Canada

Manitoba CONSERVATION

Winnipeg

FLOOD PROTECTION STUDIES FOR WINNIPEG

MAIN REPORT

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KGS GROUP

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CONSULTING ENGINEERS & PROJECT MANAGERS

EXECUTIVE SUMMARY

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

In December of 2000, the Province of Manitoba commissioned KGS Group to carry out additional studies of the two major flood protection options – the Red River Floodway Expansion and the Ste. Agathe Detention Structure. The work was subsequently approved under the Canada-Manitoba Partnership Agreement on Red River Valley Flood Protection. The City of Winnipeg also agreed to become a funding partner and to participate in the study.

The objective of the studies reported herein consisted of carrying out the following broad tasks:

- Key engineering investigations that would assist in better definition of the steps required to expand the Red River Floodway ("Floodway").

- Refinement in the estimated cost of expansion of the Floodway.

- Limited engineering studies of the Ste. Agathe Detention Structure to improve its capabilities and reduce its negative impact on the Red River Valley upstream. The engineering was limited in scope because it was considered that socio-economic and environmental issues were more important in the decision of whether the concept should be considered further.

- Socio-economic studies to identify impacts, issues, and means to improve both concepts of flood protection.

- Environmental studies of the engineering works associated with both major concepts, so that impacts can be mitigated by implementing modifications to the designs as they evolve.

- Identification and definition of future study/planning requirements.

The study demonstrated that planning of modifications to existing complex facilities such as the Floodway and the flood protection infrastructure in Winnipeg, requires considerably more effort, but not necessarily more time, than planning a new development of equal capital cost. This fact should be acknowledged in planning subsequent phases of planning/design and implementation.

- The studies that have been completed have focussed on two key single-purpose schemes:

    - a Floodway Expansion that would provide flood protection up to the 1 in 700 year flood.

- The Ste. Agathe Detention Structure that would provide flood protection up to a 1 in 1000 year flood

It must be recognized that the scheme to be ultimately selected may well fall somewhere within the range of options discussed in this report, depending on a variety of technical, financial, and social considerations.

Key Features of the Floodway Expansion Schemes

- Increase in crest elevation of the West Dike and East Dike adjacent to the Floodway Inlet Control Structure. This will provide security against water levels as high as El. 778 ft. at the Floodway Inlet.

- Upgrades to the City of Winnipeg flood protection infrastructure, including raising the crest levels of the Primary Dikes in areas where they are below the Flood Protection Level, upgrades to flood pump stations, gates for sewer outfalls, etc. This would be required to permit the safe passage of approximately 80,000 cfs at a river level of approximately el. 25.8 ft. (JAPSD).

- For channel options that provide a level of flood protection that exceeds approximately 1 in 700 years, the project must include additional works to protect the city from backwater effects from high river levels downstream. This could include raising the crest levels of the Primary Dikes in parts of the city, and providing additional flood protection measures within the city to deal with water levels higher than at the 1 in 700 year flood magnitude. It is possible that an approximately 3 mile long extension of the Floodway could be more economical than the enhanced protection works in Winnipeg, but considerable additional work would be required to confirm this.

- Expansion of the Floodway channel to convey additional floodwater, including the modifications of bridges, transmission lines, water supply aqueducts, and other facilities that would be affected. Excavation of some 45 million cubic yards of soil would be required to provide a Floodway capacity capable of protecting against a 1 in 700 year flood.

- Modifications to the Floodway Outlet Structure to permit the conveyance of more water, and expansion of the discharge channel to release the increased Floodway flow into the Red River.

- Upgrades to the Floodway Inlet Control Structure, including the fire protection system in the structure, installation of additional riprap protection on the embankment adjacent to the downstream sides of the structure, and possibly upgrading of the erosion protection on the upstream side of the embankments adjacent to the structure. A detailed review of additional measures that could increase the reliability of the inlet gates, including the installation of backup gates should be completed.

- ***The cost of the Floodway Expansion is estimated to range from $660 million for a Floodway capable of providing flood protection up to a flood of 1 in 700 years, to $1.2 billion for capability up to a 1 in 1200 year flood.*** All schemes that would be included within that range would have benefits that exceed the costs, but the maximum

net benefits are estimated to be achieved with the 1 in 700 year option, with a benefit/cost ratio of 2.5. This would provide a channel that increases the design capacity of the Floodway from the existing 60,000 cfs, to 140,000 cfs. It should be noted, however, that although the net benefits peak at the 1 in 700 year capacity, the peak is not prominent. Some latitude could be possible in interpreting the optimum development scale based on economics alone.

- Floodway Expansion would considerably reduce the present need to exceed "state-of-nature" water levels upstream of Winnipeg for large floods. The 1 in 700 year Floodway scheme could maintain "state-of-nature" levels for all floods up to approximately the 1 in 250 year magnitude, and the 1 in 1200 year Floodway scheme for all floods up to the 1 in 700 year magnitude. Currently, exceeding the "state-of-nature" water level would be necessary for floods exceeding approximately the 1 in 90 year flood (approximately that of 1997).

- The schedule of construction of the Floodway Expansion would range from approximately 4 years for the 1 in 700 year capacity to 5 years for the 1 in 1200 year capacity. Preparatory investigations, planning, funding agreements, and final design would require an additional 3 to 4 years depending on whether a fast-track approach would be taken.

Key Features of Ste. Agathe Detention Structure

The concept for the Ste. Agathe Detention Structure is less well defined than for the Floodway Expansion. The level of study is clearly at the pre-feasibility level, and was considered to be appropriate at this level, until the socio-economic aspects of the concept have been considered in further detail. The purpose of the project is to protect downstream areas from large floods by temporarily retaining floodwaters in storage upstream. For the purposes of the study, the scheme of development consists of:

- 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 structure would be about 25 miles.

- 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 at the design condition (1 in 1000 year flood) and an auxiliary control structure would be located just west of the Marsh River to handle the remainder of the flood discharge.

- A flood discharge channel downstream from the Marsh River Control Structure, 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 on the Red.

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

- A gated control structure on the Rat River to allow the Rat River to discharge past the dam without impedance during non-flood conditions on the Red River.

- Upgrades to the flood protection infrastructure in the City of Winnipeg as included for the Floodway Expansion.

- Improvements at the Floodway Inlet Control Structure, including increased security against fires in the control facilities, improvement in erosion protection on the downstream side of the embankments adjacent to the structure, and possibly improvements in erosion protection on the upstream side of the embankments adjacent to the structure (require investigation at the site, see Appendix B, Section B.6.9).

- The Ste. Agathe Detention Structure is estimated to cost approximately $500 million including the upgrades to the flood protection infrastructure in Winnipeg, and would provide downstream protection for floods up to 1 in 1000 year magnitude. The present value of average annual incremental damages upstream caused by the structure, and the present value of future operation and maintenance costs would bring the total to approximately $543 million. The project is estimated to have a benefit/cost ratio of 3.7. The cost of $543 million for the Ste. Agathe Detention Structure does not include the cost of any mitigative work upstream such as enhancement of ring dike protection.

  It should be noted that the costs of both the Ste. Agathe Detention Structure ($500 million) and the Floodway Expansion ($660 million for 1 in 700 year flood capacity) include approximately $110 million for upgrades to the flood protection infrastructure within Winnipeg.

Key Issues

Winnipeg is exposed to an inordinately high risk of severe damages due to flooding. This situation should be alleviated as quickly as possible. This urgency can be quantified by application of principles of risk analysis. The application is simple, and is based on an average annual damage that could be incurred if no additional protection works are constructed. The average annual damage combines the probability of the occurrence of floods that could exceed Winnipeg's existing defenses, and the damages that could occur. This has been estimated from the findings of previous studies and is expected to be in the range of $50 million to $75 million per year, excluding potential business losses in Winnipeg. Such a large risk exposure would justify taking the swiftest action that is possible to upgrade the flood protection system for Winnipeg, including immediately undertaking projects to upgrade the City's internal flood protection infrastructure. These upgrades are required whichever overall flood protection option is eventually selected.

There are several other key issues that must be resolved by the funding partners at the next stage of planning. Choices can be based on the findings reported in this document and its appendices, and in some cases, additional refinements and study may be required. The key issues are inter-related and consist of:

- The selection between the Floodway Expansion and the Ste. Agathe Detention Structure

- If the Floodway is selected, a series of issues must be resolved:

- The desired capacity of the expanded Floodway Channel must be selected.

- Whether or not reliance on raising the water level above the "state-of-nature" at the Floodway Inlet, when forced to be necessary by extreme floods, is acceptable to Manitobans.

- Whether or not the "Wet Floodway" option is deemed to be attractive, and whether the merits of that scheme are worth the risks and possible premium in cost that would be incurred.

- A Dam Safety Review of the Floodway facilities needs to be completed, so that a policy that is acceptable to the owners can be declared for the next stage of planning.

- There would be a substantial cost required to provide improved control of summer water levels in Winnipeg, regardless of the flood protection option that is selected. There needs to be resolution on whether or not this feature is desirable enough to be incorporated in the flood control improvements.

- If a Floodway capacity that exceeds approximately a 1 in 700 year flood is selected, a study would be required to resolve whether extension of the Floodway Channel, or whether investment in additional protection in Winnipeg, would be more economical.

- There is a variety of design issues with the Floodway Expansion that must be resolved, and will require on-going work to satisfactorily achieve a solution that will define future design work if this option is selected. The primary issue is the best strategy for modifying the Floodway bridges.

- There is a need to further analyse and predict the potential hydraulic effects of an expanded Floodway on the areas north of Winnipeg. Although this area is not expected to experience a significant change in flood levels as a result of Floodway Expansion, there is a need to further analyze and predict the potential hydraulic effects on the areas north of Winnipeg because of the poor quality of the topographical data outside of the City of Selkirk. Although the Province is currently obtaining detailed topography for this area, it was not available for this study

- If the Ste. Agathe Detention Structure is selected, other issues should be addressed:

  - Means to arrive at an acceptable formula for compensating impacted residents upstream of the Ste. Agathe Detention Structure.

  - Extent of mitigation that would be appropriate by enhancing existing ring dikes and constructing new dikes in the Red River Valley.

  - Resolution of the impacts on duration of flood levels in the U.S. that could occur for floods exceeding about a 1 in 300 year magnitude.

- Extent of project modification that would be required to satisfy environmental concerns, particularly those related to fish passage and loss of habitat.

- Resolution of dealing with impacts on the Roseau River First Nation.

Although project scheduling for the Ste. Agathe Detention Structure could not be addressed in detail this study, it is expected that the project could be completed within a period of 6 years, including approximately 2.5 years of on-site construction. That schedule would be the minimum foreseeable, and may turn out to be longer if considerable local resistance would be mounted or if an extended period was required to negotiate agreements with the United States or the Roseau River First Nation.

Comparisons between the Floodway Expansion and the Ste. Agathe Detention Structure are made from a number of perspectives in the report. ***However, it should be emphasized that the main focus of the study has been to provide key information on, and to compare, the 1 in 700 year Floodway with the 1 in 1000 year Ste. Agathe Detention Structure.***

No overall preference between these options is stated in the comparisons below, since it is KGS Group's intent to provide the fundamental information upon which the three levels of government can base a decision on behalf of the people of Manitoba. The comparisons are listed below. Some should carry more weight in the decision process than others:

1. Economics

The Ste. Agathe Detention Structure would provide more flood control benefits to a greater number of people, at a lower cost than the Floodway Expansion.

2. Socio-economic Impacts

The comparison of socio-economic impacts have been made on the basis of the 1 in 700 year Floodway option versus the 1 in 1000 year Ste. Agathe option. Furthermore, the comparisons have been made on the basis of four representative flood events that span the range of floods that exceed the current capacity and extend to an extreme event that has a reasonably low probability of occurring. The representative floods are:

- the 1 in 90 year flood – roughly equivalent to that of 1997.

- the 1 in 300 year flood – equivalent to what has been associated with the 1826 flood (largest in over 250 years).

- the 1 in 500 year flood.

- the 1 in 1000 year flood – reasonably low probability of being exceeded in next 50 years.

For floods smaller than a 1 in 90 year flood event, Floodway Expansion provides enhanced protection to the area upstream of the Inlet Structure whereas the Ste. Agathe Detention Structure would not. For all flood scenarios assessed greater than a 1 in 90 year flood event, the Ste. Agathe Detention Structure and Floodway Expansion provide

additional protection for several hundred thousand residences and residents north of Ste. Agathe, including people living between Ste. Agathe and the existing floodway inlet, and in the City of Winnipeg. The Ste. Agathe Detention Structure also provides additional protection north of the existing Floodway outlet. For 1 in 300 year and 1 in 500 year flood events, about the same number of residents could benefit from additional full or partial flood protection with the Ste. Agathe Detention Structure and Floodway Expansion. At these flood levels, the Detention Structure provides 4,000 to 9,000 more residents with **full** protection than Floodway Expansion. For a 1 in 1000 year event, the Detention Structure provides additional protection to orders of magnitude more residents than Floodway Expansion.

South of the Ste. Agathe Detention Structure, added upstream flooding associated with operation of the Detention Structure, without enhanced community ring dikes, would result in new or additional flooding to an estimated 6,300 residents. Floodway Expansion generates no similar adverse effect and in fact reduces the frequency of additional upstream flooding compared to the existing Floodway. Enhanced ring dikes in communities that experience additional flooding would reduce the number of affected residents to approximately 2,200.

In terms of the number of residents affected, Ste. Agathe Detention Structure is preferable in the three impact zones north of Ste. Agathe. Floodway Expansion is preferable in the impact zone south of Ste. Agathe.

3. Legal Perspectives

The Ste. Agathe Detention Structure would require First Nation and international permits/agreements to operate. The Floodway Expansion has no similar requirements. These requirements, along with the potential for legal issues related to project induced flooding upstream, make the Ste. Agathe Detention Structure less desirable than Floodway Expansion from a legal perspective.

4. Operational Risks

There are advantages and disadvantages of both schemes, and there is no clear preference that emerges from this perspective.

5. Management of Extreme Floods

The performance of the Floodway Expansion in flood conditions that exceed its capacity is considered superior to that of the Ste. Agathe Detention Structure. It must be recognized, however, that the limit of protection is reached at a lower flood (1 in 700 year) for the Floodway Expansion than for the Ste. Agathe Structure (1 in 1000 year).

6. Potential for Summer Flood Control in Winnipeg

The Floodway Expansion would lessen the effective cost to provide this capability as part of the improvement scheme, and would be the preferred option from this perspective.

7. Recreational Potential

The Floodway Expansion is generally considered to be more amenable to recreational developments than the Ste. Agathe Detention Structure.

8. Effects on "State-of-Nature" Water Levels

The Floodway Expansion would reduce the probability by a factor of about 3 that water levels would have to be raised above the "state-of-nature" south of the City to protect Winnipeg, compared to the existing Floodway. The Ste. Agathe Detention Structure would have the same chance of causing artificially high water levels as the existing Floodway. The Floodway Expansion is clearly superior in this respect.

9. Environmental Impacts

The Floodway Expansion would generally result in the least intrusive environmental effects of the two options. However, if the "Wet Floodway" scheme, or a Floodway Expansion that contributes to better control of summer river levels in Winnipeg, is opted for, the environmental impacts of the Floodway would be increased. It would then be difficult to identify a preference for one scheme over the other.

10. Schedule of Implementation

"Time is of the essence" in the improvement of Winnipeg's flood protection system. The Floodway Expansion is believed to be preferred from the perspective of schedule of completion. The Floodway Expansion scheme:

- Provides increased flood protection after each construction year (Ste. Agathe Detention Structure only provides the improvement at the completion of the construction).

- Could be less prone to public resistance than the Ste. Agathe Detention Structure, and the attendant delays that such action may cause.

- Does not require any international agreements, or agreement with the Roseau River First Nation, as would the Ste. Agathe Detention Structure.

Development of either the Floodway Expansion or the Ste. Agathe Detention Structure would require a concerted effort by a group that would have to be devoted full time to the task. The organizational structure that is envisaged as the most efficient for executing the work is shown in the report.

The best course of action would commence with the selection of the philosophy on project organization that is best to expedite the project (primarily a decision on the approach of mixing the public sector involvement with that of the private sector). It is proposed that the government would be assisted in this project definition period by a "Project Advisory Board". This Board would be established at the outset of the work. It would then continue through the execution of the project, acting as an overall vetting system for critical technical and administrative issues. The Board is envisaged to consist of approximately 8 recognized experts covering the fields of engineering design, construction, contract administration, and environmental science.

The original terms of reference of this study called for design of a public participation process that could assist in evaluating alternate flood control projects. The Progress Report issued in May 2001, describes initial findings from this work. A comprehensive Public Participation Program was devised and included public education, workshops and public hearings. This process would require at least 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 a risk of major flooding. In the interests of public safety, the governments are contemplating a shorter public participation process.

They considered it to be important to select a preferred alternative and scale as soon as possible, to expedite Project development. Consequently, no further documentation of a Public Participation Program has been included in this document.

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1.0 INTRODUCTION

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

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

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

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

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

The advice and support provided by the Steering Committee are gratefully acknowledged.

KGS Group worked in cooperation with InterGroup Consultants and North/South Consultants during this study. KGS Group undertook all of the engineering, the environmental assessment overview, and acted as the study manager for the consultants. InterGroup Consultants carried out all socio-economic studies and their contribution is largely incorporated in the information provided in Appendix F, Section F.3, and summarized as socio-economic findings in the Main Report. North/South Consultants provided technical expertise in the aquatic environmental area, and supported the relevant components of Appendix F.

The basic objective of the initiative is to advance the knowledge base and factual information associated with the two schemes recommended for further study by the IJC Task Force (Floodway Expansion / Ste. Agathe Detention Structure). This will advance towards the level of comfort referred to as the "pre-commitment level". Full advancement to the "pre-commitment level" would require a 2 year effort at a cost of some 5 times the budget of the current study, based on experience with other projects of similar magnitudes. The scope and nature of required future work has been noted in this report where appropriate.

The objectives of the current studies consisted of carrying out the following broad tasks:

- Key engineering investigations that would assist in better definition of the steps required to expand the Red River Floodway ("Floodway").
- Refinement in the estimated cost of expansion of the Floodway.
- Limited engineering studies of the Ste. Agathe Detention Structure to improve its capabilities and reduce its negative impact on the Red River Valley upstream of the structure.
- Socio-economic studies to identify impacts, issues, and means to improve both concepts of flood protection.
- Environmental studies of the engineering works associated with both major concepts, so that impacts can be mitigated by implementing modifications to the designs as they evolve.
- Identification and definition of future study/planning requirements.

The rationale for undertaking only limited engineering of the Ste. Agathe Detention Structure, as listed in the objectives, was that the socio-economic and environmental impacts of the project are clearly the main priority at this stage of decision. Refinements in cost estimation that could be provided on the basis of more detailed engineering would not likely affect the decision on whether the project is acceptable to Manitobans. The socio-economic and environmental evaluations will form the basis of the decision whether to further investigate the project, and have been the focus in this study. More detailed engineering would be carried out later, if the project is deemed to justify further consideration.

Details of the agreed Work Plan for the studies described in this report are provided in Annex A.

The comparison of impacts of the two options has been broken into four "impact zones":

Zone 1 – Upstream of the Ste. Agathe Detention Structure site
Zone 2 – Between the Ste. Agathe Detention Structure site and the Floodway Inlet
Zone 3 – Winnipeg
Zone 4 – Downstream of the Floodway Outlet, to Lake Winnipeg

Two elevation datums have been used in the study and in this report, that have been commonly adopted by previous planners/designers. They are:

- Canadian Geodetic Vertical Datum, 1928 (1929 adjustment), with Horizontal NAD ,1983, referenced to June, 1990.
- James Avenue Pump Station Datum (JAPSD) (gauge zero, El. 0.0 ft., or El. 727.57 ft. Canadian Geodetic Vertical Datum). A common reference system that is used by the City of Winnipeg is based on the JAPSD, but represents water levels at other locations in Winnipeg that would be associated the stated water level at James Avenue. This essentially represents a line parallel to the slope of the river that passes through the stated water level at James Avenue.

Unless elevations are specifically stated as JAPSD, they refer to Canadian Geodetic Vertical Datum (CGVD). The Imperial System of measure has been used throughout this report since most of the basic data available for the study is expressed in that system.

There are references throughout this report to peak flood flows in the Red and Assiniboine Rivers. Unless otherwise identified as actual recorded flows, or as regulated flows that include the effects of diversions or reservoirs, these flood flows are of the magnitude that would have occurred if the existing flood control system did not exist.

The annual probabilities of flood magnitude being exceeded that were used in this study were provided by the Province of Manitoba. They are listed in Table 1:

TABLE 1
Annual Probabilities of Floods Magnitudes

ANNUAL PROBABILITY OF FLOOD BEING EXCEEDED	"STATE-OF-NATURE" RIVER FLOWS (CFS)	
	RED RIVER AT FLOODWAY INLET	RED RIVER AT JAMES AVENUE
1 in 50	105,000	135,000
1 in 90	135,000	163,000
1 in 200	170,000	200,000
1 in 300	193,000	225,000
1 in 500	210,000	250,000
1 in 1,000	250,000	295,000
Estimated Probable Maximum Flood	400,000	450,000

Note: 1. Red River at James Avenue includes the flow contribution from the Assiniboine River.

The estimation of the Probable Maximum Flood has not been based on generally accepted principles of analysis of such an event. To follow normal procedures that are endorsed by the World Meteorological Organization, for example, would require a substantial amount of time, effort and cost. The approximation in Table 1 was considered suitable for the preliminary nature of the work being done. It has been selected as the 1 in 10,000 year flood peak, based on analyses of Red River flow characteristics (Warkentin, 1999).

2.0 REPORT STRUCTURE

The report “Flood Protection Studies for Winnipeg” consists of :

- The Main Report (contained in this document) that provides an overview of the study objectives, limitations, findings, recommended future work, and the original work plan.
- Appendices that provide the backup data, drawings, detailed cost estimates, socio-economic information, and detailed consideration of environmental issues. These appendices are :
    - Appendix A - River Hydraulics and Flood Damage Potential Downstream of Floodway
    - Appendix B - Floodway Expansion
    - Appendix C - Ste. Agathe Detention Structure
    - Appendix D - West Dike
    - Appendix E - Control of Summer Water Levels in Winnipeg
    - Appendix F - Environmental Considerations

3.0 STUDY LIMITATIONS

This study was structured to address key uncertainties that remained or were raised after KGS Group's study for the IJC. A Work Plan was prepared (see Annex A), and a budget established. The tasks did not cover all issues that must eventually be resolved, and during the work on some tasks, complex issues became evident that were not addressed in detail at this stage of the study. These unresolved issues included:

- The practical limitation that could be provided by Floodway Expansion turned out to be the 1 in 1200 year flood (or thereabouts), and not the 1 in 500 year flood, as originally believed. This justified preliminary design and cost estimates to be prepared for a range of channel capacities, and as a result, less detail was possible in the planning and cost estimation, than if only one concept had been studied.

- A variety of options are available for control of summer water levels in Winnipeg. They have been identified and studied at a prefeasibility level, but much further work would be required to lead to a firm plan of action, and that plan of action is inextricably linked to the selection of the desired level of improved flood protection for Winnipeg.

- Mitigation of water level increases due to the Ste. Agathe Detention Structure have been addressed in a preliminary, inventory level of analysis and engineering. The issues are complex and would require considerable additional work to resolve.

- Environmental concerns have been considered in some detail in this study, but means to provide mitigative solutions to the problems for either of the major flood protection schemes have not been studied in detail.

- The scope of hydrological analyses was limited. The prime areas that required approximations, or could not be addressed at all, include the potential effects on the projects from varying shapes of flood hydrographs, and the estimation of the Probable Maximum Flood as discussed in Section 1.

- A variety of options of the "Wet Floodway" concept were identified. These ranged from "Wet Floodway" conceptual designs intended to capture potential aesthetic and recreational benefits along the Floodway corridor, to design options which would facilitate use of the Floodway to maintain desirable summer water levels through the city. The number of possibilities exceeded the extent of funds that were allocated to assess this novel concept. If the costs of, and issues with, the "Wet Floodway" that have been identified to date are considered acceptable, then further work would be required to select the best development from the variety of options available.

- The potential for flood damages in the Selkirk area is affected differently by each flood protection option, and by the design capacity of each. The potential has been quantified at a cursory level, but will require surveys and considerable further work.

- Some issues that affect the optimum Floodway Expansion scheme are complex, and too fraught with site specific complications to permit complete resolution at this study stage. Specific strategies for each of the 13 bridges over the Floodway, for example, were elaborated only to the level of a general plan. Detailed optimization will also depend on whether the Floodway Expansion will be designed to capture other benefits/uses such as the capability to control summer water levels through the city.

The economic information that is provided in this report is intended to represent the overall benefits and costs of the alternatives considered. There is no intent to indicate funding sources.

