How are we living with the Red?

A report by R. Halliday & Associates to the International Red River Board

June 15, 2009

1909-2009
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HOW ARE WE LIVING WITH THE RED?

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2009 06 15

EXECUTIVE SUMMARY

In its November 2000 report, *Living with the Red*, the International Joint Commission (IJC) made a number of recommendations to governments aimed at reducing, mitigating, and preventing harm from future flooding in the Red River basin. The IJC noted that there is no single solution to the challenge and that comprehensive, integrated, binational approaches must be pursued and implemented.

Since the 1997 flood, governments at all levels have made changes in flood-related policies, funded new programs and changes to existing ones, invested in research into many aspects of flooding, and supported the establishment of new institutions such as the Red River Basin Commission. Not only major floods such as that of 1997, but also smaller tributary floods have been the focus for attention.

In June 2001, the United States and Canada directed the IJC and the newly created International Red River Board to monitor progress by governments in implementing the recommendations contained in *Living with the Red*, and to provide encouragement for continued cooperative, innovative, and integrated watershed management approaches. In January 2003 the Commission specifically requested the Board to provide a written report on progress. A report indicating substantial progress on many recommendations was prepared and made available to the public through the IJC website.

More recently, in 2006, the Red River experienced a significant flood with relatively little urban damage, although costs were incurred for measures such as closing ring dikes. In 2009 a flood that, at Fargo-Moorhead, exceeded those of 1997 and 1897 occurred. In the lower basin the 2009 flood was exceeded in the instrumental record only by that of 1997. The flood management measures implemented following the 1997 flood have led to a higher level of preparedness and improved mitigation measures. The basin has become more flood resilient, and this significantly reduced the effects of the 2009 flood on the people and communities of the Red River Valley.

The International Joint Commission made 28 recommendations to government and endorsed another 30 recommendations of its International Red River Basin Task Force without change. The expenditures since 1997 relating to the IJC recommendations have exceeded one billion dollars. No recommendations have been formally rejected although a few are unlikely to be implemented.

Some of the key achievements and continuing deficiencies can be summarized under headings of policy, legislation and institutions; preparedness; mitigation; and environment.

Policies, Legislation and Institutions. In 2008 Canada introduced its first national mitigation strategy. The strategy includes a number of priority actions.

Changes in data policies by the Canadian federal government, particularly Environment Canada, and by the Manitoba government have led to a better-informed public.

Manitoba has introduced a new designated flood area regulation. The associated elevation and inspection requirements for new structures will reduce future flood damages. The province has also introduced new emergency management legislation and legislation for Red River Floodway expansion.

In the United States, policy changes by the Army Corps of Engineers are aimed at a more integrated basin-wide consideration of projects. Activity by the Minnesota Red River Watershed Management Board and its North Dakota counterpart, the Red River Joint Water Resource District, also seeks more integrated approaches.

Both North Dakota and Minnesota have implemented new state building codes that include flood-proofing measures.

Key institutional developments include the formation of the International Joint Commission's International Red River Board, the Red River Basin Commission and the International Water Institute.

Preparedness. Cities such as Winnipeg and Grand Forks have upgraded detailed emergency plans. All communities in the basin now have up-to-date emergency response plans.

Another development is the significant improvements to flood forecasting. Major improvements have been made to data networks; data collection that supports forecasting, such as topographic data; model development; and communication of forecasts. These have occurred in both countries.

The US Federal Emergency Management Agency (FEMA) has instituted a national map modernization program. The program makes current information available in digital, geographic information system compatible form.

Mitigation. Many structural measures aimed at protecting both rural and urban floodplain residents have been completed or at advanced stages of development. Rural protection efforts continue and many high-risk structures have been removed from the floodplain. Major levees such as those for Grand Forks and East Grand Forks are essentially complete. The increased capacity of the Red River Floodway (Winnipeg) is now available although the project will not be complete until 2011. Fargo-Moorhead, Drayton and Grafton measures are still to come. Neche is protected only by a levee constructed under emergency conditions. Some tributary communities such as Valley City, Lisbon and Ada need additional permanent protection.

