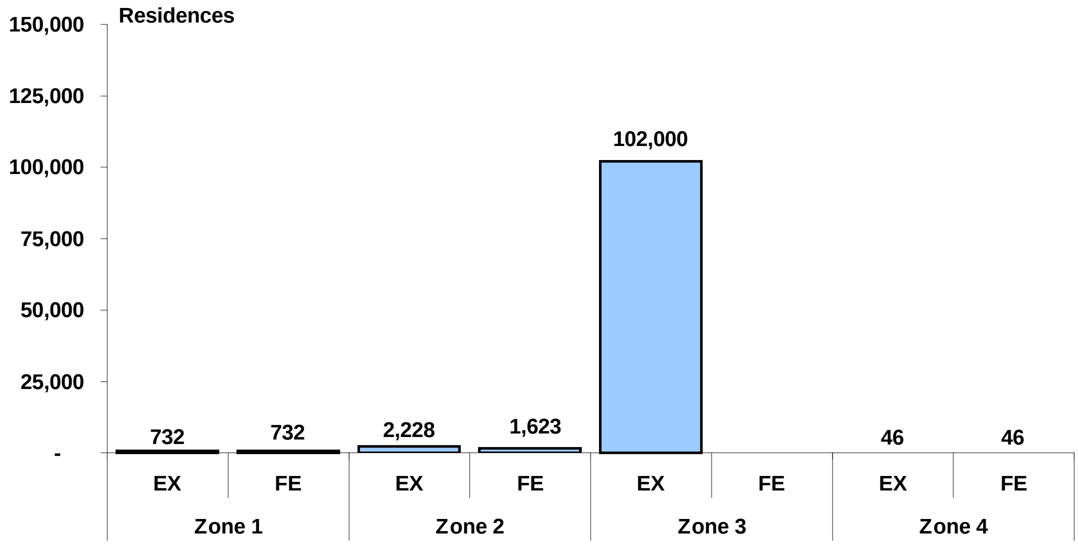
Zones	1 in 500 Year Flood		1 in 1000 Year Flood	
	Existing Floodway	Floodway Expansion	Existing Floodway	Floodway Expansion
Zone 1: Upstream of Ste. Agathe	795	795	1,991	1,991
Zone 2: Ste. Agathe to Floodway Inlet	2,234	2,171	2,243	2,243
Zone 3: City of Winnipeg and Surrounding Area	125,000	-	145,000	130,000
Zone 4: Downstream of Floodway Outlet	80	80	100	100
Total	**128,109**	**3,046**	**149,334**	**134,334**

Source: InterGroup Consultants Ltd. from KGS Depth-Damage Model, 2001.
Note: Assumes stable water conditions. Makes no provision for wave action due to wind effect.



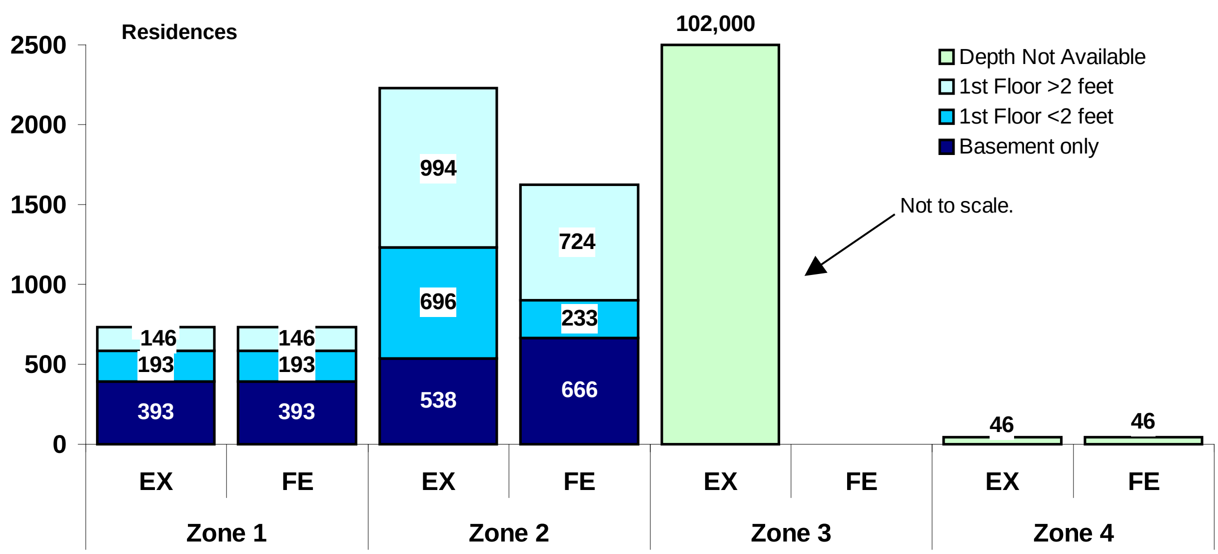
Source: InterGroup Consultants Ltd. from KGS Depth-Damage Model, 2001.
Note: Assumes stable water conditions. Makes no provision for wave action due to wind effect.
EX = Existing Floodway FE = Floodway Expansion

Figure F-1 - Total Flooded Residences by Zone for Existing Floodway and Floodway Expansion 1 in 90 Year Flood



Source: InterGroup Consultants Ltd. from KGS Depth-Damage Model, 2001.
Note: Assumes stable water conditions. Makes no provision for wave action due to wind effect.
EX = Existing Floodway FE = Floodway Expansion

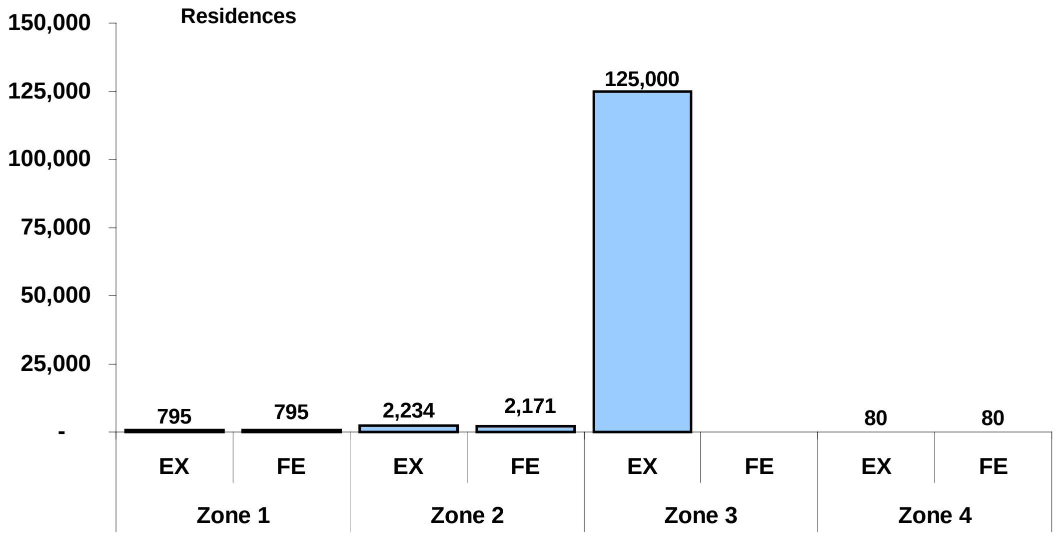
Figure F-2A - Total Flooded Residences by Zone for Existing Floodway and Floodway Expansion 1 in 300 Year Flood (Exact Scale)



Source: InterGroup Consultants Ltd. from KGS Depth-Damage Model, 2001.
Note:
1. Assumes stable water conditions. Makes no provision for wave action due to wind effect.
2. Zone 3 flooded residences shown for reference only. Actual flooded residences are greater than vertical scale shown.

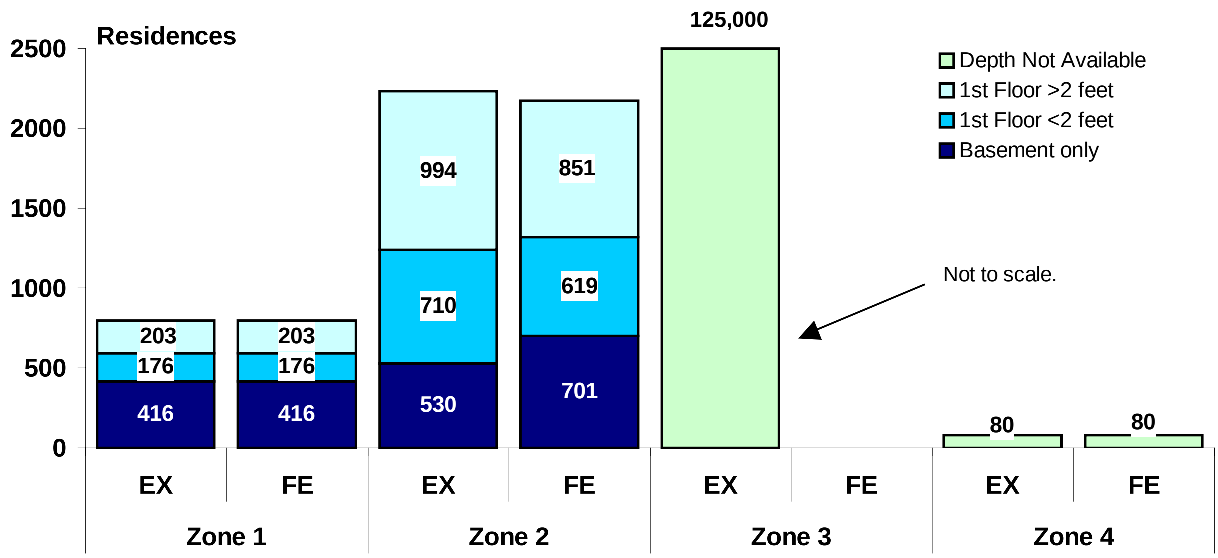
EX = Existing Floodway FE = Floodway Expansion

Figure F-2B - Total Flooded Residences by Zone for Existing Floodway and Floodway Expansion 1 in 300 Year Flood (Reduced Scale)



Source: InterGroup Consultants Ltd. from KGS Depth-Damage Model, 2001.
Note: Assumes stable water conditions. Makes no provision for wave action due to wind effect.
EX = Existing Floodway FE = Floodway Expansion

Figure F-3A - Total Flooded Residences by Zone for Existing Floodway and Floodway Expansion 1 in 500 Year Flood (Exact Scale)

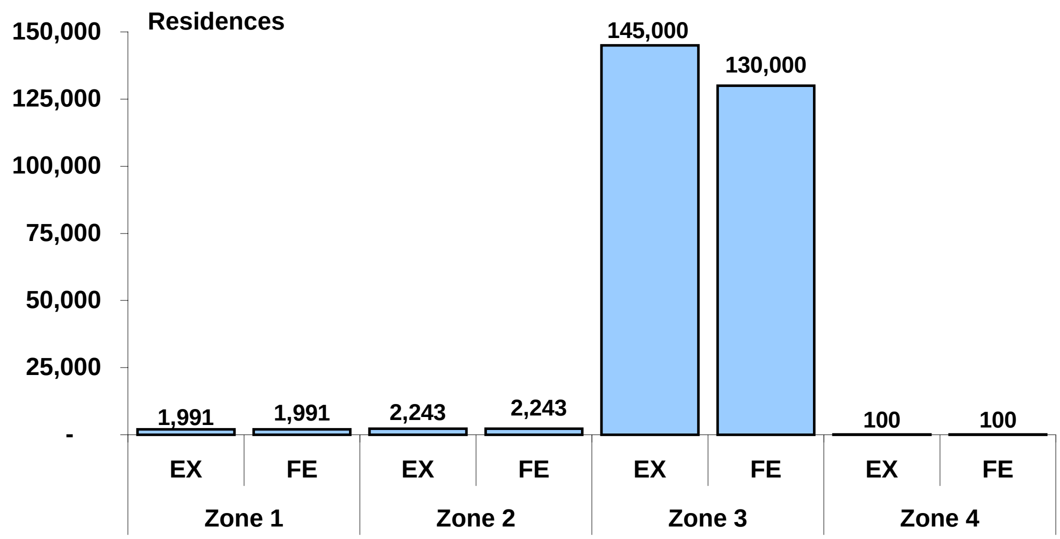


Source: InterGroup Consultants Ltd. from KGS Depth-Damage Model, 2001.
Note: 1. Assumes stable water conditions. Makes no provision for wave action due to wind effect.

2. Zone 3 flooded residences shown for reference only. Actual flooded residences are greater than vertical scale shown.

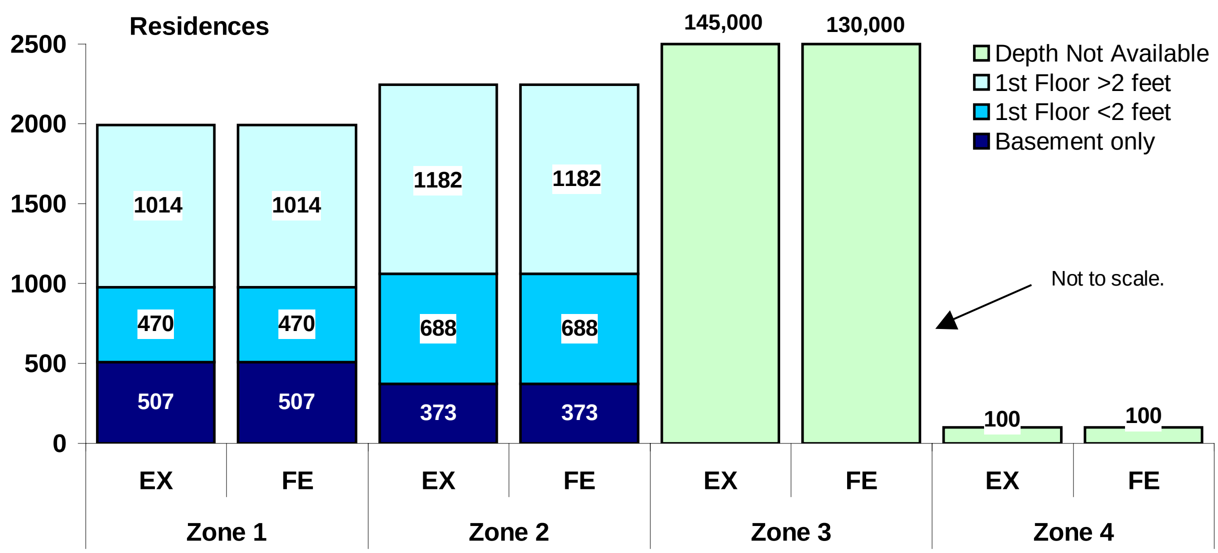
EX = Existing Floodway FE = Floodway Expansion

Figure F-3B - Total Flooded Residences by Zone for Existing Floodway and Floodway Expansion 1 in 500 Year Flood (Reduced Scale)



Source: InterGroup Consultants Ltd. from KGS Depth-Damage Model, 2001.
Note: Assumes stable water conditions. Makes no provision for wave action due to wind effect.
EX = Existing Floodway FE = Floodway Expansion

Figure F-4A - Total Flooded Residences by Zone for Existing Floodway and Floodway Expansion 1 in 1000 Year Flood (Exact Scale)



Source: InterGroup Consultants Ltd. from KGS Depth-Damage Model, 2001.
Note: 1. Assumes stable water conditions. Makes no provision for wave action due to wind effect.

2. Zone 3 flooded residences shown for reference only. Actual flooded residences are greater than vertical scale.
EX = Existing Floodway FE = Floodway Expansion

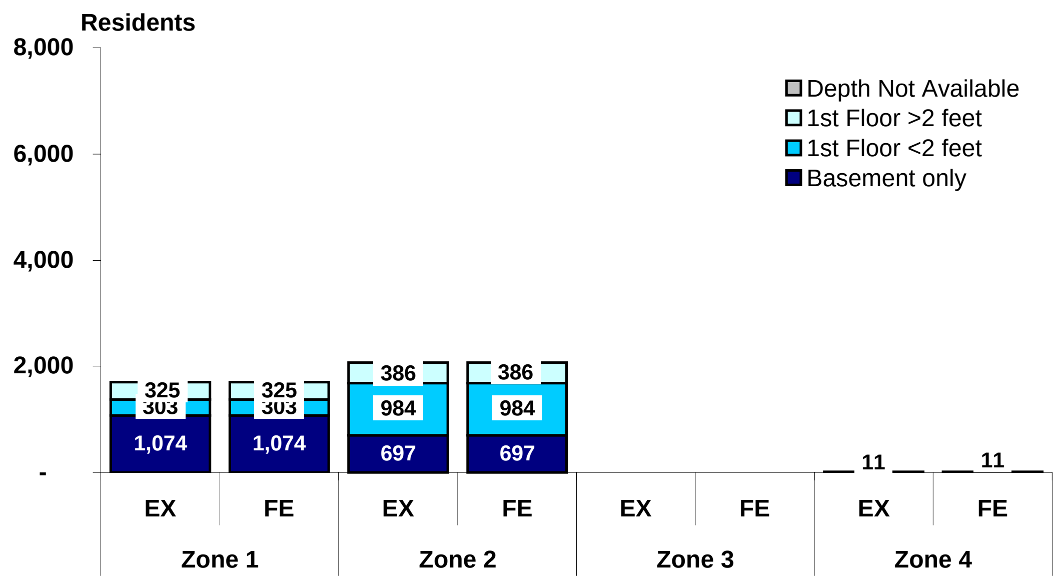
Figure F-4B - Total Flooded Residences by Zone for Existing Floodway and Floodway Expansion 1 in 1000 Year Flood (Reduced Scale)

TABLE F-7
Directly Affected Residents by Zone
Existing Floodway and the Floodway Expansion

Zones	1 in 90 Year Flood		1 in 300 Year Flood	
	Existing Floodway	Floodway Expansion	Existing Floodway	Floodway Expansion
Zone 1: Upstream of Ste. Agathe	1,702	1,702	2,241	2,241
Zone 2: Ste. Agathe to Floodway Inlet	2,066	2,066	7,664	5,563
Zone 3: City of Winnipeg and Surrounding Area	-	-	350,000	-
Zone 4: Downstream of Floodway Outlet	11	11	130	130
Total	**3,779**	**3,779**	**360,035**	**7,934**

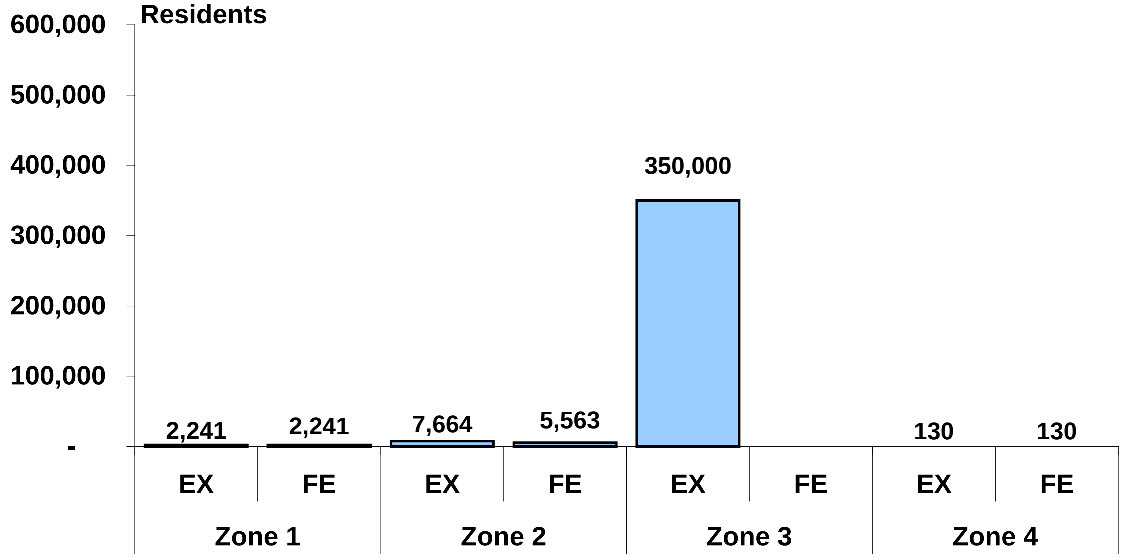
Zones	1 in 500 Year Flood		1 in 1000 Year Flood	
	Existing Floodway	Floodway Expansion	Existing Floodway	Floodway Expansion
Zone 1: Upstream of Ste. Agathe	2,416	2,416	5,864	5,864
Zone 2: Ste. Agathe to Floodway Inlet	7,683	7,475	7,711	7,711
Zone 3: City of Winnipeg and Surrounding Area	450,000	-	545,000	500,000
Zone 4: Downstream of Floodway Outlet	225	225	282	282
Total	**460,324**	**10,116**	**558,857**	**513,857**

Source: InterGroup Consultants Ltd. from KGS Depth-Damage Model, 2001.
Note: Assumes stable water conditions. Makes no provision for wave action due to wind effect.