4.0 EXISTING FLOOD PROTECTION FACILITIES FOR WINNIPEG

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

4.1 RED RIVER FLOODWAY

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

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

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

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

4.1.1 Floodway Channel

The Red River Floodway is approximately 29 miles in length with a difference in water surface under design flood conditions, of approximately 18 ft. between the inlet and the outlet. The alignment and location of the channel are shown on Plate 2. It is located in the high plasticity lacustrine clays of glacial Lake Agassiz, which are underlain generally by glacial till. An exception to this is the Birds Hill ridge which is a granular fluvio-glacial deposit from the last glacial age. The soils south and north of Birds Hill are similar but there are differences in the thickness of the lacustrine deposit.

The base width of the channel varies from 380 ft. to 540 ft., and the top widths range from 700 ft. to 1000 ft. The inlet to the Floodway is located in the east bank of the Red River and consists of a broad-crested earthen weir 700 ft. in width, with a crest elevation of 750 ft. There is a transition section below this weir which widens gradually to the normal Floodway cross section. The crest at El. 750 ft. ensures that flows below approximately 30,000 cfs pass down the Red River and do not enter the Floodway. The reach from the inlet to Birds Hill has a channel base width of 540 ft., with 6H to 1V side slopes in clay. The reach through Birds Hill has a base width of 420 ft., with side slopes of 3H to 1V in granular material, and the reach north of Birds Hill to the outlet, has a base width of 380 ft. with 6H to 1V side slopes in clay and glacial till. The design depth of flow in the channel is approximately 26 ft. The greatest depth of excavation was 65 ft. in the Birds Hill area where side slopes are 3H to 1V in the granular zone. The side slopes are reduced to 9H to 1V in clay in the vicinity of railway and road structures, due to slope stability considerations, with a corresponding reduction in base width. Transition sections are incorporated in the channel at points of change in cross section and above and below structures where the side slopes are flatter.

4.1.2 Floodway Inlet Control Structure

The Floodway Inlet Control Structure is situated in the Red River just downstream from the inlet to the Floodway Channel. The structure consists of concrete abutments and a central pier with two large submersible type gates, each 112.5 ft. wide. The gates normally are in the submerged position, with about 8 ft. of water over them in the summer months. Under these conditions the crest of the channel inlet at El. 750 ft. permits flows to enter the Floodway when the Red River discharge exceeds 30,000 cfs. As the natural river stage increases above 30,000

cfs there is a division in flow between the Floodway and the River. The purpose of the Floodway Inlet Control Structure is to counteract this drawdown and to regulate the division in flow between the Floodway and the Red River. The gates in the Floodway Inlet Control Structure are operated so as to maintain a water surface elevation upstream of the structure at the level that would occur under natural conditions.

4.1.3 Dikes

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

Extension of the West Dike westward along PR 305, to the vicinity of Brunkild is being undertaken in 2001.

4.1.4 Floodway Outlet Structure

The difference in water level over the entire reach of the Floodway channel from inlet to outlet is 18 ft. under design conditions but the corresponding difference of the Red River between those same points is about 32 ft. The purpose of the Outlet Structure therefore is to dissipate the energy in the water at its point of re-entry into the Red River near Lockport, thereby preventing damage and erosion in the River. The outlet structure is founded on bedrock and is constructed of mass concrete with an uncontrolled rollway, having a crest length of 162 ft. and a stilling basin 120 ft. in length. The design capacity of the outlet structure is 60,000 cfs.

4.2 PORTAGE DIVERSION

The Portage Diversion is an 18 mile long channel designed to carry up to 25,000 cfs of flood flow from the Assiniboine River at a point just upstream of Portage la Prairie northward to Lake Manitoba. The removal of flood flows via the Diversion provides flood protection not only to the City of Winnipeg but also to the City of Portage la Prairie and the area adjoining the Assiniboine River between those cities. Construction of the project commenced in 1965 and was completed in 1970 at a total cost of $20.5 million. It involved approximately 10,000,000 cubic yards of excavation as well as construction of several structures including three highway bridges and three railway bridges across the Diversion.

The major elements of the project are the dam in the Assiniboine River, the concrete spillway control structure (River Control Structure), the Diversion Structure that controls water entering the Diversion, the Diversion channel itself, two gradient control structures and the Outlet Structure.

4.3 SHELLMOUTH DAM

The Shellmouth Dam is located about 30 miles northwest of Russell in an area where the valley of the Assiniboine River is wide with high banks. The dam is about 70 ft. high and 4,200 ft. long. It has a reinforced concrete horseshoe-shaped conduit 15 ft. in diameter by means of which reservoir releases are made. Flood flows in excess of conduit capacity are either stored in the reservoir or are passed over an ungated concrete chute spillway.

The reservoir created by the Shellmouth Dam is approximately 35 miles long and is capable of storing 390,000 acre-ft of water. The protection afforded by the reservoir extends over the entire reach of the Assiniboine River between the Shellmouth Dam and its confluence with the Red River at Winnipeg. The Cities of Brandon and Portage la Prairie as well as Winnipeg benefit by both flood reduction and also low flow augmentation.

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

4.4 WINNIPEG DIKING SYSTEM

The diking system within the City of Winnipeg was built immediately after the 1950 Flood. The dikes enclose the Red, Assiniboine, and Seine Rivers. They consist mainly of broad boulevard type dikes referred to as the Primary Line of Defence (PLD), mostly built to the designated Flood Protection Level (FPL) or higher. The FPL is a water level profile (plus 2 ft. of freeboard) that corresponds to the maximum water level under flood conditions that would correspond to the design condition for the Floodway. At the time the Floodway was planned, the FPL was associated with an annual probability of being exceeded of 1 in 160 with the proposed Floodway in place. Current estimates of this probability, based on a flow record that is some 40 years longer than in the early 1960's, are between 1 in 90 and 1 in 100.

Pumping stations to lift storm water into the rivers are an important element of the diking system. Temporary Secondary Dikes for properties between the PLD and the rivers are also required during flood events.

5.0 OPTIONS FOR FLOOD PROTECTION IMPROVEMENT FOR WINNIPEG

5.1 REVIEW OF PREVIOUS STUDIES

In a previous study (KGS Group, 2000), KGS Group identified a variety of flood protection measures that could reduce Winnipeg's flood risks to varying degrees. The main measures identified were:

1. Raise Floodway Bridges
2. Remove portion(s) of East Embankment at Floodway Inlet
3. Expand Red River Floodway
4. Construct a twinned Red River Floodway
5. Raise West Dike
6. Construct Ste. Agathe Detention Structure
7. Improve City of Winnipeg Flood Protection Infrastructure
8. Permanent raise of crest level on Primary Dikes in Winnipeg
9. Improve Red River channel in or downstream of Winnipeg
10. Construct pump station at Floodway Inlet
11. Construct Eastern Tributaries Diversion

Other obviously less attractive measures such as expanding the Portage Diversion or constructing headwater storage projects were considered, but rejected early on the basis of judgement or preliminary calculations.

Initial screening of the list was undertaken, and pre-feasibility level comparisons led to the choice of two primary options that would have the capability to provide significant increases in flood protection for Winnipeg, and be cost-effective. Those were the Floodway Expansion and the Ste. Agathe Detention Structure. Additional work was also done to develop the concepts further and provide pre-feasibility cost estimates. Both options were shown to be cost effective, but the Ste. Agathe Detention Structure appeared to be economically superior. KGS Group recommended that the choice should consider social issues, and that further studies and public review would be required.

5.2 OVERVIEW OF FLOOD PROTECTION MEASURES UNDER REVIEW IN THIS STUDY

FLOODWAY EXPANSION

Floodway Expansion schemes ranging from a capability to pass a 1 in 500 year flood, to a capability to pass a 1 in 1200 year flood have been studied. A variety of alternative design concepts have also been addressed. The studies have focussed, however, on two key single-purpose schemes:

- a Floodway Expansion that would provide flood protection up to the 1 in 700 year flood
- the Ste. Agathe Detention Structure that would provide flood protection up to a 1 in 1000 year flood

It must be recognized that the scheme to be ultimately selected may well fall somewhere within the range of options discussed in this report, depending on a variety of technical, financial, and social considerations.

The key features of the scheme that provides protection up to the 1 in 700 year flood consist of the following:

- Increase in crest elevation of the West Dike and East Dike adjacent to the Floodway Inlet Control Structure. This will provide security against water levels as high as El. 778 ft. at the Floodway Inlet. Further details of this component of the expansion scheme are provided in Appendix D.
- Upgrades to the City of Winnipeg flood protection infrastructure, including raising the crest levels of the Primary Dikes in areas where they are below the Flood Protection Level, upgrades to flood pump stations, gates for sewer outfalls, etc. This would be required to permit the safe passage of approximately 80,000 cfs at a river level of approximately el. 25.8 ft. (JAPSD).
- For channel options that provide a level of flood protection that exceeds approximately 1 in 700 years, the project must include additional works to protect the city from backwater effects from high river levels downstream. This could include raising the crest levels of the Primary Dikes in parts of the city, and providing additional flood protection measures within the city to deal with water levels higher than at the 1 in 700 year flood magnitude. It is possible that an approximately 3 mile long extension of the Floodway could be more economical than the enhanced protection works in Winnipeg, but considerable additional work would be required to confirm this.

- Expansion of the Floodway channel to convey additional floodwater, including the modifications of bridges, transmission lines, water supply aqueducts, and other facilities that would be affected. Excavation of some 45 million cubic yards of soil would be required to provide a Floodway capacity capable of protecting against a 1 in 700 year flood. The maximum discharge through the channel would be 140,000 cfs during passage of the 1 in 700 year design flood.

- Modifications to the Floodway Outlet Structure to permit the conveyance of more water, and expansion of the discharge channel to release the increased Floodway flow into the Red River.

- Floodway Expansion would considerably reduce the present need to exceed "state-of-nature" water levels upstream of the Floodway Inlet for large floods. The 1 in 700 year Floodway scheme could maintain "state-of-nature" levels for all floods up to approximately the 1 in 250 year magnitude. Currently, exceeding the "state-of-nature" water level would be necessary for floods exceeding approximately the 1 in 90 year flood (approximately that of 1997).

- Upgrades to the Floodway Inlet Control Structure, including the fire protection system in the structure, installation of additional riprap protection on the embankment adjacent to the downstream sides of the structure, and possibly upgrading of the erosion protection on the upstream side of the embankments adjacent to the structure. A detailed review of additional measures that could increase the reliability of the Inlet gates, including the installation of backup gates should be completed.

Drawings of the modified channel (1 in 700 year flood capacity) are shown on Plate 2, Sheets 1 to 9. These plates show the general strategy of Floodway Expansion, and were prepared in parallel with the optimization studies. There are minor variations between the excavation quantities/costs used in Appendix B, Section B.6.20, and the preliminary geometry shown in Plate 2.

Important facts and study findings regarding the Floodway Expansion are as follows:

- Studies of the river characteristics north of Winnipeg to Lake Winnipeg have shown that the previously considered practical limit of flood protection that the expanded Floodway could provide was pessimistically low. The analyses showed that protection could be provided up to at least the 1 in 1200 year flood by the Floodway Expansion, and possibly greater.

- The estimated stage-discharge relationship for the Red River at the Floodway Outlet was refined. That resulted in a reduction of the estimated water level at a 1 in 1000 year flood flow by about 5 ft. compared to previous preliminary estimates. This refinement is responsible for the increased protection to Winnipeg that would be possible with an expanded Floodway.

- The magnitude of the largest flood in the last 200 years (1826) was shown to differ from the previously accepted estimate of 225,000 cfs. Uncertainties in the data show that there could be arguments for estimating the 1826 flood peak as low as 190,000 cfs, and other arguments that would justify an estimate as high as 300,000 cfs. KGS Group believes that the former is more likely, but it may never be known what the peak flood flow truly was during that event. This and the preceding findings are discussed and explained in further detail in Appendix A.

- The proposed Floodway Expansion project has been developed generally in accordance with the existing Operation Rules. A key feature that has a major influence on the cost and on the design of the Expansion is to allow raising the water level at the Floodway Inlet above the "state-of-nature". This would be done only under emergency conditions for a flood that would exceed at least the 1 in 250 year magnitude. More detail on this issue is discussed in Section 5.3, and in Appendix B. At present, emergency operation would be invoked at approximately a 1 in 90 year flood.

- The unit price of excavation would vary considerably in the channel, depending on the depth, the type of soil, and the groundwater conditions. Optimization studies have shown that there could be a considerable saving in cost (some 20%) that could be achieved in the Expansion, by selecting a channel configuration that recognizes the variability in the unit prices and the effect on hydraulic performance due to the channel configuration.

- The least costly means of dealing with the Floodway bridges is a combination of replacement of some, and modification of others so as to make use of the existing structures as much as practical. This is a complex issue and it would require further planning and engineering to fully resolve before final design could commence.

- The possibility of creating an impounded pool in the Floodway during summer, called the "Wet Floodway" was examined, and it is considered feasible. However, the scheme would cost approximately the same or possibly more than the conventional "dry" Floodway expansion, and would be more prone to erosion damage at high flows. Consideration of recreational development in the "Wet Floodway" did not lead to new opportunities that would not already be available in the Red River in Winnipeg. It is likely that there would be a greater variety and scope for recreational opportunities available from the dry option than the "Wet Floodway". Possibilities include canoe/kayaking in the low flow channel, bicycle trails, hiking trails, interpretive centres, cross country and downhill skiing routes, snowmobile routes, motorcycle routes. Some of these can be developed with the "Wet Floodway", but generally to a lesser extent. In summary, the "Wet Floodway" concept was not seen to have features that would be attractive enough to justify the probably greater cost or the risk of unpredictable channel erosion.

- An option of raising the maximum allowable water level upstream of the Floodway Inlet during emergency operation by about 4 ft. to El. 782 ft. was considered. This is expected to result in a capital cost that would be less than for the proposed scheme, but would require water levels that are some 8 ft. above the "state-of-nature" at the Floodway Inlet. More detailed study would be required to develop this concept, particularly with respect to modifications to the Floodway Inlet Control Structure, and the Floodway bridges.

- The crest level of the West Dike and the East Dike should be raised to provide adequate freeboard for potential water levels on the "Red Sea" for existing conditions. A modest additional increase is proposed to accompany the Floodway Expansion. The estimated cost for this component of the scheme is believed to be conservatively high partly because of the adoption of riprap armouring as wave protection in the preliminary design. Further study may indicate that a reduced level of protection or an alternate system may be sufficiently effective for less cost. Details of the crest level increase of the West Dike and the East Dike are described in Appendix D.

- The study showed that improvements in the flood protection infrastructure in Winnipeg to safely manage the passage of 80,000 cfs are economically viable, with benefits exceeding costs. Furthermore, the studies have shown that these improvements are less costly than providing an equal increase in flood discharge capacity in the expanded Floodway.

- The studies undertaken to this point have not permitted an assessment of improvements in land drainage facilities in Winnipeg. This is a secondary issue that is normally considered only after the primary flood protection scheme is selected. Detailed review of this aspect, and the appropriate costs that would be required to make the internal drainage system in Winnipeg compatible with the selected overall plan, should be undertaken after the preferred option is selected.

- The environmental impacts of the Floodway Expansion are relatively minor, given that the existing facility has existed for almost 35 years and has been operated in over 20 of those years. The impacts are generally associated with the potential for environmental disruption during construction and local effects on groundwater, both of which can be mitigated. A multi-purpose Floodway Expansion would have more serious impacts, particularly with respect to fish and particularly if the scheme involved operations of the Floodway Inlet Control Structure to control summer water levels in Winnipeg. Details are described in Appendix E.

- The socio-economic impacts of the Floodway Expansion compared with the Existing Floodway are substantial. For the total study area, 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 flood events. The added protection is concentrated in Zone 2 (the area between the Ste. Agathe Detention Structure and Floodway Inlet) and Zone 3 (Winnipeg and surroundings), with 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 Floodway Expansion. Even at flood levels that exceed its design capacity, 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. Beyond the fully protected residences, a significant number of residents will benefit from reduced flooding to residential property. Details are described in Appendix F, Section F.3.

- The cost of flood protection by expansion of the Floodway is estimated to range from $660 million for protection up to the 1 in 700 year flood, to $1,225 million for protection up to the 1 in 1200 year flood. The costs of major components of the scheme for a 1 in 700 year flood capability are itemized in Table 2A. Economic analysis has been undertaken that is similar to that applied by the Royal Commission on Flood Cost Benefit in 1958 as a basis for the selection of the original Floodway capacity for the needs at that time. The results show that a channel capacity to provide a 1 in 700 year flood protection would be near the economic optimum. This would increase the design capacity of the Floodway from 60,000 cfs to 140,000 cfs. Further expansion to provide additional capacity beyond a 1 in 700 year flood protection would come at an incremental cost that may exceed the direct flood damages that could be prevented. Other intangible factors could, however, justify exceeding the economic limit.

- A 1 in 1200 year Floodway Expansion scheme would only require upstream water levels to exceed the “state-of-nature” for floods in excess of 1 in 700 years (as compared to the 1 in 700 year Floodway in which this threshold would be reached at a 1 in 250 year flood).

TABLE 2A
Summary of Estimated Costs for 1 in 700 Year Floodway Expansion

ITEM	ESTIMATED COST ($MILLIONS, 2001)
Floodway Expansion	
Earthworks	168.0
Highway Bridges	36.3
Railway Bridges	45.6
Roadworks	1.7
Hydraulic Structures	19.9
Manitoba Hydro	5.0
Winnipeg Hydro	1.3
Centra Gas Manitoba	1.2
Manitoba Telecom Services	0.3
Winnipeg Pipeline Co.	1.2
Inlet Control Structure	30.1
Sub-Total	**310.6**
Owner's Cost, Engineering & Site Supervision (15%)	46.6
Contingency (20%)	62.1
Interest During Construction	49.7
Escalation During Construction	15.5
Sub-Total	**484.4**
Upgrades to Flood Protection Infrastructure in Winnipeg [1,2]	**110.0**
Raise Crest of West Dike [1,3]	**63.4**
TOTAL	**$658.0**

Note: 1. Costs include, engineering, site supervision, owner's cost, contingency, interest and escalation during 4 year construction period.

2. Refer to Table B-10 (Appendix B) for detailed breakdown of costs. Interest and escalation have been added.

3. Refer to Appendix D for detailed breakdown of costs. Price escalation has been added.

STE. AGATHE DETENTION STRUCTURE

The concept for the Ste. Agathe Detention Structure is less well defined than for the Floodway Expansion. The level of study is clearly at the pre-feasibility level, and was considered to be appropriate at this level, until the socio-economic aspects of the concept are considered in further detail. For the purposes of the study, the scheme of development consists of:

- 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 structure would be about 25 miles.

- 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 at the design condition (1 in 1000 year flood) and 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 on the Red.

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

- A gated control structure on the Rat River to allow the Rat River to discharge past the structure without impedance during non-flood conditions on the Red River.

- Upgrades to the flood protection infrastructure in the City of Winnipeg as included for the Floodway Expansion.

- Improvements at the Floodway Inlet Control Structure, including increased security against fires in the control facilities, improvement in erosion protection on the downstream side of the embankments adjacent to the structure, and possibly improvements in erosion protection on the upstream side of the embankments adjacent to the structure (this requires investigation at the site, see Appendix B, Section B.6.9).

The general arrangement of the principal structures is shown on Plate 3. Further details on the structures are provided in Appendix C.

Important facts and study findings regarding the Ste. Agathe Detention Structure are as follows:

- A limited extent of engineering has been done to refine the layout of the structures. The refinements include:

  - Provision of a discharge capacity in the concrete structures that would permit passage of the PMF without overtopping the water retaining structures.

  - Modifications of the structures and addition of flood discharge channels to eliminate any artificial increase of the water level upstream above the “state-of-nature” for floods with return periods less than 1 in 90 years.

  - Provision of structure heights and discharge capacities to permit safe freeboard on the structures for all flood flows up to the PMF.

- Water levels would be raised above the "state-of-nature", starting at flood magnitudes of approximately 1 in 90 years, or roughly equivalent to the peak of the 1997 flood. The release from the structure would be controlled at approximately 135,000 cfs (again roughly equivalent to the peak flood flow of the 1997 flood), for all incoming floods up to the design flood of 1 in 1000 years. For that extreme case, the water level would have to be raised by about 9 ft. above the "state-of-nature" at the structure, 5 ft. at Morris, and 1.2 ft. at Letellier. Detailed information on other water levels, flood magnitudes, and locations in the Red River Valley is given in Appendix C.

- The socio-economic impacts of the Ste. Agathe Detention Structure compared with the existing Floodway are substantial. Residents in Zones 2, 3 and 4 (Downstream of Floodway Outlet) would benefit from additional protection during floods much greater than the 1997 event. Residents in Zone 1 (Upstream of Ste. Agathe Detention Structure) 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. Details are described in Appendix F, Section F.3.

- The project, as presently planned, would increase durations of flooding levels in North Dakota and Minnesota. The peak water level south of Emerson would not be increased, but the flood levels would be extended in time by a few days. Impacts on farming interests could occur.

- Mitigation of the potential impacts on the U.S. may be possible through out-of-channel improvements that would lower water levels not only for large floods but also more frequent floods that cause overbank flow to occur. This option has not been studied and would require further work to confirm it as a viable scheme.

- Besides affecting many communities along the river during floods, the Ste. Agathe Detention Structure would also slightly increase the water levels above the "state-of-nature" at the Roseau River First Nation. The effect would commence at a flood flow of roughly 1 in 300 year magnitude (about 225,000 cfs), and would amount to an increase of 0.7 ft. at the 1 in 1000 year flood.

- Legal opinions obtained during this study confirm that use of the Ste. Agathe Detention Structure to protect Winnipeg would require a state of emergency to be declared. There is a little doubt that during a flood exceeding a 1 in 90 year magnitude (ie. greater than the 1997 "Flood of the Century"), this would occur. However, while there may be sound legal grounds for use of the Ste. Agathe Detention Structure, there may be practical difficulties and resistance from adversely affected residents that could lead to long delays in project implementation.

- Environmental issues with the project consist primarily of:

  - Loss of fish habitat in the river area occupied by the Main Structure.

  - Disruption to fish passage due to the passage of normal river flow through the control structure (to a large extent this has been mitigated by providing water passages that are at the same elevation as the existing riverbed).

  - Effects on the wetlands adjacent to the Rat River/Marsh River due to diversion of the Rat River flows during large floods.

- A literature review and polling of selected flood control agencies in North America, Europe, and Australia did not identify direct precedents of projects like the Ste. Agathe Detention Structure. However, there are numerous precedents of more severe cases where permanently flooded property was expropriated for use in reservoir development. There are also cases in Europe and China where breaching of dikes in lesser populated areas have been carried out in order to protect or reduce the flood impact on more heavily populated areas downstream. Again, these are not directly equivalent to the Ste. Agathe Detention Structure, and are of limited scales. The Floodway itself is a precedent in that it has the potential of raising water levels above the "state-of-nature" to protect Winnipeg. However, that capability has only been invoked once (1997) during the life of the project.

- The design of the Ste. Agathe Detention Structure has been based on a requirement to pass the PMF without overtopping/breaching. However, the existing facilities at the Floodway do not have this capability. This issue is discussed further in Section 6.5.

- The capital cost of the project is estimated to be approximately $500 million, and would provide protection for the Red River Valley north of the detention structure up to a 1 in 1000 year flood. Other economic factors are discussed in Appendix C and in Section 6.1, where an economic comparison with the Floodway Expansion is made. The costs of major components of the scheme are itemized in Table 2B.

TABLE 2B
Pre-Feasibility Cost Estimate for Ste. Agathe Detention Structure
(Including Improvements in Winnipeg)

ITEM	ESTIMATED COST ($MILLIONS, 2001)
Red River Control Structure	53.4
Detention Dike	126.4
Rat/Marsh Diversion	8.0
Marsh River Control Structure	26.7
Flood Discharge Channel	36.8
Rat River Control Structure	5.3
Utilities Impact	1.5
Sub-Total	**258.1**
Owner's Cost, Engineering & Site Supervision	36.1
Contingency	53.0
Interest During Construction	35.0
Escalation During Construction	7.7
Sub-Total	**390.0**
Upgrades to Flood Protection Infrastructure in Winnipeg (1,2)	**110.0**
TOTAL	**$500.0**

Note: 1. Costs include, engineering, site supervision, owner's cost, contingency, interest and escalation during 3 year construction period.

2. Refer to Table B-10 (Appendix B) for detailed breakdown of costs. Interest and escalation have been added.

- The negative impact of water levels raised above the "state-of-nature" upstream of the structure could be substantially reduced by raising the existing ring dikes at major communities in southern Manitoba to project against a 1 in 1000 year flood. The additional cost to the project is estimated to be $60 million (roughly 12% of the project cost) to achieve this.

5.3 PRIMARY ISSUES TO RESOLVE

There are several key issues that must be resolved by the funding partners at the next stage of planning. Choices can be based on the findings reported in this document and its appendices, and in some cases, additional refinements and study may be required. The key issues are inter-related and consist of:

- The selection between the Floodway Expansion and the Ste. Agathe Detention Structure

- If the Floodway is selected, a series of issues must be resolved:

  - The desired capacity of the expanded Floodway Channel must be selected.