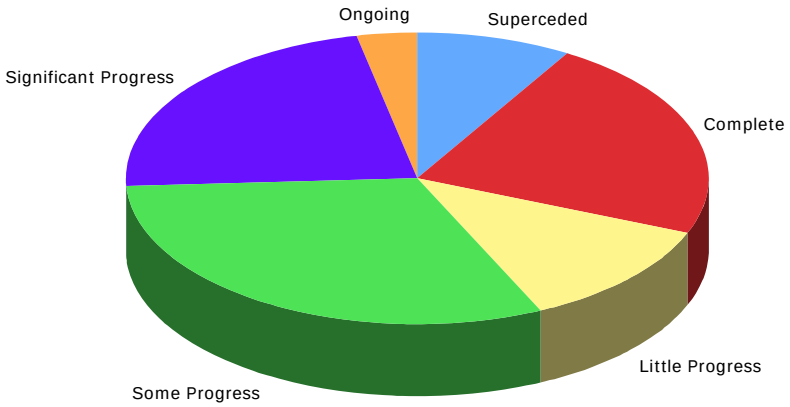
With regard to non-structural measures, the identification of areas at risk in the United States, based in part on information from the 1997 flood, is complete. As indicated previously, Manitoba introduced new floodplain management measures based on the 1997 flood level. All jurisdictions have removed some high risk structures from the floodplain.

Several agencies are collaborating with the Red River Basin Commission on the development of complex hydraulic models for the basin. A single one-dimensional hydrodynamic model of the Red River mainstem extending from Lake Traverse in the headwaters to Breezy Point near Lake Winnipeg has been completed. This model development will be useful in planning future flood mitigation work.

Current activity appears focused on the mainstem of the Red River, also the focus of the IJC investigation. More work is needed on tributary flooding, ice jam flooding and summer floods.

Environment. The IJC made recommendations concerning biota transfer, groundwater contamination and storage of hazardous goods. Some work is being accomplished in these areas, but more needs to be done. An area of considerable activity that also arose during the International Flood Mitigation Initiative concerns riparian zones. Programs are underway aimed at establishing riparian conservation reserves and developing a greenway on the Red.

The overall status of the recommendations is shown in the figure below.



The recommendations that have achieved the most success are those that involve construction of a structural measure identified in the IJC report, even if that work requires collaboration at the federal, state or province, and local level. A second group of successful recommendations relate to specific recommendations aimed at a specific agency. The improvements to flood forecasting are an example.

There are some causes for concern nonetheless. The less successful recommendations are those that involve multiple agencies and, perhaps, multiple objectives. These sorts of tasks could be deemed to be more difficult and could naturally be expected to take longer. It may be that public expectations for structural measures supercede all other post-flood pressures and that those expectations need to be met before proceeding with "softer" projects. As well, some structural measures in the upper basin have been delayed by other priorities and because of permitting issues.

While the Red River basin is unquestionably more flood resilient than it was in 1997, it will still take considerable effort to achieve the level of integration and cohesion on flood management that the IJC envisaged. The mandates and accountability of federal, state/provincial, and local government agencies make it extremely difficult to consider IJC recommendations that imply a degree of collective management or assignment of responsibilities to a third party. This problem is particularly difficult when binational approaches are contemplated. That said, there is currently a high level of interagency and intergovernmental cooperation. Adoption of binational measures, however, will still be needed before the long-term resiliency of the basin can be assured.

In considering next steps, the International Joint Commission and its International Red River Board may wish to concentrate on a short list of matters concerning Red River flooding. This would include: matters pertaining to the transboundary area, in particular the Roseau and Pembina Rivers; matters relating to the nature of flooding including environmental effects; and the development of indicators of basin resiliency. Flood governance matters would also be worthy of pursuit. Some members of the IRRB are well-placed to consider a number of concerns raised in this report. Other matters such as those mentioned previously may require financial support from the IJC's International Water Initiative. The IJC itself may wish to champion progress on some of the broad, multiagency recommendations from *Living with the Red*.

Despite the enormous strides made in the past 10 years it is important to keep in mind that floods greater than 1997 have occurred in the past and undoubtedly will occur again. It will be important to maintain the databases and models developed in recent years and to improve them as new information and technologies arise. With continuing high water events since 1997 this task appears achievable. If the Red River basin experiences a decade or more in which no serious flooding occurs, flood preparedness could decline in favour of other priorities.