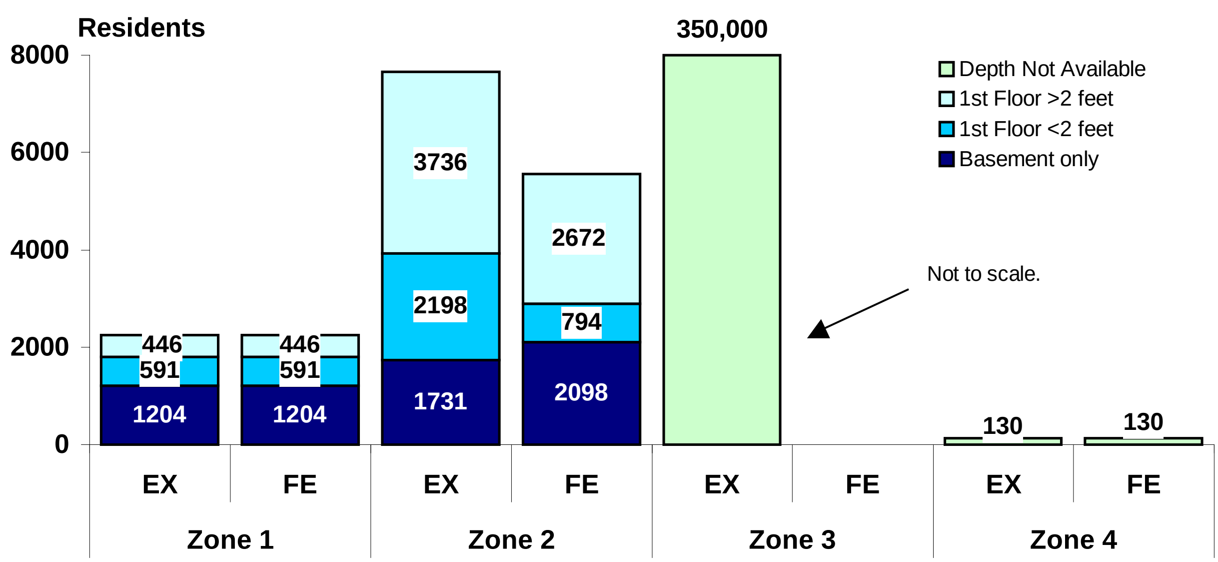
Source: InterGroup Consultants Ltd. from KGS Depth-Damage Model, 2001.
Note: Assumes stable water conditions. Makes no provision for wave action due to wind effect.
EX = Existing Floodway FE = Floodway Expansion

Figure F-5 - Directly Affected Residents by Zone for Existing Floodway and Floodway Expansion 1 in 90 Year Flood



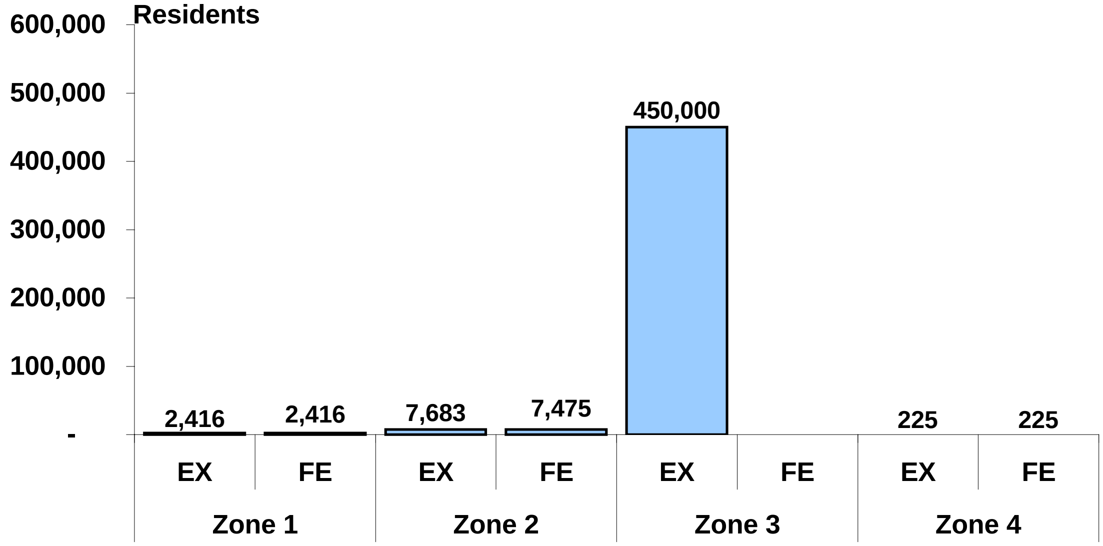
Source: InterGroup Consultants Ltd. from KGS Depth-Damage Model, 2001.
Note: Assumes stable water conditions. Makes no provision for wave action due to wind effect.
Ex = Existing Floodway FE = Floodway Expansion

Figure F-6A - Directly Affected Residents by Zone for Existing Floodway and Floodway Expansion 1 in 300 Year Flood (Exact Scale)



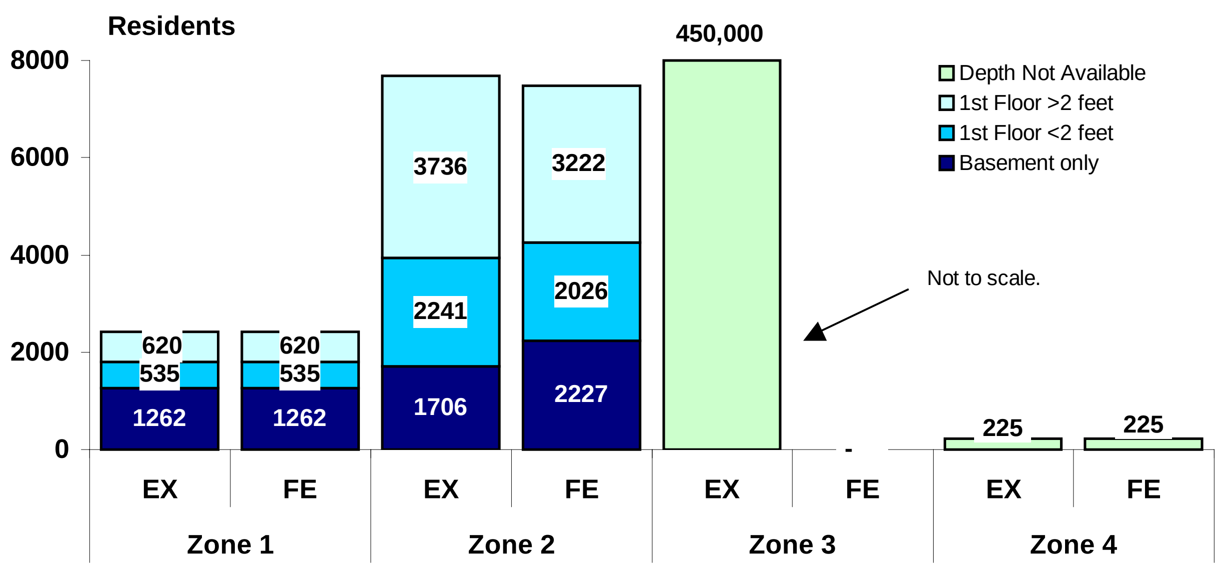
Source: InterGroup Consultants Ltd. from KGS Depth-Damage Model, 2001.
Note: Assumes stable water conditions. Makes no provision for wave action due to wind effect.
EX = Existing Floodway FE = Floodway Expansion

Figure F-6B - Directly Affected Residents by Zone for Existing Floodway and Floodway Expansion 1 in 300 Year Flood (Reduced Scale)



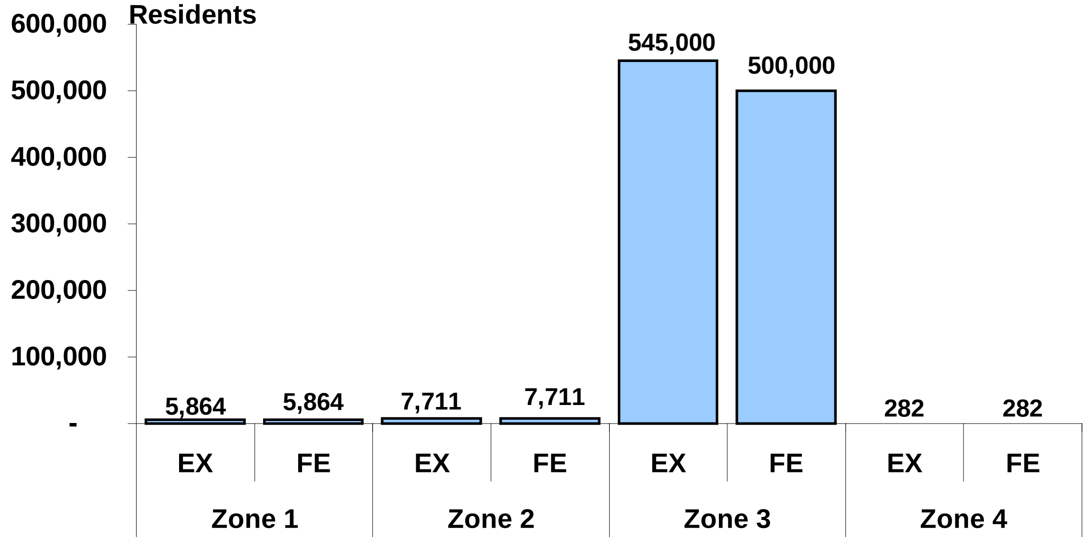
Source: InterGroup Consultants Ltd. from KGS Depth-Damage Model, 2001.
Note: Assumes stable water conditions. Makes no provision for wave action due to wind effect.
EX = Existing Floodway FE = Floodway Expansion

Figure F-7A - Directly Affected Residents by Zone for Existing Floodway and Floodway Expansion 1 in 500 Year Flood (Exact Scale)



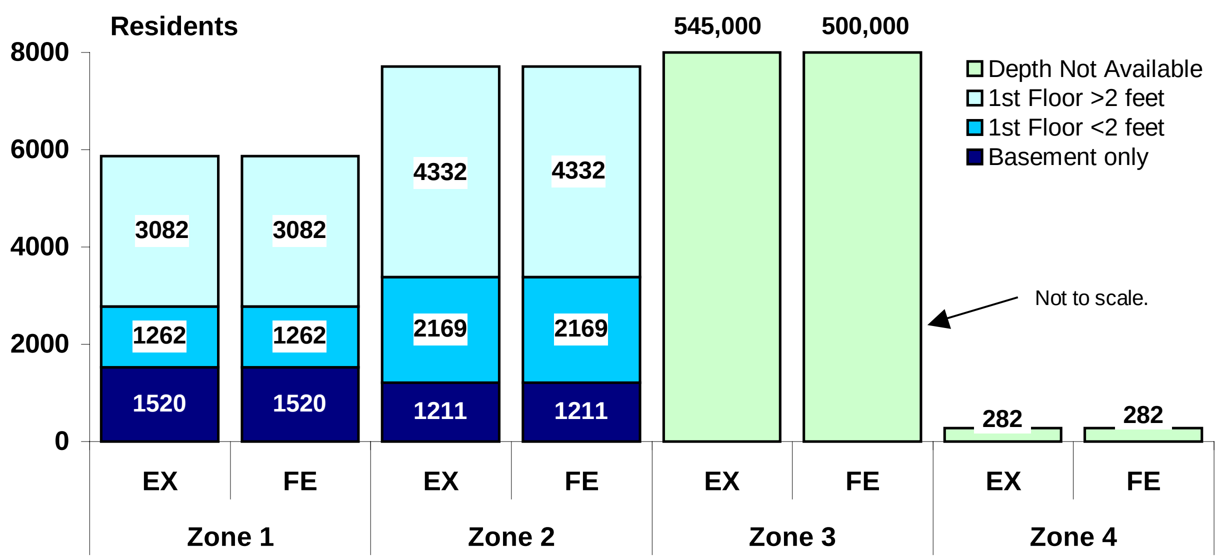
Source: InterGroup Consultants Ltd. from KGS Depth-Damage Model, 2001.
Note: Assumes stable water conditions. Makes no provision for wave action due to wind effect.
EX = Existing Floodway FE = Floodway Expansion

Figure F-7B - Directly Affected Residents by Zone for Existing Floodway and Floodway Expansion 1 in 500 Year Flood (Reduced Scale)



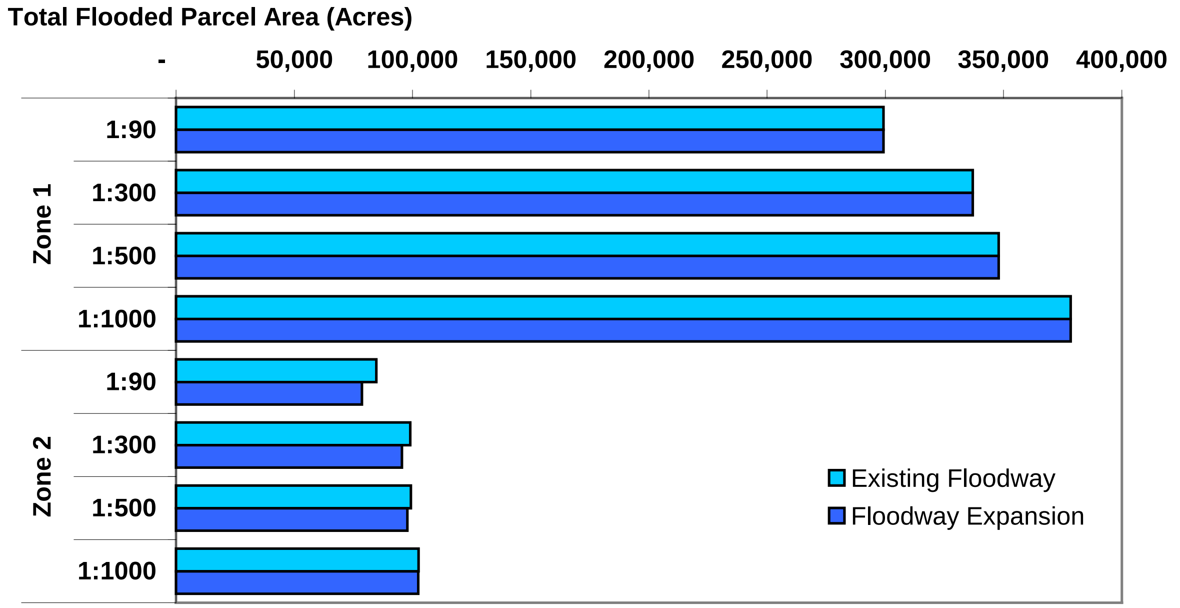
Source: InterGroup Consultants Ltd. from KGS Depth-Damage Model, 2001.
Note: Assumes stable water conditions. Makes no provision for wave action due to wind effect.
EX = Existing Floodway FE = Floodway Expansion

Figure F-8A - Directly Affected Residents by Zone for Existing Floodway and Floodway Expansion 1 in 1000 Year Flood (Exact Scale)



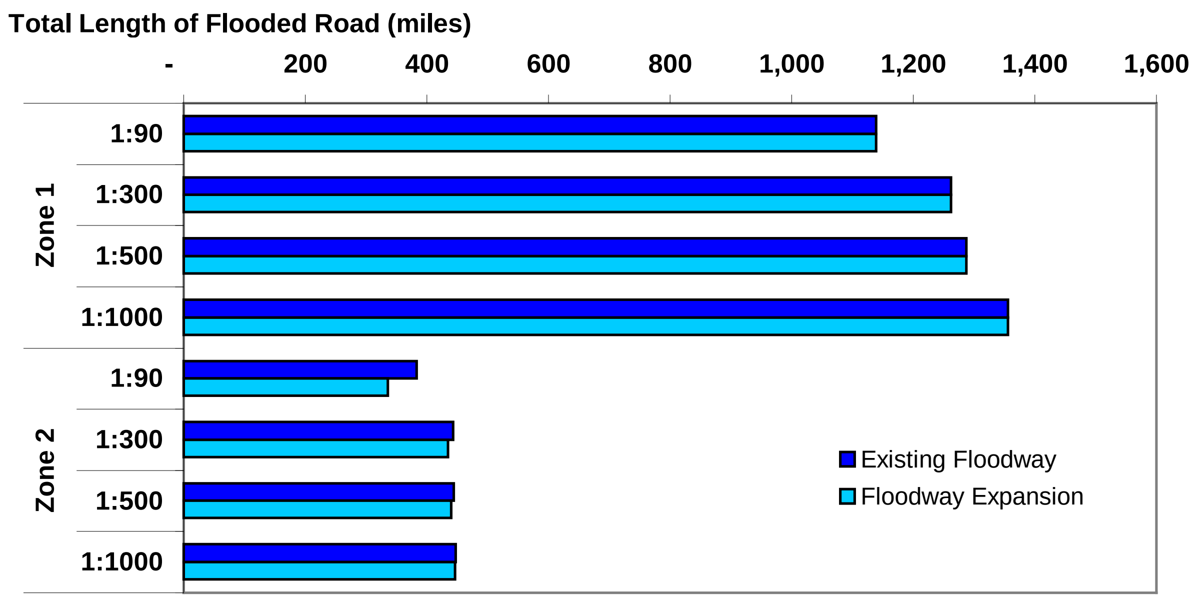
Source: InterGroup Consultants Ltd. from KGS Depth-Damage Model, 2001.
Note: Assumes stable water conditions. Makes no provision for wave action due to wind effect.
EX = Existing Floodway FE = Floodway Expansion

Figure F-8B - Directly Affected Residents by Zone for Existing Floodway and Floodway Expansion 1 in 1000 Year Flood (Reduced Scale)



Source: InterGroup Consultants Ltd. from KGS Depth-Damage Model, 2001.

Figure F-9 - Total Flooded Agricultural Area by Zone for Floodway Expansion and Existing Floodway



Source: InterGroup Consultants Ltd. from KGS Depth-Damage Model, 2001.

Figure F-10 - Length of Flooded Roads by Zone for Floodway Expansion and Existing Floodway

Zone 1: Upstream of Ste. Agathe

At its nearest point, this zone is approximately 18.6 miles from the Floodway Inlet structure. As such, the Expanded Floodway does not have any appreciable impact on flood levels in this zone. Figures F-1 through F-10 indicate that the flood effects in this zone are similar for the Expanded Floodway and the Existing Floodway under each of the flood scenarios reviewed. Floodway Expansion produces no additional protection nor flooding.

Key persons interviewed from Zone 1 generally did not believe Floodway Expansion would impact them, either positively or negatively. Comments received from Zone 1 residents with respect to the Floodway Expansion alternative include:

- Flood protection for Winnipeg is important, but Winnipeg shouldn't be the only voice heard.
- Floodway Expansion makes sense, it's a modification of an existing, tested structure rather than a new, unknown structure.
- Cost should not be the only factor in the decision. The best option may not be the cheapest one to build.
- Is the Floodway Expansion an acceptable level of protection? If it is, why shouldn't communities outside of Winnipeg be given the same level of protection?

Zone 2: Ste. Agathe to the Floodway Inlet Structure

By reducing backwater effects and increasing the Floodway's capacity, Floodway Expansion provides flood protection to parts of this zone primarily as a result of the reduction or elimination of backwater effects associated with operating the Existing Floodway in an emergency mode at water levels above the state of nature. As Figure F-2 indicates, the Floodway Expansion reduces the total number of flooded homes in this zone for the 1 in 300 year flood compared to the Existing Floodway. At the 1 in 300 year flood level, the Floodway Expansion reduces the number of flooded residents from 7,664 to 5,563, a difference of approximately 2,000 residents. Floodway Expansion also results in less severe residential flooding, as fewer homes experience first floor flooding. Figure F-6 shows that at the 1 in 300 year flood level the number of residents with first floor flooding is reduced. Figure F-10 suggests that the Floodway Expansion results in slightly less length of flooded roads at 1 in 300 year flood levels .

As flood severity increases, the amount of additional protection diminishes significantly. Table F-7 shows that for a 1 in 500 year flood, about 200 additional residents receive full protection from the Floodway Expansion. By the 1 in 1000 year flood level there is no perceptible increase in the number of residents protected over the Existing Floodway to this zone.

It is important to note that the normal operation of the Floodway Expansion does not produce additional backwater effects or associated project induced flooding in this zone. Floodway Expansion would reduce project induced flooding compared to the Existing Floodway when in an emergency mode at water levels above the "state-of-nature". Since the Floodway Expansion reduces the extent and impacts of backwater effects, there is no requirement for additional mitigation and compensation due to project induced flooding. However it is recognized that there are some highly sensitive impact management issues associated with the operation of the Existing Floodway, a subject that was brought up often during the key person interviews. Comments made by Zone 2 residents included the following:

- Significant problems with the Existing Floodway rules of operation. Province has a poor track record that would likely continue with a new floodway.
- Shift from operating rules based on river flows to operating rules based on river stages is detrimental to residents upstream of the floodway.
- Perceive that setting El. 778 ft. as the maximum water level at the Floodway entrance is the wrong level. This would result in floodwaters being 3-4 ft. higher than the design of current flood control measures immediately upstream of the floodway who aren't already protected.

Zone 3: Winnipeg and Surrounding Areas

This zone is expected to receive the most benefits from the construction of the Floodway Expansion. Figures F-1 to F-8 indicate that the Floodway Expansion significantly reduces the estimated number of flooded residences and the estimated number of affected residents for all flood levels up to and including the 1 in 1000 year flood event compared to the Existing Floodway. Figures F-2, F-3, and F-4 highlight the significance of the additional flood protection provided to the City of Winnipeg by the Floodway Expansion. For a 1 in 300 year flood the Floodway Expansion is estimated to eliminate flooding for an additional 100,000 residences or 350,000 residents. At the 1 in 500 year flood level an additional 125,000 residences or 450,000 residents are protected. Even in a 1 in 1000 year flood, which would exceed the design capacity of the project, the number of additional residences and residents protected is still sizable. At the 1 in 1000 year flood level, the Floodway Expansion is estimated to protect approximately 15,000 additional residences or 45,000 residents compared to the Existing Floodway.

Zone 3 residents were also asked to comment on the proposed Floodway Expansion during the key person interviews. General statements included:

- Need to realise that there are social costs associated with the Floodway Expansion, not sure that this message is getting out.
- The decision to go forward with the Floodway Expansion has already been made by the politicians.

Zone 4: Downstream of Floodway Outlet

This zone is not expected to experience a significant change in flood levels as a result of the operation of the Floodway Expansion. However, it is recognized there would be some minor water level increases between 1 in 90 year and 1 in 500 year flood events, although estimates of the impact on residences was not made because of the poor quality of topographical data (this is explained in greater detail in Appendix A). Figures F-1 through F-10 indicate that the estimated flood impact is similar for all flood events up to and including the 1 in 1000 year flood. Comments made during interviews with Zone 4 residents with respect to the Floodway Expansion include:

- Very little information has been forthcoming about the impact of increased flows.
- Lack of information has resulted in frustration in determining what the impacts of the Floodway Expansion alternative might be.
- Perceived that additional flows from an Expanded Floodway would increase flooding dramatically.

F.3.4.1 Floodway Expansion – Summary of Quantitative/Qualitative Impacts

Tables F-8 and F-9 estimate the number of additional residences and residents protected by the Floodway Expansion compared to the Existing Floodway. For the study area in total, Floodway

Expansion provides a higher level of protection for all flood events and major improvements for the 1 in 300 and 1 in 500 year events. The added protection is concentrated in Zones 2 and 3, with the City of Winnipeg (Zone 3) capturing the majority of the benefits.

At the 1 in 90 year flood level, the Floodway Expansion protects no additional residences or residents. These benefits increase significantly for larger flood events as the design capacity of the Existing Floodway is exceeded. The project is projected to provide full protection and eliminate flooding for over 100,000 residences and more than 350,000 residents for 1 in 300 year flood events. At the 1 in 500 year flood level as many as 125,000 additional residences or 450,000 residents are fully protected by the Floodway Expansion. Even at flood levels that exceed its design capacity, the Floodway Expansion continues to provide additional protection compared to the Existing Floodway. For a 1 in 1000 year flood, the Floodway Expansion protects approximately 15,000 more residences or 45,000 residents than the Existing Floodway in the socio-economic study area. Beyond the fully protected residences, a significant number of residents will benefit from reduced flooding to residential property.

During the key person interviews, Zone 2 residents were most likely to express concern about the Floodway Expansion. These concerns generally centred around the operating rules associated with the proposed structure. Zone 2 residents noted dissatisfaction with the current operating rules for the Existing Floodway and the way in which the Province has operated the Existing Floodway during previous floods. In order to improve the acceptability of the proposed Floodway Expansion to Zone 2 residents, the operating rules would need to be clear and residents would have to have confidence that the Province would adhere to the rules as stated. A meaningful and effective public consultation process with Zone 2 residents about the operating rules and operating regime for the Floodway Expansion project is a key element for achieving these goals.

TABLE F-8
Estimated Additional Residences Protected by the Floodway Expansion over the Existing Floodway

Zones	1 in 90 Year Flood		1 in 300 Year Flood	
	Reduced Flooding	Flooding Eliminated	Reduced Flooding	Flooding Eliminated
Zone 1: Upstream of Ste. Agathe	-	-	-	-
Zone 2: Ste. Agathe to Floodway Inlet	528	-	1,623	605
Zone 3: City of Winnipeg and Surrounding Area	-	-	-	102,000
Zone 4: Downstream of Floodway Outlet	-	-	-	-
Total	**528**	**-**	**1,623**	**102,605**

Zones	1 in 500 Year Flood		1 in 1000 Year Flood	
	Reduced Flooding	Flooding Eliminated	Reduced Flooding	Flooding Eliminated
Zone 1: Upstream of Ste. Agathe	-	-	-	-
Zone 2: Ste. Agathe to Floodway Inlet	2,171	63	-	-
Zone 3: City of Winnipeg and Surrounding Area	-	125,000	130,000	15,000
Zone 4: Downstream of Floodway Outlet	-	-	-	-
Total	**2,171**	**125,063**	**130,000**	**15,000**

Source: InterGroup Consultants Ltd. from KGS Depth-Damage Model, 2001.
Note: Blank spaces indicate no additional flood protection

TABLE F-9
Estimated Additional Residents Protected
by the Floodway Expansion over the Existing Floodway

Zones	1 in 90 Year Flood		1 in 300 Year Flood	
	Reduced Flooding	Flooding Eliminated	Reduced Flooding	Flooding Eliminated
Zone 1: Upstream of Ste. Agathe	-	-	-	-
Zone 2: Ste. Agathe to Floodway Inlet	2,066	-	5,563	2,101
Zone 3: City of Winnipeg and Surrounding Area	-	-	-	350,000
Zone 4: Downstream of Floodway Outlet	-	-	-	-
Total	**2,066**	**-**	**5,563**	**352,101**

Zones	1 in 500 Year Flood		1 in 1000 Year Flood	
	Reduced Flooding	Flooding Eliminated	Reduced Flooding	Flooding Eliminated
Zone 1: Upstream of Ste. Agathe	-	-	-	-
Zone 2: Ste. Agathe to Floodway Inlet	7,475	208	-	-
Zone 3: City of Winnipeg and Surrounding Area	-	450,000	500,000	45,000
Zone 4: Downstream of Floodway Outlet	-	-	-	-
Total	**7,475**	**450,208**	**500,000**	**45,000**

Source: InterGroup Consultants Ltd. from KGS Depth-Damage Model, 2001.
Note: Blank spaces indicate no additional flood protection.