  - Whether or not reliance on raising the water level above the "state-of-nature" at the Floodway Inlet, when forced to be necessary by extreme floods, is acceptable to Manitobans.

  - Whether or not the "Wet Floodway" option is deemed to be attractive, and whether the merits of that scheme are worth the risks and possible premium in cost that would be incurred.

  - A Dam Safety Review of the Floodway Facilities needs to be completed, so that a policy that is acceptable to the owners can be declared for the next stage of planning.

  - There would be a substantial cost required to provide improved control of summer water levels in Winnipeg, regardless of the flood protection option that is selected. There needs to be resolution on whether or not this feature is desirable enough to be incorporated in the flood control improvements.

  - If a Floodway capacity that exceeds approximately a 1 in 700 year flood is selected, a study would be required to resolve whether extension of the Floodway Channel, or whether investment in additional protection in Winnipeg, would be more economical.

  - There is a variety of design issues with the Floodway Expansion that must be resolved, and will require on-going work to satisfactorily achieve a solution that will define future design work if this option is selected. The primary issue is the best strategy for modifying the Floodway bridges.

  - There is a need to further analyse and predict the potential hydraulic effects of an expanded Floodway on the areas north of Winnipeg.

- If the Ste. Agathe Detention Structure is selected, other issues should be addressed:

  - Means to arrive at an acceptable formula for compensating impacted residents upstream of the Ste. Agathe Detention Structure.

  - Extent of mitigation that would be appropriate by enhancing existing ring dikes and constructing new dikes in the Red River Valley.

  - Resolution of the impacts on duration of flood levels in the U.S. that could occur for floods exceeding about a 1 in 300 year magnitude.

  - Extent of project modification that would be required to satisfy environmental concerns.

- Resolution of dealing with impacts on the Roseau River First Nation.

Further comments on some of these points, and on related issues are discussed in the paragraphs below:

Selection Between Floodway Expansion and Ste. Agathe Detention Structure

This is a fundamental issue that should be resolved as soon as possible. Comparisons between the key options are made from a variety of perspectives in Section 6. It is clear that the Ste. Agathe Detention Structure is less costly than the Floodway Expansion for a given level of flood protection, and provides flood protection to more residents than the Floodway Expansion. The Ste. Agathe Detention Structure relies solely on induced flood storage compared to existing conditions, whereas the Floodway Expansion improves the current potential extent of induced flooding. The Ste. Agathe Detention Structure has social consequences that would involve balancing the interests of residents north of structure against those of their neighbours to the south of the structure. KGS Group believes that this decision needs to be made by government representatives, based on considerations of technical findings and advice provided in this report.

Floodway – Capacity

At the start of this study, it was believed (tentatively) that the practical limit for Floodway Expansion would be at a discharge capacity associated with a 1 in 500 year flood. The limitation appeared to be due to the potential for back-flooding into Winnipeg due to high river levels downstream of the Floodway Outlet. This study showed that that limitation would be reached at floods considerably greater than a 1 in 500 year magnitude, and could in fact be even greater than the 1 in 1000 year flood, with innovative planning of the protective measures against this backwater effect in North Winnipeg.

The choice of capacity of the Floodway Expansion now would seem to be based on what is economically affordable for the owners, and on what may be considered socially acceptable and desirable.

On the point of economic affordability, economic analyses that are similar to those that were undertaken by the Royal Commission on Flood Cost Benefit in 1958 were done by KGS Group for the Floodway Expansion. The studies in 1958 were the basis of selection of the original Floodway design capacity. The results from the current study are documented in Appendix B, and suggest that the economic limit of protection (based on the point of maximum net benefits) is approximately a 1 in 700 year flood capacity. This scheme would involve raising the water level at the Floodway Inlet above the "state-of-nature" for floods exceeding approximately a 1 in 250 year magnitude. It should be noted, however, that a 1 in 1200 year Floodway would still have a benefit/cost ratio that is greater than 1.0.

With respect to social acceptability, there are precedents of protection against floods exceeding a 1 in 500 year magnitude (examples are dikes at Minneapolis/St. Paul, and flood protection works along the Mississippi River), and even 1 in 1200 year magnitude (Holland). A common theme of local technical groups in Winnipeg has been the desirability of reducing Winnipeg's risk of flooding during the next 50 years from about 37% under existing conditions, to 5%. That major step would require adopting the 1 in 1000 year flood (or greater) as the protection objective.

The cost of protection against a 1 in 700 year flood with expansion of the Floodway is estimated to be approximately $660 million. This would reduce Winnipeg's risk of flooding from 37% to 7% for a 50 year period.

The cost of Floodway expansion rises significantly for protection against a 1 in 1200 year flood, to approximately $1.2 billion. This would reduce the risk from 37% to 4% for a 50 year period.

Floodway – Raising Water Level Above "State-of-Nature"

Any Floodway channel has the capability of providing a considerable increase in discharge capacity with increased water levels above the "state-of-nature" at the Floodway Inlet. This would be available at relatively modest cost, including primarily those costs for increasing the height of the West Dike and the East Dike, and modifying the bridges so that failure of bridge decks and possible partial blockage of flow would not be a major concern. The probable additional cost of compensating upstream residents for the incremental amount of flooding that

would be caused is relatively small compared to the potential savings in Floodway Expansion cost. That compensation does not change the economic balance between a design and operation policy of no increases of the Floodway Inlet water level above the "state-of-nature", and one in which emergency increases of the water level are permitted. This is demonstrated in Table 3, which compares the overall costs of two schemes ***that each provide protection for a maximum flood of 1 in 500 years.*** It should be noted that these schemes were selected because they both represent an equal extent of flood protection. Neither scheme is exactly equivalent to the main scheme addressed in this study (that being a 1 in 700 year Floodway Expansion). The schemes that are compared in Table 3 are:

1. Restricted Inlet Water Levels to "State-of-Nature"

Expanded Floodway, maximum design water level at the Floodway Inlet, El. 773.5 ft. ("state-of-nature", 1 in 500 year flood), flooding in Winnipeg would commence at flood flows exceeding the 1 in 500 year magnitude; discharge capacity of Floodway at a water level of El. 773.5 ft. would be approximately 140,000 cfs.

2. Surcharge of Inlet Water Level Allowed to El. 778 ft.

Expanded Floodway, maximum water level at the Floodway Inlet, El. 778 ft., (maximum emergency condition to pass 1 in 500 year flood), flooding in Winnipeg would commence at floods exceeding the 1 in 500 year magnitude; discharge capacity of the Floodway at a water level of El. 778 ft. would be 130,000 cfs (10,000 cfs is "shaved" off the peak of the 1 in 500 year flood due to the ponding action of raising the water level at the Floodway Inlet from the "state-of-nature" condition to El. 778 ft.), maximum discharge capacity of the Floodway at "state-of-nature" water level would be approximately 100,000 cfs and would correspond to approximately a 1 in 200 year flood (at this point the Floodway Inlet water level would have to start to be raised under emergency conditions).

The latter scheme would require that the question of fair compensation for affected upstream residents be addressed and resolved.

TABLE 3
Comparison of Costs for Protection Against 1 in 500 Year Flood
(Costs in Millions of 2001 dollars)

ITEM	SCHEME 1 "STATE-OF-NATURE" ONLY	SCHEME 2 EMERGENCY OPERATION ABOVE "STATE-OF-NATURE"
Floodway Expansion[1]	$792	$450
West Dike Modifications[2]	45	63
Upgrades to City of Winnipeg Flood Protection Infrastructure	110	110
Upstream Damages (Present Value of Average Annual Damages)	38	51
TOTALS	**$985**	**$674**

Notes: 1. Credit applied to Scheme 1 to acknowledge that protection to Floodway bridges would be less expensive.

2. Credit applied to Scheme 1 to acknowledge less raising of West Dike near Floodway Inlet would be required compared to Scheme 2.

3. Costs are adjusted based on estimates for 1 in 700 year Floodway described in Appendix B.

Dam Safety Issues

A comprehensive Dam Safety Review of the flood protection facilities for Winnipeg should be carried out. This would include the Portage Diversion, the Shellmouth Dam, and the Floodway. Assumptions and proposals have been made in this study regarding the Floodway (see Appendix B), but these need to be examined by the funding partners and confirmed as acceptable. The Dam Safety Review should follow the Canadian Dam Safety Guidelines.

Floodway – Control of Summer Water Levels in Winnipeg

Control of summer flood water levels in Winnipeg is a desirable objective that would have value in the city. The current studies have shown that control of summer floods is possible to a much greater degree than now exists. It is clear that control of summer flood levels in Winnipeg cannot be achieved free of cost. That cost would be in the form of:

- Upstream impacts caused by raising the water level above the "state-of-nature" during the summer flood events, or,

- constructing modifications to either the existing Floodway or to an expanded Floodway. The modifications would consist of deepening the Floodway channel and adding a control structure that could control inflow and prevent ice from entering the channel, or

- some combination of the above.

The Floodway can be expanded in such a way that it can provide flood protection for the large spring floods, as well as to control summer flood levels in Winnipeg. However, serving both purposes cannot be achieved as economically as can providing only the spring flood protection.

The cost of serving both purposes (spring flood protection and summer flood water level control) could range from $30 million, to as much as $100 million, ***in addition to*** the cost of only designing for spring flood protection. The actual amount within that range would depend largely on whether raising the water level above the "state-of-nature" at the Floodway Inlet using the existing inlet gates could be accepted. Even a modest amount over the "state-of-nature", while still keeping the river within its bankfull capacity, would substantially reduce the cost from the estimated upper limit of $100 million.

A range of options for providing for summer water level control in Winnipeg is described in Appendix E. The options could take these or many other forms and would require further planning once the basic selection of the spring flood protection capacity is resolved.

Floodway – Design Issues

The strategy for modifying or replacing the Floodway bridges is critical in the overall design of the Floodway Expansion. The preliminary plan that has been devised during this study, based on the work described in Appendix B, is as follows:

- Retrofitting 8 bridges that include the St. Mary's Road, GWWD, PTH 15, CPR-Keewatin, PTH 59 North, CNR-Pine Falls, PTH 44 Bridges. This work would consist of:

  - extension of the bridge decks as required to suit the channel dimensions at each location

  - upgraded pier foundations

  - pier replacement, where necessary

- reinforcement of the deck structure to resist the drag forces and debris loads that would result from submerged flow conditions

- Replacing 4 bridges that include the CPR-Emerson, PTH 59 South, CNR-Spraque, Trans-Canada No. 1 E Bridges. The replacement would include raising the elevation of the girders/decks so that they would be above the maximum water level. While design of bridges does not normally require bridge decks to be above the water surface at a 1 in 700 year flood, in this case, the heightening of the bridge decks is offset by cost savings in channel excavation that would accrue (ie. lower losses at bridge so channel can be smaller).

- Removal of the abandoned CPR-Lac du Bonnet bridge.

The bridges differ in configuration, with varying foundation conditions, and surrounding infrastructure that could influence the modifications. The current study could not fully accommodate all of the influencing factors to develop a comprehensive final plan. Furthermore, additional detailed planning and cost optimization studies will be required. At this time, however, the estimated cost of the preliminary plan, with its contingency allowance, is believed to provide a representative budget for the required extent of bridge modifications that would eventually be finalized and carried out.

6.0 COMPARISON OF OPTIONS

This section compares the Floodway Expansion and the Ste. Agathe Detention Structure from a variety of perspectives. Obvious preferences are stated for each basis of comparison. However, an overall preference is not selected, since it is KGS Group's intent to provide the fundamental information upon which the three levels of government can base a decision on behalf of the people of Manitoba.

6.1 COSTS AND BENEFITS

The traditional means of comparing and selecting preferred flood protection options are founded on economics. In this regard, direct comparison of the two projects is hampered by the fact that the ultimate flood protection capacity is a variable for the Floodway Expansion, and to a greater extent, is fixed for the Ste. Agathe Detention Structure (the design capacity could be varied, but the cost is not as variable).

As a simplification to assist in comparing the two projects on a basis of equal protection, the cost for a 1 in 1000 year Floodway Expansion has been estimated from the information assembled in this study for a variety of optional channel sizes. That version of the Floodway Expansion can be directly compared to the Ste. Agathe Detention Structure, which also provides maximum flood protection capacity to the 1 in 1000 year flood. The salient information for comparison is summarized in Table 4.

TABLE 4
Economic Comparison of Floodway Expansion and
Ste. Agathe Detention Structure (Both Providing 1 in 1000 Year Flood Protection)

	FLOODWAY EXPANSION[1] (1 in 1000 year Flood Protection)	STE. AGATHE DETENTION STRUCTURE	
		NO ADDITIONAL PROTECTION UPSTREAM	WITH ENHANCED RING DIKES UPSTREAM
Capital Cost (millions of $, 2001)	$1,100	$500	$560
Present Value of Operation and Maintenance Costs[2] (millions of $, 2001)	$0	$10	$10
Present Value of Average Annual Incremental Upstream Damages[3] (millions)	$0[4]	$33	$20
Total	**$1,100**	**$543**	**$590**
Benefits[5] (millions)	$1,880	$2,020	$2,020
Benefit/cost	1.7	3.7	3.4
Net Benefits (millions)	$790	$1,480	$1,430

Notes:
1. Floodway Expansion incorporates provisions to raise water levels above "state-of-nature" under emergency conditions.
2. Present value of 50 years of O&M costs that would be incremental to O&M costs for existing Floodway. No significant increase is foreseen for the Floodway Expansion.
3. Present value of the difference between damages that would be incurred upstream of the facility, with vs. without the flood protection project.
4. Reduction in damages upstream of Floodway due to less frequent raising of water levels upstream of the Floodway above "state-of-nature" are included in benefits.
5. Present value of average annual averted flood damages north of Ste. Agathe and in Winnipeg, as estimated by KGS Group in previous studies, and average annual averted damages north of Winnipeg estimated in the current study.
6. Financial statistics are based on:
   - economic life, 50 years
   - interest, 8% per year
   - inflation, 3% per year for O&M and flood damages
   - allowance for economic/population growth, 1%

Knowledge of two factors is important to supplement the information in Table 4:

- From an economic perspective, investment in a Floodway Expansion with a capability less than a 1 in 1000 year flood could provide better economic indicators than Table 4 shows. Economic analysis described in Appendix B shows the point of maximum net benefits for the Floodway Expansion at approximately the 1 in 700 year flood protection.

This is a theoretical perspective, and does not include some tangible benefits such as the avoidance of major business disruption due to flooding in Winnipeg, and intangible benefits such as related to avoidance of the stress and anxiety that accompanies widespread flooding. Nevertheless, it suggests that using conventional economic principles, the optimum Floodway Expansion would be able to provide a capacity that is less than that which is compared to the Ste. Agathe Detention Structure in Table 4.

- The figures in any table of the type shown in Table 4 should be used cautiously. They represent the current estimate of future performance and do not represent all the possible future outcomes.

- If the two projects were compared using a design criterion of a 1 in 700 year flood, the Ste. Agathe Detention Structure would be shown to be less favourable. However, such a comparison would require further engineering analysis that was not part of the current scope.

It appears from Table 4 that the Ste. Agathe Detention Structure is superior to the Floodway Expansion from the economic perspective alone.

6.2 SOCIO-ECONOMIC CONSIDERATIONS

Appendix F presents quantitative and qualitative socio-economic impacts of operating the Floodway Expansion and Ste. Agathe Detention Structure alternatives using an analysis of four key socio-economic variables: residences, residents, agricultural land and roads. These sections also include key perspectives and insights about project socio-economic impacts derived from interviews with key persons living in each impact zone. The degree of protection and amount of project induced flooding that occurs as a result of the operation of each alternative were compared with those under the Existing Floodway to provide an indication of the socio-economic impact. This section brings together the results in Appendix F and presents a comparison of the socio-economic effects of the 1 in 700 year Floodway Expansion and the Ste. Agathe Detention Structure. Protection and project induced flooding associated with the two alternatives are depicted side by side. Notable features and differences that flow from the comparison are described. The impact of the alternatives on people varies in different areas of the flood zone. These differences have 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.

The general location of the four zones is shown on Plate F-1 (Appendix F). To focus the presentation and discussion on key features and differences between the alternatives, this section examines the effects on the most important socio-economic indicator – number of residents affected (i.e. people living in the impact zones whose residence is affected by project related protection or flooding). The number of additional residents protected or flooded as a result of each alternative project is compared in each of the four impact Zones and in total for all Zones.

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

The Floodway Expansion that is represented in this comparison is the one that provides flood protection up to the 1 in 700 year flood, and has been the primary focus in this study. Effects of using additional community ring diking to address backwater effects of the Ste. Agathe Detention Structure are also considered. This part of the analysis assumes additions or enhancements to ring dikes are made to provide protection up to the 1 in 1000 year flood event in the communities experiencing backwater affects (i.e. Morris, St. Jean Baptiste, Letellier, Dominion City, Rosenort, Aubigny, St. Pierre-Jolys, Riverside and Roseau River FN). Communities not experiencing backwater affects (i.e. Emerson, Gretna and Rosenfeld), are not included in the ring dike enhancements.

Three types of findings are presented in tabular form in the comparisons by Impact Zones.

- Table 5 compares total number of residents experiencing a combination of natural and project induced flooding when the alternatives are in operation. This provides an indication of how many residents would continue to be flooded in each zone once the alternatives are operational.

- Table 6 compares the total number of residents who experience additional flood protection as a result of the operation of the flood protection alternative. This illustrates the amount of added protection that is being provided by each alternative beyond what would have been provided by the Existing Floodway. **Additional flood protection refers to situations where residents experience full protection from flooding and increased protection from flooding. Fully protected residents would not experience any flooding; residents with increased protection would experience flooding but with lower water levels and/or shorter durations.**

- Table 7 compares the total number of residents who experience project induced flooding as a result of the operation of the flood protection alternative. This illustrates the amount of additional flooding generated by each alternative beyond what would have occurred with the Existing Floodway. **Project induced flooding covers situations where residents experience new flooding and increased flooding. Newly flooded residents are ones that would not have experienced natural flooding with the Existing Floodway; residents with increased flooding would experience flooding but with higher water levels and/or longer durations.**

- The comparison of residents affected by added protection and project induced flooding is also presented graphically for 1 in 300 year flood events in Zone 1 and Zone 2 and all zones combined.

Additional protection and project induced flooding comparisons use the Existing Floodway as a baseline. The analysis assumes that the flooding effects associated with the Existing Floodway are common to each flood protection alternative. As such, comparisons of additional protection or project induced flooding presented in this section pertain to **impacts that are incremental to those experienced with the existing Floodway.**

Figures 1 and 2 show the number of residents experiencing additional protection and project induced flooding for Zone 1 and Zone 2. Figures 3 and 4 show the number of residents experiencing flooding for all Zones for the 1 in 90 year, 1 in 300 year, 1 in 500 year, and 1 in 1000 year flood events.

TABLE 5
Comparison of Flood Protection Alternatives
Total Number of Residents Experiencing Flooding

ZONE	FLOOD EVENT	FLOODWAY EXPANSION[1]	STE. AGATHE DETENTION STRUCTURE	STE. AGATHE (MITIGATION) [2]
1	1 in 90	1,702	1,702	1,702
	1 in 300	2,241	6,300	2,478
	1 in 500	2,416	6,334	2,512
	1 in 1000	5,864	8,741	4,045
2	1 in 90	2,066	2, 066	2,066
	1 in 300	5,563	2,066	2,066
	1 in 500	7,475	2,066	2,066
	1 in 1000	7,711	2,066	2,066
3	1 in 90	0	0	0
	1 in 300	0	0	0
	1 in 500	0	0	0
	1 in 1000	500,000	0	0
4	1 in 90	11	11	11
	1 in 300	130	11	11
	1 in 500	225	11	11
	1 in 1000	282	11	11
TOTAL ALL ZONES	1 in 90	3,779	3,779	3,779
	1 in 300	7,934	8,377	4,555
	1 in 500	10,116	8,412	4,590
	1 in 1000	513,857	10,818	6,122

Source: InterGroup Consultants Ltd. from KGS Depth-Damage Model, 2001.
Note: 1. For 1 in 700 year flood protection

2. Provides additions or enhancements to ring dikes for protection up to the 1 in 1000 year flood event in the communities experiencing backwater affects (i.e. Morris, St. Jean Baptiste, Letellier, Dominion City, Rosenort, Aubigny, St. Pierre-Jolys, Riverside and Roseau River FN). Communities not experiencing backwater affects (i.e. Emerson, Gretna and Rosenfeld), are not included in the ring dike enhancements.

TABLE 6
Comparison of Flood Protection Alternatives
Number of Residents with Additional Flood Protection

ZONE	FLOOD EVENT	FLOODWAY EXPANSION[1]		STE. AGATHE DETENTION STRUCTURE		STE. AGATHE (MITIGATION) [2]	
		Full Protection	Increased Protection	Full Protection	Increased Protection	Full Protection	Increased Protection
1	1 in 90	0	0	0	0	0	0
	1 in 300	0	0	0	0	3,822	0
	1 in 500	0	0	0	0	3,822	0
	1 in 1000	0	0	0	0	4,696	0
2	1 in 90	0	2,066	0	0	0	0
	1 in 300	2,101	5,563	5,598	2,067	5,598	2,067
	1 in 500	208	7,475	5,616	2,067	5,616	2,067
	1 in 1000	0	0	5,645	2,067	5,645	2,067
3	1 in 90	0	0	0	0	0	0
	1 in 300	350,000	0	350,000	0	350,000	0
	1 in 500	450,000	0	450,000	0	450,000	0
	1 in 1000	45,000	500,000	545,000	0	545,000	0
4	1 in 90	0	0	0	0	0	0
	1 in 300	0	0	119	11	119	11
	1 in 500	0	0	214	11	214	11
	1 in 1000	0	0	271	11	271	11
TOTAL ALL ZONES	1 in 90	0	2,066	0	0	0	0
	1 in 300	352,101	5,563	355,717	2,078	359,539	2,078
	1 in 500	450,208	7,475	455,830	2,078	459,652	2,078
	1 in 1000	45,000	500,000	550,916	2,078	555,612	2,078

Source: InterGroup Consultants Ltd. from KGS Depth-Damage Model, 2001.
Note: 1. For 1 in 700 year flood protection

2. Provides additions or enhancements to ring dikes for protection up to the 1 in 1000 year flood event in the communities experiencing backwater affects (i.e. Morris, St. Jean Baptiste, Letellier, Dominion City, Rosenort, Aubigny, St. Pierre-Jolys, Riverside and Roseau River FN). Communities not experiencing backwater affects (i.e. Emerson, Gretna and Rosenfeld), are not included in the ring dike enhancements.

TABLE 7
Comparison of Flood Protection Alternatives
Number of Residents with Project Induced Flooding

ZONE	FLOOD EVENT	FLOODWAY EXPANSION[1]		STE. AGATHE DETENTION STRUCTURE		STE. AGATHE (MITIGATION)[2, 3]
		New Flooding	Increased Flooding	New Flooding	Increased Flooding	New Flooding and Increased Flooding
1	1 in 90	0	0	0	0	0
	1 in 300	0	0	4,059	2,241	2,478
	1 in 500	0	0	3,918	2,416	2,512
	1 in 1000	0	0	2,876	5,864	4,044
2	1 IN 90	0	0	0	0	0
	1 in 300	0	0	0	0	0
	1 in 500	0	0	0	0	0
	1 in 1000	0	0	0	0	0
3	1 in 90	0	0	0	0	0
	1 in 300	0	0	0	0	0
	1 in 500	0	0	0	0	0
	1 in 1000	0	0	0	0	0
4	1 in 90	0	0	0	0	0
	1 in 300	0	0	0	0	0
	1 in 500	0	0	0	0	0
	1 in 1000	0	0	0	0	0
TOTAL ALL ZONES	1 in 90	0	0	0	0	0
	1 in 300	0	0	4,059	2,241	2,478
	1 in 500	0	0	3,198	2,417	2,512
	1 in 1000	0	0	2,876	5,864	4,044

Source: InterGroup Consultants Ltd. from KGS Depth-Damage Model, 2001.
Note: 1. For 1 in 700 year flood protection

2. Provides additions or enhancements to ring dikes for protection up to the 1 in 1000 year flood event in the communities experiencing backwater affects (i.e. Morris, St. Jean Baptiste, Letellier, Dominion City, Rosenort, Aubigny, St. Pierre-Jolys, Riverside and Roseau River FN). Communities not experiencing backwater affects (i.e. Emerson, Gretna and Rosenfeld), are not included in the ring dike enhancements

3. Damage Model does not generate the number of residents who are either flooded or have higher water levels as a result of enhanced ring diking in Zone 1. Ring diking is considered a reduction to number of residents who experience project induced flooding.

6.2.1 Comparative Impacts on Zone 1

For Zone 1 (upstream of Ste. Agathe Detention Structure) the comparative impacts for the two flood protection alternatives are:

- The two alternatives have decidedly different impacts on Zone 1 residents. Floodway Expansion has a neutral impact, causing no changes on flooding, while the Ste. Agathe Detention Structure creates additional upstream flooding on residences, agricultural operations and other lands and properties.

