
FLOOD PROTECTION STUDIES FOR WINNIPEG

MAIN REPORT



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KGS
GROUP

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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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Note: Appendices are bound in two separate volumes:

- Appendices A, C, D, E, and F
- Appendix B