F.3.5 SOCIO-ECONOMIC EFFECTS OF THE STE. AGATHE DETENTION STRUCTURE

This section compares socio-economic effects of the Ste. Agathe Detention Structure with those of the Existing Floodway. Estimates are presented of:

- the extent of flooding that occurs with the Existing Floodway and the Detention Structure; and
- the additional protection and project induced flooding that result from the operation of the Detention Structure.

The first part of this section is organized in a similar manner to Section F.3.4 on the Floodway Expansion. Specifically, the section includes analysis and discussion of:

Residences Affected: Table F-10 and Figures F-11 to F-14 summarise the number of flooded residences for the four flood scenarios and four flood Zones.

Residents Affected: The estimated number of residents who experience some degree of flooding are presented in Table F-11 and Figures F-15 to F-18.

Agricultural Area Affected: Figure F-19 shows the amount of agricultural land flooded in Zones 1 and 2.

Roads Affected: The length of flooded roads for Zones 1 and 2 is shown in Figure F-20.

Zone by Zone Impacts: This section presents highlights from the graphical and tabular material as well as from the key person interviews for each Zone. A discussion of the effect of the Ste. Agathe Detention Structure on the key socio-economic indicators is also included.

The operation of the Ste. Agathe Detention Structure causes backwater and additional flooding in Zone 1. Damage caused by this project induced flooding is the most significant adverse effect associated with either the Detention Structure or the Floodway Expansion. The project induced flooding has led to widespread concern about the Detention Structure in Zone 1. In recognition of the high degree of concern over this issue and its important role in establishing project acceptability, the latter part of this section delves into the issues and options associated with managing backwater impacts of the Detention Structure. Mitigation, compensation and legal issues associated with project induced flooding during normal operation of the Ste. Agathe Detention Structure are examined. As well, this section includes a discussion of socio-economic impacts of flooding not covered elsewhere.

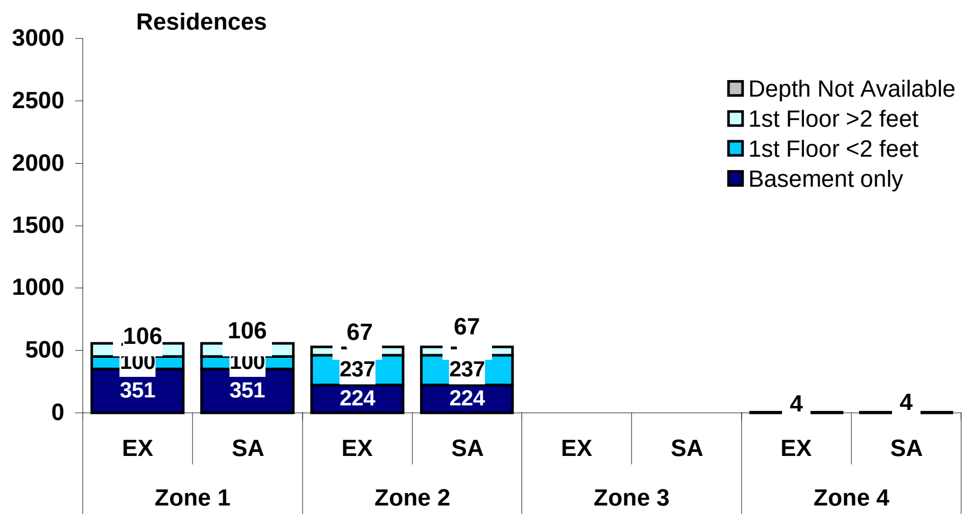
TABLE F-10
Estimated Number of Flooded Residences by Zone
Existing Floodway and Ste. Agathe Detention Structure

Zones	1 in 90 Year Flood		1 in 300 Year Flood	
	Existing Floodway	Ste. Agathe Structure	Existing Floodway	Ste. Agathe Structure
Zone 1: Upstream of Ste. Agathe	557	557	732	2,053
Zone 2: Ste. Agathe to Floodway Inlet	528	528	2,228	528
Zone 3: City of Winnipeg and Surrounding Area	-	-	102,000	-
Zone 4: Downstream of Floodway Outlet	4	4	46	4
Total	**1,089**	**1,089**	**105,006**	**2,585**

TABLE F-10 (CONTINUED)
Estimated Number of Flooded Residences by Zone
Existing Floodway and Ste. Agathe Detention Structure

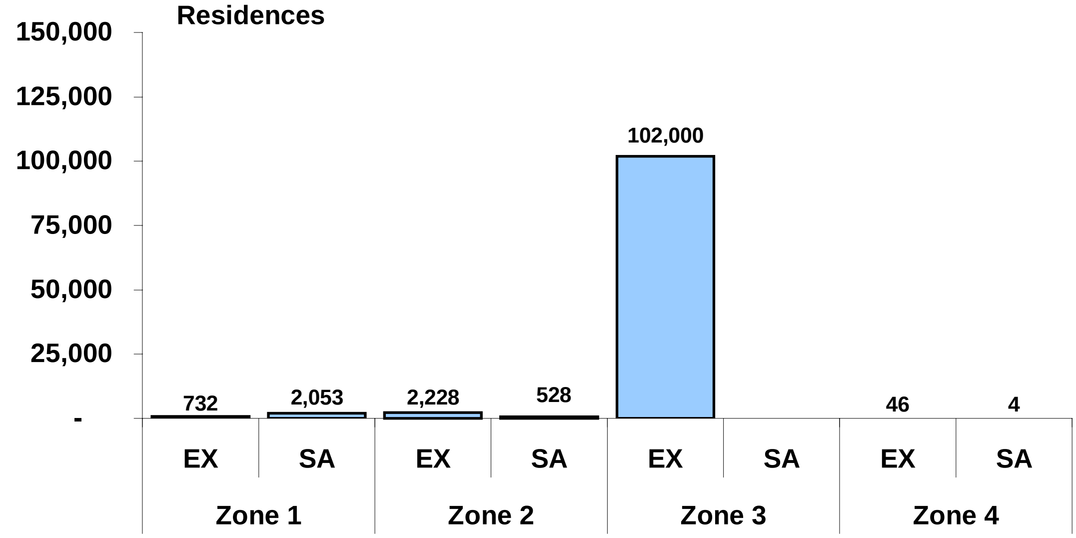
Zones	1 in 500 Year Flood		1 in 1000 Year Flood	
	Existing Floodway	Ste. Agathe Structure	Existing Floodway	Ste. Agathe Structure
Zone 1: Upstream of Ste. Agathe	795	2,065	1,991	2,916
Zone 2: Ste. Agathe to Floodway Inlet	2,234	528	2,243	528
Zone 3: City of Winnipeg and Surrounding Area	125,000	-	145,000	-
Zone 4: Downstream of Floodway Outlet	80	4	100	4
Total	**128,109**	**2,597**	**149,334**	**3,448**

Source: InterGroup Consultants Ltd. from KGS Depth-Damage Model, 2001.
Note: Assumes stable water conditions. Makes no provision for wave action due to wind effect.



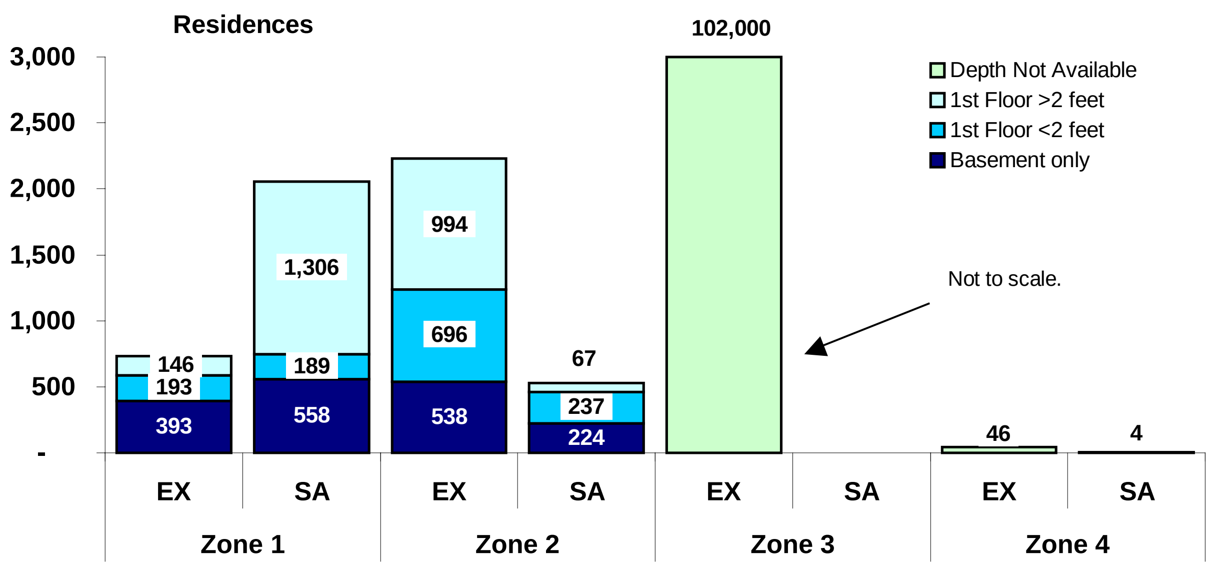
Source: InterGroup Consultants Ltd. from KGS Depth-Damage Model, 2001.
Note: Assumes stable water conditions. Makes no provision for wave action due to wind effect.
EX = Existing Floodway SA = Ste. Agathe Detention Structure

Figure F-11 - Total Flooded Residences by Zone for Existing Floodway and Ste. Agathe Detention Structure 1 in 90 Year Flood Event



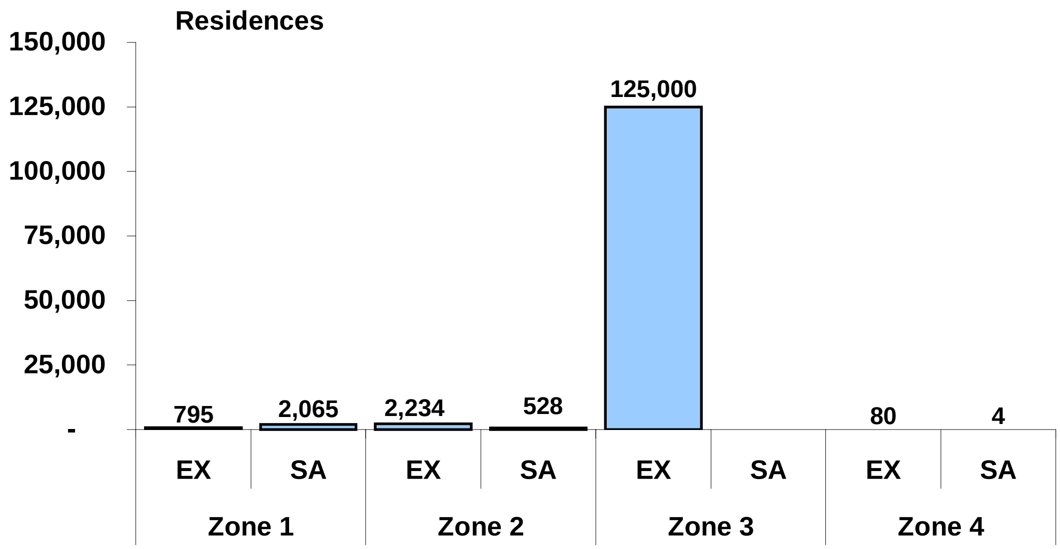
Source: InterGroup Consultants Ltd. from KGS Depth-Damage Model, 2001.
Note: Assumes stable water conditions. Makes no provision for wave action due to wind effect.
EX = Existing Floodway SA = Ste. Agathe Detention Structure

Figure F-12A - Total Flooded Residences by Zone for Existing Floodway and Ste. Agathe Detention Structure 1 in 300 Year Flood Event (Exact Scale)



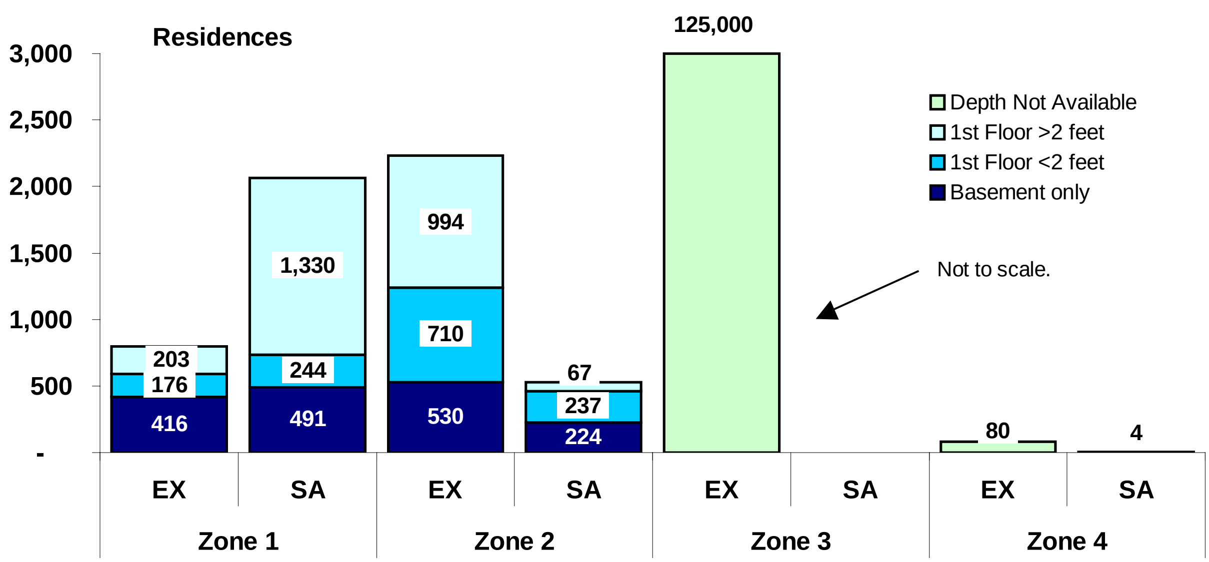
Source: InterGroup Consultants Ltd. from KGS Depth-Damage Model, 2001.
Note: Assumes stable water conditions. Makes no provision for wave action due to wind effect.
EX = Existing Floodway SA = Ste. Agathe Detention Structure

Figure F-12B - Total Flooded Residences by Zone for Existing Floodway and Ste. Agathe Detention Structure 1 in 300 Year Flood Event (Reduced Scale)



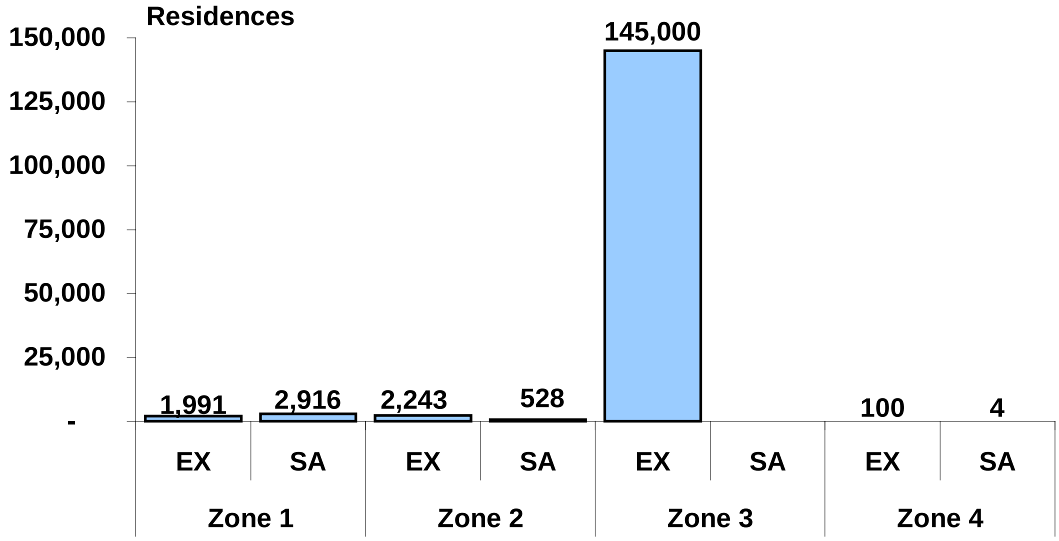
Source: InterGroup Consultants Ltd. from KGS Depth-Damage Model, 2001.
Note: Assumes stable water conditions. Makes no provision for wave action due to wind effect.
EX = Existing Floodway SA = Ste. Agathe Detention Structure

Figure F-13A - Total Flooded Residences by Zone for Existing Floodway and Ste. Agathe Detention Structure 1 in 500 Year Flood Event (Exact Scale)



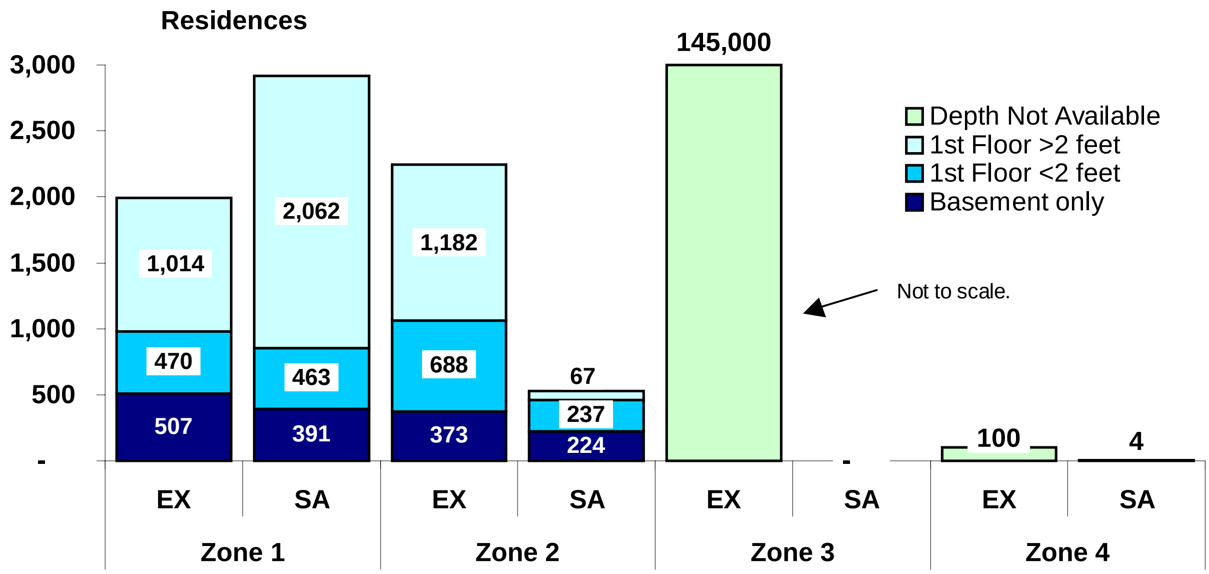
Source: InterGroup Consultants Ltd. from KGS Depth-Damage Model, 2001.
Note: Assumes stable water conditions. Makes no provision for wave action due to wind effect.
EX = Existing Floodway SA = Ste. Agathe Detention Structure

Figure F-13B - Total Flooded Residences by Zone for Existing Floodway and Ste. Agathe Detention Structure 1 in 500 Year Flood Event (Reduced Scale)



Source: InterGroup Consultants Ltd. from KGS Depth-Damage Model, 2001.
Note: Assumes stable water conditions. Makes no provision for wave action due to wind effect.
EX = Existing Floodway SA = Ste. Agathe Detention Structure

Figure F-14A - Total Flooded Residences by Zone for Existing Floodway and Ste. Agathe Detention Structure 1 in 1000 Year Flood Event (Exact Scale)



Source: InterGroup Consultants Ltd. from KGS Depth-Damage Model, 2001.
Note: Assumes stable water conditions. Makes no provision for wave action due to wind effect.
EX = Existing Floodway SA = Ste. Agathe Detention Structure

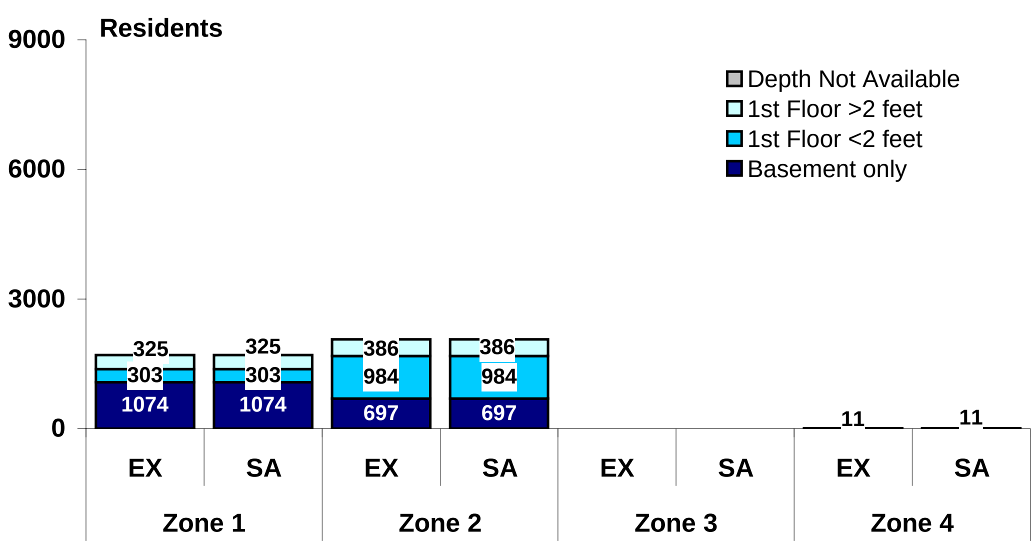
Figure F-14B - Total Flooded Residences by Zone for Existing Floodway and Ste. Agathe Detention Structure 1 in 1000 Year Flood Event (Reduced Scale)

TABLE F-11
Directly Affected Residents by Zone
Existing Floodway and Ste. Agathe Detention Structure

Zones	1 in 90 Year Flood		1 in 300 Year Flood	
	Existing Floodway	Ste. Agathe Structure	Existing Floodway	Ste. Agathe Structure
Zone 1: Upstream of Ste. Agathe	1,702	1,702	2,241	6,300
Zone 2: Ste. Agathe to Floodway Inlet	2,066	2,066	7,665	2,067
Zone 3: City of Winnipeg and Surrounding Area	-	-	350,000	-
Zone 4: Downstream of Floodway Outlet	11	11	130	11
Total	**3,779**	**3,779**	**360,036**	**8,378**

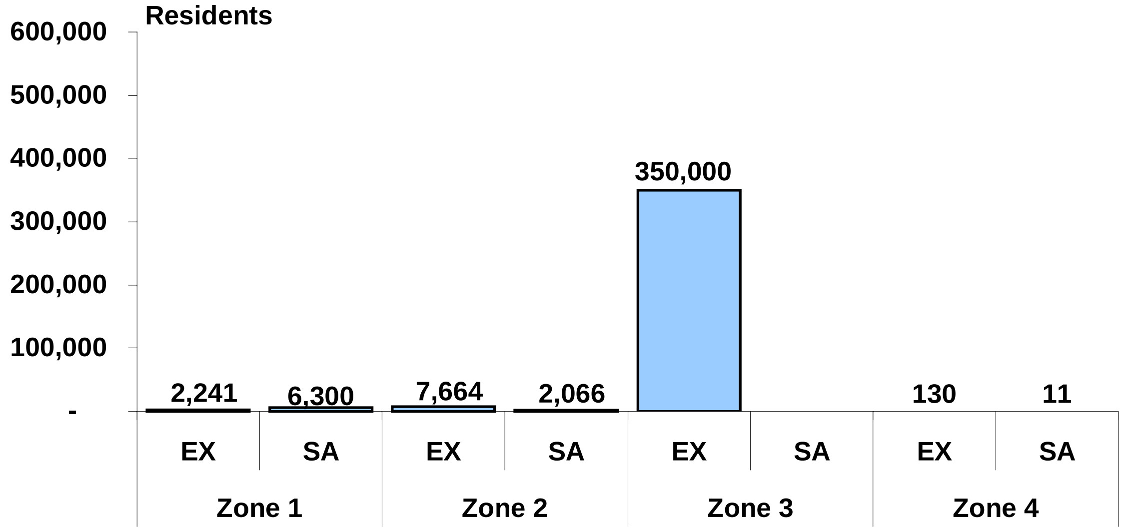
Zones	1 in 500 Year Flood		1 in 1000 Year Flood	
	Existing Floodway	Ste. Agathe Structure	Existing Floodway	Ste. Agathe Structure
Zone 1: Upstream of Ste. Agathe	2,417	6,335	5,864	8,740
Zone 2: Ste. Agathe to Floodway Inlet	7,683	2,067	7,712	2,067
Zone 3: City of Winnipeg and Surrounding Area	450,000	-	545,000	-
Zone 4: Downstream of Floodway Outlet	225	11	282	11
Total	**460,325**	**8,413**	**558,858**	**10,818**

Source: InterGroup Consultants Ltd. from KGS Depth-Damage Model, 2001.
Note: Assumes stable water conditions. Makes no provision for wave action due to wind effect.