- Floodway Expansion does not provide added flood protection nor does it result in project induced flooding to residents in Zone 1 for any of the analysed flood events.

- The Ste. Agathe Detention Structure, for floods greater than the 1 in 90 year flood event, generates a backwater effect that results in additional flooding for a sizeable number of residents in Zone 1. For a 1 in 300 year flood event, approximately 6,300 residents are affected by project induced flooding in Zone 1(Table 7). An estimated 4,059 residents would experience new flooding and 2,241 residents would experience higher water levels and/or longer flood durations. Ste. Agathe increases the duration of flooding for all events greater than the 1 in 90 year flood event (Figure 1).

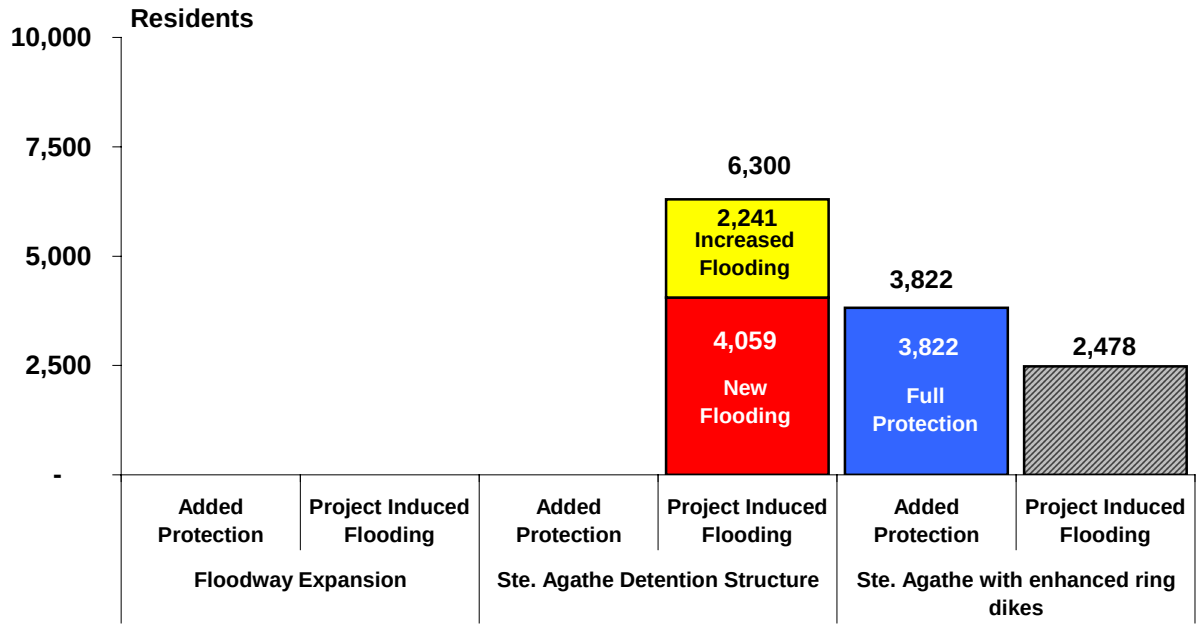
- Enhanced community ring diking significantly reduces the number of residents who experience project induced flooding in Zone 1, if later confirmed to be feasible. For example, in a 1 in 300 year flood event, enhanced ring diking reduces the number of residents who experience project induced flooding (i.e., new flooding or increased flood levels) by 3,822, from 6,300 to 2,478 residents. Approximately the same number of residents would be protected by the enhanced diking in a 1 in 500 year flood event. For enhanced community ring dikes, it was not possible to distinguish between the number of residents experiencing new flooding and increased flooding. It is important to note that community ring diking protects from both natural and project induced flooding to the 1 in 1000 year flood event and therefore a benefit to affected Zone 1 residents if mitigation is introduced.

- Based on the above, Floodway Expansion is preferred for Zone 1 with or without community ring dike enhancements. The sizeable level of project induced flooding, without ring dike mitigation, makes the Detention Structure unattractive for this zone. Enhanced community dikes significantly reduce the number of residents affected by project induced flooding, but still leaves about 2,500 residents with added flooding.

  It should be noted that the examples analysed in the section only range up to the 1 in 1000 year flood. Floods could occur that exceed this range, however, the probability of this happening is low and detailed analysis was not considered justified at this time. Also of note, for events approaching a 1 in 300 year flood operation of the Detention Structure results in project induced flooding impacts that are incremental to those experienced with Existing Flooding, on the Roseau River First Nation and its Treaty Land Entitlement selections. For the 1 in 1000 year flood event, backwater from this project extends over the international border and increases the duration of flooding in

parts of North Dakota and Minnesota, although this may be mitigable. Permits and agreements would have to be obtained before the Detention Structure proceeds to allow project related flooding on these areas.

It should be noted that the examples analysed in this section only range up to the 1 in 1000 year flood. Floods could occur that exceed this range, however, the probability of that happening is low and detailed analysis was not considered justified at this time.



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

Figure 1 - Comparison of Flood Protection Alternatives
Residents Experiencing Additional Protection and Project Induced Flooding
Zone 1, 1 in 300 Year Flood Event

6.2.2 Comparative Impacts on Zone 2

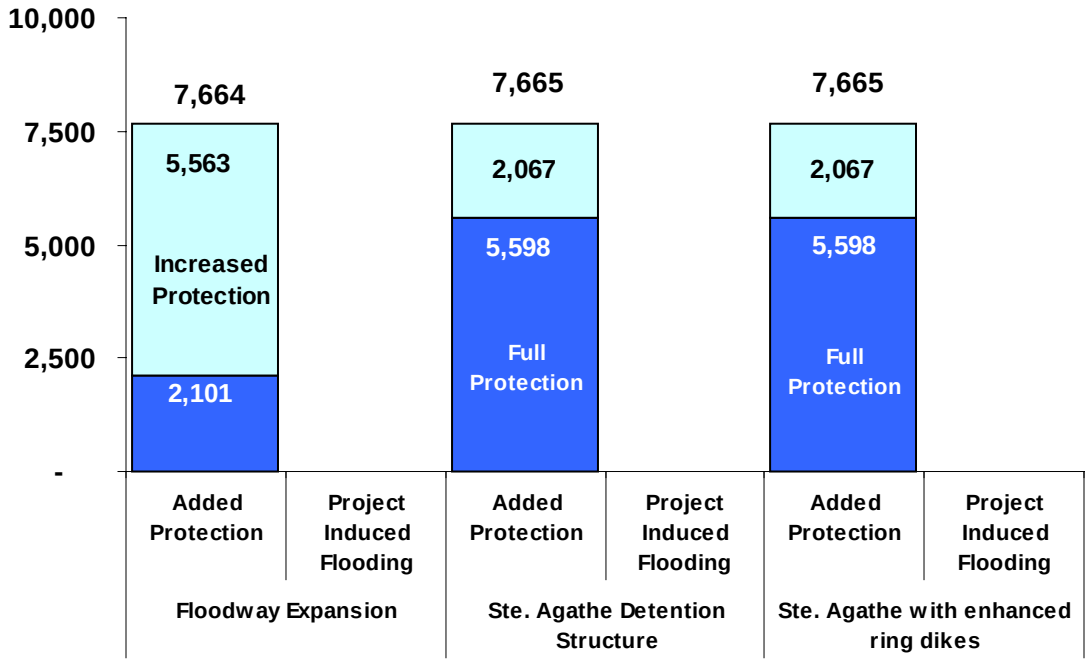
For Zone 2 (Ste. Agathe Detention Structure to Floodway Inlet), the comparative impacts for the two flood protection alternatives are:

- Both alternatives contribute additional protection to Zone 2 residents.

- Additional protection occurs under each of the three lower flood scenarios with Floodway Expansion. The extent of flooding Zone 2 is reduced under Floodway Expansion 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. At the 1 in 90 year flood event, an estimated 2,066 residents experience reduced flooding. Floodway Expansion does not result in additional new flooding to residents in Zone 2 under the flood scenarios assessed (see Table 5). As the size of flood increases beyond the 1 in 300 year flood event, the benefit (in increased number of residents experiencing additional full flood protection) decreases (see Table 6).

- The Ste. Agathe Detention Structure provides significant additional protection for each event greater than a 1 in 90 year flood event. Unlike Floodway Expansion, this additional protection is generally full protection (removal of flooding) rather than increased protection (Table 6). Approximately 5,600 residents are fully protected for each flood scenario greater than the 1 in 90 year flood event up to the 1 in 1000 year flood level. However, the Detention Structure increases the duration of flood event for any event greater than 1 in 90 year flood event (Figure 2).

- On the basis of the above, the Ste. Agathe Detention Structure is preferred for Zone 2 because of the larger number of additional residents it fully protects.



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

Figure 2 - Comparison of Flood Protection Alternatives
Residents Experiencing Additional Protection and Project Induced Flooding
Zone 2, 1 in 300 Year Flood Event

6.2.3 Comparative Impacts on Zone 3

For Zone 3 (Winnipeg and Surroundings), the comparative impacts of the two flood protection alternative are:

- Each of the flood protection alternatives provides additional protection to a very large number of Winnipeg residents for all flood events greater than 1 in 90 year flood event. In the 1 in 1000 year flood event, where the design capacity of the 1 in 700 year Floodway Expansion is exceeded, there is significant difference between the Floodway Expansion and the Ste. Agathe Detention Structure. At the 1 in 1000 year flood event, Floodway Expansion provides additional protection to 45,000 residents and reduces flooding for 500,000 residents (Table 6).

- The Ste. Agathe Detention Structure provides additional full protection for residents in Zone 3 for all flood events including the 1 in 1000 year, considered in the study. Operation of the Detention Structure increases the duration of flooding for all events greater than the 1 in 90 year flood event.

- Because of its greater design capacity (1 in 1000 year event), the Ste. Agathe Detention Structure is preferred in this zone, whereas Floodway Expansion protects Winnipeg residents up to about 1 in 700 year flood event.

6.2.4 Comparative Impacts on Zone 4

For Zone 4 (Downstream of Floodway Outlet), the comparative impacts of the two flood protection alternatives are:

- The two alternatives will affect Zone 4 residents differently.

- Floodway Expansion offers no additional protection for Zone 4 residents for all flood event scenarios considered in this study. However, it is recognized there would be some minor water level increases between 1 in 90 year and 1 in 500 year flood events (this is explained in greater detail in Appendix A).

- The Ste. Agathe Detention Structure provides additional protection beyond the 1 in 90 year flood event. For the 1 in 300 year flood event an estimated 119 residents north of Lockport are fully protected from flooding. Estimates of residents experiencing additional protection of flooding between the Perimeter Highway and Lockport were not made because of the poor quality of the topographical data. Ste. Agathe Detention Structure increases the duration of flood event for any event greater than the 1 in 90 year flood event (Table 6).

- The Ste. Agathe Detention Structure would be the preferable alternative for Zone 4 residents by virtue of the full protection it would provide to some residents for events beyond the 1 in 90 year flood.

6.2.5 Overall Perspective – Zone By Zone Analysis

For all zones, the comparative impacts of the two flood protection alternatives are:

- In terms of residents experiencing added flood protection and project induced flooding, the Ste. Agathe Detention Structure is, with or without enhanced community ring dikes, the preferred alternative for Zones 2, 3 and 4.

- Floodway Expansion is preferable in Zone 1 with or without enhanced community ring dikes and mitigation. However, the inclusion of enhanced ring diking for communities in Zone 1 significantly reduces the number of residents who would experience project induced flooding as a result of the operation of the Ste. Agathe Detention Structure.

- Project induced flooding of Roseau River First Nation lands would require a permit to flood lands prior to operation of the Ste. Agathe Detention Structure. The community of Roseau River First Nation would be protected to a 1 in 1000 year flood level with enhanced community ring diking, if confirmed to be feasible.
- Increased duration of flooding on agricultural lands and access roads across the international boundary, if not mitigated, would also require permits prior to operation of the Ste. Agathe Detention Structure.

- For higher frequency flood events (1 in 90 year and 1 in 300 year) without enhancement of ring diking, both Floodway Expansion and the Ste. Agathe Detention Structure result in similar numbers of residents in all zones combined experiencing flooding. For larger flood events (1 in 500 year and 1 in 1000 year), the Ste. Agathe Detention Structure results in fewer residents experiencing flooding. Additional ring diking would significantly reduce the number of residents who experience flooding with the Ste. Agathe Detention Structure.

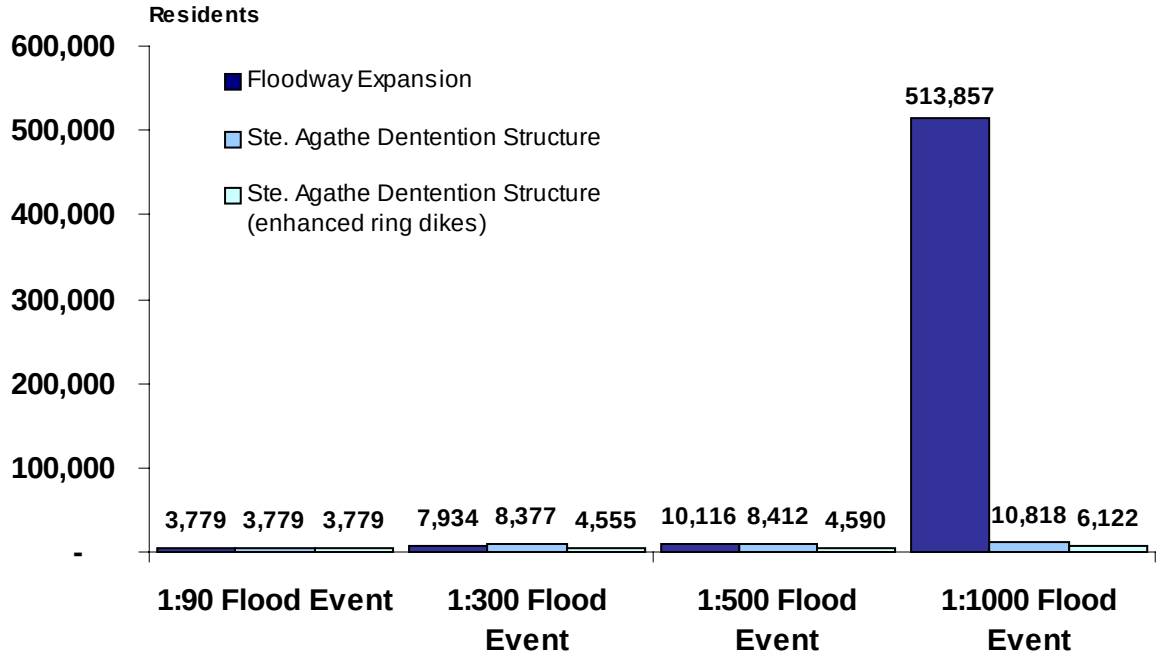
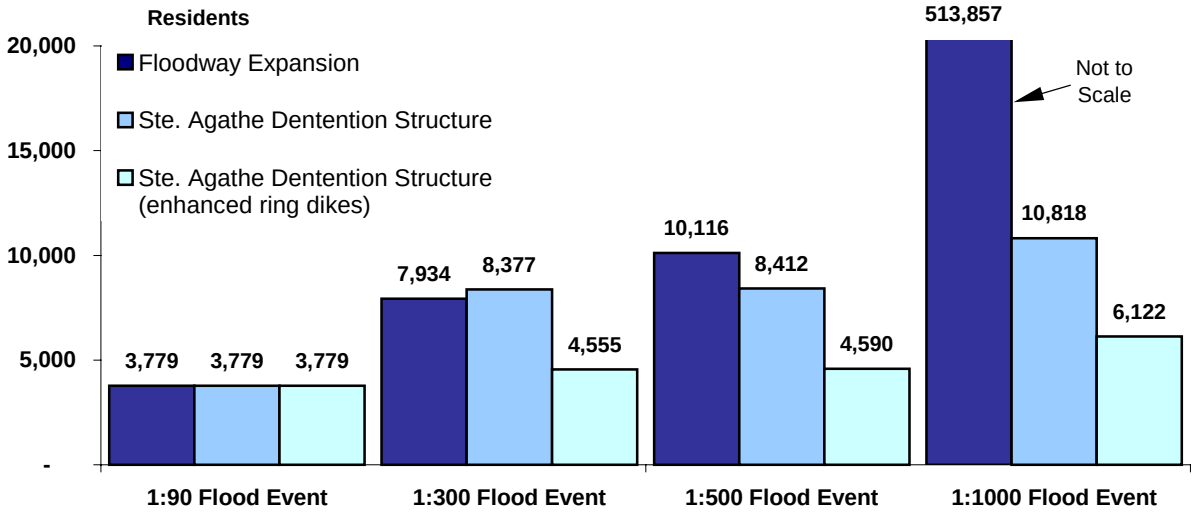
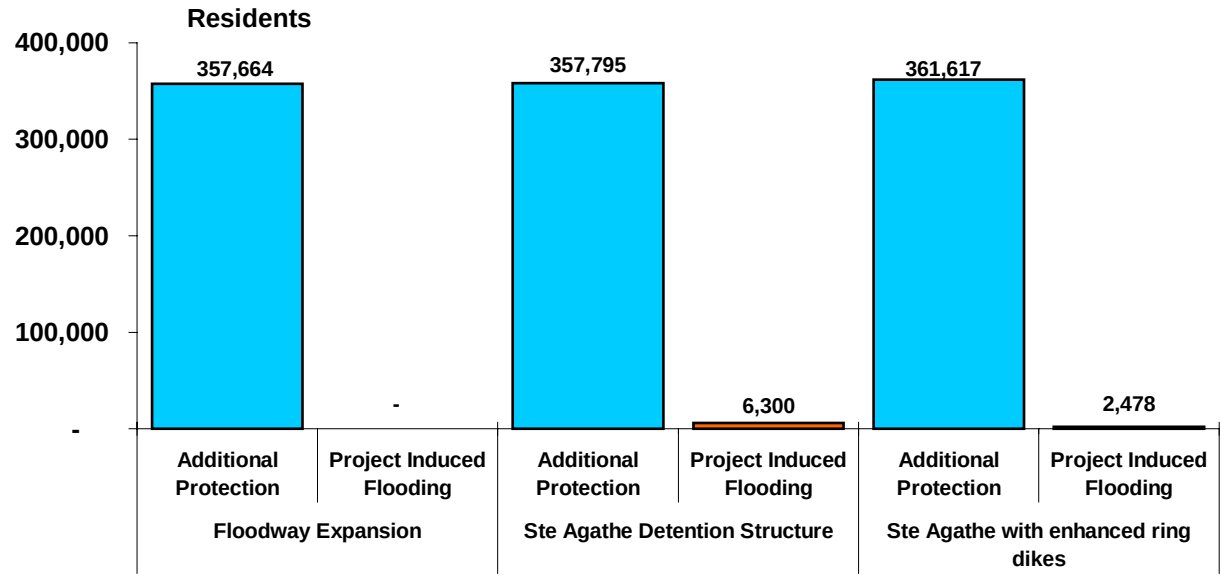


Figure 3 - Comparison of Flood Protection Alternatives
Number of Residents Experiencing Flooding All Zones (Exact Scale)



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

Figure 4 - Comparison of Flood Protection Alternatives
Number of Residents Experiencing Flooding All Zones (Reduced Scale)



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

Figure 5 - Comparison of Flood Protection Alternatives
Residents with Additional Protection and Project Induced Flooding All Zones, 1 in 300 Year Flood Event

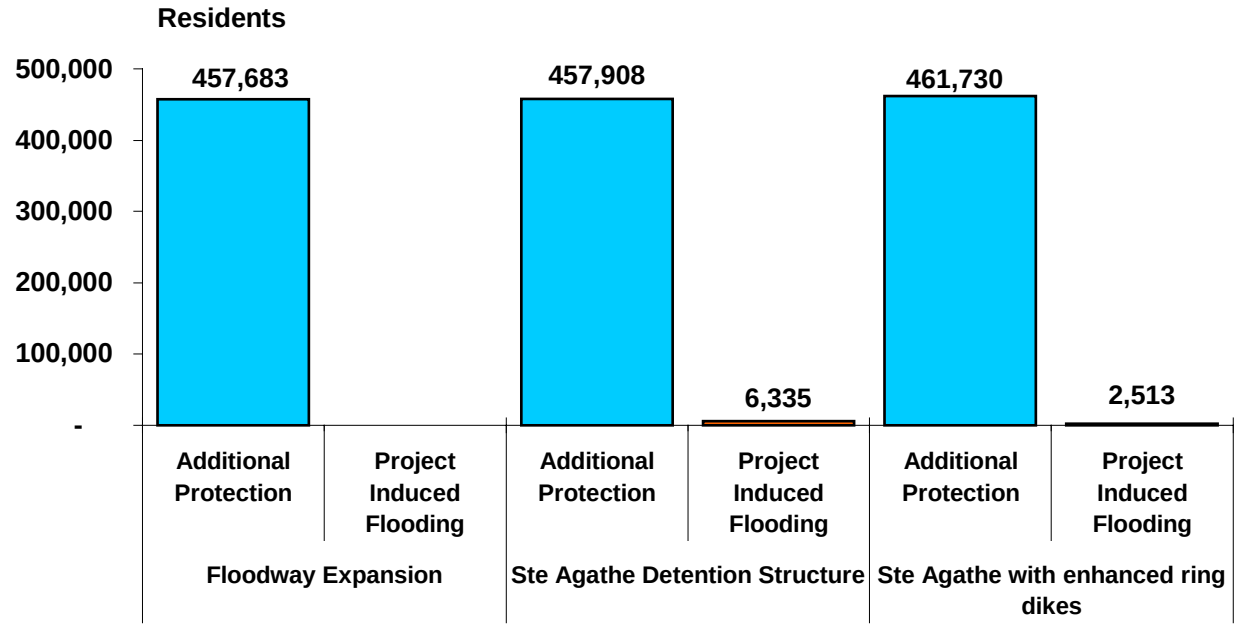


Figure 6 - Comparison of Flood Protection Alternatives
Residents with Additional Protection and Project Induced Flooding All Zones, 1 in 500 Year Flood Event

- Floodway Expansion provides additional protection for a large number of residents in the Red River Flood zone in each of the flood event scenarios considered in the study. At the 1 in 500 year flood level, Floodway Expansion fully protects an additional estimated 450,000 residents (Table 5 and Table 6).

- Ste. Agathe Detention Structure provides additional flood protection including full protection and increased protection to study area residents for all flood events greater than a 1 in 90 year flood event. In the absence of enhancements to community ring dikes, the added number of residents protected is roughly comparable to the Floodway Expansion for the 1 in 300 year and 1 in 500 year flood events (i.e 357,000 and 457,000 residents respectively). Additional ring diking in Zone 1 could increase the number of protected residents by about 4000 residents. At the 1 in 1000 year level, the number of residents getting added protection from the Detention Structure is orders of magnitude greater than with the Floodway Expansion.

- There is no significant increase in the number of residents experiencing project induced flooding with Floodway Expansion. Those who experience such flooding when the Floodway Expansion is operating would generally have experienced it under the baseline conditions with the Existing Floodway. However, the frequency of induced flooding is substantially reduced.

- In contrast, the Ste. Agathe Detention Structure creates project induced flooding in Zone 1 during flood events greater than the 1 in 90 year flood level. At the 1 in 300 year flood levels, 6,300 residents are impacted by project induced flooding. Enhanced ring diking could reduce this total to approximately 2,500 residents. Operation of the Ste. Agathe Detention Structure results in increased flood duration for all Zones in all flood events larger than the 1 in 90 year flood level (Table 7).

- Without improvements to community dikes, about 4,000 to 5,000 more residents are fully protected with the Ste. Agathe Detention Structure than the Floodway Expansion for 1 in 300 year and 1 in 500 year events. Enhanced ring diking raises this number by about 4,000 residents. At the 1 in 500 year flood event, the Ste. Agathe Detention Structure fully protects 456,000 residents compared to 450,000 for Floodway Expansion. With enhanced ring diking, the number of protected residents rises by 4,000 residents to approximately 460,000 (Table 6).

- At the 1 in 1000 year flood event (not shown in Figures), the design capacity of the Floodway Expansion has already been exceeded (at 1 in 700 year event) and Winnipeg is flooded. Floodway Expansion still provides additional full protection to 45,000 residents in Winnipeg who otherwise would have been flooded with Existing Floodway. Ste. Agathe Detention Structure, which is still within its design capacity, provides full protection to over 450,000 residents. Enhancement to community ring dikes would add about 5,000 protected residents.

In summary, for 1 in 300 year and 1 in 500 year flood events, about the same number of residents could benefit from additional full or partial flood protection with the Ste. Agathe Detention Structure and Floodway Expansion. At these flood levels, the Detention Structure

provides 4,000 to 9,000 more residents with full protection than Floodway Expansion. The latter figure would require enhancements to the ring dikes in the Valley, and would require additional cost to be added to the project. On the other hand, added upstream flooding associated with operation of the Ste. Agathe Detention Structure at the 1 in 300 year and 1 in 500 year flood events could adversely affect 2,500 to 6,300 residents. For a 1 in 1000 year event, the Detention Structure provides full protection to over 550,000 residents compared to only 45,000 residents with the 1 in 700 year Floodway Expansion.