One particular impediment to progress is the advent of lawsuits among various jurisdictions, for example related to the lower Pembina River. Lawsuits tend to inhibit the free exchange of information and have a profound effect on the ability or willingness of parties to reach consensus on a course of action that could resolve the issue in question.

The apocryphal quote that the Red River basin has two problems, "too much water and too little", has a firm foundation in reality. In attempting to deal with concerns related to flooding, it is important to determine the consequences of any proposed measures during

times of drought. Integrated water resources management should be the overarching goal for the basin. This should become the new challenge of “living with the Red”.

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INTRODUCTION

In its November 2000 report, *Living with the Red*, (IJC, 2000) the International Joint Commission (IJC) made a number of recommendations to governments aimed at reducing, mitigating, and preventing harm from future flooding in the Red River basin. The IJC noted that there is no single solution to the challenge and that comprehensive, integrated, binational approaches must be pursued and implemented. In the course of its work, the IJC had also initiated the development of products of continuing utility to the basin, including hydraulic models, high resolution topographic and land use data for flood-prone areas, and a virtual network to link people, information, and the decision-making process.

Since the 1997 flood, and in response to the IJC recommendations and others such as those arising from the International Flood Mitigation Initiative (IFMI), significant investments have been made in the basin to better understand flooding along the Red River, to protect communities, and to develop partnerships amongst governments, the private sector, and non-profit organizations to address flood damage and mitigation concerns. Governments at all levels have made changes in flood-related policies, new programs and changes to existing ones have been established, research continues into many aspects of flooding, and new institutions such as the Red River Basin Commission have been established. Not only major floods such as that of 1997, but also smaller tributary floods have been the focus for attention.

In June 2001, the United States and Canada directed the IJC and its newly formed International Red River Board (IRRB) to monitor progress by governments in implementing the recommendations contained in *Living with the Red* (International Joint Commission 2000), and to provide encouragement for continued cooperative, innovative, and integrated watershed management approaches. In January 2003 the IJC requested that the IRRB provide a written report on what has been accomplished. As it was then almost six years since the Red River flood, this appeared to be an opportune time to take stock of what has been achieved.

One approach to this stock-taking was to conduct a survey of agencies having an interest in flood preparedness and mitigation in the Red River basin. The survey was aimed at providing a consolidated overview of the nature and extent of flood related activities since 1997. In this way the International Red River Board could lend its support and influence towards continued preparedness and mitigation activities in the basin.

The survey was conducted for the International Joint Commission's International Red River Board by R. Halliday & Associates Ltd. in co-operation with the Canadian Water Resources Association. Funding for the work was made available by the Canadian Departments of Western Economic Diversification and of the Environment. The results are reported in R. Halliday & Associates (2003). The report is available on the International Joint Commission’s website.

In 2006 the Red River basin experienced the fifth largest flood to that time in the approximately 100-year instrumental record. Despite the significance of this flood, there were only minor disruptions and damages were small. This demonstrated a considerable improvement in flood resiliency in the basin since the 1997 event. In 2009 a flood whose peak was second only to that of 1997 in the instrumental record struck the Red River basin. (Preliminary indications are that the 2009 flood volume exceeded that of 1997 in the lower basin.) Managing this flood proved more difficult than managing the 2006 flood, particularly in upper basin communities such as Fargo and Moorhead, where the 2009 event became the flood of record. Severe ice conditions in some reaches north of Winnipeg led to record high water levels. Nonetheless, although flood-fighting costs were significant, actual damages were relatively small compared to what they might have been in the absence of measures taken following the 1997 flood.

Large Red River Floods

1826
1997
1852
2009
1861
1979
1950
1996
2006

(based on measured or estimated peak water level at Morris, MB)

In 2008 the IRRB concluded that another examination of the legacy of the IJC's recommendations on Red River flooding would be timely. This examination would also include the establishment of a database compiling the results of actions taken by governments in response to the recommendations. R. Halliday & Associates Ltd. was engaged to perform this work. Representatives of key agencies were contacted in the course of the work. There were two deliverables from the work: a technical report and the text for a public information brochure.