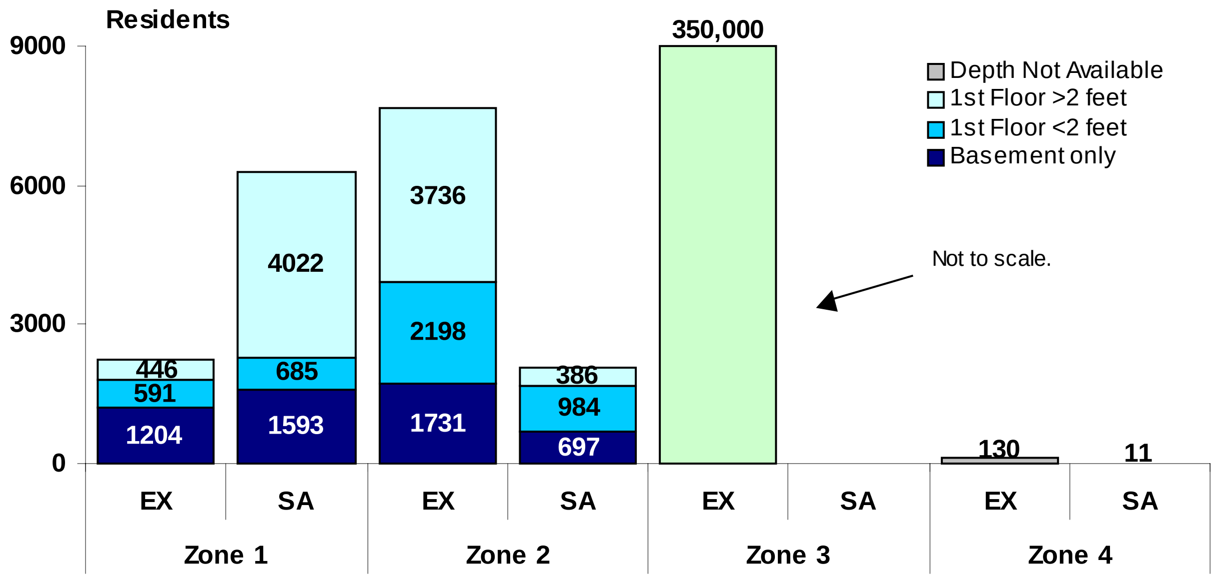
Source: InterGroup Consultants Ltd. from KGS Depth-Damage Model, 2001.
Note: Assumes stable water conditions. Makes no provision for wave action due to wind effect.
EX = Existing Floodway SA = Ste. Agathe Detention Structure

Figure F-15 - Directly Affected Residents by Zone for Existing Floodway and Ste. Agathe Detention Structure 1 in 90 Year Flood Event



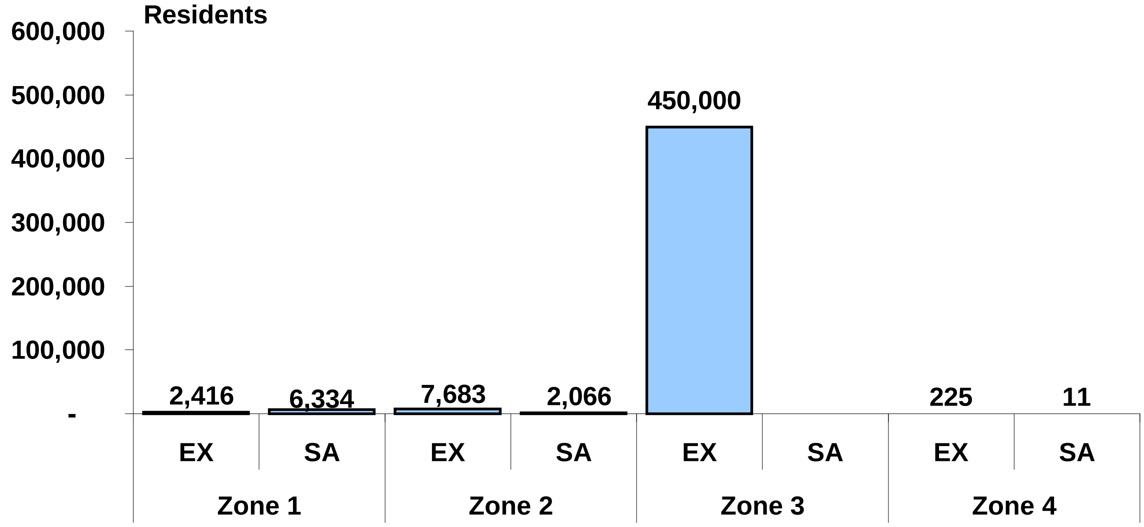
Source: InterGroup Consultants Ltd. from KGS Depth-Damage Model, 2001.
Note: Assumes stable water conditions. Makes no provision for wave action due to wind effect.
EX = Existing Floodway SA = Ste. Agathe Detention Structure

Figure F-16A - Directly Affected Residents by Zone for Existing Floodway and Ste. Agathe Detention Structure 1 in 300 Year Flood Event (Exact Scale)



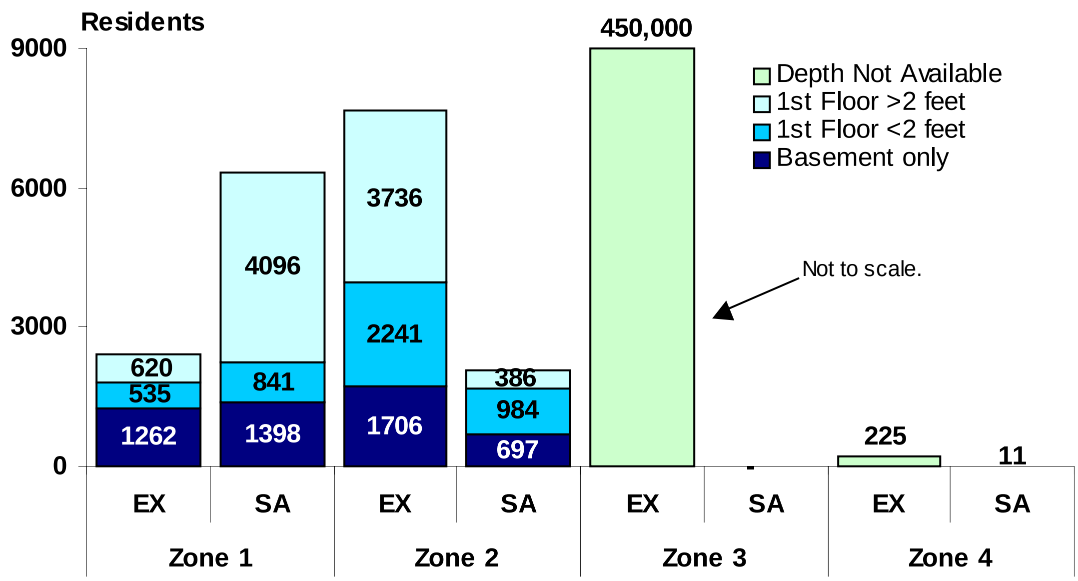
Source: InterGroup Consultants Ltd. from KGS Depth-Damage Model, 2001.
Note: Assumes stable water conditions. Makes no provision for wave action due to wind effect.
EX = Existing Floodway SA = Ste. Agathe Detention Structure

Figure F-16B - Directly Affected Residents by Zone for Existing Floodway and Ste. Agathe Detention Structure 1 in 300 Year Flood Event (Reduced Scale)



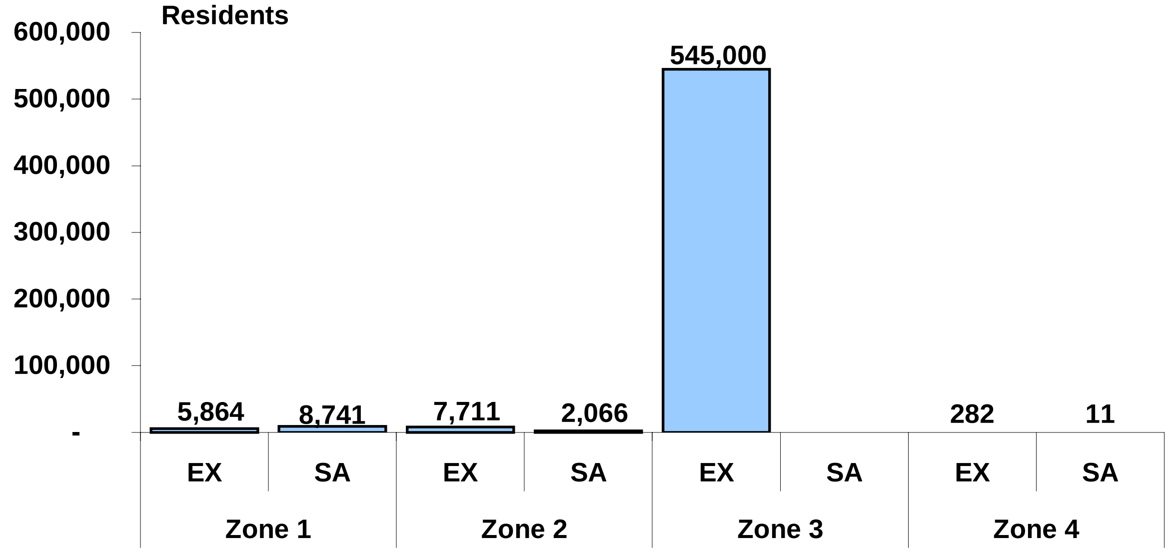
Source: InterGroup Consultants Ltd. from KGS Depth-Damage Model, 2001.
Note: Assumes stable water conditions. Makes no provision for wave action due to wind effect.
EX = Existing Floodway SA = Ste. Agathe Detention Structure

Figure F-17A - Directly Affected Residents by Zone for Existing Floodway and Ste. Agathe Detention Structure 1 in 500 Year Flood Event (Exact Scale)



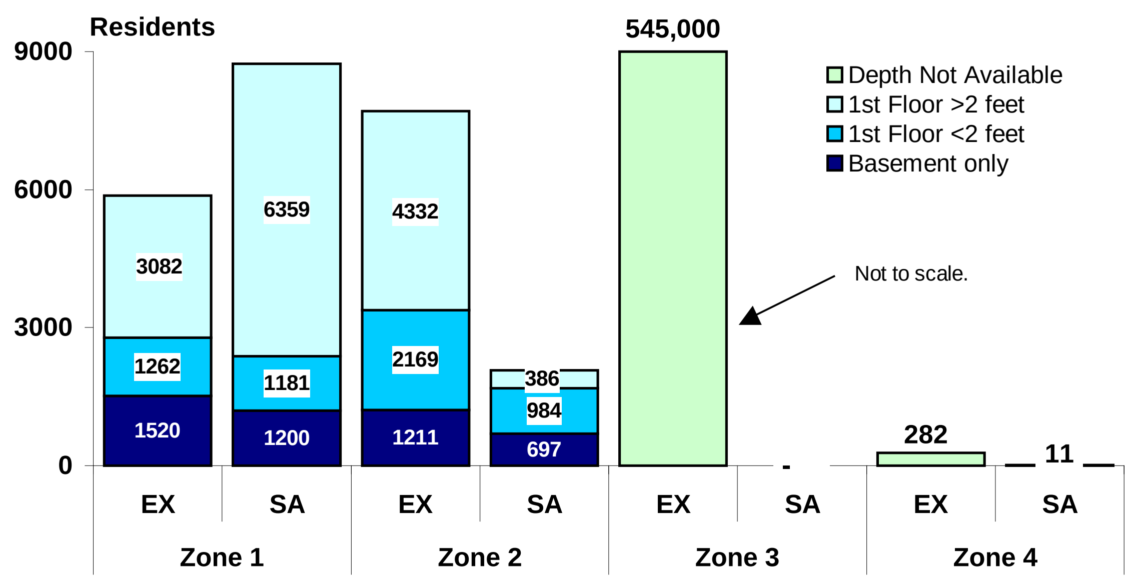
Source: InterGroup Consultants Ltd. from KGS Depth-Damage Model, 2001.
Note: Assumes stable water conditions. Makes no provision for wave action due to wind effect.
EX = Existing Floodway SA = Ste. Agathe Detention Structure

Figure F-17B - Directly Affected Residents by Zone for Existing Floodway and Ste. Agathe Detention Structure 1 in 500 Year Flood Event (Reduced Scale)



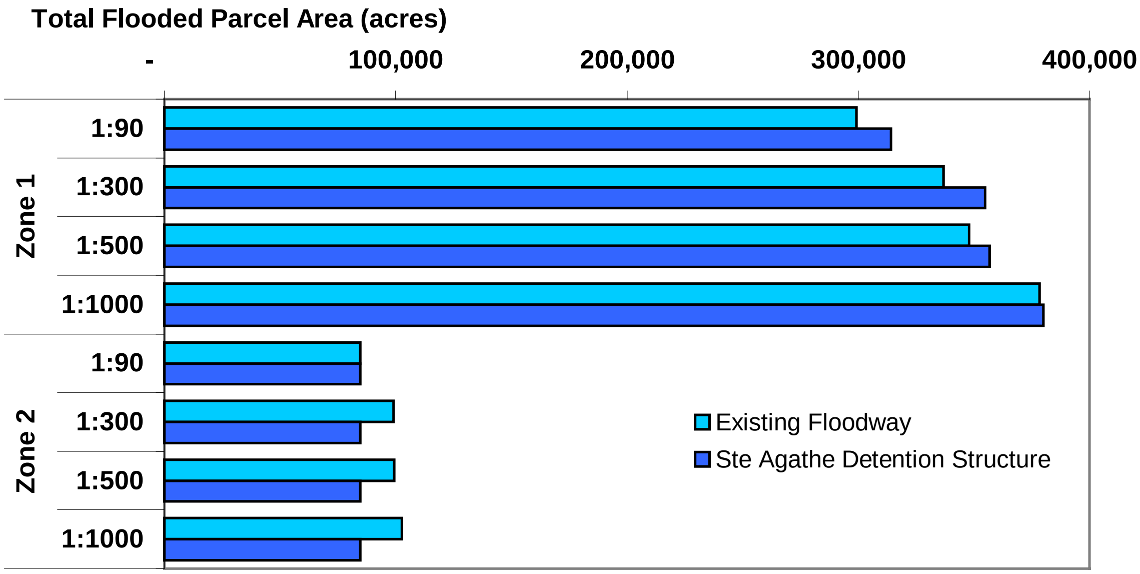
Source: InterGroup Consultants Ltd. from KGS Depth-Damage Model, 2001.
Note: Assumes stable water conditions. Makes no provision for wave action due to wind effect.
EX = Existing Floodway SA = Ste. Agathe Detention Structure

Figure F-18A - Directly Affected Residents by Zone for Existing Floodway and Ste. Agathe Detention Structure 1 in 1000 Year Flood Event (Exact Scale)



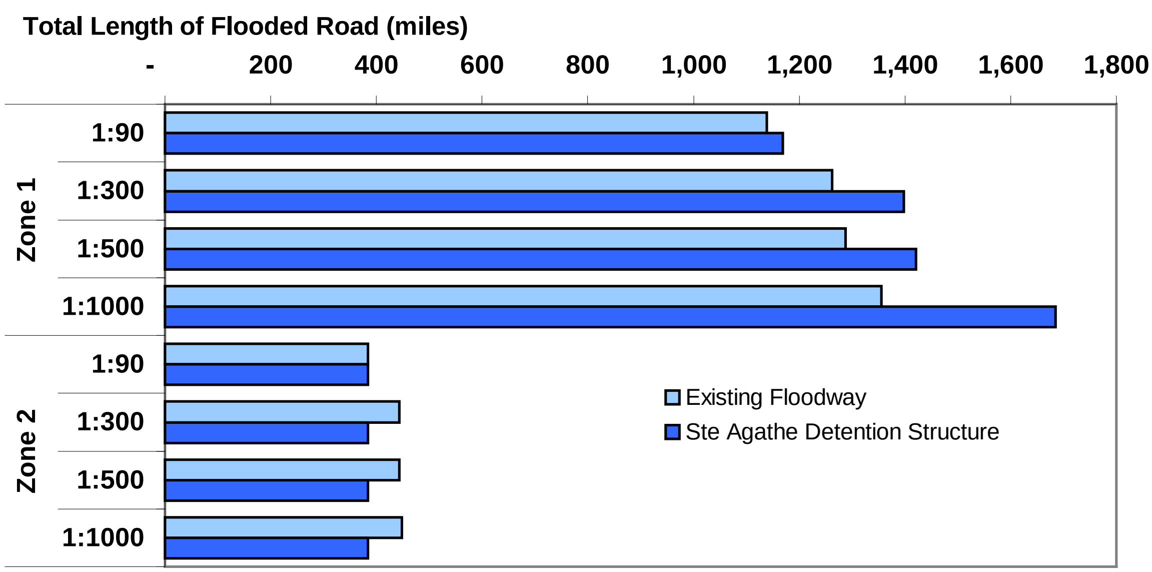
Source: InterGroup Consultants Ltd. from KGS Depth-Damage Model, 2001.
Note: Assumes stable water conditions. Makes no provision for wave action due to wind effect.
EX = Existing Floodway SA = Ste. Agathe Detention Structure

Figure F-18B - Directly Affected Residents by Zone for Existing Floodway and Ste. Agathe Detention Structure 1 in 1000 Year Flood Event (Reduced Scale)



Source: InterGroup Consultants Ltd. from KGS Depth-Damage Model, 2001.

Figure F-19 - Total Flooded Agricultural Area by Zone for Ste. Agathe Detention Structure and Existing Floodway



Source: InterGroup Consultants Ltd. from KGS Depth-Damage Model, 2001.

Figure F-20 - Length of Flooded Roads by Zone for Ste. Agathe Detention Structure and Existing Floodway

Zone 1: Upstream of Ste. Agathe

At the 1 in 90 year flood level, flooding effects would be the same in this Zone for both the Ste. Agathe Detention Structure and Floodway Expansion. Under the proposed operating rules, the gates of the Ste. Agathe Detention Structure would be used to hold back flood waters for floods greater than the 1 in 90 year flood event. Backwater created by operation of the Detention Structure leads to higher than natural water levels and increased flooding in parts of Zone 1. The distribution, depth and duration of the project induced flooding becomes greater as the severity of the flood increases.

Figures F-11 to F-18 indicate that operation of the Ste. Agathe Detention Structure increases the number of residences and residents that experience flooding. In some cases, the flooding affects residences that would not otherwise be flooded. In other cases the project induced flooding adds to natural flooding. For floods at the 1 in 300 year, 1 in 500 year, and 1 in 1000 year levels, the distribution and depth of flooding show a substantial increase. The increase is particularly pronounced at the 1 in 300 year and 1 in 500 year levels, where backwater would reach as far south as Letellier, as far west as Rosenort and as far east as St. Pierre-Jolys. As Table F-11 shows, at the 1 in 500 year flood level, an estimated 6,335 residents experience project induced flooding, either in the form of new flooding (3,918 residents) or higher water levels (2,417 residents). Beginning at approximately the 1 in 200 year flood level, project induced flooding would contribute to overflowing existing community dikes or create new flooding in the following communities:

- Morris
- St. Jean-Baptiste
- Letellier
- Dominion City
- Rosenort
- Aubigny
- St. Pierre-Jolys
- Riverside
- Roseau River First Nation

Figures F-19 and F-20 indicate a higher incidence of both flooded agricultural land and length of flooded roads under the Ste. Agathe option. Flooding duration would increase throughout this Zone, affecting agricultural lands and road access to some communities.

The results of the key socio-economic indicator analysis indicate that for Zone 1 residents, operation of the Ste. Agathe Detention Structure results in significant project induced flooding that adversely affects a sizable number of residents. Additional flood mitigation and compensation are required to address the damage created by this flooding. A discussion of possible mitigation and compensation mechanisms is included in Section F.3.5.4.

Key persons interviewed in Zone 1 had severe concerns about the Ste. Agathe Detention Structure, largely related to the socio-economic impacts of project induced flooding. Comments received from Zone 1 residents with respect to the Ste. Agathe Detention Structure included:

- Ste. Agathe Detention Structure is not a viable option for social and environmental reasons.
- This alternative has social costs that aren't being looked at.
- The project would have an enormous impact on the viability of the area upstream of the structure. The construction of the structure would have a crippling effect on economic development and community vitality in the region.
- The Ste. Agathe option treats residents outside the City as second-class citizens, sacrificed for Winnipeg's sake. The Province is guilty of ' perimeter vision'.
- If it's unacceptable to build something that floods the U.S., why is it acceptable to flood your own citizens?
- How can you ever compensate someone for the loss of their heritage? How do you compensate someone for the loss of a home that has been in the family for generations or for a centennial farm?
- No amount of compensation or mitigation would ever make the Detention Structure an acceptable option.
- Residents are prepared to file a lawsuit with the Province if the Ste. Agathe Detention Structure is built.

Zone 2: Ste. Agathe to the Floodway Inlet Structure

Most residences in this Zone are currently protected to approximately the 1 in 90 year flood level. Floods of greater magnitude would exceed the design capacity of the current flood control measures. Parts of this Zone can experience backwater effects when the Existing Floodway operates in an emergency mode at water levels above the "state-of-nature".

The Ste. Agathe Detention Structure provides additional flood protection to this Zone compared to the Existing Floodway. During significant floods, the detention structure would be operated to maintain flood water depth and distribution in this Zone at approximately the 1 in 90 year flood level (similar to 1997 water levels). The flood duration in this Zone would be somewhat longer, as water from behind the detention structure passes through the system more slowly. These features would be maintained up to the design capacity of the Ste. Agathe Detention Structure, approximately the 1 in 1000 year flood.

Figures F-11 through F-18 show that the Ste. Agathe Detention Structure reduces both the number of residences flooded and the severity of flooding for Zone 2. At larger flood levels a considerable number of residences and residents are protected. For example, at the 1 in 300 year flood level, an estimated 1,700 additional residences and 5,600 residents are fully protected from flooding by the Ste. Agathe Detention Structure. A further 2,000 residents receive improved protection in the form of lower peak water levels. The following communities benefit from increased protection, beginning at approximately the 1 in 90 year flood:

- Ste. Agathe
- Niverville
- St. Adolphe
- Grande Pointe

As shown in Figures F-19 and F-20, the amount of additional flooded agricultural land and length of flooded roads in Zone 2 are also reduced with the Ste. Agathe Detention Structure. However, the duration of flooding of agricultural land and roads would generally increase, compared with the Existing Floodway.