While this concept has not been studied to date, it would clearly be possible to enhance ring dikes or build new ring dikes in Zone 2 to protect against high water levels caused by the Floodway operation. This would require more detailed analysis.

6.3 LEGAL PERSPECTIVES

Development of either flood protection alternative raises a variety of legal issues that will require consideration. Discussions were held with Manitoba Justice and an independent legal opinion was provided by the firm of Thompson, Dorfman, Sweatman. The independent legal opinion covered the following three broad areas of legal issues related to the proposed flood control alternatives:

Accessing Private Property

- The Province has the power to proceed with either the Floodway Expansion or the Ste. Agathe Detention Structure options pursuant to The Water Resources Administration Act.

- Where land is to be acquired by expropriation, The Expropriation Act applies, and requires that compensation be paid to affected landowners according to the value of the land.

- If private land is to be used for water storage on a clearly foreseeable, regular basis, it is likely that this would qualify as a ‘taking of land’ that would require compensation.

- 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.

Compensation for Project Induced Flooding

- The powers granted under The Emergency Measures Act are subject to compensation being paid to any person who suffers loss of real or personal property as a result of exercising those powers. Compensation is to be in accordance with guidelines approved by the Lieutenant Governor in Council.

- Damages may be apportioned where it can be shown that a separate part of any damage or loss suffered would have occurred in any event (e.g. damage which would have been caused by flooding under natural conditions). The Province's liability could accordingly be confined to the portion for which it was found to be responsible.

Accessing Reserve Lands

- Aboriginal or treaty rights, unlike other property rights, are explicitly protected by the Constitution. If some anticipated activity of the Province is 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 either of the structures would result in a future purposeful storage of water on reserve land, a permit or easement should be obtained prior to commencing construction of the structure.

- Lands acquired under the Treaty Land Entitlement Agreement by Roseau River First Nation or any other First Nation 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.

The Ste. Agathe Detention Structure flood protection alternative would require additional permits and agreements, including the need for some form of international agreement. This, along with the potential for legal issues related to project induced flooding upstream of the Ste. Agathe Detention Structure, would make this flood protection alternative less desirable than that of the Floodway Expansion. It could also extend the completion date of the Ste. Agathe Detention Structure beyond that of the Floodway Expansion. On the other hand, project induced flooding would also occur, to a lesser degree, with Floodway Expansion when operating under emergency conditions greater than the 1 in 250 year flood event This would similarly necessitate the need to resolve legal issues, and potentially extend the completion date of the Floodway Expansion. The duration of such extensions are uncertain.

From the perspective of potential legal issues and problems, the Floodway Expansion is believed to be more favourable.

6.4 OPERATIONAL RISKS

Backup System for Control of Flood Waters into Winnipeg

In previous studies, KGS Group identified the vulnerability of Winnipeg to gate malfunction in the Floodway Inlet Control Structure during major floods. The construction of the Ste. Agathe Detention Structure was seen to be a backup or redundancy to the Floodway Inlet Control Structure. It could be used to cut back river flows if a problem with control of the Floodway Inlet Control Structure gates were to occur and Winnipeg could be threatened by uncontrolled flood releases into the city.

Almost all of that concern and risk would be eliminated if the Floodway Inlet Control Structure were to be equipped with backup gates that could be used in an emergency if the main (existing) gates or their hoists would malfunction. ***The proposed concept for the Floodway Expansion that is described in this report, including its cost estimate, has tentatively included the backup gates.*** The gate concept and its justification are described in Appendix B, Section B.6.9. If that gate concept is ultimately accepted by the funding partners as a requirement, then the issue of gate redundancy could be excluded as a basis of comparison (since both options would have comparable backup capability). It is true that the Ste. Agathe Detention Structure would provide a modest advantage in that it would still provide a mechanism to reduce inflow to the Floodway if some other operational hazard other than the control gates were to occur. However, given the nature of the other components of the Floodway system, that likelihood is very low.

Furthermore, there is a possibility that response to operational problems at the Floodway Inlet Control Structure could not be sufficiently swift at the Ste. Agathe Control Structure to prevent flooding in Winnipeg. A scenario, for example, that involves damage to the Flood Inlet Control Structure gates could result in a relatively rapid release of dangerously high flows into the Red River in Winnipeg. This could occur before a cutback of flow at the Ste. Agathe Detention Structure could be carried out, and before that cutback could effectively reach the Floodway area. Consequently, the availability of the Ste. Agathe Detention Structure would not guarantee prevention of flooding due to malfunctions at the Floodway facilities.

If further study and review of the backup gate concept for the Floodway Inlet Control Structure would lead to exclusion of that safety measure from the development concept of the Floodway Expansion, then the Ste. Agathe Detention Structure would still provide a modest advantage. It could be argued, however, that if the backup gate concept were rejected after further study and review, it would be because the concern for gate malfunction would be so low that it would not be significant. In that case, the Ste. Agathe Detention Structure would not offer an advantage in gate reliability that would be significant.

Frequency of Use

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 operation frequently. It is likely that the gates would only have to be lowered once or twice (if at all) 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.

The Floodway Expansion, on the other hand, if it were constructed, would continue to require operation on a frequent basis, roughly once each two years. It is unlikely that that protection measure could fall into a state of neglect and disrepair and become ineffective.

On the basis of operational risks, it is KGS Group's opinion that there is no clear advantage of one scheme over the other.

6.5 MANAGEMENT OF EXTREME FLOODS

The operations of each of the options under extreme flood conditions up to and exceeding the limit of their protection, up to the Probable Maximum Flood (refer to Section 1 for definition and estimated magnitude of the PMF) are summarized below.

Floodway Expansion

The operation of the expanded Floodway is envisaged to be similar to the existing Floodway. The Operation Rules would be followed as described in Appendix B, Section B.2.1. If a flood occurs that would exceed the limit of flood protection afforded by the selected channel size, it would require release of the excess water through Winnipeg, causing widespread flooding. This mode of release of excess flood water through Winnipeg (Operation Rule #3) would continue as the flood increases. At some point, both the capacity of the expanded Floodway and the capacity of the Floodway Inlet Control Structure may be exceeded, if the flood is large enough. This is a relatively improbable (but not impossible) flood that would have a magnitude that is described in Table 8, and depends on the Floodway Expansion that is selected. The proposed Floodway Expansion is not capable of passing the PMF without overtopping portions of the retaining structures (West Dike and East Dike), or causing a dangerous incipient overtopping condition.

TABLE 8
Flood Magnitude at Which Combined Discharge Capacity of Floodway Channel and Floodway Inlet Control Structure Would be Exceeded

	EXISTING FLOODWAY	1 IN 700 YEAR EXPANDED FLOODWAY	1 IN 1200 YEAR EXPANDED FLOODWAY
Estimated Capacity of Floodway Channel at El. 778 ft. at Inlet (cfs)	92,000	140,000	190,000
Estimated Capacity of Floodway Inlet Control Structure at El. 778 ft. at Inlet (cfs)	140,000	140,000	140,000
Total Capacity[1] (cfs)	**232,000**	**280,000**	**330,000**
Flood Return Period to Exceed Total Capacity (years)	1,250	2,500	6,000
Total Floodway/Control Structure Capacity at Incipient Overtopping of West Dike (cfs)	250,000	325,000	390,000
Flood Return Period to Reach Incipient Overtopping (years)	1,600	5,500	9,000

Note: 1. Emergency raising of West Dike/East Dike crest elevation could increase these capacities for all cases.

2. All capacities are based on theoretical calculations, and are approximate only.

On the other hand, at the point at which overtopping of the West Dike would occur, much of Winnipeg would already have been flooded for over a week. The release of a large amount of additional flow from the breached dike (estimated at 50,000 cfs to 70,000 cfs) to an already flooded city would cause additional damage. However, it is not likely to cause more damage (whether in terms of damage of property or loss of life) than would have occurred if the Floodway did not exist. This point is important in the context of Dam Safety, and would mean that the Floodway facilities would not necessarily require a capacity to release the PMF without overtopping. This is consistent with the current Canadian Dam Association Dam Safety Guidelines (1999).

Ste. Agathe Detention Structure

The operation of the Ste. Agathe Detention Structure is relatively simple. For floods that are less than about the 1 in 90 year magnitude, the gates would remain up and the project would allow free release of incoming flood flows. For floods between the 1 in 90 year and 1 in 1000 year magnitude, the gates would be lowered (closed) gradually so as to maintain an outflow that would be manageable downstream (approximately 135,000 cfs, depending on the contribution of the Assiniboine River). This detention of water would cause the reservoir upstream of the control structures to rise. At the 1 in 1000 year flood condition, the water level would rise as much as 9 ft. above the “state-of-nature” at the structure, reaching a reservoir level of El. 791 ft.

If the flood inflow would continue to rise after this maximum ponded level is reached, the structure outflow would have to be increased so as not to risk overtopping of the water retaining structures and triggering of an unpredictable dam breach. The outflow increase from the control structures could occur over a relatively short period of time, and would have to reach an outflow that could exceed the 1 in 1000 year flood under natural conditions. The existing Floodway Inlet Control Structure would have to be opened to increase the flood flow through Winnipeg. Once the operation of the Ste. Agathe Detention Structure would reach this point at which control of a constant reservoir level would be required, then flooding in Winnipeg would be a certainty. Furthermore, it is possible that the capacity of the existing Floodway facilities could not prevent the rise of the water over the crest of the West Dike, and a breach of the West Dike would ensue. Winnipeg would have been already flooded by the opening of the Floodway Inlet Control Structure.

The Ste. Agathe Detention Structure is itself capable of passing the PMF without overtopping or other damaging failure. However, Winnipeg would be flooded, and rapidly thereafter, the West Dike would breach.

It is also evident that once the capacity of the Ste. Agathe Detention Structure is exceeded, it provides a rapidly decreasing protection against the rising floodwaters. The flooding that would ensue in Winnipeg could be more extensive (deeper and wider extent) during such extreme floods than for the Floodway Expansion. In this respect, the Ste. Agathe Detention Structure performs in a way similar to a dike, in that it would provide limited residual benefits[2].

To assist in understanding the consequences of an extreme flood with either of the two options, a sequence of milestone events has been prepared that would occur during an arbitrarily selected 1 in 5000 year flood event. This is estimated to be a flood that would peak at 395,000 cfs in Winnipeg under natural conditions. The component of the Red River upstream of the Floodway would be approximately 320,000 cfs at the peak. The 1 in 700 year Floodway is compared to the Ste. Agathe Detention Structure, and the sequence of events for both options is summarized in Table 9.

The following factors should be noted in Table 9:

- The West Dike is nearly overtopped on day 22 with the Floodway Expansion. It could possibly get through this hypothetical flood event with no breaching if no winds occur from the south. However, if it does breach, the increase in release of water into Winnipeg would likely follow by at least a week after the initial flooding of the city.
- For the Ste. Agathe Detention Structure, the West Dike is certain to be overtopped (at day 20 in this hypothetical event) and that would occur less than 24 hours after the initial flooding of Winnipeg (day 19).

[2] "Residual benefits" are those that would be provided by the flood protection scheme for flood magnitudes that exceed its design flood protection capacity.

TABLE 9
Comparison of Operation of 1 in 700 Year Floodway Expansion to Ste. Agathe Detention Structure With a 1 in 5000 Year Flood

DAY	DESCRIPTION	OPTION		
		FLOODWAY EXPANSION 1 IN 700 YEAR	STE. AGATHE DETENTION STRUCTURE	
			CONDITIONS AT EXISTING FLOODWAY FACILITIES	CONDITIONS AT STE. AGATHE DETENTION FACILITY
1	Start of sharp rise of inflow hydrograph	Floodway gates fully open	Gates fully open	Gates fully open
3	Red River flow increasing, now at approximately 30,000 cfs	Floodway gates used to divert water into Floodway and maintain "state-of-nature" water level (Operation Rule #1)	Floodway gates used to divert water into Floodway and maintain "state-of-nature" water level (Operation Rule #1)	Gates fully open
8	Red River flow increasing, now at 100,000 cfs	Gates manipulated to maintain "state-of-nature" at Floodway Inlet	Gates manipulated to maintain "state-of-nature" at Floodway Inlet	Gates fully open
9	Red River flow increasing, now at 140,000 cfs	Gates manipulated to maintain "state-of-nature" at Floodway Inlet	Gates maintain El. 771 ft. at Inlet	Gates lowered (closed) to begin to detain water, maintain outflow of 135,000 cfs
12	Red River flow increasing, now at 200,000 cfs	Gates used to raise water level above "state-of-nature" (Operation Rule #2)	Gates maintain El. 771 ft. at Inlet	Gates lowered (closed) to begin to detain water, maintain outflow of 135,000 cfs
14	Red River flow increasing, now at 230,000 cfs	Limit of protection exceeded, gates now lowered (opened) to start controlled flooding in Winnipeg	Gates maintain El. 771 ft. at Inlet, 80,000 cfs in Winnipeg	Gates lowered further (closed) to detain water, outflow continues to be controlled at 135,000 cfs
18	Red River flow increasing, now at 280,000 cfs	Winnipeg flooded, Floodway Inlet gates lowered (opened) to fully open; 140,000 cfs in Winnipeg	Gates lowered (opened) to start to allow flooding in Winnipeg	Gates now have to start to be raised (opened) to prevent further rise of reservoir level
19	Red River flow increasing, now at 290,000 cfs	Winnipeg continues to flood	Floodway Inlet structure must be rapidly opened to release 140,000 cfs into Winnipeg	Gates begin to be opened to prevent further rises of reservoir level.
20	Red River flow increasing, now at 300,000 cfs	2 ft. freeboard remaining on West Dike, high risk of breach formation	Gates in fully lowered condition, West Dike overtopped, flow through Winnipeg >200,000 cfs	Gates continue to be controlled to maintain constant reservoir level
22	Red River flow increasing, now at 310,000 cfs	Flooding in Winnipeg increases, Floodway still carrying > 140,000 cfs; freeboard 1.5 ft. on West Dike	Flooding widespread in Winnipeg	Gates continue to release outflow equal to reservoir inflow
25	Red River flow now at 320,000 cfs	Flooding in Winnipeg increases, Floodway still carrying > 140,000 cfs; freeboard on West Dike 1 ft.	Flooding in Winnipeg increases	Gates continue to release outflow equal to reservoir inflow
32	Red River flow decreasing, now at 270,000	Winnipeg continues to be flooded	Winnipeg continues to flood.	Gates continue to release flow equal to inflow.

Notes: 1. Red River flows referred to in this column is at the Floodway Inlet, upstream of the Floodway channel and upstream of the Floodway Inlet Control Structure.

In spite of the fact that the Ste. Agathe Detention Structure would not itself likely be overtopped by extreme floods, Table 9 demonstrates that its operation would cause rapid flow increase downstream. This would occur when its protection capacity is exceeded. Flooding in Winnipeg would be followed relatively quickly (probably less than 24 hours) by overtopping and breaching of the West Dike. The confusion and destruction, and possibly risk to life, that this rapid sequence could cause, would clearly be a danger that would be attributable to the Ste. Agathe Detention Structure.

In the opinion of KGS Group, the performance of the Floodway Expansion in flood conditions that exceed its flood protection capacity is superior to that of the Ste. Agathe Detention Structure.

6.6 POTENTIAL FOR SUMMER FLOOD CONTROL IN WINNIPEG

Control of summer flood water levels in Winnipeg would require:

- Investment in special measures that do not now exist (Floodway entrance structure, deeper channel, use of gates in summer), nor would exist in a Floodway Expansion for protection against spring floods only, or
- raise water levels above “state-of-nature” with the Floodway Inlet Control Structure gates to force water into the Floodway when summer floods occur, or
- some combination of the above.

In general, the Floodway Expansion would lessen the cost or impacts of these requirements, as compared to the Ste. Agathe Detention Structure, and would be preferred from this perspective.

6.7 RECREATIONAL POTENTIAL

The Floodway Expansion is believed to provide more potential for recreational development than the Ste. Agathe Detention Structure.

6.8 AFFECTING "STATE-OF-NATURE" WATER LEVELS

With the existing facilities, increase in water level above the "state-of-nature" would be required for floods exceeding approximately the 1 in 90 year flood (similar magnitude to 1997 flood). The gates in the Ste. Agathe Detention Structure would also have to be lowered, and would increase water levels above the "state-of-nature" for floods exceeding the 1 in 90 year magnitude. Concommittant with that would be the elimination of raising the water level artificially in the zone between the Floodway Inlet and the Ste. Agathe Detention Structure, for floods up to the 1 in 1000 year magnitude.

The Floodway Expansion, on the other hand, would eliminate raising of water levels above the "state-of-nature" for floods up to the 1 in 250 year magnitude for the 1 in 700 year Floodway, and up to 1 in 700 years for the 1 in 1200 year Floodway.

The Floodway is clearly superior in the ability to minimize the annual risk of having to raise water levels above the "state-of-nature" anywhere in the Red River Valley. The risk of having to invoke such artificially high water levels is reduced by approximately a factor of 3 compared to either the existing conditions or the Ste. Agathe Detention Structure.

In the opinion of KGS Group, the Floodway Expansion is favoured in respect to raising water levels above the "state-of-nature".

6.9 ENVIRONMENTAL EFFECTS

In general, the Floodway Expansion results in the least intrusive environmental effects of the two options. The Floodway Expansion is essentially the modification of a facility that has been in existence for nearly 35 years, and the environmental impacts have already occurred or would be incremental to what has already occurred. Some drawdown of the water table in the area of the Floodway would occur, and costs would be incurred in adjusting local wells to suit. These costs are included in the current project cost estimate.

The Ste. Agathe Detention Structure, on the other hand, is a "greenfield" project and would cause new impacts. These impacts are identified and discussed in Appendix F.

The Floodway Expansion may cause new environmental impacts if a "Wet Floodway" were to be selected, or if a system of summer water level control would be implemented. The "Wet Floodway" concept would cause impacts to local groundwater resources, and could develop stagnant water conditions during periodic droughts in the Red River. Control of summer flood levels in Winnipeg would be most economically achieved by using some extent of controlling the river water level at the Floodway Inlet. The implications of modifying the existing operation rules would trigger a possible need to provide fish passage facilities at the structure. That issue would require further review in the event that serious consideration of summer control of water levels is pursued.

6.10 SCHEDULES OF IMPLEMENTATION

Winnipeg is exposed to an unacceptably high risk of major flood damages. Every year that this situation persists leaves Winnipeg at risk to potential damages that are many times the cost of any scheme discussed in this report. Consequently, the comparison of the two options from the perspective of completion time is important.

The Ste. Agathe Detention Structure would require a minimum of approximately 6 years before effective use could be relied upon (see Section 8 for further details). The Floodway Expansion would require a minimum of 7 years, and possibly 9 years before full completion. However, unlike the Ste. Agathe Detention Structure, the expansion of the Floodway can be constructed in annual phases such that an increase in flood protection capacity could be achieved in each successive year of construction. This could start with raising the West Dike, for example, which would substantially improve the emergency capacity of the system compared to existing conditions.

Furthermore, the Ste. Agathe Detention Structure is a highly controversial project. It could be expected that there would be resistance to it by some interest groups, and may require considerable time to resolve the difficulties.

There appears to be an advantage by the Floodway Expansion in providing significant improvement in flood protection for Winnipeg in as short a time as possible.

6.11 SUMMARY OF COMPARISONS

The Floodway Expansion is rated superior from the following perspectives:

- susceptibility to legal issues
- management of extreme floods that would exceed the selected flood protection capacity of both options
- providing the opportunity to control summer water levels in Winnipeg at the least cost
- potential for recreational development
- providing flood protection improvements to Winnipeg as soon as possible
- approximately one third of the risk of having to raise water levels above the “state-of-nature” conditions compared to existing Floodway or Ste. Agathe Detention Structure
- environmental impacts (this may not be a clear advantage if the “Wet Floodway” were to be pursued, or if the use of the Floodway Inlet Control Structure were to be invoked to control summer water levels in Winnipeg).

The Ste. Agathe Detention Structure is rated as superior in:

- benefit/cost ratio (economics)
- level of flood protection that would likely be provided
- numbers of Manitoba residents that would be provided flood protection

From the perspective of operational risks, there is no clear advantage of one option over the other.

7.0 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. 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 Appendix F. 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.

8.0 ORGANIZATION FOR IMPLEMENTATION OF MAJOR PROJECT

It is clear that implementation of a project of the magnitude of either the Floodway Expansion or the Ste. Agathe Detention Structure would require a concerted effort by a group that would be devoted full time to the task. The general nature of the organizational structure that is envisaged as the most efficient for executing the work is shown in Figure 7. An organizational structure is shown that is similar to the one used during the original construction of the Floodway. At that time, a separate division of the provincial government was established for the sole purpose of executing the Floodway construction.

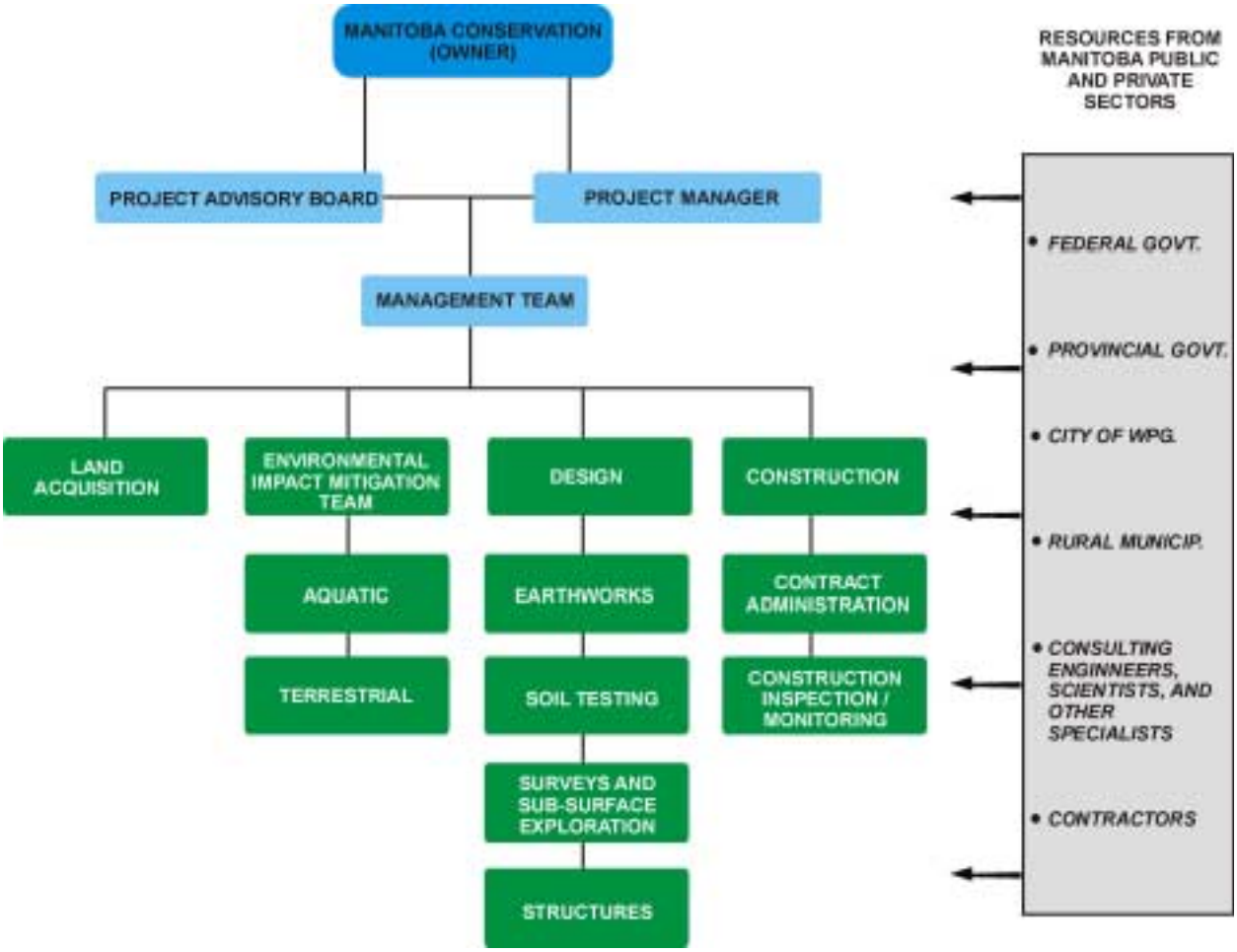


Figure 7 – Proposed Structure For Implementation of a Major Winnipeg Flood Protection Project

The organization of the structure that would be required to complete a major project could be made up in a number of ways. It could range from, on one extreme, a design/build agreement with a contractor or group of contractors, to a more traditional composition that would draw from government staff, and using consultants and contractors as appropriate. The latter approach was adopted in the Floodway Division of the 1960's. An intermediate option would be assignment of specific management, design, and/or construction supervision responsibilities to capable companies in the private sector. The design/build approach is not favoured because it would result in an unacceptable loss of project control by the owner and provide only the bare minimum in quality of the product. Furthermore, it is likely that the project requirements cannot be sufficiently defined at an early stage.