This report summarizes the findings of the study. The results are presented in the context of the emergency planning cycle of preparedness, mitigation, response and recovery. The report includes an Appendix Two that identifies each recommendation made by the International Joint Commission and each recommendation made by the Commission's International Red River Basin Task Force (IRRBTF) that was endorsed by the Commission without alteration. For each recommendation there is a background statement and a status report. It would be reasonable for the IJC to request that the its IRRB be responsible for periodic updates of this appendix. In addition to describing the legacy of accomplishments the report also discusses remaining challenges and vulnerabilities.

Acronyms and abbreviations used in this report are defined when they first appear. A complete listing can be found in Appendix One.

HOW ARE WE LIVING WITH THE RED

In the course of its work the IJC drew 7 conclusions, made 28 recommendations, and endorsed 2 conclusions and 30 recommendations of the IRRBTF without re-statement (International Joint Commission 2000). For the most part the recommendations deal with preparedness and mitigation in the basin. In the ten years following the 1997 flood there has been a legacy of accomplishments in many areas such as new legislation, increased interjurisdictional cooperation, improved flood protections measures, enhanced flood forecasting, and increased public involvement. These accomplishments are described later in this section.

The spatial extent of the report is confined to the Red River basin as defined in *Living with the Red*. That is, the Assiniboine River and Devils Lake sub-basins are not included. The Assiniboine River, in particular its Souris River tributary, is not covered in the mandate of the IRRB. Although the Devils Lake sub-basin is part of the Red River basin (and falls within the geographic mandate of the IRRB) it has had no natural hydraulic connection to the Red River in the last millennium. After a record low in 1940, Devils Lake is now at its highest level in the instrumental record, exceeding the previous high in 1830 (Upham, 1895).

Although it is geologically incorrect, this report uses the expression Red River Valley to denote the flat central portion of the Red River basin that takes in the Red River mainstem and its floodplain. For the most part, this is the portion of the basin that appears flooded in 1997 satellite images.

All financial figures are expressed as Canadian dollars for Canada and US dollars for the United States. One Canadian dollar was about 90 cents in US currency in early June, 2009.

Policies, Legislation and Institutions

In 2008, Canada introduced its first national mitigation strategy (Public Safety Canada 2008). The strategy includes a number of priority actions. It also provides an opening for federal contributions for flood mitigation measures.

Changes in data policies by the Canadian federal government, particularly Environment Canada, and by the Manitoba government have led to a better-informed public. Environment Canada climate, streamflow and sediment data are now available for download from departmental websites.

Manitoba has introduced a new designated flood area regulation. The associated elevation and inspection requirements for new structures will reduce future flood damages. The province has also introduced new emergency management legislation and legislation for Red River Floodway expansion.

In the United States, policy changes by the Army Corps of Engineers (USACE) are aimed at a more integrated basin-wide consideration of projects. Activity by the Minnesota Red River Watershed Management Board and its North Dakota counterpart, the Red River Joint Water Resource District, also seeks more integrated approaches.

Both North Dakota and Minnesota have implemented new state building codes that include flood-proofing measures.

Key institutional developments include the formation of the International Joint Commission's International Red River Board (IRRB), the Red River Basin Commission (RRBC) and the International Water Institute (IWI, formerly the Red River Basin Institute). The IRRB is an advisory board to the IJC. This 18-person board is co-chaired by representatives from the United States and Canada and is tasked, among other things, with monitoring the status of the IJC's recommendations pertaining to Red River flooding.

Flood Preparedness

Flood preparedness includes developing a plan for emergency operations, identifying available resources that can be tapped during a disaster, delivering integrated training programs and exercises, and practicing the actions outlined in national, regional or local emergency operations plans. Flood forecasting capability and development of databases to support that capability are a fundamental requirement of flood preparedness. The recommendations pertaining to flood preparedness are shown below.

IJC Conclusions	IJC Recommendations	TF Recommendations*
1, 6, 7	8, 17-19, 22, 26	2, 16-19, 26, 30, 35-40, 44, 46, 48, 50

Emergency Plans. Following the 1997 flood North Dakota passed legislation specifically requiring cities, townships and counties to address natural and man-made hazards in their comprehensive emergency plans. Each county must maintain an emergency management organization; cities must maintain an emergency management organization or participate in the county organization.

Minnesota Emergency Management has requirements for emergency plans and for exercising these plans.

Flood preparedness meetings are conducted in late winter with state and local officials to update local, state, and USACE Flood Response Plans. These meetings review how flood response is coordinated through the county to the respective State Division of Emergency Management for the allocation of state and USACE flood response resources.