Interviews with Zone 2 residents revealed mixed opinions about the Ste. Agathe Detention Structure. Some residents believed it to be the better option for their community while others expressed doubt. Statements noted during interviews included:

- Wasn't the Ste. Agathe option reviewed in the 1960's and determined not to be acceptable? What has changed? Why would it be considered now?
- Seems wrong to protect some people by making flooding worse for others. Doesn't seem fair that some pay the costs while others reap the benefits.
- Ste. Agathe seems like the better option, it protects more people.

- Duration of flooding is just as important as peak water levels; need to think about both when choosing a flood protection option.

Zone 3: Winnipeg and Surrounding Areas

This Zone is currently protected by the existing Floodway and a dike system to approximately the 1 in 90 year flood level. The operation of the Ste. Agathe Detention Structure maintains water levels in this Zone at approximately the 1 in 90 year flood level for all flood events up to the 1 in 1000 year flood. Table F-10 indicates that for flood events larger than the 1 in 90 year flood, the Ste. Agathe Detention Structure significantly reduces the number of flooded residences. For example, at the 1 in 300 year to 1 in 500 year flood levels between 100,000 and 125,000 additional residences are fully protected from flooding by the Ste. Agathe Detention Structure. Table F-11 shows the same trend for the number of directly affected residents. Approximately 350,000 to 450,000 more residents would be protected from flooding, far in excess of the number beneficially or adversely affected in any of the other Zones. Overall, the Ste. Agathe Detention Structure provides considerably greater protection to this Zone compared to the Existing Floodway for all flood levels up to the 1 in 1000 year level.

General statements regarding the Ste. Agathe Detention Structure made by Zone 3 residents during interviews included:

- From a social perspective, the Ste. Agathe option would be hard to justify.
- Should choose the option that provides the best protection while causing the least amount of damage. Can't let cost be the only consideration.
- We need to think about broader impacts in our planning. We can't look for one structure that will solve all our flood problems. Need a flood protection strategy that grows with us.

Zone 4: Downstream of Floodway Outlet

For floods larger than the 1 in 90 year flood, the operation of the Ste. Agathe Detention Structure maintains water levels in this Zone at approximately the 1 in 90 year level. For Zone 4, flood peaks would be considerably lower than with the Existing Floodway, but flood duration would be extended. Figures F-11 through F-18 indicate that in terms of the number of flooded residences and directly affected residents, the Ste. Agathe Detention Structure provides additional flood protection to this Zone compared to the Existing Floodway. For example, at the 1 in 500 year flood level, approximately 80 more residences and 200 more residents north of Lockport are fully protected from flooding as a result of the operation of the Ste. Agathe Detention Structure. Some residents from the Winnipeg to Lockport reach of the Red River would also experience added protection, however, this number could not be determined.

Comments made by Zone 4 residents with respect to the Ste. Agathe Detention Structure include:

- Have to think about who gets the benefits of the project and who pays the costs? Should be some idea of fairness in the decision making.
- Don't have a good understanding of what all the costs of the project would be. Would need to understand that before we could choose one option or the other.

F.3.5.1 Ste. Agathe Detention Structure – Summary of Quantitative Impacts

Tables F-12 and F-13 show the estimated number of residences and residents protected from flooding or affected by project induced flooding as a result of the operation of the Ste. Agathe Detention Structure. Residents in Zones 2, 3 and 4 would benefit from additional protection during floods greater than the 1997 event. Residents in Zone 1 would be adversely affected by increased flooding during such events.

At the 1 in 90 year flood level, the Detention Structure would not operate and therefore would not result in any additional flood protection or project induced flooding. At the 1 in 300 year flood level, 104,000 additional residences and 356,000 additional residents in Zones 2, 3 and 4 are fully protected from flooding. However, 1,700 residences and 4,059 residents in Zone 1 experience flooding who do not experience any flooding with the Existing Floodway. A further 732 residences and 2,241 residents in Zone 1 experience higher water levels or longer flood duration as a result of project induced flooding. For the 1 in 1000 year flood level, the Ste. Agathe Detention Structure fully protects more than 550,000 residents in Zones 2, 3 and 4 while 8,700 Zone 1 residents experience project induced flooding.

During the key person interviews, residents from all four Zones expressed concern about the project induced flooding created by operation of the Ste. Agathe Detention Structure. Many of the people interviewed noted that it did not seem socially acceptable or equitable to protect some residents while making flooding worse for others. In addition, several comments were made about the fact that while the Ste. Agathe Detention Structure lowers the peak water levels for Zones 2, 3 and 4, it increases the flood duration in all Zones. This raised concerns about the delay in seeding for agricultural land and the extended loss of road access for many communities.

TABLE F-12
Estimated Additional Residences Protected or Flooded by the Ste. Agathe Detention Structure over the Existing Floodway

Zones	1 in 90 Year Flood		1 in 300 Year Flood	
	Reduced/ (Increased) Flooding	Flooding Eliminated/ (Induced)	Reduced/ (Increased) Flooding	Flooding Eliminated/ (Induced)
Zone 1: Upstream of Ste. Agathe	-	-	(732)	(1,321)
Zone 2: Ste. Agathe to Floodway Inlet	-	-	528	1,700
Zone 3: City of Winnipeg and Surrounding Area	-	-	-	102,000
Zone 4: Downstream of Floodway Outlet	-	-	4	42
Total Increased/Induced Flooding	**-**	**-**	**(732)**	**(1,321)**
Total Reduced/Eliminated Flooding	**-**	**-**	**532**	**103,742**

Zones	1 in 500 Year Flood		1 in 1000 Year Flood	
	Reduced/ (Increased) Flooding	Flooding Eliminated/ (Induced)	Reduced/ (Increased) Flooding	Flooding Eliminated/ (Induced)
Zone 1: Upstream of Ste. Agathe	(795)	(1,270)	(1,991)	(925)
Zone 2: Ste. Agathe to Floodway Inlet	528	1,706	528	1,715
Zone 3: City of Winnipeg and Surrounding Area	-	125,000	-	145,000
Zone 4: Downstream of Floodway Outlet	4	76	4	96
Total Increased/Induced Flooding	**(795)**	**(1,270)**	**(1,991)**	**(925)**
Total Reduced/Eliminated Flooding	**532**	**126,782**	**532**	**146,811**

Source: InterGroup Consultants Ltd. from KGS Depth-Damage Model, 2001.
Note: Blank spaces indicate no additional flooding or flood protection

TABLE F-13
Estimated Additional Residents Protected or Flooded by the Ste. Agathe Detention Structure over the Existing Floodway

Zones	1 in 90 Year Flood		1 in 300 Year Flood	
	Reduced/ (Increased) Flooding	Flooding Eliminated/ (Induced)	Reduced/ (Increased) Flooding	Flooding Eliminated/ (Induced)
Zone 1: Upstream of Ste. Agathe	-	-	(2,241)	(4,059)
Zone 2: Ste. Agathe to Floodway Inlet	-	-	2,067	5,598
Zone 3: City of Winnipeg and Surrounding Area	-	-		350,000
Zone 4: Downstream of Floodway Outlet	-	-	11	119
Total Increased/Induced Flooding	**-**	**-**	**(2,241)**	**(4.059)**
Total Reduced/Eliminated Flooding	**-**	**-**	**2,078**	**355,717**

Zones	1 in 500 Year Flood		1 in 1000 Year Flood	
	Reduced/ (Increased) Flooding	Flooding Eliminated/ (Induced)	Reduced/ (Increased) Flooding	Flooding Eliminated/ (Induced)
Zone 1: Upstream of Ste. Agathe	(2,417)	(3,198)	(5,864)	(2,876)
Zone 2: Ste. Agathe to Floodway Inlet	2,067	5,616	2,067	5,645
Zone 3: City of Winnipeg and Surrounding Area	-	450,000	-	545,000
Zone 4: Downstream of Floodway Outlet	11	214	11	271
Total Increased/Induced Flooding	**(2,417)**	**(3,198)**	**(5,864)**	**(2,876)**
Total Reduced/Eliminated Flooding	**2,078**	**455,616**	**2,078**	**550,916**

Source: InterGroup Consultants Ltd. from KGS Depth-Damage Model, 2001.
Note: Blank spaces indicate no additional flooding or flood protection

F.3.5.2 Consideration of International Agreements

The Ste. Agathe Structure may have international implications and require international approvals. Backwater effects resulting from the operation of the Detention Structure could extend beyond the international boundary into Minnesota and North Dakota. Water levels at the international boundary are not expected to increase above natural levels for floods up to at least the 1 in 1000 year size, but the duration of flooding may be extended from between a day or less at the 1 in 300 year flood to three or four days at the 1 in 1000 year flood. This effect and its implications are described in greater detail, in Appendix C, Section C.10 (Ste. Agathe Detention Structure – Impacts on USA).

F.3.5.3 Induced Flooding of Roseau River Anishinabe First Nation

Roseau River First Nation IR2 is located on the east side of the Red River, between Letellier to the west and Dominion City to the east. The reserve covers approximately 8.5 square miles. Almost all of the Reserve's population lives within a ring dike. During the 1997 flood, the First Nation was evacuated from April 23 to May 22. Despite the ring dike, which performed as designed, basement flooding occurred in almost half the homes, mostly due to seepage below grade or sewer back-up. (CMHC, 1998).

Beginning at approximately the 1 in 200 year flood level, there is a discernible backwater effect and increased flooding at the Roseau River First Nation due to the Ste. Agathe Detention Structure. Authorization, in the form of a permit or easement, is required to flood reserve lands under any type of circumstance. A negotiation would have to be carried out with the First Nation and Canada to secure the needed permit or easement. Failure to secure the needed permit or easement prior to the start of construction would put the First Nation in a position to seek an injunction or other legal recourse on the basis of anticipated interference with treaty rights to land.

A permit or easement would also be required for other lands currently held by Roseau River First Nation including lands acquired under Treaty Land Entitlement. The First Nation has selected and acquired the following land parcels that could also be subject to backwater effects of the Ste. Agathe Detention Structure; these would also need to be included in the permit or authorization:

- Pt 11-03-02 E
- N ½ 02-03-02 E
- Pt S ½ 36-02-02 E
- NW ¼ 24-02-02-E
- NW ¼ 05-02-03 E
- S ½ 16-02-05 E
- W ½ 09-02-05 E.

F.3.5.4 Mitigation and Compensation of Project Induced Flooding In Zone 1

Flood Mitigation

This section examines three options for mitigating project induced flooding associated with the operation of the Ste. Agathe Detention Structure. Some of the measures proposed would also apply to natural flooding and backwater effects of the Existing Floodway. The options examined are:

- Expansion or construction of community ring dikes
- Government buy-outs of chronically flood prone properties
- Development of flood zoning and building codes.

Community Ring Dikes

Community ring dikes can be an effective method for protecting more densely populated communities in the Red River Valley. A program of community ring dike building and enhancement was undertaken following the 1997 flood. One approach to mitigating the effects of project induced flooding from the Ste. Agathe Detention Structure would be to enhance ring dike protection in those communities subject to the backwater effect. This would involve increasing the level of protection for communities who already have ring dikes or building dikes around communities that currently do not have protection. The same level of protection could be provided for these communities as for communities downstream of the Ste. Agathe Detention Structure, i.e. sufficient protection to meet a 1 in 1000 year flood event. This mitigation alternative would only enhance community dikes and not the individually protected residences and farmyards.

If this mitigation alternative were implemented it would result in a significant reduction in the total number of people who would experience flooding from backwater effects. Enhanced ring dike protection would also serve to increase the level of protection from natural flooding. Table F-14 compares the estimated number of residents affected in Zone 1 under the Ste. Agathe Detention Structure with the community ring dikes in place in 1999 and with the enhancement or building of ring dikes in Morris, St. Jean-Baptiste, Letellier, Dominion City, Brunkild, Rosenort, Aubigny, St. Pierre-Jolys, Riverside and Roseau River FN. The analysis is based on enhanced dike protection up to and including a 1 in 1000 year flood event. The analysis presumes that the larger dikes would be technically and socially feasible. The table indicates that for floods between the 1 in 300 year and 1 in 1000 year levels, ring dike protection to the 1 in 1000 year level could fully protect an additional 3,800 to 4,700 residents.

TABLE F-14
Impact of Ring Dikes on Residents Upstream of Ste. Agathe Detention Structure by Flood Event

FLOOD LEVEL	RESIDENTS FLOODED WITH RING DIKES AT EXISTING LEVEL	RESIDENTS FLOODED WITH RING DIKES AT 1 IN 1000 YEAR LEVEL	ADDITIONAL RESIDENTS PROTECTED BY ENHANCED RING DIKES
1 in 90 Year	4,214	4,214	0
1 in 300 Year	8,367	4,544	3,822
1 in 500 Year	8,402	4,578	3,822
1 in 1000 Year	10,807	6,111	4,696

Source: InterGroup Consultants Ltd. from KGS Depth-Damage Model, 2001.
Note: Includes the communities of Morris, St. Jean-Baptiste, Letellier, Dominion City, Rosenort, Aubigny, St. Pierre-Jolys, Riverside and Roseau River FN. Communities of Emerson, Gretna and Rosenfeld have been excluded from this analysis.

Preliminary cost estimates for enhanced community ring dikes at Morris, St. Jean-Baptiste, Letellier, Dominion City, Brunkild, Rosenort, Aubigny, St. Pierre-Jolys, Riverside and Roseau River FN were completed by Manitoba Water Resources. These estimates are presented in Appendix C.

Emerson, Gretna and Rosenfeld were not included in the enhanced ring dike analysis (protection to 1 in 1000 year flood event) because they do not experience higher water levels as a result of project induced flooding. It is anticipated that these communities, which are subject to substantial natural flooding, would request enhanced ring dike protection if such protection were provided to other communities.

Participants in the key person interviews were asked about their views on the acceptability and usefulness of enhanced community ring dikes as part of a flood mitigation strategy. Comments received during the interviews included:

- Ring dikes can prevent a lot of damage but have social costs and technical weaknesses. We can’t just keep raising ring dikes forever.
- Flood damages in 1997 would have been much worse without the community ring dikes.

- Ring dikes split up plots of land; always arguments about where to put them.
- Like to see if ring dikes can be made useful for things other than just flood protection. Could they be seeded for hay or used for recreation in some way? People would accept them more if they could be useful during dry years too.
- Access during a flood is critical; with a ring dike a community is cut off, like an island.

Buy-Outs of Flood Prone Land

This mitigation option was mentioned often during the key-person interviews. The buy-out of a small number of properties subject to back-water from the Existing Floodway creates a precedent for this type of mitigation. However, the number of buy-outs required to remove residents from the area affected by backwater from the operation of the Ste. Agathe Detention Structure would be much larger. Buy-outs of this scale would come at a prohibitive economic and social cost. While a detailed examination of the costs of such buy-outs was not undertaken as part of this study, several residents commented that they would expect the Province to pay a premium (i.e., higher than current market value) for their land as part of a buy-out. The following general comments were noted during the interviews:

- Buy-outs should be considered as a mitigation option for flood prone homes. Develop a flood risk map and use it to identify properties that could be bought out.
- If the Government wants to build the Ste. Agathe dam they'll have to buy me out and they'll pay for it.
- Would hate to think that the solution is not to let anyone live in the Valley; we'd lose a lot more than just land.

Flood Zoning and Building Codes

The establishment and enforcement of stringent flood zoning regulations and building codes was mentioned often during the key person interviews. Generally, those interviewed were in favour of flood zoning as a mitigation measure but acknowledged that its benefits would be difficult to measure. Several people commented on the lack of enforcement of existing regulations and expressed concern about the ability to enforce such regulations in the future. Comments made during the interviews included:

- Land use restrictions and zoning are the keys to flood mitigation.
- Don't feel that zoning regulations are receiving the attention they deserve.
- Zoning enforcement is a major weakness.
- Learn what works from other jurisdictions. Building codes, if enforced, can reduce the damage considerably.
- Zoning regulations are a good idea but I don't know if they're enforceable.
- Municipalities need to take responsibility for enforcing zoning regulations. Need to make it a priority.

In addition to these mitigation options, several people commented on the need to examine the enhancement of wetlands and upstream storage as flood mitigation options. Comments on these topics included:

- Drought is as much of a problem as flooding. Upstream storage could help protect us from floods and be used as a source of water during dry years.
- Wetland enhancement has many environmental and social benefits beyond flood control. Like to see money for wetland projects.

Compensation

While mitigation measures such as enhanced community diking can significantly reduce the number of residents who experience project induced flooding during operation of the Ste. Agathe Detention Structure, not everyone affected by backwater can be protected through mitigation. Even under the most elaborate mitigation program, many upstream residents will experience project induced flooding. This creates additional requirements for flood related compensation and raises questions about the form of compensation. Compensation was perhaps the single most contentious issue related to the 1997 flood. Frustration with all aspects of the compensation process was noted during the key person interviews. General comments with respect to compensation recorded during the interviews included:

- Compensation was the second disaster.
- Adjustors and people who administer compensation need to be better trained.

- Compensation rules were set by people in the City who don't understand what it takes to run a farm.
- Since compensation uses public money, the process should be open and transparent, no hiding behind privacy. This will also help cut down on misuse of compensation money.
- Use local knowledge; people know how much land and houses in their community are worth.
- People are ' once bitten, twice shy' about compensation. No reason to believe the Province will handle compensation better next time.
- Compensation issues remain from 1997; these need to be resolved before any new compensation packages are discussed.

Type of Damages

Many of the residents interviewed during the study stated that compensation should be different in form and more generous where project induced flooding occurs. Compensation for three classes of damages were identified and are examined further below:

- Property value loss;
- Increased flood risk; and
- Event specific damages

Many residents, particularly those living in Zone 1, mentioned property value loss as a concern. A review of the literature related to property value loss in flood prone areas indicated that where flooding is infrequent but at times severe (as it is in much of the Red River Valley), property value loss is generally experienced immediately following a flood event but does not appear to be permanent. After approximately five years, memory of the flood fades and property values return to levels similar to pre-flood conditions. However, there were no available case studies similar to the Ste. Agathe Detention Structure, where impacts upstream of the structure are the result of project induced as well as natural flooding. It is unlikely that residents would agree that property value losses associated with the Ste. Agathe Detention Structure are temporary.

Increased flood risk was another type of damage discussed during interviews with residents. As some residents noted, part of their spring routine now includes checking flood forecasts and following water levels. The need for these activities, and the attendant stress, would increase if the risk of flooding increased as a result of a new flood control structure.

Event specific damages are the types that are most often associated with flooding. They include physical damages, stress and anxiety, loss of access and business interruption losses associated with a flood event. Frustration with the level of compensation available for these damages and the way in which it was administered after the 1997 flood was one of the most prominent themes noted during the key-person interviews.

Each of the three classes of flood damages noted above has different characteristics, both in the type of damage and the time at which the damage occurs. As such, compensation for each type of damage must be addressed in a different manner.

Compensation Mechanisms

Property Value Loss

Property value loss may occur in areas that would be impacted by backwater effects as a result of the Ste. Agathe Detention Structure. Such effects would generally be experienced immediately following a flood event but do not appear to be permanent. During interviews with residents, it was noted that this damage would generally be perceived to be a permanent loss suffered at the time of construction. This suggests that compensation for property value loss should be addressed prior to the start of construction and be included as a project cost. A one-time compensation payment would be awarded to those properties expected to experience a loss in property value due to the prospect of project induced flooding. Presumably developments taking place after construction would already include the adjustment for any construction related property value losses.

Any attempt to compensate for property value losses in advance of project construction will be confronted with a major challenge in establishing a fair and acceptable compensation level. The amount and duration of project induced property value losses resulting from introducing a new or improved flood control structure is highly uncertain and cannot be reliably predicted. Nevertheless, for illustration purposes, an order of magnitude estimate of what such a compensation mechanism could cost has been produced for the Ste. Agathe Detention Structure. The analysis is presented in Table F-15 and Table F-16 for residential properties in

Zone 1 that would experience increased flooding as a result of the Ste. Agathe Detention Structure during a 1 in 1000 year flood. Property value is approximated using two measures, the average assessed value of residential buildings (which does not include land value) used in the KGS stage-damage model and the average value of private dwellings from the 1996 Census of Canada. The amount of compensation to owners of these properties is based on 10% and 20% of the value of the residences. Based on these criteria, between approximately $10 million and $45 million would have to be added to the capital cost of the Ste. Agathe Detention Structure to compensate for anticipated property value losses. Consideration of property value losses for agricultural, commercial, industrial and municipal land would increase the required compensation amount.

Any form of property value loss compensation will encounter difficulties in separating project induced losses from other sources of loss. There is also risk of overcompensation, where some of those receiving compensation do not experience an actual loss when selling their property. This risk could be mitigated by compensating only for realized losses at the time of sale. However, this approach is unlikely to gain significant local acceptance.

TABLE F-15
Property Value Compensation Zone 1
Ste. Agathe Detention Structure
1 in 1000 Year Flood
KGS Damage Stage-Model

RM OR TOWN	NUMBER OF DWELLINGS IN ZONE 1 FLOOD AREA	AVERAGE ASSESSED VALUE	10% OF PROPERTY VALUE	20% OF PROPERTY VALUE
DeSalaberry	283	31,374	887,879	1,775,758
Franklin	248	27,696	686,870	1,373,741
Hanover	9	51,432	46,288	92,577
Montcalm	452	34,226	1,547,034	3,094,068
MacDonald	71	69,648	494,504	989,008
Morris (RM)	706	43,745	3,088,410	6,176,820
Ritchot	39	60,852	237,322	474,645
Rhineland	36	37,668	135,603	271,206
Emerson	228	29,749	678,282	1,356,563
Morris (Town)	561	41,962	2,354,058	4,708,116
St. Pierre-Jolys	283	39,949	1,130,565	2,261,130
Total	**2,916**		**11,286,816**	**22,573,632**

Source: InterGroup Consultants Ltd. from KGS Depth-Damage Model, 2001.

TABLE F-16
Property Value Compensation Zone 1
Ste. Agathe Detention Structure
1 in 1000 Year Flood
1996 Census Data

RM OR TOWN	NUMBER OF DWELLINGS IN ZONE 1 FLOOD AREA	AVERAGE VALUE OF DWELLINGS (1996 CENSUS)	10% OF PROPERTY VALUE	20% OF PROPERTY VALUE
DeSalaberry	283	125,258	3,544,801	7,089,603
Franklin	248	50,904	1,262,419	2,524,838
Hanover	9	88,881	79,993	159,986
Montcalm	452	62,473	2,823,780	5,647,559
MacDonald	71	130,499	926,543	1,853,086
Morris (RM)	706	77,202	5,450,461	10,900,922
Ritchot	39	114,016	444,662	889,325
Rhineland	36	84,576	304,474	608,947
Emerson	228	67,289	1,534,189	3,068,378
Morris (Town)	561	71,250	3,997,125	7,994,250
St. Pierre-Jolys	283	65,392	1,850,594	3,701,187
Total	**2,916**		**22,219,041**	**44,438,082**

Source: InterGroup Consultants Ltd. from KGS Depth-Damage Model, 2001 and 1996 Census of Canada.

Increased Flood Risk

The damages associated with increased flood risk could manifest in several ways, including perpetual uncertainty, additional stress and anxiety and loss of community vitality. All of these damages would commence with the construction of the project. However, unlike property value losses, the impacts would be borne both by current and future residents of the valley. Several of the residents interviewed indicated that a possible compensation mechanism for these types of damages would be an annual provincial subsidy of municipal property taxes. Another approach could base compensation on the present value of damages. In order to satisfy both the requirement that the compensation be considered a construction cost of the project and that the compensation should be available to present and future residents of the valley, an appropriate compensation method may be to establish a trust fund. The interest from the trust fund would be used to provide a subsidy for residences subject to project induced flooding. For the area south of the Ste. Agathe Detention Structure, a trust of $11 million to $22 million paying 5% interest would generate an annual property tax supplement of $550,000 to $1.1 million which is equivalent to 0.5% to 1.0% of residential property values in the Zone 1 flood area. For local property taxes this amounts to 1% to 3% of property values. Proceeds from a trust fund of This size could offset a significant portion of the local property taxes, conceivably in excess of one-sixth of the annual property tax.