The best course of action would commence with the selection of the philosophy on project organization that is best for expediting the project execution (primarily a decision on the approach of mixing the public sector involvement with that of the private sector). In this regard, it is likely that the size and complexity of the organization could be less for the Ste. Agathe Detention Structure than for the Floodway Expansion. This is largely due to the "greenfield" nature of the Ste. Agathe Detention Structure, with fewer, and less complicated interaction required with impacted groups and agencies.

The government is proposed to be assisted in the project definition period by a "Project Advisory Board". This Board would be established at the outset of the work. It would then continue through the execution of the project, acting as an overall vetting system for critical technical and administrative issues. The Board is envisaged to consist of approximately 8 recognized experts covering the fields of engineering design, construction, contract administration, and environmental science.

The scale of the organizational framework will depend on the option selected, and in the case of the Floodway Expansion, the size/capacity of the scheme selected. Given these uncertainties, further definition of the organizational aspects of either major project was considered inappropriate at this time.

9.0 MASTER PLANNING SCHEDULE

Winnipeg is exposed to an inordinately high risk of severe damages due to flooding. This situation should be alleviated as quickly as possible. This urgency can be quantified by application of principles of risk analysis. The application is simple, and is based on an average annual damage that could be incurred if no additional protection works are constructed. The average annual damage combines the probability of the occurrence of floods that could exceed Winnipeg's existing defenses, and the damages that could occur. This has been estimated from the findings of previous studies and is expected to be in the range of $50 million to $75 million per year, excluding potential business losses in Winnipeg. Such a large risk exposure would justify taking the swiftest action that is possible to upgrade the flood protection system for Winnipeg. Based on this principle, KGS Group developed a "fast-track" schedule of implementation that is summarized in Plate 4. It schedules many activities in parallel, and assumes that interim funding could be obtained to permit environmental studies and engineering to proceed in the early months/years, possibly before final funding agreements amongst the governments are in place. It assumes that the pre-commitment level of engineering and cost estimation, that is a common requirement for both schemes, can be done in 12 to 15 months. This would be an aggressive, but possibly manageable, schedule, should the project proceed on a fast-track basis. KGS Group recognizes that this strategy would be a challenge. However, pursuit of the fast-track option would be in the best interest of Winnipeg.

An alternate, more conventional schedule of major project implementation is shown in Plate 5. It is based on the premise that a funding agreement amongst the three levels of government would have to be established before major activities such as collection of environmental data and substantial engineering can proceed. An allowance of 27 months has been made for completion of the pre-commitment planning. That schedule would be at least one year longer than the "fast track" schedule.

Both schedules assume that the Environmental Approval process goes "reasonably well" and that there is no significant public opposition to the selected scheme. As noted on the schedule, an extended public hearing process could potentially delay the project construction start-up.

Fast progress is indeed important to Winnipeg, and early funding approval will be important to support that. However, excessive haste in making technical and some other decisions may not be in the best public interest, in the long-term especially. It is important to make sound decisions as the project proceeds.

10.0 FUTURE PLANNING/INVESTIGATIONS

Studies/planning/investigations that would be required, and could not be achieved within the budget for this study have been identified throughout this report, and appendices. This section amalgamates those recommended tasks and lists them in Table 10. They are organized in three groups:

- Tasks recommended before selection of the preferred option.
- Tasks required at the next level of planning of the Floodway Expansion (if it is selected for implementation).
- Tasks required at the next level of planning of the Ste. Agathe Detention Structure (if it is selected for implementation).

References are made in Table 10 to locations in the report where more information can be found regarding that particular task.

TABLE 10
Summary of Recommended Future Work

	TASK	REFERENCE SECTION
Recommended Before Project Selection		
1.	Consideration of implications of adopting policy of raising water level above "state-of-nature" at Floodway Inlet, and adoption or rejection of this. This action will be required to make a logical basis for comparison of the Floodway Expansion to the Ste. Agathe Detention Structure.	B.8.1 and B.9.2
2.	Consideration of whether the potential recreational benefits could justify the additional cost of $20 to $50 million for the "Wet Floodway" option, and exclude or include that option for comparison to Ste. Agathe Detention Structure.	Appendix E
3.	More detailed study of recreational benefits of controlled summer river levels in Winnipeg, combined with engineering refinement of options identified in Appendix E. This would provide a better perspective for comparison of the major flood protection options.	Appendix E
4.	Additional flood routings and sensitivity analyses for different flood hydrographs using MIKE-11 numerical model of Red River Valley to determine attenuation effects and their influence on the ultimate flood protection limit for the Floodway Expansion or the Ste. Agathe Detention Structure.	B.2.4
5.	Investigate possible means to mitigate water level impacts of Ste. Agathe Detention Structure by out-of-channel improvements near Emerson (only required if the Ste. Agathe Detention Structure is seriously considered).	C.11
6.	Investigate means to mitigate flood impacts on the Roseau River First Nation and on the other affected residents in Zone 1 (only required if Ste. Agathe Detention Structure is seriously considered).	C.6
7.	Review the need for and potential for obtaining an international agreement for the above effects of the Ste. Agathe Detention Structure. This may also require further hydraulic analyses to supplement findings to date.	C
Required if Floodway Expansion is Selected		
1.	Select channel flood discharge capacity that is socially acceptable to Manitobans and financially achievable. The minimum, based on economic justification alone, is about a 1 in 700 flood capacity.	B.6, B.7, B.10
2.	Undertake Dam Safety Review of the structures, including inspections, condition assessments, design and extreme flood management capability, and structure and embankment stability review. This would include confirmation of flood management strategy for all floods, including greater than current or expanded capacity, and estimation of the PMF in the Red River.	B.2.2.4
3.	Detailed investigation of Floodway Inlet Control Structure gates, including emergency operation, independencies, probability of failures, and justification of installation of modifications to improve reliability or to install a backup system.	B.6.9

TABLE 10 (CONTINUED)
Summary of Recommended Future Work

	TASK	REFERENCE SECTION
4.	Further optimization of the channel configuration and the associated modifications of the bridges is required before a definitive plan of expansion can be adopted for final design.	B.6.5
5.	If Floodway Expansion is contemplated for flood protection limits greater than 1 in 700 year flood passage, the merits of extending the Floodway channel downstream by about 3 miles should be reviewed.	B.6
6.	Conduct a 2-dimensional finite element analysis of flow entering the expanded Floodway to refine/confirm assumed inflows through the Floodway entrance and the existing and proposed openings in the East Embankment. This will affect the final selection of improvements that would (or would not) be required in the upstream 4 miles of the channel.	B.7.1.4
7.	Prepare detailed topographic mapping of the lower Red River from the North Perimeter Bridge to Netley Creek.	A.5
8.	Review hydraulic calculations of river water levels along the lower Red River using the mapping results to confirm assumptions of potential backwater effects in Winnipeg due to high flows, and to investigate the induced flood levels downstream of Floodway Outlet	A.3.2
9.	Subsurface investigation at the Floodway Outlet area to provide better basis for planning expansion of the Outlet Structure and Outlet Channel.	B.6.10/B.6.11
10.	Review and refine strategies for Floodway expansion at Winnipeg Aqueduct. Consideration of local channel armouring may show economic justification for leaving the channel as it now exists at this location.	B.6.12.3
11.	Undertake other planning/studies/preliminary design that is required to reduce uncertainties in cost estimation and extent of modifications required.	B
12.	Undertake studies of operation rules to confirm/refine findings of the current studies, and to identify emergency modes of operation to deal with abnormal spring ice conditions below the Floodway Outlet	A
13.	Perform subsurface investigations along the Floodway centreline to provide better information on the foundation soils and the existing piezometric levels.	B.6
14.	Investigate filter layers under riprap on upstream slope(s) of the Floodway Inlet Control Structure.	B.6.9

TABLE 10 (CONTINUED)
Summary of Recommended Future Work

TASK	REFERENCE SECTION
Required if Ste. Agathe Detention Structure is Selected	
1. Estimation of PMF in Red River	Main Report - 1
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, and confirmation of the appropriate design flood capacity.	C.4
3. Refinement of mitigation schemes for environmental enhancements.	F
4. Additional flood routing studies to address a broader range of potential flood hydrographs so that operational uncertainties can be clarified.	C.5/C.6
5. 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.	C.3/C.4

REFERENCES

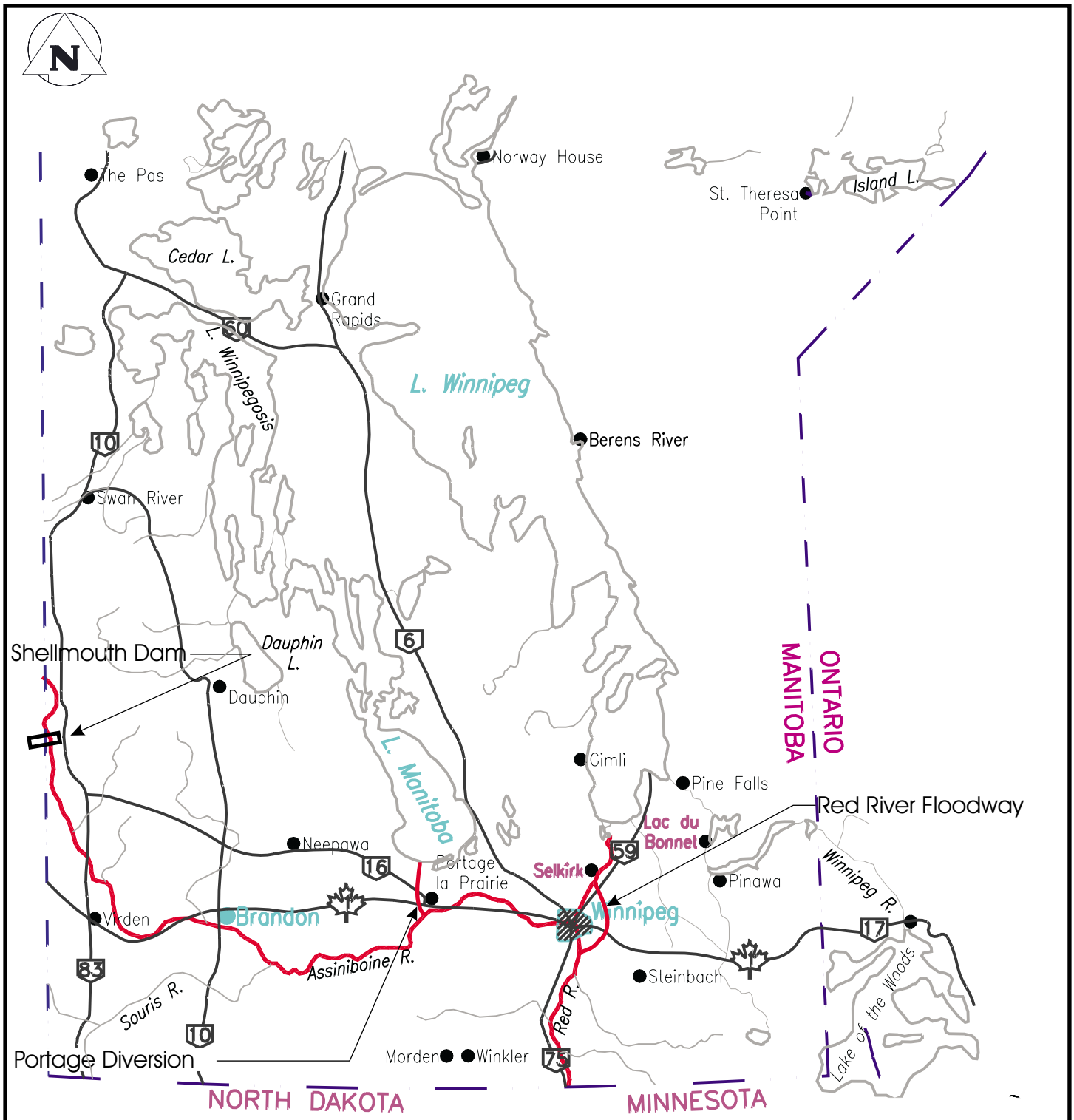
REFERENCES

1. *Canadian Dam Association, 1999, "Dam Safety Guidelines".*

2. *KGS Group, 2000, "Flood Protection for Winnipeg" – Report to IJC.*

3. *Warkentin, 1999, "Hydrometeorologic Parameter Generated Floods For Design Purposes".*

PLATES



Canada Manitoba Winnipeg

FLOOD PROTECTION STUDIES FOR WINNIPEG

MAIN REPORT

LOCATION OF MAJOR FLOOD CONTROL WORKS

PLATE 1

FINAL REPORT – SEPTEMBER 2001

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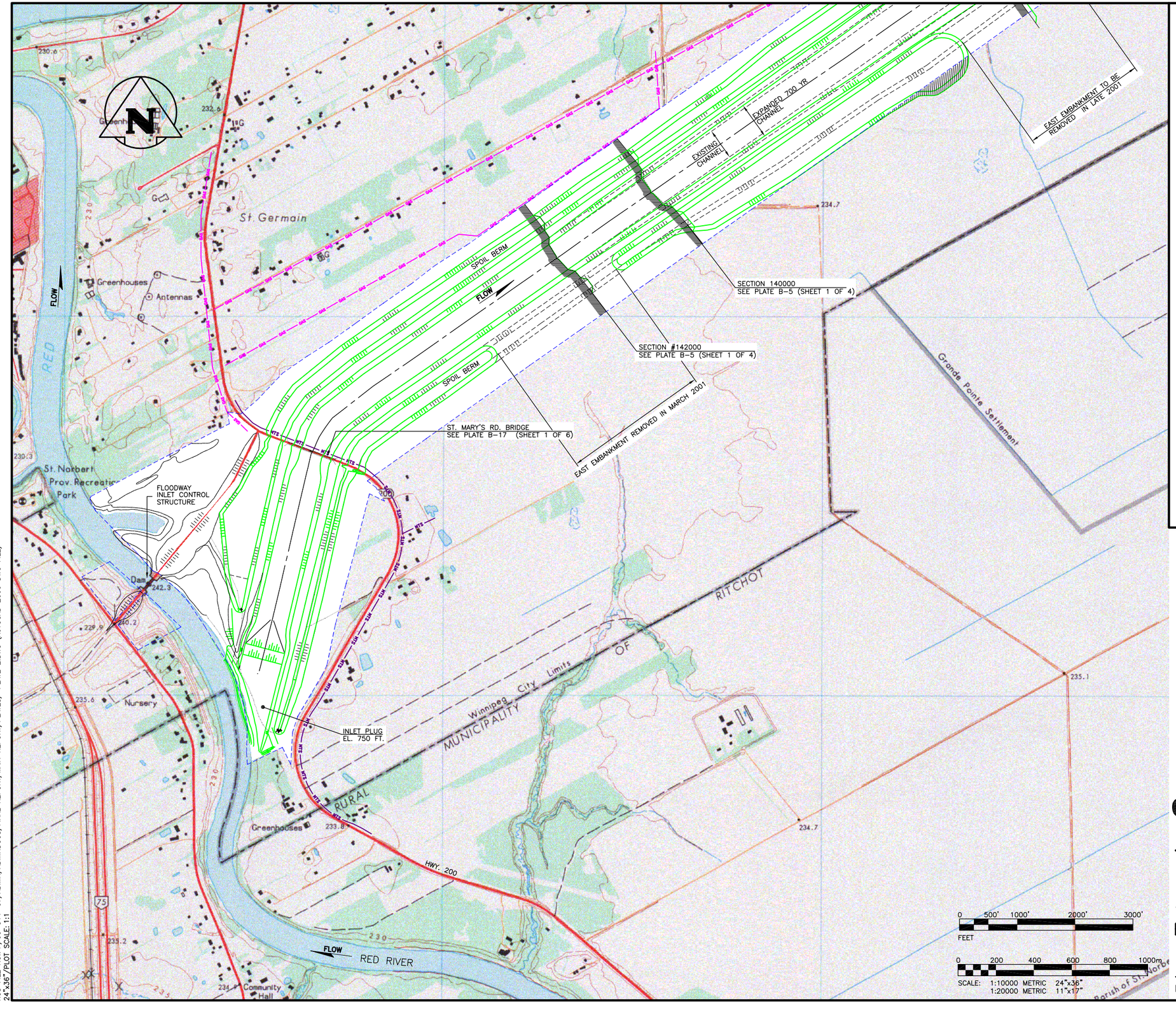

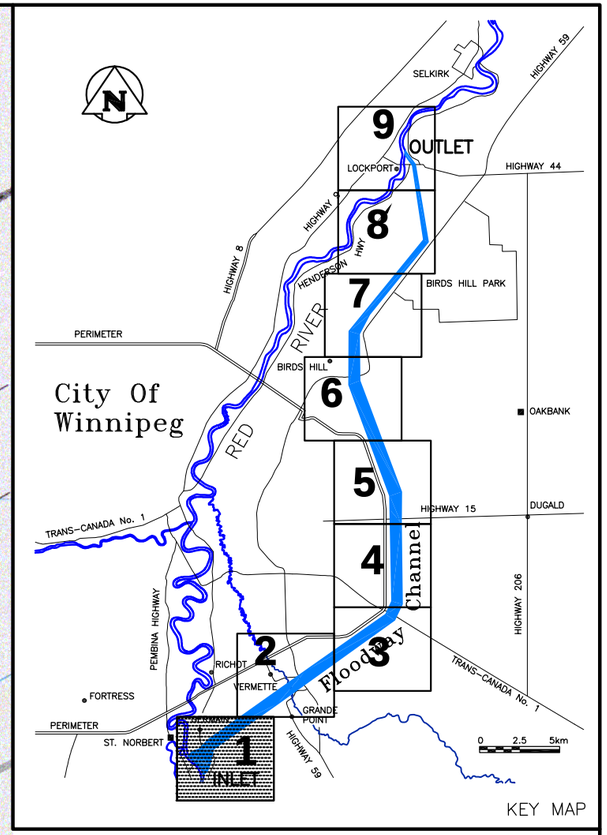

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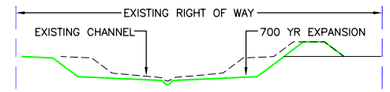

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FLOOD PROTECTION STUDIES FOR WINNIPEG

MAIN REPORT

1 IN 700 YEAR EXPANDED FLOODWAY PLAN

PLATE 2 ***(SHEET 1 OF 9)***

FINAL REPORT – SEPTEMBER 2001

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KGS FILE NO.: P/00-311-07/ADMIN/ADMINDOCS/FINAL REPORT/MAIN REPORT/PLATES/ PLATE 2.DWG (AUTOCAD 2000 DWG FILE)
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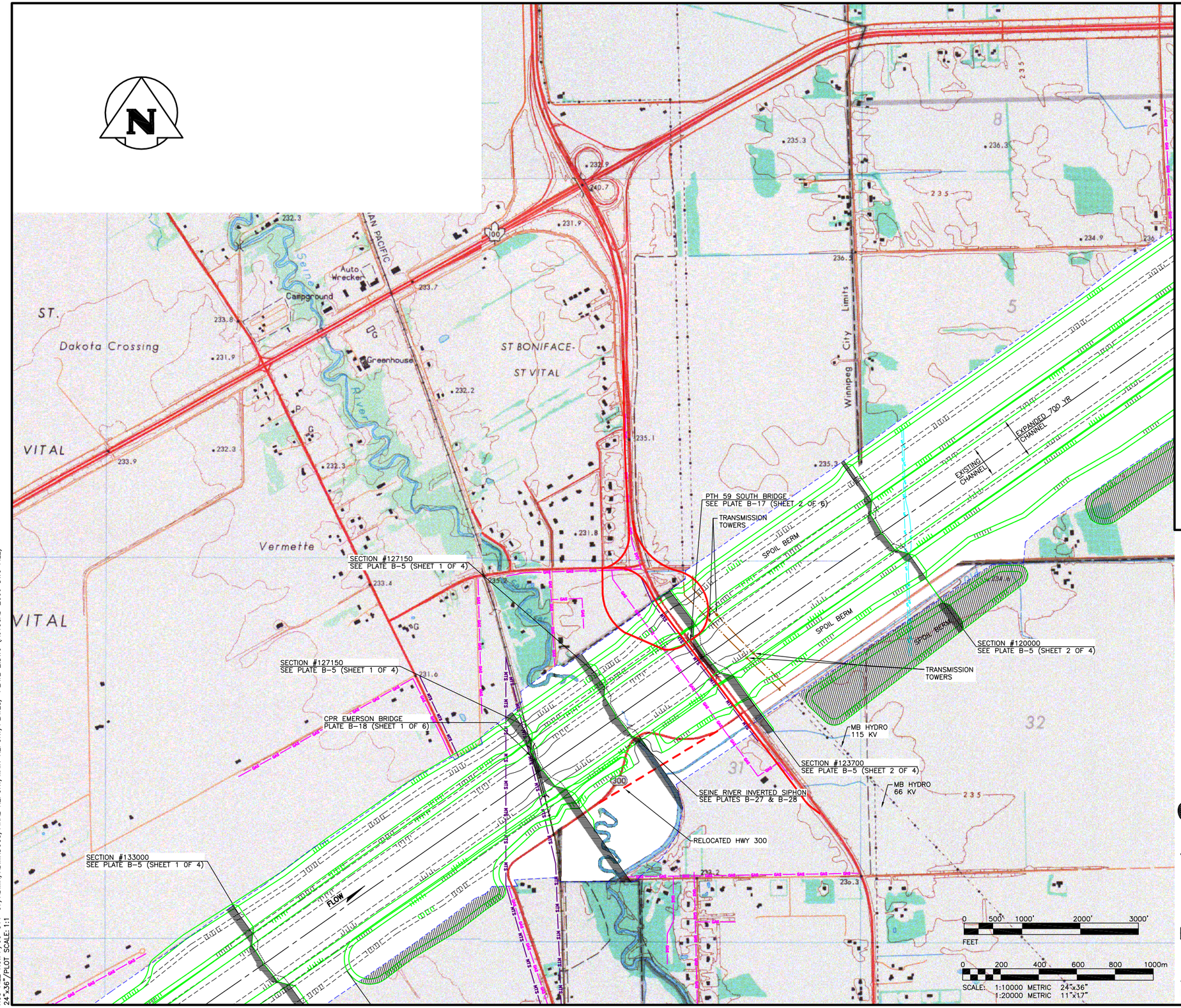

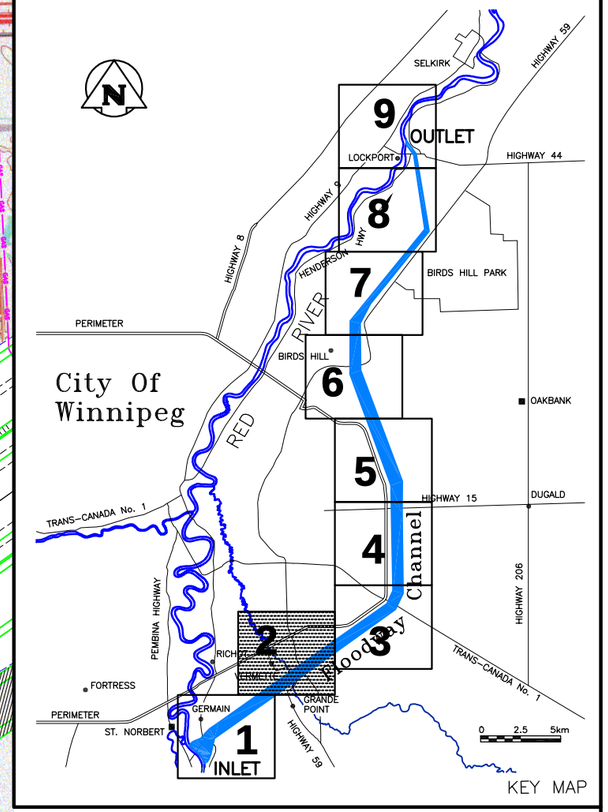

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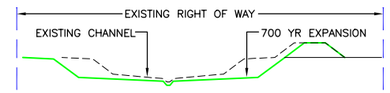

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FLOOD PROTECTION STUDIES FOR WINNIPEG