Event Specific Damages

Event specific damages are those that occur at the time of a flood event. They include both those damages that are generally compensated at the time of the event, such as physical damage to residences or property, and less tangible damages such as business interruption losses and event related stress and anxiety. The independent legal opinion obtained as part of this study stated that property owners must be compensated for any project related flooding damages according to provincially established guidelines. Payment for event specific damages would take place shortly after a flood event. Unlike the previous mechanisms, the value of damage compensation is not incorporated into project construction costs. It is nevertheless a legitimate project cost to be incurred at a future date and is therefore factored into the project benefit-cost analysis.

Discussions with Zone 1 residents during the key person interviews revealed enormous dissatisfaction with both the level of compensation available and the manner in which the compensation was distributed after the 1997 flood. Specific comments on the shortcomings of the compensation package available in 1997 included:

- Don't try to save money on flood compensation. Pay people the replacement costs for what they lost, don't nickel and dime them to death.
- Social, emotional and psychological costs aren't compensated.
- Compensation should be for 100% of damages suffered in a flood event.
- Compensation should be viewed as a cost of flood fighting.
- Compensation is different than flood or disaster assistance. Compensation for artificial flooding needs to be higher.

The KGS stage-damage model provides estimates of the structural, infrastructure and agricultural damages for Zones 1 and 2 based upon the compensation criteria in place during the 1997 flood. Table F-17 presents all flooding damage estimates including those which project-induced, for buildings, agricultural land and roads for four flood events. The table is not meant to provide a comprehensive estimate of damages for each scenario (for example, pre- and post-flood fighting costs and damages to community ring dikes are not included). Rather, the table is presented as a coarse estimate of the magnitude of flood related costs that may be incurred.

Table F-17 includes a 20% addition to the building and agricultural damage estimates. The addition is intended to represent the expansion of the compensation available in 1997 and to address issues such as stress and anxiety and business interruption losses. The figure of 20% is by no means intended as a hard figure but instead as an initial recognition of how the inclusion of these types of damages might impact the compensation analysis. Using this more expansive approach raises the amount of compensation that would be paid in Zones 1 and 2 by between $13 million and $72 million, depending on the size of the flood event.

Table F-17 also includes an estimate of how the building or enhancement of community ring dikes at St. Pierre-Jolys, Morris and Emerson might impact the damage estimates for each scenario. Previous analysis indicates that with the Ste. Agathe Detention Structure, a larger proportion of the damages incurred in a 1 in 300 year flood or a 1 in 500 year flood are associated with these larger towns. This suggests that if the Ste. Agathe Detention Structure were to be constructed, the building or enhancement of the community ring dikes to the 1 in 1000 year flood level could considerably reduce the building damages associated with a 1 in 300 year or a 1 in 500 year flood. The three community ring dikes examined for this analysis reduce damages and compensation requirements by an estimated $125 million in a 1 in 300 year and 1 in 500 year flood and by almost $160 million for a 1 in 1000 year flood. These benefits would be expected to be even larger if all the existing community ring dikes in Zone 1 were upgraded to the 1 in 1000 year level.

TABLE F-17
Estimated Zones 1 & 2 Building, Agricultural and Road Flood Damages
Ste. Agathe Detention Structure

	Ste. Agathe Detention Structure			
	1 in 90 Year Flood	**1 in 300 Year Flood**	**1 in 500 Year Flood**	**1 in 1000 Year Flood**
	($) millions			
Building Damages	55	229	233	346
Agricultural Damages	8	11	12	13
Road Damages	23	30	30	41
Sub-Total Damages Using 1997 Criteria	86	270	275	400
20% Addition for Building and Agricultural Damages	13	48	49	72
Total Estimated Zone 1 and 2 Damages	99	318	324	472
Potential Building Damages Averted by Enhanced Ring Dikes[1]	0	127	128	160
Total Estimated Zone 1 and 2 Damages with Enhanced Ring Dikes	99	191	196	312

Source: InterGroup Consultants Ltd. from KGS Depth-Damage Model, 2001.

Note 1. The Depth-Damage model tracks damages by incorporated community. This estimate includes only the damages potentially averted in Emerson, Morris and St. Pierre-Jolys. Enhanced community ring dikes could provide additional protection to other communities, further reducing damage estimates.

The subject of compensation for project induced flooding was discussed often during the key person interviews. As noted above, many residents stated that people subject to project induced flooding should receive a higher level of compensation than those subject only to natural flood levels. One interviewee went so far as to make a distinction between flood or disaster assistance (of the type provided in 1997) and flood compensation for those impacted by project induced flooding. Operationally, these distinctions would be challenging to implement. Initial questions to be resolved would include:

- What portion of the damage is ‘ project induced’ and what portion is ‘ natural’ ?
- Since in many instances project induced flooding increases the level of flooding (rather than causing new flooding) would compensation be only for the difference between damages determined to be related to natural flooding versus damages related to artificial flooding or for all damages suffered by residents subject to any amount of artificial flooding?

The above discussion examines the three forms of compensation separately. In reality, more than one mechanism is likely to be considered at a time and the outcome of one would undoubtedly have impacts upon another. For example, if valley residents were confident that an appropriate, acceptable compensation mechanism was in place for event specific damages, the level of compensation required for property value losses or increased flood risk might be mitigated. There are numerous administrative and operational challenges that would need to be negotiated between the Province and those impacted by the presence of a new flood control structure. These are complicated issues that will not be resolved quickly. However, the comments received during the key person interviews have made two things clear:

- Public support for a new flood control structure will not be forthcoming until the issue of flood compensation is addressed.
- Development of an appropriate and acceptable compensation mechanism needs to be pursued as part of a public involvement process.

F.3.5.5 Legal perspectives on Project Induced flooding

The project induced flooding associated with the Ste. Agathe Detention Structure raises legal issues with regard to:

- Accessing private property;
- Compensation for project induced flooding;
- Accessing First Nation lands; and
- International issues.

Discussions were held with Manitoba Justice and an independent legal opinion was provided by Thompson, Dorfman, Sweatman. The key findings and conclusions of these analyses are presented below. International issues are discussed in greater detail in Appendix C, Section C.10 (Ste. Agathe Detention Structure – Impacts on USA).

Accessing First Nation Property

- Under normal conditions, the Crown has no right to flood or store water on private property without the permission of the owner.
- Pursuant to The Emergency Measures Act, lands may be flooded without liability during a declared state of emergency, subject to the payment of compensation in accordance with the Act, if necessary.
- Flood easements do not appear to be required to flood lands beyond the state-of-nature during a flood emergency. As such, there would be no requirement to include an amount for flood easement capital costs for either project.
- With regard to the construction of either flood protection alternative, lands can be expropriated for flood protection purposes under Section 9(1) of Water Resources Administration Act.
- Where only part of an owner's land is expropriated, but as a result the remaining land is rendered less valuable, the expropriating authority may be required to pay compensation for injurious affection to the remaining part, including 4the amount of the reduction in market value of the remaining land caused by the expropriation of the part and the damage sustained by the owner as a result of the existence and use (but not the construction) of the works on the part of the land expropriated.

Compensation for Project Induced Flooding

- Compensation for incremental project induced damages would have to be paid when an event occurs. This amount would need to be factored into the cost equation for the project cost-benefit analysis.
- Compensation guidelines are the responsibility of the Province of Manitoba. The amount of compensation would correspond to the damage estimates produced by the damage models applied by KGS Group. These estimates are based on existing disaster assistance guidelines.
- Compensation is likely required for actual damages incurred with the principle being that an affected party should be no better off after compensation. Where stress and inconvenience elements have been considered, compensation amounts for those elements have historically been small.

Accessing First Nation Lands

- Aboriginal or treaty rights, unlike other property rights, are explicitly protected by the Constitution. Since 1982, existing aboriginal and treaty rights of the aboriginal peoples of Canada have been recognized and affirmed in subsection 35(1) of the Constitution Act, 1982. If some anticipated activity of the Crown is very likely to interfere with a recognized right of this nature, injunctive or declaratory relief would be available.
- If there is any possibility that the operation of these works will result in a future purposeful storage of water on reserve land, a permit or easement should be obtained prior to commencing construction of any water control works or structures.
- Lands acquired under the Treaty Land Entitlement Agreement by Roseau River FN or any other FN community that could be subject to project induced flooding as a result of the operation of either flood protection alternative would similarly require a permit prior to construction. Lands acquired after construction under the Treaty Land Entitlement would also require a similar permit.

F.3.6 ADDITIONAL PERSPECTIVES ON SOCIO-ECONOMIC IMPACTS OF FLOODING

During the key person interviews, participants were asked about the socio-economic impacts of flooding. Comments, which would apply to both Floodway Expansion and the Ste. Agathe Detention Structure, noted during the interviews included:

- Loss of control during a flood is an incredible stress on families.
- Handling compensation and flood response badly makes the problem even worse.
- People can handle a natural disaster but the loss of dignity as they go through the claims process and have their lives put on display and judged is much worse.
- Artificial flooding is worse than natural flooding. Uncertainty every year, watch flood forecasts every spring, wonder how the Province will change the rules this time.
- Emergency response plans, equipment and infrastructure are much improved since 1997. However, the key now is to maintain this level of readiness.

These comments indicate that flood event response (the actions taken by governments and individuals before, during and after a flood) can have a significant impact on the socio-economic severity of a flood. Event response can be considered an intervening variable between the physical flood event and the perceived severity of the socio-economic effects of the flood. The frustration, stress and anxiety resulting from poor response during a flood event can persist for months or even years after the flood waters recede. Similar perspectives have been documented in the literature including the work of Morris-Oswald and Simonovic (1997) who conducted in depth post event interviews with a cross section of people in the Red River Valley affected by the 1997 flood. It therefore seems important to include a consideration of flood event response in the development of future flood control strategies.

F.4 BIOPHYSICAL ENVIRONMENTAL EFFECTS ASSESSMENT

F.4.1 INTRODUCTION

The intent of the environmental assessment process for the proposed flood control alternatives is to describe the proposed development and existing surrounding environment, and to identify the potential environmental effects associated with the proposed development. Actions to mitigate or eliminate adverse biophysical and socioeconomic effects will be identified, and the significance of the residual effects will be evaluated. Mechanisms for a follow up program will also be identified.

As discussed in Section F.4.5, a comprehensive environmental assessment of the potential environmental effects will be conducted in the next level of study. However, potential effects were identified in the preliminary scoping exercise as warranting additional attention at this early development stage.

The potential effects of the project activities on groundwater flows and elevations, and aquatic habitat and wildlife are discussed separately for the Red River Floodway Expansion and the Ste. Agathe Detention Structure in Section F.4.3 and F.4.4, respectively. The intent of these sections is to describe the prevalent biophysical effects of each flood control alternative as anticipated at this early stage, and to identify some measures for mitigation.

Information gaps and deficiencies, and research/study required to fulfill requirements of the next level of study are identified in Section F.4.5. Preliminary schedules to meet all requirements of the federal and provincial regulatory processes are provided in the Main Report.

Socioeconomic issues have been considered previously in Section F.3.

A description of the existing aquatic conditions within the Red River based upon available information is provided below. Site-specific information is not available for either flood control alternative at this time, and as discussed previously, baseline studies will need to be conducted for each option in order to rectify this.

F.4.2 CURRENT LEVEL OF UNDERSTANDING OF THE EXISTING AQUATIC ENVIRONMENT IN THE RED RIVER

The Red River originates near the North Dakota/South Dakota border, and flows north for 550 miles into the south end of Lake Winnipeg. The drainage basin encompasses approximately 107,000 square miles, including much of northern Minnesota, northern North Dakota, southeastern Saskatchewan and southern Manitoba. The Assiniboine River, which converges with the Red River in downtown Winnipeg, accounts for approximately 59,000 square miles of the total drainage area (Environment Canada 1991). At Lockport, 45% of the flow originates from Manitoba, 46% from the United States and 9% from Saskatchewan (Gurney 1991).

The Red River flows through glaciolacustrine deposits that aggraded within glacial Lake Agassiz. It has a fairly uniform, continuous descent northward, averaging less than 0.5 ft/mile. Consequently, water velocities are low. It is a typical lowland zone stream, consisting of oxbows and meanders, highly turbid waters, and substrates composed of sand/silt and/or gravel/cobble. In general, substrates from St. Adolphe to the north end of the City of Winnipeg are primarily composed of silt, clay, sand and/or gravel. From the north end of the city downstream to Selkirk, substrates are composed primarily of limestone boulders and cobble. Substrates return to silt, mud and clay as the river approaches Netley Marsh at the south end of Lake Winnipeg. River bathymetry from the City of Winnipeg to Lake Winnipeg is relatively well understood, but there is little recent detailed information from south of the City.

Water chemistry

Red River water quality is relatively well understood. The City of Winnipeg, Province of Manitoba and Environment Canada all test water quality in the Red River on a regular basis and have long-term Red River water quality databases. Red River water is characterized by high levels of turbidity, total suspended solids (TSS), and nutrients. Turbidity and TSS levels are related to discharge and are generally highest during April and lowest during the winter. Red River water often exceeds Manitoba Water Quality Objectives for TSS, phosphorus, ammonia, and fecal coliform. Many of the exceedences are related to low flow periods (i.e., in winter and during drought).

Biota

Lower Trophic Levels

With the exception of a couple of studies conducted during the early 1980's, there is very little information on the phytoplankton community in the Red River. Macrophyte growth in the Red River is relatively sparse because of low light penetration (as a result of high turbidity and suspended solids), water velocity, and ice scour. Site-specific occurrences of macrophytes have not been documented.

The distribution of benthic invertebrates in the Red River is spatially heterogeneous. Studies conducted for the City of Winnipeg identified twenty-five taxa from between St. Adolphe and Lockport. The greatest number of taxa was found within the City of Winnipeg, and Insecta (primarily Trichoptera) were the most abundant group.

Freshwater bivalves (clams) are of special concern because: 1) the Red River has the most diverse assemblages of freshwater clam species of any river in Canada; 2) general aquatic habitat degradation and destruction within the Red River, over the last 20-30 years, has resulted in a considerable decline in abundance of all clam species within the river; and 3) most mussel species present are at the limit of their range, and any degradation of habitat would be difficult to rebound from (Stewart 1990; Carney 1993; Williams et. al 1993; Dr. E. Pip, U of W., pers. comm in: MacPlan 1994). Because of specialized habitat requirements, the occurrence of clams along river beds is usually patchy and discontinuous. Recent studies have examined clam distribution in the Red River, but site-specific information is rare.

Fish

At least 57 species of fish are known to occur in the Red River and its tributaries, in Manitoba. The most abundant species include: channel catfish, sauger, goldeye, white sucker, freshwater drum, emerald shiner, and river shiner. There are no endangered species occurring in the river, however, bigmouth buffalo, silver chub, and chestnut lamprey have been designated "Of Special Concern" by the Committee on the Status of Endangered Wildlife in Canada (http://www.cosewic.gc.ca/ updated 15 August 2000). Four species, the channel catfish, flathead chub, brassy minnow and spotfin shiner, are on the Manitoba Endangered Species Act "Watch List" due to concern for declining populations or the paucity of information on their current status within the province.

The majority of Red River fish species spawn during spring, when discharges are high and water temperatures are rising. A few species such as channel catfish, freshwater drum, carp and goldeye and a number of cyprinid species, spawn during late spring and into early summer. Burbot are the only species that spawn under the ice during late winter. None of the species found in the Red River upstream of Lockport spawn in the Red River or its tributaries during fall. Specific spawning locations within the Red River are unknown, however, tributaries and tributary mouths are known to provide important spawning habitat for many Red River fish. Lake whitefish spawn in the fall off rock/gravel shoreline areas of Lake Winnipeg. The dates of dredging in Lake Winnipeg and in the mouth of the Red River have been established in relation to whitefish spawning.

Red River fish populations are highly mobile during open-water periods. Fish tagged in Winnipeg have been recaptured as far south as Halstad, Minnesota (approximate distance of 256 miles), and as far north as Dogwood Point on Lake Winnipeg (approximate distance of 153 miles). Fish in the river have been shown to travel up to 34 miles in two days and 250 miles within 14 days. A large proportion of fish within the City of Winnipeg during summer move out of the city during fall. Fish that remain within the city limits during winter remain relatively stationary within the deeper reaches.

Manitoba Conservation Fisheries Branch considers most Red River fish safe for human consumption. However, there is an advisory in the Manitoba Anglers Guide each year warning anglers that some fish from the Red River (i.e., large walleye and northern pike) may have elevated mercury levels. The Environmental Protection Agency (EPA) in the United States has issued thirty-three advisories with regard to elevated mercury levels in a number of fish species in the Red River (EPA 2000). The EPA has also issued one advisory of elevated PCB levels in white sucker between five and fifteen inches. A recent paper provided an overview of concentrations of trace elements and organochlorine compounds in fish from the upper Red River.

F.4.3 FLOODWAY EXPANSION

Options for the Red River Floodway Expansion consist of enlargement in channel depth, channel width, or a combination of the two, along the 29 mile length of the channel. Additionally, any significant expansion of the floodway must be accompanied by a modification of the outlet structure, since it presently has a limited design capacity associated with the existing Floodway channel. A detailed description of the Floodway Expansion alternative is provided in Appendix B.

F.4.3.1 Potential Environmental Effects

A preliminary Project-Environment Interaction Matrix has been completed for the floodway expansion option (Table F-1). The purpose of the matrix is to allow for the preliminary identification of potential positive or adverse environmental effects associated with the option, and to assist in the identification of data/information requirements. The information also assists with the socioeconomic assessment. Potential aquatic and groundwater effects identified as warranting further discussion at this early stage of development are described below.

Groundwater Effects

The most significant effects associated with the Floodway Expansion will be related to potential changes to the existing groundwater regime. Each of the Floodway expansion options under consideration will have an impact on adjacent groundwater levels and wells to varying degrees.

The carbonate aquifer is extensive and underlies the Red River Floodway and adjacent areas and is the prime source of domestic and commercial water supply for most of the Floodway area. Towards the south end of the Red River Floodway, groundwater quality generally does not meet potable requirements, such that water hauling is more common in this area.

In terms of the proposed options considered to expand the capacity of the Red River Floodway, deepening the Floodway will be expected to lower groundwater levels locally by approximately the amount of Floodway base lowering and will have a greater effect on groundwater levels than widening the Floodway.

Potential changes to the groundwater table and water quality associated with the floodway expansion option are discussed in detail in Section B.4 of Appendix B.

Aquatic Effects

A number of aquatic issues and concerns have been identified as a part of the ongoing assessment and input from DFO.

Erosion Control During Construction – Construction associated with Floodway expansion will result in a minor disturbance and destabilization of the Floodway channel banks and Red River banks in the downstream portion of the channel and outlet control structure that may result in erosion and introductions of sediment to the Red River. This activity could lead to increased levels of turbidity and TSS in the river and to deposition of sediments in downstream areas resulting in direct effects on aquatic life or a harmful alteration to fish habitat. The vulnerability of the Floodway to erosion would be increased substantially if it were required to carry flood flows during the construction period.

Decreased Groundwater Levels – Lowering groundwater levels in the vicinity of the Floodway may affect small local streams near the Floodway that rely on groundwater discharge as a significant component of the overall flow within the streams.

Fish Stranding - Although fish stranding would likely occur at a number of locations within the flood plain if the Floodway did not exist, stranding within the Floodway could be viewed as an incremental effect of the project. The extent that fish become "stranded" in the Floodway after cessation of spring flows is currently unknown.

Barrier to Fish Passage - Operation of the existing Floodway Inlet Control Structure and its effect on fish passage has never been evaluated. The Inlet Control Structure may presently be a barrier to fish passage when the gates are raised during a flood event and possibly under high flows when the gates are down. Effects are likely greatest during spring (April through May) when flows are highest and fish spawning migrations occur. Effects on fish passage during summer flood conditions are less of a concern, but have the potential to affect fish foraging activity. Changes to the floodway operation, which may accompany an enlarged floodway, could affect the level of attention that this issue receives.

Loss of Fish Habitat – Fish habitat may be lost associated with the construction and operation of the expanded Red River Floodway.

F.4.3.2 Proposed Mitigation Measures

Groundwater Effects

The hydro-geological impacts associated with each of the Floodway alternatives can be relatively well defined prior to construction. Regardless of the anticipated effects, an extensive monitoring system would be established to define baseline pre-construction conditions and any changes during and after construction. Mitigation of groundwater effects will include upgrading, or deepening of some wells. Costs for mitigation have been estimated (Appendix B) and are included in the cost estimate of the alternative.

Aquatic Effects

Erosion of Channel and River Banks - With good construction practices and attention to isolating the work areas from the river, aquatic concerns arising from construction activities should not be difficult to mitigate (i.e. use of silt fences). Further investigation is needed to determine the extent to which the floodway will be vulnerable to erosion during construction and mitigation methods that can prevent extensive erosion. The cost for the mitigation measures to reduce erosion of the channel and riverbanks has been estimated and included in the capital cost of the alternative.

Decreased Groundwater Levels – Decreased groundwater discharge to streams near the floodway (Bottomly Creek, Bunns Creek, Seine River, Gunns Creek, and Cooks Creek) is not anticipated to be significant and will be assessed as a part of the groundwater investigations.

Fish Stranding - Given that fish stranding is not known to currently be a problem in the floodway and that the capacity of the downstream control structure to pass fish will likely be improved, fish stranding is not anticipated to be a significant issue.

Barriers to Fish Passage **-** Operation of the floodway inlet structure is by the Province of Manitoba. The need for mitigating the effects of fish passage should be discussed with the Department of Fisheries and Oceans at the next level of study. The assessment requirements for mitigation, if any, will in part depend on whether the operation rules have changed or not.

F.4.3.3 Additional Costs for Potential Mitigation Measures

Should further study indicate that the inlet control structure is acting as a barrier to fish passage, modifications to the structure may have to be initiated to ensure the safe passage of fish. However, a large cost would be associated with this mitigation measure, and the cost has not been included in the initial capital cost estimate, nor has an estimate been considered given the unknown nature of the requirements.

Additional measures and costs to mitigate environmental effects identified in the environmental impact assessment report will be provided in the next level of study. An allowance of $1,000,000.00 has been included in the total project estimate for those items not identified at this level.

F.4.4 STE. AGATHE DETENTION STRUCTURE

Implementation of the Ste. Agathe Detention Structure involves the construction of a river control structure and an earth dam across the Red River just upstream of Ste. Agathe. Under flood conditions greater than the 1997 flood magnitude, water levels will be increased by up to 9 ft. above natural conditions upstream of Ste. Agathe. The differential flooded area and the project are described in greater detail in Appendix C. The impacts of the changed water levels are primarily socio-economic and are described in Section F.3. The aquatic community in the Red River and a number of smaller watercourses, including the Rat and Marsh rivers and Tourand Creek, will be substantially impacted by the structure and it's operation.

F.4.4.1 Potential Environmental Effects

A preliminary Project-Environment Interaction Matrix has been completed for the Ste. Agathe Detention Structure option (Table F-2). The purpose of the matrix is to allow for the preliminary identification of potential adverse environmental effects associated with the option. Potential aquatic effects identified as warranting further discussion at this early stage of development are described below.

Barriers to Fish Passage – Detriments to fish passage will be caused by the development of structures on the Red, Marsh and Rat Rivers, and Tourand Creek.

Erosion of River Banks - Construction associated with the Ste. Agathe structure will result in disturbance and destabilization of banks on the Red, Rat, and Marsh rivers and Tourand Creek that may result in erosion and introductions of sediment to the Red River and its tributaries. This activity could lead to increased levels of turbidity and TSS in these streams and to deposition of sediments in downstream areas resulting in direct effects on aquatic life or a harmful alteration to fish habitat. Erosion of the riverbanks may also hinder navigation on the Red River in the vicinity of the structure.

Flow Diversion - Diversion of less than bank-full flows from the Red River, and diversion of flows from the Marsh River and Tourand Creek, to the Rat River will cause alterations to fish habitat in the lower portions of the Rat and Marsh rivers, and Tourand Creek. Diversion of less than bank full flows from the Red River to the Marsh River Control Structure will affect fish habitat between the Red River control structure and the mouth of the Rat River.

Fish Habitat Loss - Loss of habitat at the structure locations. Removal of the meander bend for construction of the Red River Control Structure represents a loss of fish habitat in the Red River. Structures on the Marsh and Rat rivers and the dike across Tourand Creek will also result in losses of fish habitat.

F.4.4.2 Proposed Mitigation Measures

A number of potential effects have been identified in the design process for the Ste. Agathe project. Since the design is at a pre-feasibility level of development, it is premature to have fully assessed the impacts of the project or to have developed mitigation methods to accommodate them. Based on preliminary feedback from DFO, a number of modifications to the detention structures have been initiated to mitigate or eliminate aquatic habitat impacts. These include:

Barriers to Fish Passage

- Elimination of the rollway crests (fish passage barrier) at two of the six spillway bays for the Red River Control Structure. This change was made for a number of reasons including facilitating fish passage, the need to eliminate low-level backwater effects upstream of the structure and to increase the overall capacity of the structure. In addition to enhancing fish passage, the low-level bays will facilitate navigation.
- Removal of the culvert control structure on the Rat River. A low-level control structure is now considered in the plan for the Rat River Control Structures. It is anticipated that this will allow fish passage through the dam at the Rat River in most years. At this time, no control structure has been planned for the Marsh River or Tourand Creek. Further study is needed to determine the value of fish habitat in the upper reaches of the watersheds.

Erosion of River Banks - With good construction practices and attention to isolating the work areas from the river, aquatic concerns arising from construction activities should not be difficult to mitigate (i.e. use of silt fences). The cost for the mitigation measures to reduce erosion of the riverbanks has been estimated and included in the capital cost of the alternative.

Flow Diversion – A review of operation priorities could eliminate or substantially reduce the alterations of fish habitat caused by flow diversions.

Fish Habitat Loss - It is possible that some of the fish habitat losses associated with the Ste. Agathe project (i.e. the loss of the meander bend in the Red River and the potential loss of fish habitat in the upper reaches of the Marsh River and Tourand Creek) will not be able to be mitigated and will require compensation under the habitat provisions of the *Fisheries Act*. Compensation would need to be negotiated with the Department of Fisheries and Oceans and would result in an increased cost to the project.

F.4.4.3 Additional Costs for Potential Mitigation Measures

As the construction of the Ste. Agathe Detention Structure is proposed to take place on a meander bend of the Red River, it is apparent that fish habitat within the bend will be lost. This habitat loss could be partially mitigated in the event that the structure was constructed on a straight path of the river. The cost to construct the structure at different locations to mitigate some of the effects of fish habitat loss has not been included in the original capital cost estimate. The estimated additional project cost for excavation to eliminate the use of the meander bend is 2 to 3 million dollars.

Although a control structure with no fish passage has been planned for the Marsh River at this time, a structure to allow for fish passage could be implemented if further study indicated that valuable fish habitat would be lost in the upper reaches of the Marsh River. The cost to allow for fish passage on the Marsh River has not been included in the original capital cost estimate. The cost to implement an additional structure on the Marsh River to allow for fish passage based on the type of structure currently planned on the Rat River is estimated to cost 6 million dollars, including contingency and local channel modification.

Measures and costs to mitigate environmental effects identified in the environmental impact assessment report will be provided in the next level of study, and an additional allowance of 1 million dollars has been included at this time. Total estimated additional potential costs for mitigation associated with the Ste. Agathe Detention Structure are summarized in Table F-18.

TABLE F-18
Total Estimated Additional Cost for Potential Mitigation Measures
Ste. Agathe Detention Structure

ITEM DESCRIPTION FOR MITIGATION	ESTIMATED POTENTIAL COST
Excavation for habitat loss at meander loop	$2 to $3 Million
Marsh River Control Structure for Fish Passage	$6 Million
Allowance for additional mitigation measures not identified at this time	$1 Million
Contingency Costs	$2 Million
Total Estimated Cost of Potential Mitigation Measures	**$12 Million**

As described in Appendix C, the Ste. Agathe Detention Structure is a complex scheme, which considers diversion of flows from the Red River, Marsh River and Rat River at varying flow frequencies. Preliminary aquatic issues as described above associated with fish passage and loss of habitat have been considered in the development of the current scheme. Should the alternative proceed to advanced levels of design, it is apparent that considerable additional effort will be required to define the nature of the effects, to evaluate mitigation measures and to work with DFO through the definition of compensation, if any.

F.4.5 REQUIREMENTS FOR THE NEXT LEVEL OF STUDY

F.4.5.1 Aquatic Environment

To obtain an environmental license, Fisheries Act Authorization and other approvals for a project, a proponent must provide the regulatory organizations with a sufficient amount of information such that they will be able to determine whether the project will comply with the Fisheries Act, and whether it falls within DFO's policy objectives for the Management of Fish Habitat. The information must provide an understanding of the effects of the project on fish, including movements, and habitats for spawning, foraging, rearing and overwintering. Although there is a general understanding of the importance of Red River and Red River tributary habitat with regard to these life history requirements, there is virtually no site-specific information with regard to fish habitat and fish habitat utilization.

It is anticipated that a minimum of two years of aquatic baseline studies will be required to provide the necessary information. Studies may need to focus on determining the following:

Floodway Expansion Option

- the potential to strand fish in the Floodway channel;
- the potential to block fish movement by the existence and operation of the Floodway Inlet control gate;
- the potential for erosion in the Floodway channel during and after construction; and
- the potential loss of fish habitat.

Ste. Agathe Detention Structure Option

- the value of habitat in Tourand Creek, and the Marsh and Rat rivers;
- the value of the Red River meander bend that will be lost due to construction of the Red River Control Structure;
- the extent to which fish passage is required in the Red, Rat and Marsh rivers and Tourand Creek;
- how habitat will be affected in the lower reach of the Marsh and Rat rivers, and Tourand Creek because of flow changes;
- how habitat will be affected in the Red River between the Ste. Agathe Detention Structure and the mouth of the Rat River because of flow changes.

F.4.5.2 Terrestrial Environment

The environmental assessment of the proposed project must address both aquatic and terrestrial biophysical environmental components as well as social, economic and cultural components. The level of information on terrestrial environmental and social, economic and cultural components is not known. It is assumed that a general level of information is available for the region but the specific level of detail for the study area is not adequate for environmental assessment and decision-making purposes. A review of the available literature is required to identify information/data gaps and deficiencies and to determine what additional information/data is essential for the environmental assessment.

It is anticipated that a minimum of two years of terrestrial baseline studies will be required to provide the necessary information. Studies may need to focus on determining the following:

Floodway Expansion Option

- Socio-economic survey along the Floodway corridor;
- Land-use mapping upstream from the Floodway Inlet Structure and downstream from the Floodway Outlet Structure;
- Wildlife and wildlife habitat inventory along the Floodway corridor;
- Riparian wildlife and vegetation survey upstream from the Floodway Inlet Structure and downstream from the Floodway Outlet Structure;
- Heritage resource impact assessment upstream from the Floodway Inlet and downstream of the Outlet Structure.

Ste. Agathe Detention Structure Option

- Socio-economic survey of the Red River valley in the Ste. Agathe study area;
- Land-use mapping of the Red River valley in the Ste. Agathe study area;
- Wildlife and wildlife habitat inventory along the Red River valley in the Ste. Agathe study area;
- Protected species (vegetation) inventory in the Ste. Agathe study area;
- Riparian wildlife and vegetation along the Red River in the Ste. Agathe study area;
- Heritage resource impact assessment along the Red River in the Ste. Agathe study area.

F.4.5.3 Estimated Cost for Baseline Studies

Estimated costs for the biophysical baseline studies for the project are based on the description of anticipated studies and are tabulated in Table F-19.

TABLE F-19
Total Estimated Cost for Baseline Studies at the Next Level of Study
Floodway Expansion and Ste. Agathe Detention Structure

BASELINE STUDIES	ESTIMATED POTENTIAL COST
Aquatic Baseline Studies	$100,000 to $150,000 (Floodway) $250,000 to $300,000 (Ste. Agathe)
Terrestrial Baseline Studies	$200,000 to $300,000
Total Estimated Cost of Baseline Studies (Annually)	**$550,000 to $750,000**

Requirements for socioeconomic concerns at the next level of study were discussed previously in Section F.3.

REFERENCES

REFERENCES

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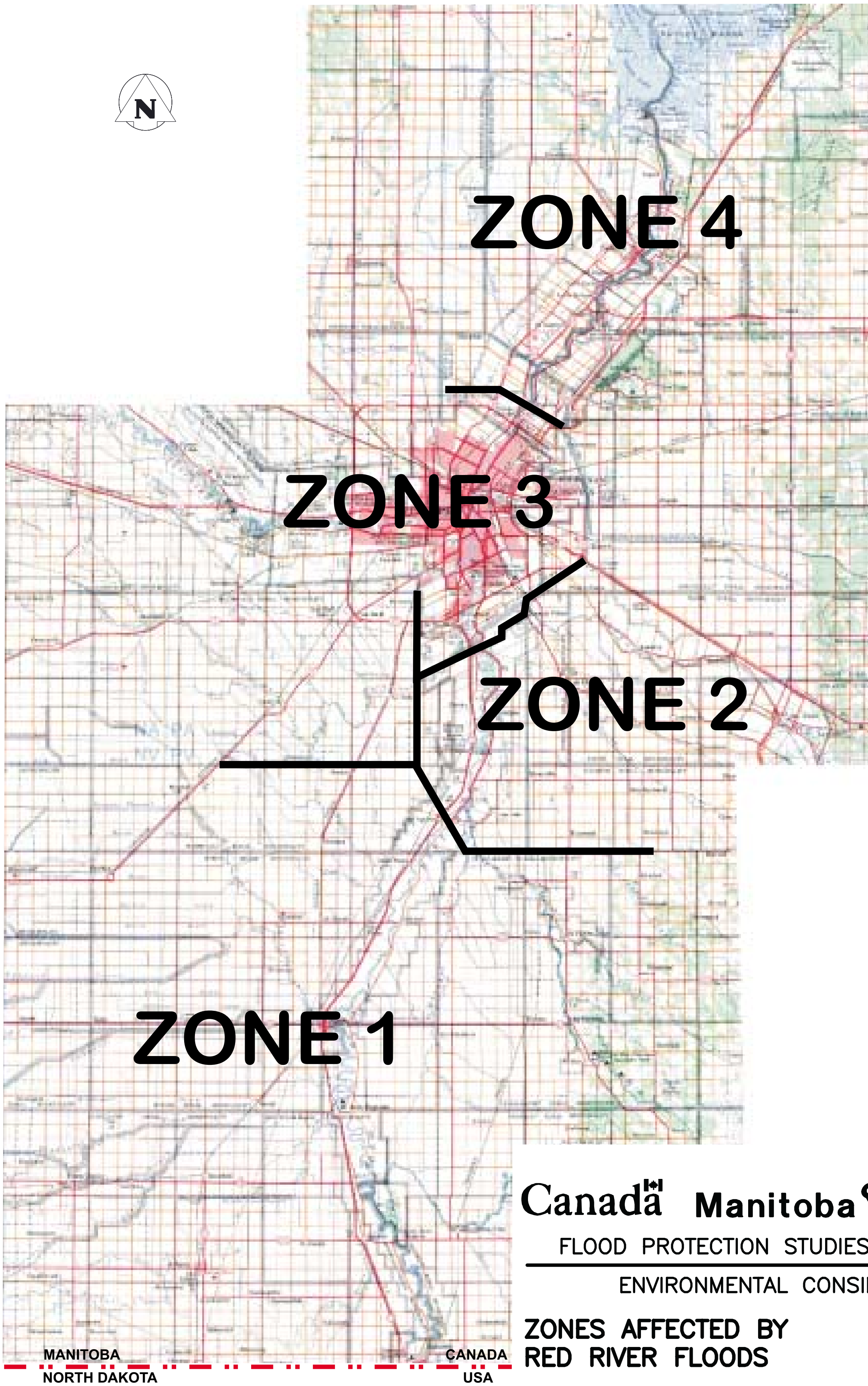
PLATES



Canada Manitoba Winnipeg

FLOOD PROTECTION STUDIES FOR WINNIPEG

ENVIRONMENTAL CONSIDERATIONS

ZONES AFFECTED BY RED RIVER FLOODS

PLATE F-1

FINAL REPORT – SEPTEMBER 2001

KGS GROUP

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ANNEX A

PROCESS DESCRIPTION
COMPREHENSIVE PUBLIC PARTICIPATION PROCESS
FOR WINNIPEG FLOOD PROTECTION

ANNEX A
PROCESS DESCRIPTION
COMPREHENSIVE PUBLIC PARTICIPATION PROCESS
FOR WINNIPEG FLOOD PROTECTION

This annex describes a comprehensive and independent public participation process for evaluating the two Winnipeg Flood protection alternatives. A modified version of this approach could also be used for evaluating alternative scales and key features of a preferred project. The process is depicted in Figure A1.

COMPONENTS AND KEY FEATURES

The comprehensive process consists of three main components:

- **Education process** There is a strong need for the residents of the Red River valley to understand how the basin works hydrologically, how the alternative projects protect against floods, and what impacts the alternative projects may give rise to. Similarly, it is important for the decision-makers to learn what the needs and concerns of the residents and communities are and to ensure such knowledge is integrated into the decision-making process.

- **Consensus-building process** which allows selected representatives from each geographic zone in the valley to work towards agreement on approaches to compensation and mitigation as well as on project preference. Full consensus across the basin is not anticipated. However, the focus of this small group activity will be on developing common ground.

- **Informal hearing/meeting process** which allows all residents to share their concerns and preferences and reasons for same. The education materials and the products of the consensus-building process will inform and support the hearing/meeting process.

To achieve independence, an **independent commission** would be appointed to be engaged in and oversee virtually the entire public participation process. This commission also makes the final recommendations on the preferred project and the conditions under which it should be built.

The public participation process requires **12 to 14 months** from the initial appointment of the commissioners until the final recommendations are delivered.

INITIAL STEPS

- Members of the independent Commission would have to be identified and appointed.
- The public participation process must be described and advertised.
- Locations and timing of initial meetings must be chosen and advertised.
- Processes for the participation of those not living in the communities where meetings will be held should be developed and advertised.

EDUCATION PROCESS

- This process is for the general public, the participants in the multi-stakeholder processes as well as for the appointed commissioners.
- It is a two-way process. The public learns about alternatives, known effects and the decision-making process. In addition, the commissioners learn more about impacts and needs of individuals and communities.
- The starting point is the Phase I report, due in the fall of 2001. The Steering Committee could get the education component off the ground while the commission is being formed.
- Materials (wall charts, simplified diagrams, storyboards, etc.) would be prepared which would make the conclusions of the report more easily understood by the general public.
- The public participation process would be described and laid out diagrammatically so this component would be seen in the correct context. Effectively, there would be education on process as well as on substance.
- Presentations for selected organizations, including local governments, would be prepared.
- Town hall discussions would be held. These would engage people in the issues well before an alternative project was due to be selected. This could be integrated with the consensus-building process. For example, the town hall "education" meeting could take place on one evening in preparation for the consensus-building process beginning the next morning.
- A research ability would be built in to support extra-ordinary information needs of the education process and the consensus-building process.

Thoughts on Implementation of the Education Process

<u>Mechanisms:</u>

- Initiated with an open house
- And, with presentations to groups
- Town hall discussions

- Distribution of printed materials
- Interactive web site

Role of Commission:

- One or two along for each community visit
- Chair any formal sessions
- Observe other situations, such as the open houses

Resources Required:

- Simplified information materials derived from the Phase I report.
- Recording or transcribing capability to ensure the education is two-way and lessons are retained.
- Web site to help keep any interested party abreast of meetings, outcomes, new information.

Logistical Challenges

- Allowing sufficient lead-time for the whole public participation process to get started.
- Should probably attempt to visit five locations in each zone (5 meetings x 4 zones = 20 meetings).
- Two days should be spent in each location (forty meeting-days).
- Will need to respond to requests for more locations.
- If not linked logistically to the consensus-building process, each group could do two meetings per week.
- Might make sense to have two teams on the road. If so, five weeks would be required to deliver the information once the materials were ready. Should add a sixth week to allow for requests for more meeting locations.

Costs:

- Staff time for planning the overall public participation process and, more specifically, the education process.
- Specialized assistance in creating education materials, presentations, etc.
- Assistance in creating and then maintaining the web site.
- Production costs for education materials.
- Two support people for each “tour” or four support people for the meetings for three months.
- Research support for the duration of the process.

- Commissioners' time.
- Meeting locations and refreshments.

CONSENSUS-BUILDING PROCESS

- This takes the form of facilitated multi-stakeholder workshops - one group per zone. There would need to be some kind of a process towards the end of this phase for integrating or combining the results of all groups.
- The selection of participants for these groups would need to be carefully planned and executed. One would be looking at groups not exceeding 15 members and preferably around 12 members. One would want each group to have representatives from a range of interests and be, effectively, a mini round table.
- Participants would have to make a significant commitment of their time over the few months these groups would be active (say, five meetings for each group of a half-day or more each, plus some discussion time between meetings, both with the facilitator and the broader public).
- The groups would look at the whole range of issues from mitigation and compensation to project preferences and would attempt to reach agreement on these topics or at least on some elements of them.
- The groups would be facilitated.
- The integration process among the individual groups would also be consensus-driven, but there would likely be insufficient time to drive it fully to completion. Integration options could include:
    - One or two-day workshop involving all participants from the four working groups.
    - A process spread over a longer period involving representatives of the four working groups.
- Where consensus was not possible, the goal would be to enhance understanding of the various choices, points of view and mechanisms required to make project alternatives more palatable.
- The commissioners are involved in this process, probably as observers, but visible nonetheless
    - This means that they would be available to answer questions such as "how will you respect the outcomes of the multi-stakeholder processes?"
- It would also be possible that the commissioners be chairs of the small groups.
- There needs to be a process for keeping the groups in communication with the broader public.

Thoughts on Implementation of the Consensus-building Process

Mechanisms:

- Multi-stakeholder workshops, one per zone of 12 to 15 members each, facilitated by an impartial third party.
- Reports back to group members throughout.
- Web postings on a timely basis.
- Connection between the individual groups and the communities they represent.
- Undefined approach to integrating the results of the four working groups.

Role of Commission

- Chair meetings or observe

Resources Required

- Willing and able (capable of representing their particular interests in a constructive manner) participants from each of the four zones.
- Four facilitators and four recorders (one each per working group).
- Workshop aids (flip charts, etc.).
- Research support (from education process) for the working groups.

Logistical Challenges

- Four groups each requiring five meetings (20 meetings in total).
- Each meeting would take the best part of a day.
- If the frequency of meetings was once every three to four weeks and if these meetings could be delivered by four teams in the field, four months would be required to complete all meetings.
- There would have to be considerable between-meeting contact with the members of each working group.
- Meeting locations may have to move around within any particular zone.
- There would have to be either some overlap or some integration with the education process for the overall schedule to succeed.

Costs

- Planning and organizing time.
- Meeting locations and refreshments; mid-day meals; support for some participants' travel and sustenance.
- Full-time recorder/logistics support persons.
- Part-time facilitators.

- Commissioners' time.

INFORMAL HEARINGS / MEETINGS

- There are drawbacks to the traditional formal public hearing approach
  - Formal hearings tend to intimidate some, frustrate others and give a very brief opportunity in the limelight for yet others.
  - They are adversarial in nature.
  - Participants rarely see how their input has affected the outcome.
- This hearing process needs to be different in some regards:
  - It follows an intense effort to build broader consensus and would need to be structured such that common ground rather than differences are emphasized.
  - Meetings could be more informal - a couple of commissioners go to a community and meet with individuals and groups for a day or two and then host a town hall meeting to share with the people what they have heard thus far.
  - There would need to be meetings in key areas of each zone to allow for opportunities for engagement.
  - This is not a start-from-scratch public hearing process as most issues will be dealt with in the multi-stakeholder discussions, so the hearings schedule can be truncated. The participants provide final thoughts - their final position and the reasons for it.

Thoughts on Implementation of the Hearing Process

<u>Mechanisms</u>

- More informal meetings held with community organizations (probably the same ones involved in the education phase as well as those represented in the multi-stakeholder process).
- Summary town hall meeting in each selected community.
- Opportunity at the end of the hearings period for the commissioners to bring together all the findings and products of the PP process.
- Final reporting process which shows what was heard and what was done with opinions and products.

<u>Role of Commission</u>

- Chair all meetings.
- Consolidate all findings and results or products.

- Formulate recommendations respecting what has been heard and what has been produced throughout the process.

Resources Required

- Staff to organize all meetings and assist in their conduct.
- Staff to record results and assist the Commission in its analysis.
- Research support.
- Writer for the final report/recommendations.

Logistical Challenges

- If three communities could be visited in a week and if all commissioners participated in all meetings, seven weeks would be required for the meetings.
- This would allow two to three weeks for the formulation of recommendations and reasons for those recommendations.

Costs

- Support staff for the full 2½ month period of the hearings and recommendation formulation period, plus some preparatory time in advance.
- Commissioners full time for this period including some preparatory time.
- Meeting locations, refreshments, meeting aids.
- Printing of final recommendations/report.
- Intervenor funding?

THE COMMISSION

- A model worth considering would include a widely known chairperson that would bring overall credibility to the process. However, other commissioners would not be appointed for their notoriety and would be expected to take a greater role in the early parts of the public participation.
- All commissioners should have some engagement in all parts of the public participation process.
- All appointees to the commission would have to be process-sensitive. This is an uncommon expectation and would need to be taken into account during the commissioner identification and appointment process.
- Appointees could be determined on the basis of their expertise. Alternatively, they might be selected on the basis of their zone of residence, i.e. 1) south of the possible Ste. Agathe structure, 2) between Ste. Agathe and the Floodway gates, 3) Winnipeg, or 4) north of the Floodway Outlet.

- The stress on process in this model would lessen the likelihood that a strong substantive mark would have to be left on the product of the commission by the commissioners. In fact, it would make that tendency undesirable.
- It would be expensive to keep the high profile chair engaged throughout the process, but less expensive for the other commissioners.

Thoughts on Implementation of Commission

<u>Membership</u>

- Chair is noteworthy and brings credibility to process; must have an interest in good process and be willing to ensure process integrity.
- Members identified firstly on the basis of geography. Key person interviews revealed that some commissioners would have to have local roots to ensure credibility of the process.
- A second criterion relates to their area of expertise, knowing that hydrology, social concerns, environmental impacts and financial concerns will all be important in all zones.

<u>Challenges</u>

- Require commissioners who will dedicate a large percentage of their time (two to three days per week) over the course of a year.
- Require commissioners on short notice - will need them by soon after the Phase I report is released.
- Require a blue ribbon chair who is process-sensitive and prepared to respect the results of consensus processes.