MAIN REPORT

1 IN 700 YEAR EXPANDED FLOODWAY PLAN

PLATE 2 ***(SHEET 2 OF 9)***

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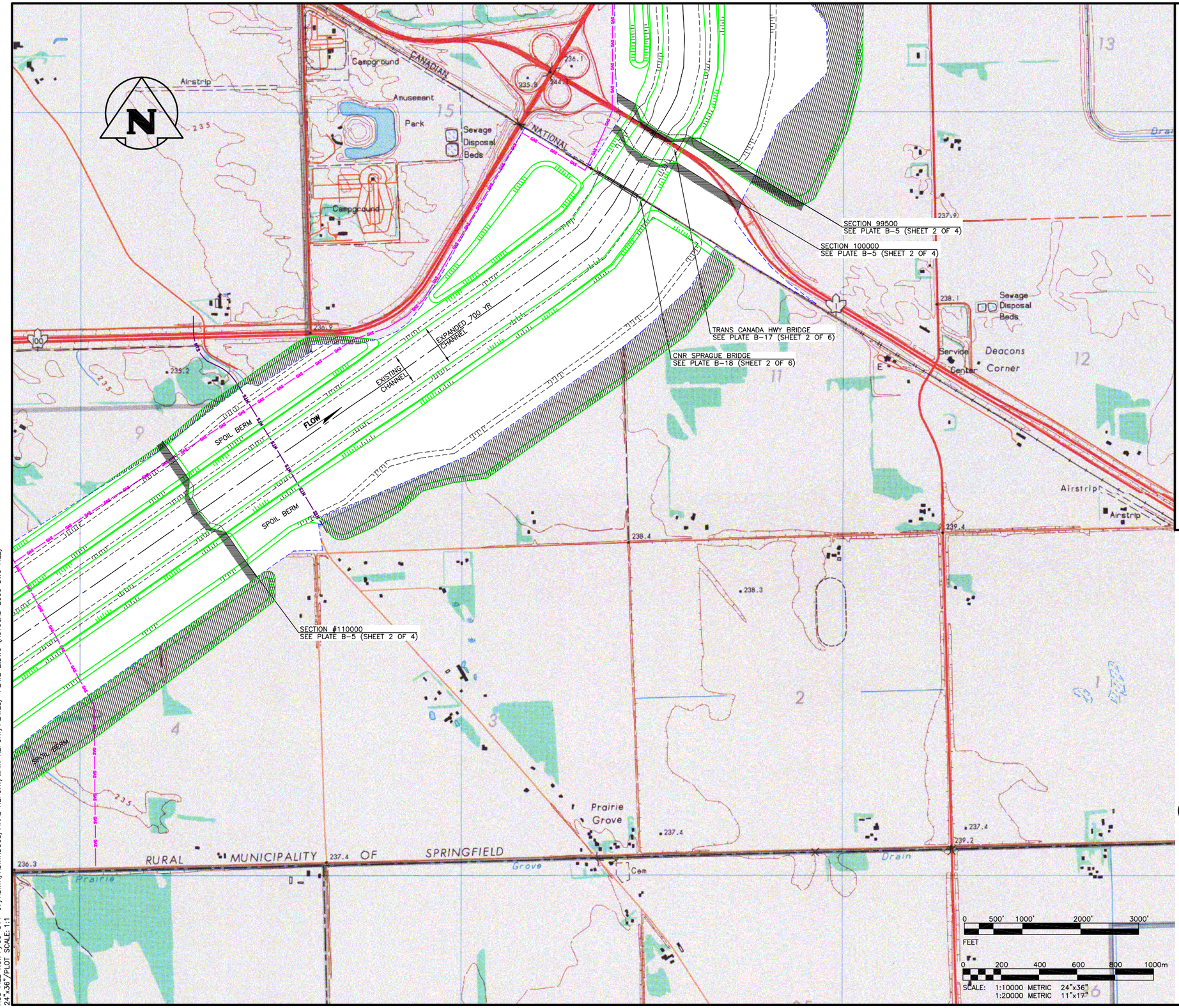

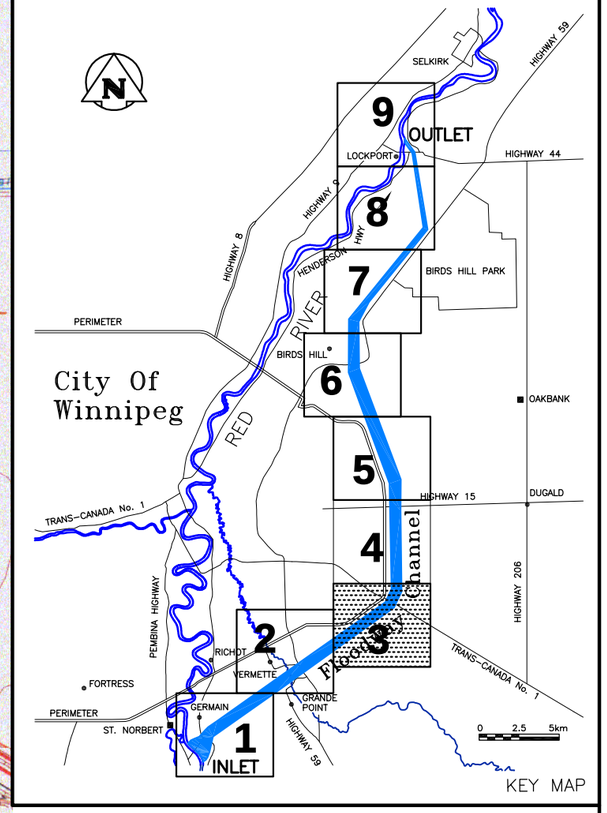

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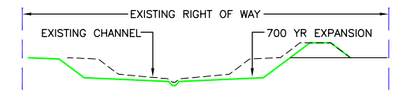

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FLOOD PROTECTION STUDIES FOR WINNIPEG

MAIN REPORT

1 IN 700 YEAR EXPANDED FLOODWAY PLAN

PLATE 2 ***(SHEET 3 OF 9)***

FINAL REPORT – SEPTEMBER 2001

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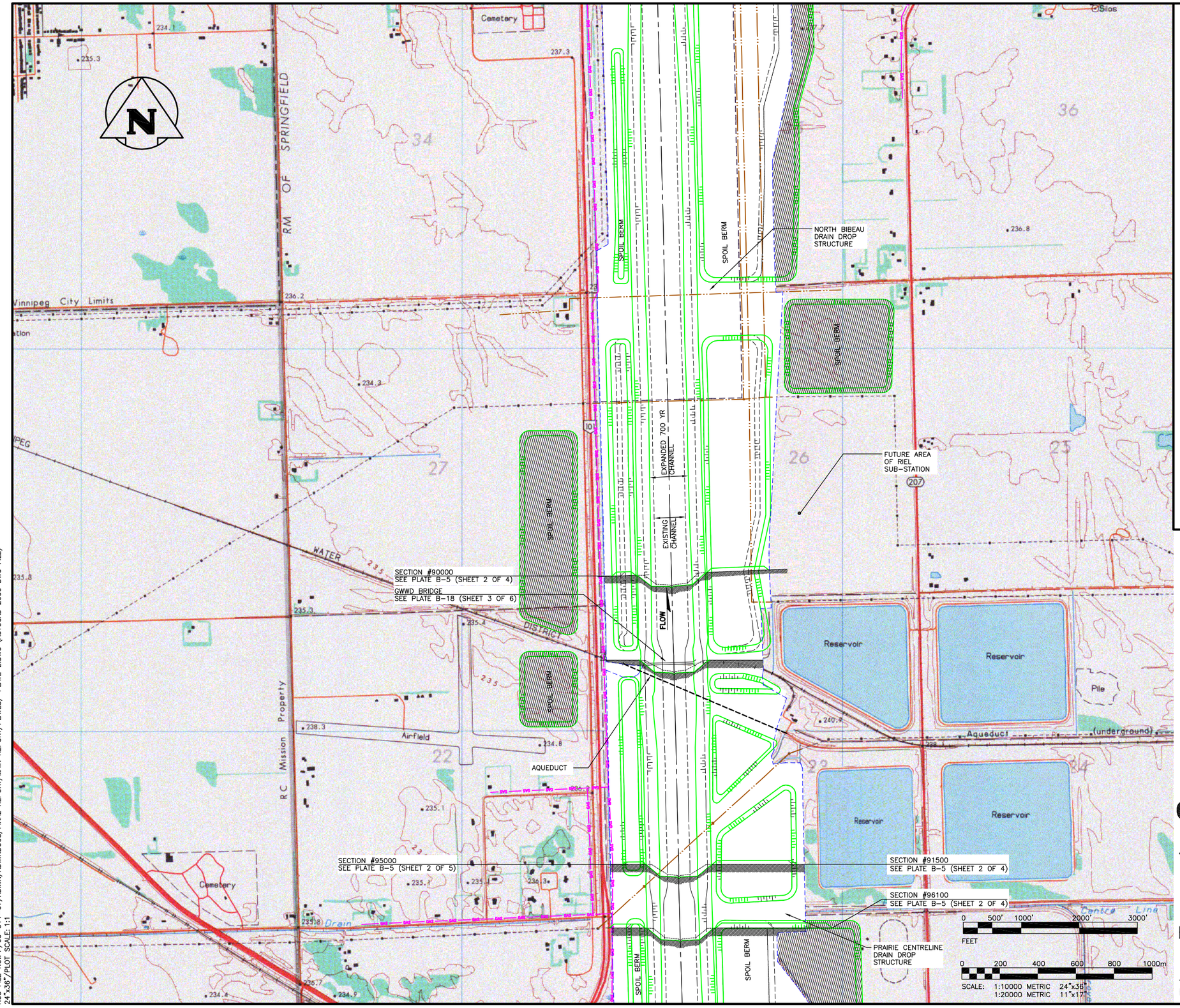

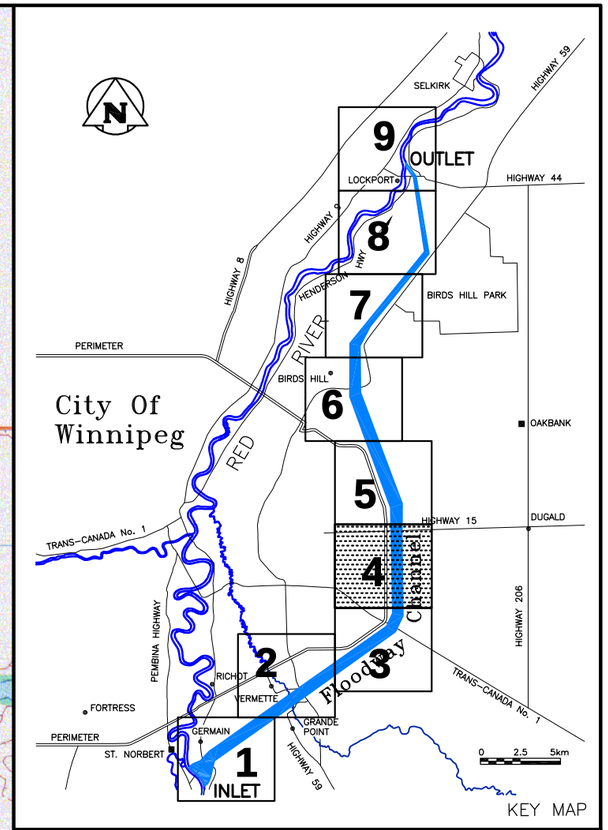

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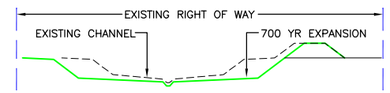

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FLOOD PROTECTION STUDIES FOR WINNIPEG

MAIN REPORT

1 IN 700 YEAR EXPANDED FLOODWAY PLAN

PLATE 2 ***(SHEET 4 OF 9)***

FINAL REPORT – SEPTEMBER 2001

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SECTION # 64700
SEE PLATE B-5 (SHEET 3 OF 4)

CPR KEEWATIN BRIDGE
SEE PLATE B-18 (SHEET 5 OF 6)

SECTION #70000
SEE PLATE B-5 (SHEET 3 OF 4)

TRANSMISSION TOWERS TYP.

SECTION #73000
SEE PLATE B-5 (SHEET 3 OF 4)

COOKS' CREEK DIVERSION
DROP STRUCTURE
SEE PLATES B-25 & B-28

CNR REDDITT BRIDGE
SEE PLATE B-18 (SHEET 4 OF 6)

PTH 15 BRIDGE
SEE PLATE B-17 (SHEET 4 OF 6)

SECTION #79500
SEE PLATE B-5 (SHEET 3 OF 6)

Winnipeg City Limits

North Transcona

Canterbury Park

Kern Park

TRANSCONA YARDS

SPOIL BERM

EXPANDED 700 YR CHANNEL

EXISTING CHANNEL

FLOW

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FEET

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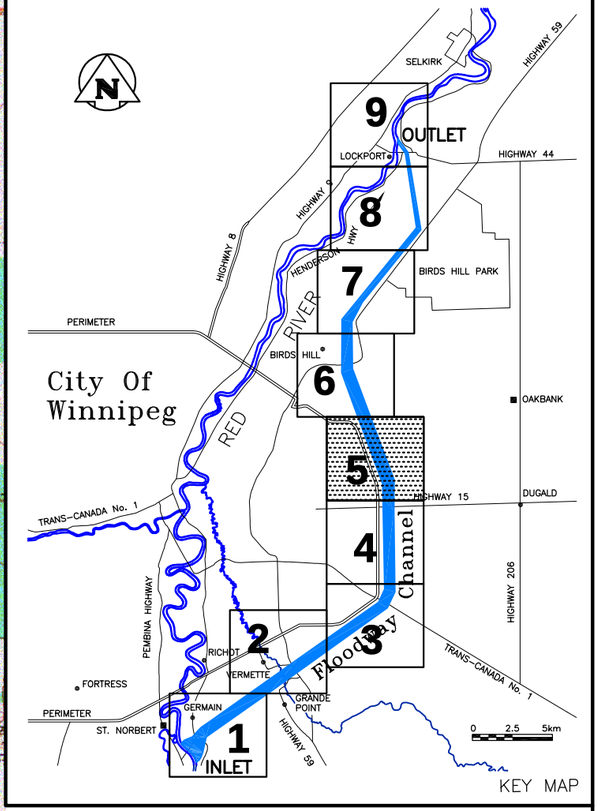

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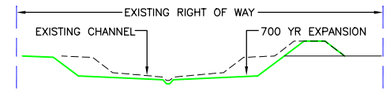

Canada Manitoba Winnipeg

FLOOD PROTECTION STUDIES FOR WINNIPEG

MAIN REPORT

1 IN 700 YEAR EXPANDED FLOODWAY PLAN

PLATE 2 ***(SHEET 5 OF 9)***

FINAL REPORT – SEPTEMBER 2001

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COUNTRY VILLA ESTATES DRAIN

PTH 59 NORTH BRIDGE
SEE PLATE B-17 (SHEET 5 OF 6)

SECTION #48900
SEE PLATE B-5 (SHEET 3 OF 4)

SECTION #50000
SEE PLATE B-5 (SHEET 3 OF 4)

SECTION #51000
SEE PLATE B-5 (SHEET 3 OF 4)

WINNIPEG HYDRO LINE

SPRINGFIELD ROAD DRAIN
DROP STRUCTURE

SECTION #57000
SEE PLATE B-5 (SHEET 3 OF 4)

SECTION #60000
SEE PLATE B-5 (SHEET 3 OF 4)

EXISTING CHANNEL

EXPANDED 700 YR CHANNEL

FLOW

CANADIAN NATIONAL

RM OF EAST ST PAUL

RM OF SPRINGFIELD

Birds Hill

Seniors

Pit

Municipal Hall

Fire Hall

Sewage Disposal

Tower

Substation

Greenhouses

Weigh Station

Yard

Campground

Golf Course

Wharf

Parkmount

Parish of St Paul

Winnipeg City Limits

Cem

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FEET

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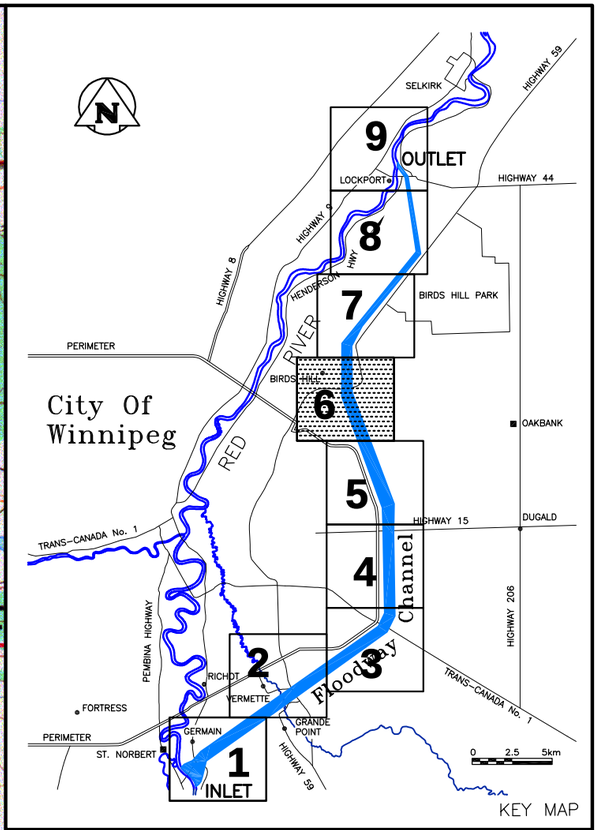

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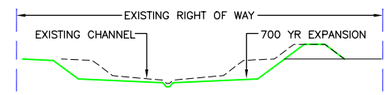

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FLOOD PROTECTION STUDIES FOR WINNIPEG

MAIN REPORT

1-700 YEAR EXPANDED FLOODWAY PLAN

PLATE 2 ***(SHEET 6 OF 9)***

FINAL REPORT – SEPTEMBER 2001

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KGS FILE NO.: P/00-311-07/ADMIN/ADMINDOCS/FINAL REPORT/MAIN REPORT/PLATES/ PLATE 2.DWG (AUTOCAD 2000 DWG FILE)
24"x36"/PLOT SCALE: 1:1

DUNNING ROAD LOW LEVEL CROSSING

SKHOLNY DRAIN DROP STRUCTURE

SECTION #30000
SEE PLATE B-5 (SHEET 4 OF 4)

SECTION #40000
SEE PLATE B-5 (SHEET 4 OF 4)

PTH 59

BIRDS HILL PROVINCIAL PARK

Park Boundary

Gate

Dump

Trailer Park

Sewage

Airstrip

Pit

RM OF

SPOIL BERM

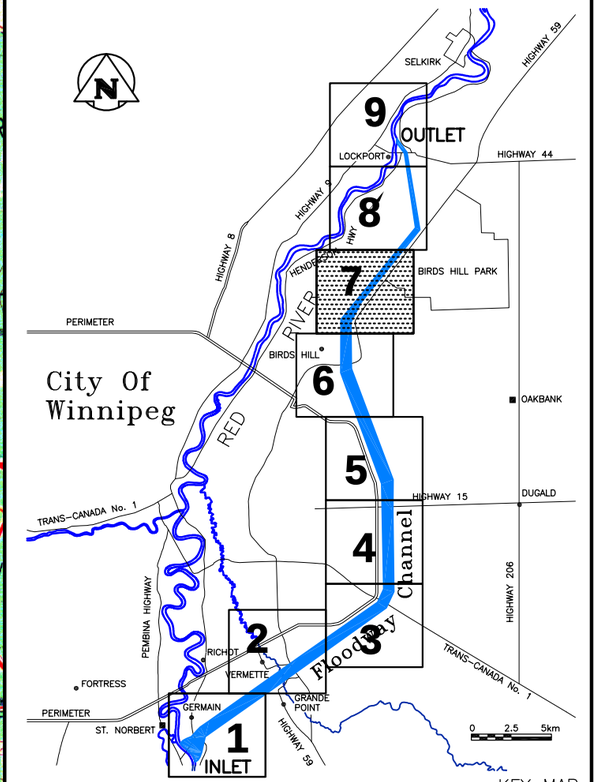
FLOW

EXPANDED CHANNEL 700 YR

EXISTING CHANNEL

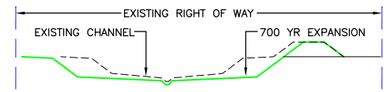
(abandoned)

232.4 233.6 231.7 234.8 232.3 239.2 234.1 232.7 231.1 235.5 234.7



LEGEND

- EXISTING SLOPE
- PROPOSED SLOPE
- BURIED HYDRO LINES (EXISTING)
- TRANSMISSION LINES (EXISTING)
- CENTRA GAS – BURIED PIPELINES (EXISTING)
- MTS – BURIED FIBER LINES (EXISTING)
- WPG OIL PIPELINE CO. – BURIED PIPELINES (EXISTING)
- LAND TO BE ACQUIRED OUTSIDE OF EXISTING RIGHT OF WAY



Canada Manitoba Winnipeg

FLOOD PROTECTION STUDIES FOR WINNIPEG

MAIN REPORT

1 IN 700 YEAR EXPANDED FLOODWAY PLAN

0 500' 1000' 2000' 3000'
FEET
0 200 400 600 800 1000m
SCALE: 1:10000 METRIC 24"x36"
1:20000 METRIC 11"x17"

PLATE 2 ***(SHEET 7 OF 9)***

FINAL REPORT – SEPTEMBER 2001

KGS GROUP

KGS FILE NO.: P/00-311-07/ADMIN/ADMINDOCS/FINAL REPORT/MAIN REPORT/PLATES/ PLATE 2.DWG (AUTOCAD 2000 DWG FILE)
24"x36"/PLOT SCALE: 1:1

ASHFIELD DRAIN DROP STRUCTURE

SECTION #10000
SEE PLATE B-5 (SHEET 4 OF 4)

CPR-LAC DU BONNET BRIDGE (ABANDONED)

EXPANDED 700 YR CHANNEL

EXISTING CHANNEL

SECTION #20000
SEE PLATE B-5 (SHEET 4 OF 4)

FLOW

SPOIL BERM

SPOIL BERM

Gonor

Gonor Station

Narol

Fire Hall

Fire Hall

Gunns Creek

RIVER

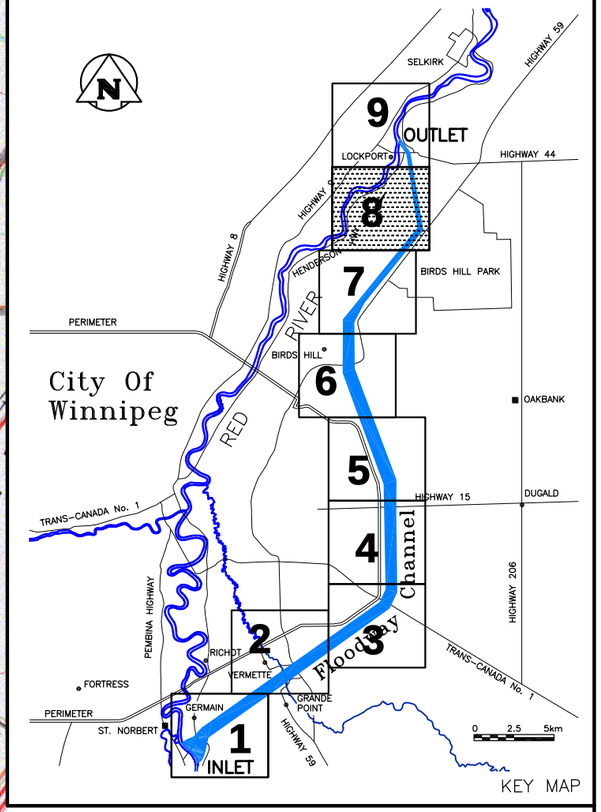
RED

CANADIAN NATIONAL

CANADIAN PACIFIC (abandoned)

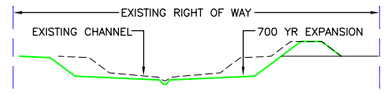
0 500' 1000' 2000' 3000'
FEET

0 200 400 600 800 1000m
SCALE: 1:10000 METRIC 24"x36"
1:20000 METRIC 11"x17"



LEGEND

- EXISTING SLOPE
- PROPOSED SLOPE
- BURIED HYDRO LINES (EXISTING)
- TRANSMISSION LINES (EXISTING)
- CENTRA GAS – BURIED PIPELINES (EXISTING)
- MTS – BURIED FIBER LINES (EXISTING)
- WPG OIL PIPELINE CO. – BURIED PIPELINES (EXISTING)
- LAND TO BE ACQUIRED OUTSIDE OF EXISTING RIGHT OF WAY



Canada Manitoba Winnipeg

FLOOD PROTECTION STUDIES FOR WINNIPEG

MAIN REPORT

1 IN 700 YEAR EXPANDED FLOODWAY PLAN

PLATE 2 ***(SHEET 8 OF 9)***

FINAL REPORT – SEPTEMBER 2001

KGS GROUP

KGS FILE NO.: P/00-311-07/ADMIN/ADMINDOCS/FINAL REPORT/MAIN REPORT/PLATES/ PLATE 2.DWG (AUTOCAD 2000 DWG FILE)
24"x36"/PLOT SCALE: 1:1

OUTLET CHANNEL
SEE PLATES B-24

OUTLET STRUCTURE
SEE PLATES B-22 & B-23

SECTION #-1000
SEE PLATE B-5 (SHEET 4 OF 4)

RELOCATE EXISTING ROAD

SECTION #500
SEE PLATE B-5 (SHEET 4 OF 4)

ST. ANDREWS
LOCK AND DAM

PTH 44 BRIDGE
SEE PLATE B-17 (SHEET 6 OF 6)

SECTION #3000
SEE PLATE B-5 (SHEET 4 OF 4)

SECTION #4550
SEE PLATE B-5 (SHEET 4 OF 4)