<u>Costs</u>

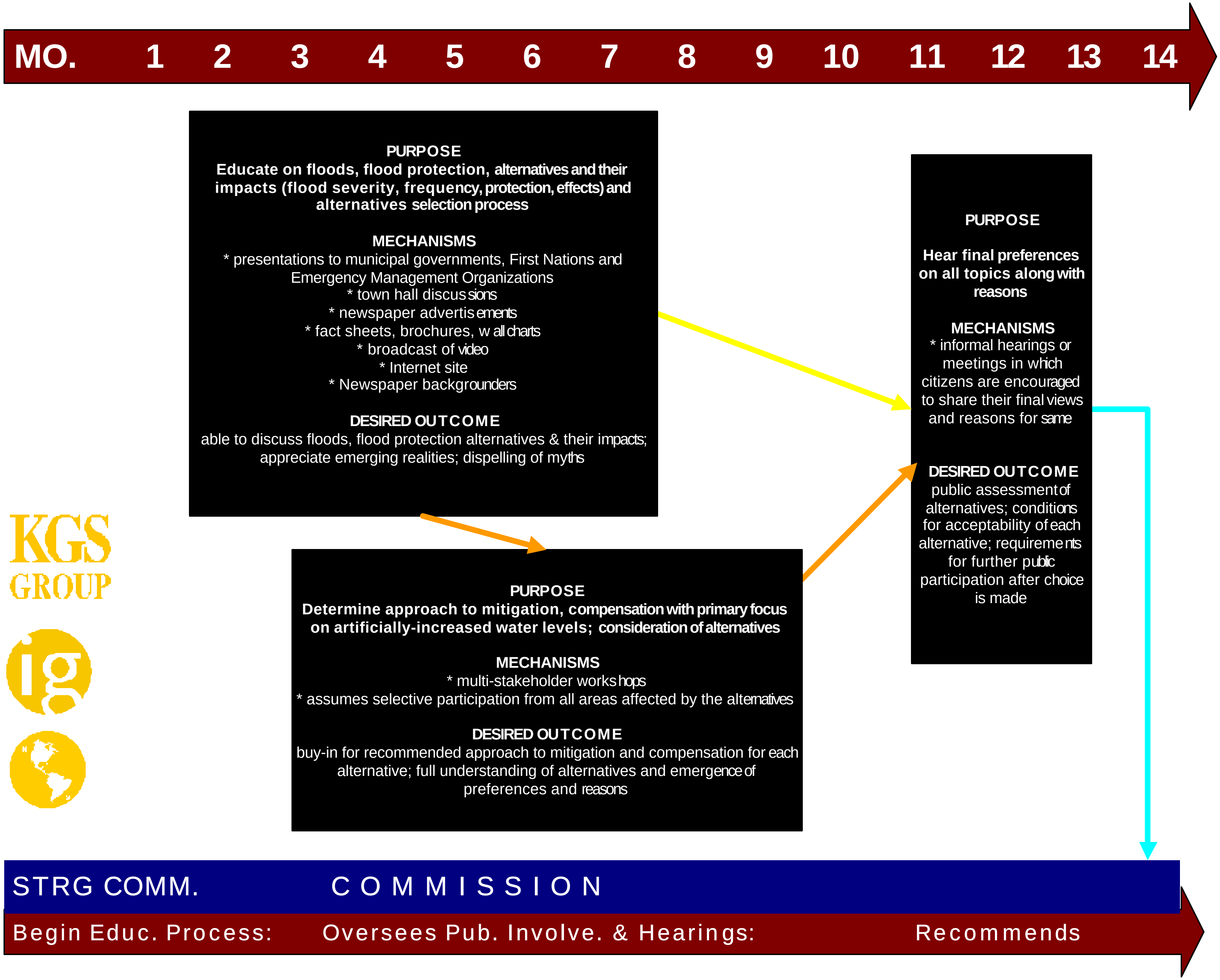
- Four commissioners plus a chair for a year + for forty percent of their time.
- Travel and sustenance costs.
- Secretariat costs.

THE COMMISSION'S RECOMMENDATION

- The commission will make recommendations on the whole package of issues:
  - A preferred flood protection project.
  - Essential mitigation features and mechanisms for that project.
  - A compensation regime and mechanisms for that project.
  - Needs for continuing public engagement.
  - Other issues requiring further work.

- However, the Commission will need to respect the work done in the consensus-building process. If consensus is reached, the commission should be loathe to alter those conclusions.
- Consideration should be given to a different type of product. Rather than a final detailed report, perhaps simply a summary of process and of key findings and reasons for them is all that is required.

FIGURE A1
COMPREHENSIVE PUBLIC PARTICIPATION PROCESS



ANNEX B

KEY PERSON INTERVIEWS WORKING PAPER

ANNEX B
KEY PERSON INTERVIEWS WORKING PAPER

INTRODUCTION

This working paper documents the results of the key person interview program conducted as part of the Ste. Agathe Floodway Expansion Study. The Key Person Interview Program was intended to support other information being collected and analysed in the assessment of socio-economic issues related to the two alternatives.

The overall objective of the research program was to collect information and perspectives from directly affected individuals on how the two projects might affect personal, family and community life in each of the four study zones. The four study zones are as follows:

- Zone 1: Area Upstream of the Ste. Agathe Control Structure
- Zone 2: Area Between the Ste. Agathe Control Structure and the Existing Winnipeg Floodway Inlet Control Structure
- Zone 3: The City of Winnipeg and Surrounding Area
- Zone 4: Area Downstream of the Floodway Outlet

The KPI program consisted of in-person and telephone interviews conducted with key community leaders and persons, business owners, service providers, and academics selected by the members of the Steering Committee. The interview guide is included in Attachment A. It should be noted that not all questions were posed to all respondents. A total of 26 people were interviewed in the Red River Valley in June and July, 2001.

This working paper consists of the following sub-sections:

- Objectives
- Methods
- Findings

OBJECTIVES

The general objectives for the key person interviews were to:

- Determine the level of understanding people had about the two options being considered.

- Determine nature and type of concerns people may have with the alternatives.
- Identify affected groups from the 1997 flood and nature of impacts.
- Understand response to preliminary thoughts on mitigation, event response, and compensation.
- Solicit comments about potential recreational options associated with the alternatives.
- Solicit input on the public participation program.
- Determine any other comments about the project.

METHODS

The key person interviews were conducted either in-person or by telephone from June 12 to July 13 2001. Respondents were advised that their name or representative group might appear in the final report, but that no statements would be directly attributed to them. The interviews were conducted using an interview guide that addressed five broad categories of issues:

- Flood Protection Alternatives: Floodway Expansion and Ste. Agathe Detention Structure
- Socio-Economic Impacts of Flooding
- Mitigation Needs/Event Response/Compensation
- Recreational Opportunities Associated with Flood Control Options
- Public Involvement Planning
-
- At times, respondents answering one question also provided responses to other questions in the guide, therefore not all questions were posed to all respondents. Detailed handwritten notes were kept on each interview and these notes were used as the basis for the analysis contained within this working paper.

FINDINGS

The following section reports on responses of key persons to questions posed. The responses are organized by topic, as laid out in the interview guide, and reflect responses to questions asked under that heading. Responses to the last question in the interview guide, regarding any other comments, yielded a broad range of comments. These have been included where possible under the relevant topic headings rather than under an "other comments" section.

Under each topic, responses received most often or reflect the general responses for the topic area are dealt with first in the section. This is followed by comments that were received on the specific topic from each of the four study areas. Unique individual responses are also indicated. For this reason, the space devoted to commonly-held or indicative views of the topic may appear to be less than space devoted to individual comments. Quotes or paraphrased comments are used often in the Findings section to reflect, as closely as possible, what was heard.

FLOOD PROTECTION ALTERNATIVES

General findings

- General statement that flood protection is essential for Winnipeg, moderated by a desire that Winnipeg not dominate the analysis.
- Focus should be on protecting as many Manitobans as possible.
- Concern that cost not be the only factor in the consideration.
- Expressed need to understand that both projects have costs and benefits. This message is not getting out. Would like to know more about the magnitude and distribution of those costs and benefits.
- General need for broader eye to planning, construction of bridges, roads, drainage all mentioned as things that have an impact on flooding, possibly centralised coordination of such developments with an eye to flood impacts.
- International implications, why give more consideration to U.S. citizens than Manitoba citizens.
- Floodway Expansion first stage is to increase height of West Dike to El. 778 ft. Impacts many outside of the City.
- Must consider duration of flood events under each option, not just depth or distribution.
- Are these two projects really the best option, are they an acceptable level of protection?

Zone 1

- Ste. Agathe Detention Structure is not a viable option.
- Ste. Agathe option has prohibitive social costs that aren't being considered. Would have an enormous impact on the vitality and viability of the area upstream of the structure. True costs aren't factored into the analysis.
- Ste. Agathe treats the rest of the Valley as second class citizens, sacrificed for Winnipeg's sake. Province is guilty of a ' perimeter vision'.

- Modification of an existing structure is preferred to construction of a new structure with unknown impacts.
- Consider implementation of co-ordinated water management regime for the entire Red River Valley (U.S. and Canada).

Zone 2

- Concern about distribution of costs and benefits during a flood, seems some are required to pay the costs while others reap the benefits.
- Need to consider not only peak flood level but also distribution and duration of flooding under each option.
- Problems with the existing floodway rules of operation. Province has poor track record in this respect, fears that problems would continue for new structures.
- El. 778 ft. as starting point for new floodway is wrong, already beyond 1997 + 2 ft. in Ritchot.
- Post-1997 change in JAPS from 25.5 ft. to 24.5 ft. benefits Winnipeg at an added cost to Ritchot.
- Shift from flow driven operating rules to stage driven rules is detrimental to those upstream of the floodway.
- Ste. Agathe option was reviewed in 1960's and determined to be not acceptable, what has changed, why would it be considered now?

Zone 3

- General perception that socially, Ste. Agathe would be harder to undertake. Floodway also has negative impacts but should be more mitigable/compensable.
- Need to understand that there are social costs with both options though.
- Should not be a primarily political decision, fear it is becoming such.
- Focus should be on the long term, not short term criteria like costs.
-

Zone 4

- Since 1997 very little information from the Province on impacts of increased flows within the region.
- Lack of information has resulted in frustration in determining what the impacts of each option may be.
- Concerns about existing floodway operation:
  - Divides R.M. - fire, ambulance, municipal services impacted.
  - Water wells – well deepening required (Example of water being trucked in to residents of Turnbull Drive – Zone 2).
  - Overland flooding – culverts, backflow east of Floodway.
- Need to resolve outstanding issues with existing Floodway before considering another.

- Floodway Expansion will increase these impacts.

SOCIO-ECONOMIC INFORMATION

General findings

- Dealing with Bureaucracy in 1997 was more difficult than dealing with physical flood levels.
- Socio-economic impact area is much larger than just the area flooded, access issues, business interruption, disruption of families.
- Loss of control felt during a flood, incredible stress on families.
- Feel that Manitoba would be better prepared for a similar flood in the future, but caution that as memories fade this flood readiness could be lost.

Zone 1

- Flooding can have a permanent impact on a community, some people relocate, businesses shut down, community vitality suffers.
- Seniors and children are often the most dramatically impacted during a flood.
- Farmers and businesses in the Valley dramatically impacted, this impact did not disperse with flood waters.
- Clean-up, sludge on fields, in culverts and ditches is a large impact and burden on municipalities and residents.
- Handling compensation and event response badly makes the problem even worse. People can handle a natural disaster, the loss of dignity as they go through the claims process and have their lives put on display and judged is much worse than the physical flood damage.
- Impacts on farmers who reside in ring dike protected communities may be lower than those who live outside of the community.
- Additional stresses on livestock producers, not simple or even possible sometimes to move livestock.

Zone 2

- Loss of access in all flood years, not just moderate floods is a large impact.
- Uncertainty, having to watch flood forecasts every spring.
- Impact of artificial flooding is worse than natural, especially when there is not rational reason for causing artificial flooding. Homes were flooded in 1997 in order to spare basements in Winnipeg, is this rational or reasonable?
- 2 to 3 ft. of extra water in 1997 because of operation of the floodway.

- Many people would be reluctant to evacuate again in a similar flood, lost their homes because they left.

Zone 3

- Flood impacts amount to more than just physical damage.
- Come a long way since 1997, impacts of a similar flood would be much less.
- Most of attention directed at 1997 level, however, not sure that we'd be as well prepared for a larger flood.

Zone 4

- 1996 ice jam had more significant impacts than the 1997 flood, six week peak. Better prepared in 1997 because of what occurred in 1996.
- Emergency response plans, equipment and infrastructure are much improved. Key is to keep these practiced and in working order.

MITIGATION, EVENT RESPONSE COMPENSATION

Mitigation

General findings

- Land use restrictions and zoning are key to a flood mitigation policy. Not receiving nearly the attention they deserve. Enforcement is a major weakness.
- Ring dikes are generally useful, prevent a lot of damage but have social costs and weaknesses technically. How high can a dike be built both technically and socially?
- Buy-outs need to be considered as a mitigation option, remove people from the flood-plains.
- Mitigation is preferable to compensation.
- Education, knowledge of flood areas and risk is a key to mitigation.

Zone 1

- Ring dikes split up plots of land, always arguments about where to put them.
- Social costs for ring dikes, including archaeological costs.
- Access during a flood critical, with a ring dike a community is cut off, like an island.
- Build a consideration for the style of building into zoning regulations. Learn from other jurisdictions, don't put valuables in the basement.
- Investigate other uses for ring dikes, e.g. could they be seeded for hay? Find ways to make them multi-use.

- Need to consider upstream storage and wetland restoration as flood control measures.
- Mitigation standards should be the same for everyone, if Winnipeg gets protection to 1 in 500 year, 1 in 1000 year then so should the rest of the valley.
- Assumption that 100 years from now Ste. Agathe Structure will operate in the current design manner wrong. Future land development will place pressure to change the operating rules to benefit Zone 2 at the cost of Zone 1.

Zone 2

- Smaller scale options, wetland restoration or upstream storage won't solve the problem by themselves, but deserve some consideration.
- Buyouts should be considered as a mitigation option for flood prone homes, tied to risk of flooding, develop a flood map.
- Debate whether zoning regulations are enforceable.
- Good flood forecasting can help mitigate flood impacts, makes damages more foreseeable or predictable.
-

Zone 3

- Ring dikes a feasible option.
- Would hate to think re-zoning would mean no one could live in the Valley.
- Municipalities need to take responsibility for their zoning regulations and enforcing them.

Zone 4

- Difficult to enforce zoning regulations.
- Building codes should force utilities to be located in the attic and not in the basement.
- Mitigation is preferable to compensation.
- Encourage recreational use in the floodplain but not industrial.
- Flood culture is essential and must be maintained.

Event Response

General findings

- Response was generally good in 1997, all things considered but we got lucky on a number of counts, can't expect to be as lucky again.
- Not as confident about ability to respond to a larger than 1997 flood.
- Response plays a big part in how damaging a flood is, can make it better or worse.

- We'll lose our ability to respond the longer we go without a major flood, degradation of structural flood controls.
- Need a higher level of coordination of flood mitigation and flood management plans.

Zone 1

- Use local knowledge during a flood, in 1997 residents were taking out of the decision making process but these are the people who know their area the best.
- Military involvement could have been handled a lot better than it was, they treated the residents as the ' enemy' in some cases.
- Province can't assume the authority but absolve itself of responsibility.
- Flood forecasting has improved, but is still an important part of event response.
- Coordination between local leadership and Emergency Management Officer difficult.

Zone 2

- Lack of respect demonstrated by some responders in 1997.
- Too many competing authorities in 1997, need a more centralised response plan.
- Confidence is lost when expectations are not met.
- Clarity needed in the legislation that governs event response.
- Infrastructure needs to be safe and reliable, need electricity to be able to operate pumps. Need to ensure safe reliable water supply during flood.

Zone 3

- Need to keep the level of response we have now, not lose it during inactivity.
- Possibly develop an emergency response reserve, provincial employees seconded to the emergency response effort in times of crisis.

Zone 4

- Very confident about ability for 1997, emergency plans in place, practiced and refined.
- 1997 is the tested flood level, unknown for anything larger than this.
- For First Nation Communities, coordination between Canada-Manitoba for flood fighting was a significant problem.

Compensation

General findings

- Compensation often referred to as the ‘ second disaster’.
- Adjustors and people who administer compensation need to be better trained. Need to involve competent, trained professional assessors and negotiators.
- Don’t be concerned about “nickel and dime-ing” people to death.
- NGO role in compensation and disaster assistance was misguided, needs to be improved.
- Since compensation uses public money, the process should be open, no hiding behind privacy.
- Social, emotional and psychological costs of flooded aren’t compensated.
- Disparity in who pays for compensation and flood assistance, city residents pay a much smaller percentage of their actual costs than rural residents.
- Compensation rules for a new flood structure need to be established long before the structure is ever operated. Need clear operating rules and compensation rules established in a public forum and debate.
- Compensation for artificial flooding needs to be higher than for natural flooding.
- Compensation costs need to be factored into the analysis of both flood protection alternatives. Compensation needs to be viewed as a cost of flood fighting.

Zone 1

- Compensation rules set by people in the City who don’t understand what it takes to run a farm or rural business.
- Compensation should be open and transparent, local people should be involved in assessing how valuable someone’s property is and what are reasonable replacement costs. This would cut down on misuse of the system.
- How do you compensate someone for the loss of their home or of a farm that has been in the family for a century?
- Private insurance will never work.
-

Zone 2

- Compensation is different than flood or disaster assistance. Residents flooded by the actions of the Province have never been compensated.
- Compensation issues remain from 1997, these need to be addressed before any compensation packages for new structures are considered.

- Compensation needs to be at three levels, 100% of flood damage costs in a flood event, compensation for nuisance floods that restrict access or cause damage to yards and roads and a third level for the annual stress and anxiety associated with living in an area that is prone to artificial flooding.
- Determination of natural flooding levels for existing structures needed as a baseline for these compensation negotiations.
-

Zone 3

- Considerable confusion about which level of government is responsible for what level of compensation.
- Operational challenges to distinguishing compensation for artificial flooding from compensation for natural flooding.
- People are ' once bitten, twice shy' about the compensation issue. The Province did not handle the claims process well at all in 1997.

Zone 4

- Compensation rules aren't well understood, who is responsible? Need for more clarity and transparency in the process.
- Compensation bureaucracy should focus on people affected and not on the agencies delivering it.
- If damage due to combination of natural and project-induced flooding, then impacted parties need to be compensated fully, but perhaps this could be reflected through the tax assessment.
- For First Nation Communities, process was frustrating and confusing. Level of compensation was unclear, and process complicated.
-

RECREATION OPTIONS

General findings

- These are flood control structures, if some recreational benefit is possible then fine, but not at any great expense.
- The City of Winnipeg is already getting all the benefits of these two flood control options, why sweeten the pot with more recreation options?
- If there's money for recreation options for Winnipeg, there should be at least as much money for recreation options for the rest of the Valley.

Zone 1

- Would rather see any recreation money spent on riverbank stabilization or wetland restoration, both of which improve flood protection as well as having recreational and aesthetic benefits.
- Investigate multiple-uses for all flood structures in the Valley.

Zone 2

- Controlling summer river levels in Winnipeg only makes sense if there is no artificial flooding involved. Don't believe this is the case.
- Can't believe the Province would consider a project that causes residents upstream of the Floodway to be flooded to keep The Forks riverwalk dry a few extra weeks a year.

Zone 3

- Need to realise that this is spending public money, is this the best use of that money?

Zone 4

- Recreational developments throughout the floodplain are more preferrable than new institutional developments such as hospitals or schools.

PUBLIC INVOLVEMENT PROCESS

General findings

- Province is already off to a bad start. Perception is that the decision has been made without any public involvement at all.
- General need for a good discussion paper on the costs and benefits of both projects. Not prohibitively long, but with enough detail to satisfy the interested lay-person.
- Process must consider social impacts of flooding, operating rules of structures, compensation criteria.
- Objectivity and rigour are essential.
- Be prepared for a lot of meetings in many towns, won't do just to have meetings in Winnipeg and Morris.
- Process must be transparent and thorough, this isn't the place to try to save money.

Zone 1

- Residents south of the City aren't convinced they will be consulted in a meaningful way.
- Any commission must have members who live outside of Winnipeg.
- Province needs to realise that Winnipeg benefits from a vibrant Red River Valley.

Zone 2

- Province currently has a large credibility problem with people in the Valley. People in charge right now just aren't trusted and this trust won't ever be restored. Will need to be a turnover of people in the government departments before the Province can regain this trust.

- Several different forums will be required.
- Public hearings have never been held on the operating rules of the floodway. Operating rules of any new structure must be on the table in a public involvement process.
- Require intervener funding so that those outside of Winnipeg can hire their own objective technical experts and negotiators.

Zone 3

- Big public hearings can be intimidating and can degenerate into ‘ moan and groan’ sessions.
- Many different methods need to be used.
- Make use of an interactive website, keep the issue warm and on the minds of people to ensure a good public interest in the topic.
- Don’t try to skirt the fact that there will be opposition, deal with it head on and it will be diffused somewhat.

Zone 4

- Needs to involve representatives from each of the zones in broad and open discussion.
- Accept the fact that the process may take considerable time to complete.
- Consider a working group made up of coalitions from each of the zone instead of consulting with one region at a time.
- Workshop environment with smaller groups would provide better opportunity for people to express themselves than large meetings.

SAFE Study Key Person Program

Interview Guide

Person: **Group:**

Zone: **Date:**

A: MAJOR FLOOD PROTECTION ALTERNATIVES

(Purpose is to determine the level of knowledge of flood protection alternatives)

Description of Projects

A1: Have you heard about the two major Winnipeg flood protection alternatives currently being considered?

Where have you heard about the two projects?

Can you briefly describe what you know about them?

Ste. Agathe Detention Structure	Floodway Expansion

After respondent has had the opportunity to provide a response, briefly describe each alternative to interviewee for clarification.

A2: Are there concerns about these flood protection alternatives?

A3: If Yes, **What are the concerns?**
How serious and widespread are these concerns?

A4: Could anything be done to make any of the alternatives more acceptable?

B: SOCIO-ECONOMIC INFORMATION

To identify experience of interviewee with the 1997 event and secure additional relevant information that may have been omitted.

B1: What do you think most affected people in your community during the 1997 flood?

Why?

B2: Who do you think suffered most in your community during the 1997 flood? Why?

B3: Are there any non-farm businesses in your area that are outside of ring-diked communities?

How do you think they were affected in the 1997 flood?

B4: How do you think farmers were affected during the 1997 event? Why?

B5: If the 1997 flood happened today, do you think the impacts would be different?

Why?

C: MITIGATION NEEDS/EVENT RESPONSE/COMPENSATION

Purpose is to understand preliminary thoughts and conclusions on mitigation/event response and compensation. Describe the concepts of mitigation (actions taken prior to event), event response (actions taken at the time of event) and compensation (actions taken after an event) to interviewee.

Mitigation

C1: Please comment on the value of the following mitigation measures to enhance flood protection outside of Winnipeg:

- **i)** **Raising ring dikes in communities that have an existing dike or building new dikes for communities that do not have one.**
- **ii)** **Zoning or land use regulations to restrict development along the Red River or its tributaries or in the entire floodplain.**
- **iii)** **Are there any other possible measures? (Suggest)**

Event Response

Describe Event Response to interviewee and the role of event response in reducing individual flood impacts.

C2: How confident are you about the ability of the authorities to support flood preparation and flood fighting for a flood equal to the 1997 flood? Why?

C3: How confident are you about the ability of the authorities to support flood preparation and flood fighting for a flood worse than the 1997 flood? Why?

C4: Is there anything that could be done to increase confidence of people in your community in the ability to support flood preparation and flood fighting?

C5: In your opinion, what was good and bad about the way compensation was handled in 1997?

Positive	**Negative**

C6: What do you think needs to be done to improve compensation for damages to flooded people?

C7: Do you have concerns about who delivers compensation? If Yes, suggest how to address.

C8: Should compensation for flooding caused by a flood control measure or structure be handled differently than compensation for natural flooding?
If Yes, describe how compensation should be different.
How should compensation be handled when flooding is due to a combination of natural flooding and project-induced flooding?

C9: Did you experience or do you know of any property value losses in your area as a result of the 1997 flood? If Yes, explain.

C10: Should property owners be compensated if project-induced flooding results in short-term property value loss?

Explain answer. If so, why and how?

C11: What needs to be done with Mitigation/Event Response/Compensation to enhance the acceptability of the alternatives?

C12: Do you have any other comments on Mitigation/Event Response/ Compensation?

D: RECREATIONAL OPPORTUNITIES

Applicable to Zones 2, 3 and 4, areas within a possible floodway recreational catchment area.

The Floodway Expansion alternative could potentially include some recreation options.
Possible options include:

- **Use of the floodway to manage Red River summer water levels within Winnipeg, possibly making the river walk more accessible at certain times of the year.**
- **Providing for summer water storage within the floodway to either partially or completely cover floodway with water**
- **Developing a white water park within the floodway**
- **Developing a greenbelt parkway along the floodway.**
- **Developing no additional recreational infrastructure**

D1: What do you think about any or all of these recreation options?

E: CONCLUSIONS

E1: Development of a major flood protection project for Winnipeg will include extensive public consultation. How would you prefer the consultation to be conducted?

E2: What are the key topics you would like to be considered?

E3: Do you have any other questions or comments you would like to provide us with at this time?