CNR PINE FALLS BRIDGE
SEE PLATE B-18 (SHEET 6 OF 6)

0 500' 1000' 2000' 3000'
FEET
0 200 400 600 800 1000m
SCALE: 1:10000 METRIC 24"x36"
1:20000 METRIC 11"x17"

KEY MAP

City Of Winnipeg

RED RIVER Floodway Channel

0 2.5 5km

LEGEND

- EXISTING SLOPE
- PROPOSED SLOPE
- BURIED HYDRO LINES (EXISTING)
- TRANSMISSION LINES (EXISTING)
- CENTRA GAS – BURIED PIPELINES (EXISTING)
- MTS – BURIED FIBER LINES (EXISTING)
- WPG OIL PIPELINE CO. – BURIED PIPELINES (EXISTING)
- LAND TO BE ACQUIRED OUTSIDE OF EXISTING RIGHT OF WAY

EXISTING RIGHT OF WAY
EXISTING CHANNEL
700 YR EXPANSION

Canada Manitoba Winnipeg

FLOOD PROTECTION STUDIES FOR WINNIPEG

MAIN REPORT

1 IN 700 YEAR EXPANDED FLOODWAY PLAN

PLATE 2 ***(SHEET 9 OF 9)***

FINAL REPORT – SEPTEMBER 2001

KGS GROUP

KGS FILE NO.: P/00-311-07/ADMIN/ADMINDOCS/FINAL REPORT/MAIN REPORT/PLATES/ PLATE 2.DWG (AUTOCAD 2000 DWG FILE)
24"x36"/PLOT SCALE: 1:1

EXISTING WEST DIKE

EARTH STRUCTURE

RM OF MACDONALD

TOWN OF STE. AGATHE

HIGHWAY 75

RED RIVER

ROAD RELOCATION

RAT RIVER

TOURAND CREEK

DOWNSTREAM FLOOD DISCHARGE CHANNEL

MARSH RIVER

CONNECTING CHANNEL

RED RIVER CONTROL STRUCTURE (SEE PLATE C-2)

MARSH RIVER CONTROL STRUCTURE (SEE PLATE C-4)

RAT RIVER CONTROL STRUCTURE (SEE PLATE C-5)

EARTH STRUCTURE

EARTH STRUCTURE

MARSH RIVER DIVERSION CHANNEL

UPSTREAM FLOOD DISCHARGE CHANNEL

HIGHWAY RELOCATION

RURAL MUNICIPALITY OF MORRIS

RURAL MUNICIPALITY OF ROSSER

RURAL MUNICIPALITY OF RITCHOT

RURAL MUNICIPALITY OF DE SALABERRY

WINNIPEG

ALIGNMENT OF STRUCTURES

STE. AGATHE

LEGEND

235.0 TOPOGRAPHIC CONTOUR (GEODETIC ELEVATION IN METRES)

0 500 1000 1500 2000 2500m

SCALE 1:40000

Canada Manitoba Winnipeg

FLOOD PROTECTION STUDIES FOR WINNIPEG

MAIN REPORT

PROJECT GENERAL ARRANGEMENT FOR STE. AGATHE DETENTION STRUCTURE

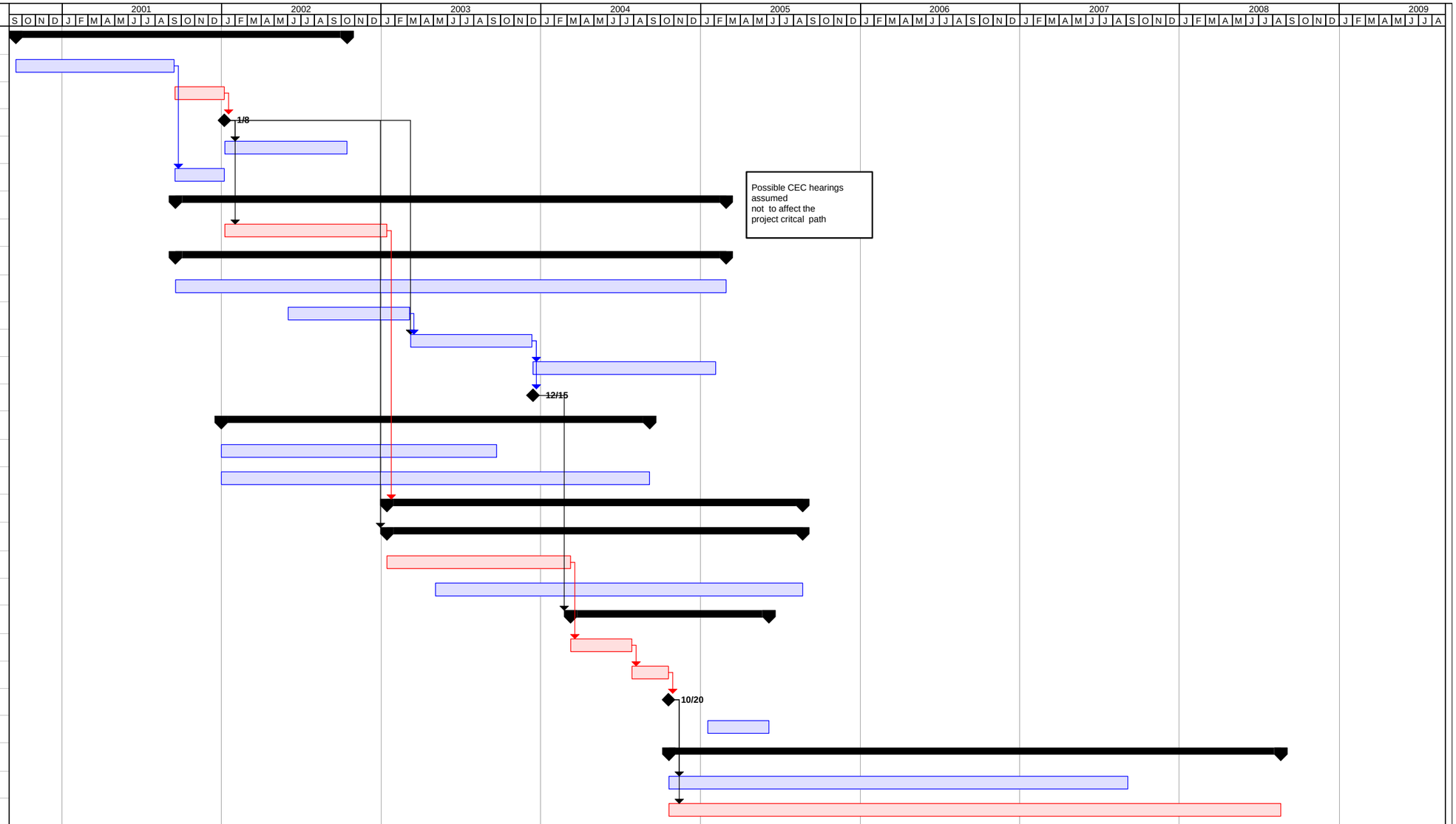
PLATE 3

FINAL REPORT–SEPTEMBER 2001

KGS GROUP

KGS FILE NO.: P:/00-311-07/ADMIN/ADMINDOCS/FINAL REPORT/MAIN REPORT/PLATES/PLATE 3.DWG
24"x36" PLOT SCALE: 1:1200 (1"=100'-0")

ID	Task Name
1	**Stage 1 - Planning and Project Selection**
2	Flood Protection Studies
3	Review of Alternatives
4	Selection of Preferred Alternative
5	Funding Approval
6	Ongoing Studies Technical Support
7	**Stage 2 - Pre - Design and Environmental Approvals**
8	Pre-commitment Design / Particip. Support
9	**Environmental Approvals**
10	Baseline Studies
11	Environmental Assessment Report
12	License Application/Approval
13	CEC / Panel Hearings (Contingency)
14	Project Commitment
15	**Preparatory Requirements**
16	Utilities - Preliminary Design and Approvals
17	Land Acquisition Definition / Surveys
18	**Stage 3 - Final Design and Tendering**
19	**Final Design**
20	Design Phase 1
21	Design (subsequent phases)
22	**Tender (Staged Contract)**
23	Tender Period (Phase 1)
24	Evaluation
25	Award
26	Tender (Phase 2……..)
27	**Stage 4 Construction**
28	Earthworks /Civil Works (Ste. Agathe)
29	Earthworks /Civil Works (Floodway)



Canada Manitoba Winnipeg

FLOOD PROTECTION STUDIES FOR WINNIPEG

MAIN REPORT

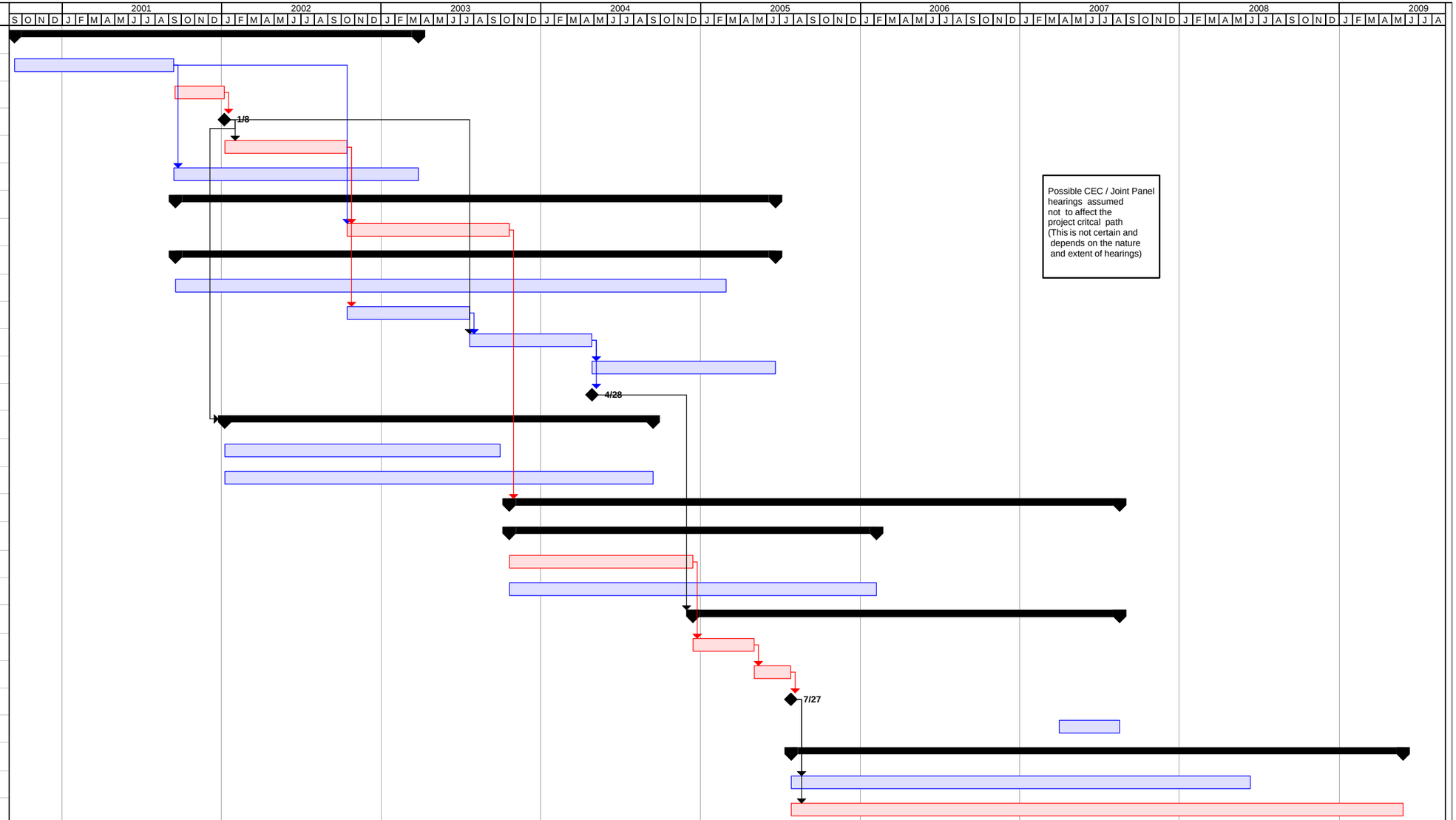
PRELIMINARY PROJECT MASTER PLANNING SCHEDULE – FAST TRACK OPTIMISTIC SCHEDULE

PLATE 4

FINAL REPORT – SEPTEMBER 2001

KGS GROUP

ID	Task Name
1	**Stage 1 - Planning and Project Selection**
2	Flood Protection Studies
3	Review of Alternatives (Floodway / Ste. Agathe)
4	Selection of Preferred Alternative
5	Project Funding Approval
6	Interim Funding and on going studies / technical support
7	**Stage 2 - Pre - Design and Environmental Approvals**
8	Pre-commitment Design
9	**Environmental Approvals**
10	Baseline Studies
11	Environmental Assessment Report
12	License Application/Approval
13	CEC / Panel Hearings (Contingency)
14	Project Commitment
15	**Preparatory Requirements**
16	Utilities - Preliminary Design and Approvals
17	Land Acquisition Definition / Surveys (including acquisition)
18	**Stage 3 - Final Design and Tendering**
19	**Detailed Design**
20	Design Phase 1
21	Design (subsequent phases)
22	**Tender (Staged Contract)**
23	Tender Period (Phase 1)
24	Evaluation
25	Award
26	Tender (Phase 2……..)
27	**Stage 4 Construction**
28	Earthworks /Civil Works (Ste. Agathe)
29	Earthworks /Civil Works (Floodway)



Canada Manitoba Winnipeg

FLOOD PROTECTION STUDIES FOR WINNIPEG

MAIN REPORT

PRELIMINARY PROJECT MASTER PLANNING SCHEDULE – CONVENTIONAL FOLLOWING FUNDING APPROVAL

PLATE 5

FINAL REPORT – SEPTEMBER 2001

KGS GROUP

ANNEX A

WORK PLAN

Studies of Winnipeg Floodway Expansion / Ste. Agathe Detention Structure

Work Plan

Basic Assumptions

1 General

1.1 Study Team would be comprised of staff from KGS Group, InterGroup, and from North South Consultants.
1.2 The most advantageous means of public interaction and assessment of support or opposition to the will be addressed in this study. Implementation of the selected plan is not budgetted under this study.
1.3 All hydraulic simulations of the "Red Sea" using the established MIKE-11 model that are required for this study would be done by Manitoba Conservation, at the request of KGS Group.
1.4 Examination of required protective measures to mitigate the backwater effects from the Ste. Agathe Detention Structure, and to estimate costs of achieving that protection will be undertaken by Manitoba Conservation staff, based on input provided by KGS Group.

2 Intent is for minimum work that would be required to advance the understanding of both Projects

2.1 No subsurface exploration for either option (Note : Ste. Agathe cannot therefore be considered to be at full feasibility level of study)
2.2 No environmental permits required at this stage, and no requirement for an EIA
2.3 Capital cost estimates for Floodway expansion will be prepared to a target accuracy of 15 to 20% and will be based on pessimistic assumptions of subsurface conditions in lieu of information from new subsurface explorations.
2.4 Capital cost estimates for Ste. Agathe Detention Scheme are those provided in KGS Report to IJC and are considered accurate to +/-25%.
2.5 Report by March 31, 2001 would indicate results to date (in summary form) covering all major issues.
2.6 Report by July 31, 2001 would provide results of overall study. Completion by this date, and completion of the report under Item 2.5 would be contingent upon a start date of Dec. 1/2000.

Number	*Work Item*		*Comments*
1	***Ste Agathe Detention Structure***		
1.1	**Identify socio-economic issues for the project**		
	1.1.1	Understanding project	
	1.1.2	Define study area and affected groups	
	1.1.3	Socio-economic characterization	Determine under what baseline socio-economic conditions the projects will be assessed. Sources could include key person interviews, case studies, and comments received during Commission meetings with the public.
	1.1.4	Identify socio economic issues and how projects compare on these issues	Using the characteristics identified in 1.1.3 and 2.2.3, this task would develop a list of issues and means of comparing alternatives against these issues.
	1.1.5	Identify strategies to mitigate key adverse socio-economic impacts	
1.2	**Investigate precedents of this type of concept**		
	1.2.1	Flood protection works involving increased water levels	These reviews would include literature searches, as well as contact with authorities
	1.2.2	Process of public consultation/consensus building	
1.3	**Identification of impacts of concept on communities in R.R. Valley**		
	1.3.1	Review hydraulic analyses to date	This would entail review of previous calculations with Mike-11 and discussion with Manitoba Conservation about additional work required, and limitations of results to date. The issue of wind effets would be considered.
	1.3.2	Prescribe additional Mike-11 runs if necessary, liaise with Man. Conserv. on execution of Mike-11 simulations, and review results when available	
	1.3.3	Undertake backwater analyses where required on tributaries to develop estimates of impacts on communities	
	1.3.4	Develop table of increased water levels caused by the Ste. Agathe Detention Structure on water level and duration of flooding at key locations in Valley, relative to "natural condition", for range of flood events (1:100 to 1:1000 year)	Table would include list of existing flood protection measures, and existing ring dike crest elevations.
1.4	**Investigate all identified environ. impacts of project and means to mitigate**		
	1.4.1	Review previous studies by KGS Group	Main issues have been identified and described in KGS Group Report to the IJC Task Force.
	1.4.2	Confirm/identify environmental impacts of project	This would include review and consideration of all aquatic, terrestrial, and air quality impacts both during construction and in the loing term.
	1.4.3	Identify means to mitigate impacts	This would entail working with the engineering staff to identify and develop schemes to mitigate as much as possible the potential impacts.
	1.4.4	Liaise with government agencies to solicit their input on impacts and mitigation measures	Descriptions of the project would be discussed with key government representatives to solicit their input into the process of dealing with environmental impacts.
1.5	**Investigate means to mitigate increased water levels, including estimated costs**		
		Note : This task to be undertaken by Manitoba Conservation.	
		information provided by KGS Group	
1.6	**Consider modifications to Ste. Agathe Detention Concept**		
	1.6.1		
	1.6.2		

Number	*Work Item*		*Comments*
2	***Winnipeg Floodway Expansion Project***		
2.1	**Investigate river regime downstream of Floodway Outlet**		
	2.1.1	Review aerial photos/topo maps to identify overbank flow zones and areas vulnerable to ice jams	This task will investigate both open water and conditions of potential ice jams to determine the appropriate water level at the Floodway Outlet to be used for design considerations, both in the Floodway expansion, and in the City of Wpg.
	2.1.2	Undertake limited surveys of river banks or potential overflow zones along the river as required to supplement existing information where necessary for resolution of the backwater issue	
	2.1.3	Undertake open water backwater analyses with existing bathymetric and topographic information for lower Red River (1826 flood up to 1:1000 year flood)	
	2.1.4	Assemble and review records of historical ice jam occurrences	Existing documented evidence as well as anecdotal evidence will be solicited from government agencies and local sources to be identified in the course of the search.
	2.1.5	Estimate potential volume of fragmented ice inflow that could be reasonably expected to accumulate in an ice jam	This information will be based on evidence that may be identified for the Red River, and from other similar rivers.
	2.1.6	Undertake ice jam simulations with existing proven software to estimate reasonable upper limit of potential ice jam effects on water levels	
	2.1.7	Estimate river stage/discharge curves at the Floodway Outlet that have varying degrees of probability of being exceeded	This task will combine the hydraulic conditions of the river for open water conditions and the probabilistic effects from ice jam formation.
	2.1.8	Estimation of backwater profiles from Floodway Outlet upstream through Winnipeg	Based on standard step backwater analyses with existing river bathymetric data.
	2.1.9	Allowance for additional investigations as required that will result from evidence prepared	
2.2	**Identify socio-economic issues for the project**		
	2.2.1	Understand project (transfer of knowledge to socio-economists)	
	2.2.2	Define study area and affected groups	
	2.2.3	Socio-economic characterization	Determine under what baseline socio-economic conditions the projects will be assessed. Sources could include key person interviews, case studies, and comments received during Commision meetings with the public.
	2.2.4	Identify socio-economic issues and how projects compare on these issues	Using the characteristics identified in 1.1.3 and 2.2.3, this task would develop a list of issues and means of comparing alternatives against these issues.
	2.2.5	Estimate benefits/disbenefits of using Floodway to minimize water level fluctuations in Wpg during summer months	This would include consideration of conditions in Wpg and the impacts of raising water levels upstream of the floodway to mitigate fluctuations of water levels in Wpg.

Number	*Work Item*		*Comments*
2 (Cont'd)	***Winnipeg Floodway Expansion Project***		
2.3	**Invest. all identified environ. impacts and means to mitigate**		
	2.3.1	Review previous studies by KGS Group	Main issues have been identified and described in KGS Group Report to the IJC Task Force
	2.3.2	Confirm/identify environmental impacts of project	This would include review and consideration of all aquatic, terrestrial, and air quality impacts both during construction and in the long term.
	2.3.3	Identify means to mitigate impacts	This would entail working with the engineering staff to identify and develop schemes to mitigate as much as possible the potential impacts.
	2.3.4	Liaise with government agencies to solicit their input on impacts and mitigation measures	Descriptions of the project would be discussed with key government representatives to solicit their input into the process of dealing with environmental impacts.
2.4	**Resolve mode of operation of expanded Floodway**		
	2.4.1	Estimate benefits/disbenefits of water levels above/below the "state-of-nature" at the Floodway Inlet	This task will take advantage of GIS models of damage potential developed previously by KGS Group.
	2.4.2	Consider feasibility of modifying expanded Floodway design to avoid exceeding "state-of-nature" water level at Floodway Inlet	
2.5	**Preliminary Design of Floodway Expansion**		
	2.5.1	Select design flow based on results of analysis of lower Red River, backwater effects in Wpg, and review of Floodway expansion economics	
	2.5.2	Assemble backwater profiles in Winnipeg for selected design condition of Floodway	
	2.5.3	Address requirements (and costs) for raising Primary Dikes in Winnipeg to suit Floodway design condition	
	2.5.4	Address requirements (and costs) for improving internal flood protection system within Wpg to suit design condition for Floodway	
	2.5.5	Assess appropriate treatment of bridge decks to minimize risk of failure when decks are submersed (applies to expansion schemes that do not require replacement or substantial modification of existing bridges)	
	2.5.6	Optimize design of Floodway expansion, including all bridges, structures, and the channel geometry, to minimize costs and environmental impacts	
	2.5.7	Develop alternative design of Floodway expansion to provide "wet Floodway" in summer months	
	2.5.8	Assess economic justification of adopting a "wet Floodway" concept, considering recreational benefits identified in Task 2.2	
	2.5.9	Refine selected expansion scheme (either conventional Floodway or "wet Floodway")	
	2.5.10	Develop requirements for adjustments to local wells to suit modified Floodway design	
	2.5.11	Prepare preliminary design drawings to demonstrate the proposed modifications required to the Floodway channel, structures and "crossings" (approximately 15 drawings are envisaged and budgetted)	

Number	*Work Item*		*Comments*
2 (Cont'd)	***Winnipeg Floodway Expansion Project***		
2.6	**Develop design criteria for all structures/channel**		
2.7	**Refine strategy of modifying "crossings"**		
	2.7.1	Provide proposed channel modifications to individual Owners of "crossings"	
	2.7.1	Review possible channel modifications with Owners	
	2.7.1	Evaluate input from Owners	
	2.7.1	Refine selected strategy and confirm costs	
2.8	**Develop construction schedule**		
2.9	**Cost estimation for all components of project**		
	2.9.1	Excavation	
	2.9.2	Outlet structure	
	2.9.3	Crossings	
	2.9.4	Environmental mitigation requirements	
	2.9.5	Engineering	
	2.9.6	Interest during construction	
	2.9.7	Estimate construction cost contingency appropriate for the level of definition of the project	
2.10	**Develop strategy for contracting for optimum execution of project**		
	2.10.1	Consult with excavation contractors regarding current/future capabilities	
	2.10.2	Review strategy used in original excavation of existing Floodway	
	2.10.3	Develop proposed strategy for proposed expansion scheme	

Number	*Work Item*	*Comments*
3	***Common Items for Overall Study***	
3.1	**Preparation for Public Participation Program**	
	1.1.1 Preparation of information on Projects (both Floodway and Ste. Agathe Detention Concept)	This task requires the assembly of detailed information from previous work.
	1.1.2 Attendance as required at meetings with key persons of Public (covers both Projects)	This is undefined at this time, but is an allowance for probable small-scale meetings with selected stakeholders, probably late in the study period, and prior to commencement of the public participation program.
	1.1.3 Public Participation Program Planning / Development	This task would include identification of possible approaches to public participation, examination of alternatives, consensus on appropriate approach, and preparation of an implementation plan.
3.2	**Disbursements**	
3.3	**Progress Meetings with Steering Committee (budget for 5)**	
3.4	**Study Management / Coordination / Progress Reporting**	
3.5	**Reports**	
	3.4.1 Report in March / 2001	
	3.4.2 Report in July / 2001	
3.6	**Secretarial Support Services (1200 hrs@$30/h)**	
3.6	**Special Consultants (Bert Lukey)**	