* Task Force recommendations endorsed but not restated by the IJC

Manitoba has rewritten its emergency legislation since 1997. All communities are required to have an emergency response plan. The plans take an all-hazard approach. These plans are submitted to the Manitoba Emergency Measures Organization for review on a four-year cycle. Each community is required to conduct exercises every 14 months. All 198 Manitoba communities have approved plans and all have designated emergency coordinators. In smaller communities these coordinators may be volunteers or shared with an adjacent community.

In Canada Public Safety Canada (PSC) administers the Joint Emergency Preparedness Program (JEPP) to assist communities in improving their readiness and response capabilities for all types of emergencies. Since 1997, PSC has provided funding through the JEPP to enhance "all hazards" response capabilities of several Red River Basin communities. In 2009-2010 there will be 23 JEPP projects funded in Manitoba, many of which pertain to the Red River basin.

Databases. Significant improvements have been made in databases in the years following the 1997 flood. These improvements include not only new data but also much improved data distribution.

A lidar-based digital elevation model (DEM) has been prepared for the entire Red River floodplain from the international boundary to Winnipeg and from Winnipeg north to the Red River delta. In the United States lidar DEMs are available for the lower Pembina basin, Wahpeton, an extensive area south of Fargo, the Sheyenne River valley and an area in the lower Wild Rice River near Ada MN, and a small area in Wilkin county, MN. The International Water Institute is working with partners to develop a non-proprietary high resolution DEM for the entire United States portion of the basin. About one-half of the required lidar data have been acquired, but not processed. These lidar data have been supplemented by surveys of roads and railways. An accurate topographic database is fundamental to preparation of detailed hydrological and hydraulic models for the basin.

About 70 percent of all individual residences and businesses in the Canadian portion of the basin have been geo-referenced using Global Positioning System (GPS) technology and the nature of their flood protection works entered into a database. This database does not include structures within ring-diked communities. As well, all groundwater wells (including abandoned wells) in the valley have been inventoried and geo-referenced.

Many layers of spatial data have been made available in GIS-ready formats through federal or state websites. Major efforts have been devoted to creating national spatial data infrastructure that facilitates data sharing among data custodians and users. This requires a common framework data, metadata standards and web protocols. This work is led by the Federal Geographic Data Committee in the United States and Natural Resources Canada in Canada. Basin specific examples of spatial data portals include the Minnesota Data Deli (http://deli.dnr.state.mn.us/index.html), North Dakota's GIS Hub (http://www.nd.gov/gis/)and Agriculture Canada's National Land and Water Information Service (http://www4.agr.gc.ca/AAFC-AAC/display-afficher.do?id=1226330737632&lang=eng). Other basin specific data can be found

through the Red River Basin Decision Information Network RRBDIN (http://www.rrbdin.org/)

Throughout the IJC study there was a marked difference in data availability between Canada and the United States. Organizations such as the US Geological Survey have had a long history of making historic and current data freely available to users. Since 1997, Environment Canada has made its historical hydrometric (HYDAT) and climate data available for download via the Internet. Current water level data and streamflow from 1200 sites are now available in real time. Manitoba has also taken steps to make its data more readily available, with the Internet being the preferred method of distribution. As Canadian data have become more readily available, so has the development of sophisticated data portals aimed at meting public demands for both basic data and information products. To some extent Canadian data providers are still playing 'catch-up'.

Flood Forecasting. The US National Weather Service (NWS) has implemented significant changes in its flood forecasting methodology since the 1997 flood. A sophisticated set of improvements to the Sacramento model have been implemented based on the Advanced Hydrologic Prediction System (AHPS). By better quantifying the risks, AHPS has the potential of providing more effective early protection, reducing the number of emergency actions that weren't needed, decreasing the chance of missing emergency actions that are needed, and assisting the USACE with emergency levee freeboard design.

In 1999 the NWS implemented the FLDWAV hydraulic model for flood routing. A further 161 cross-sections were added to the model in 2005, bringing the total to 554.

In 2002 Manitoba Water Stewardship implemented a Mike-11 hydraulic model for flood routing in the Manitoba portion of the basin. A decision support system that allowed rural residents to obtain a personalized forecast of spring flood elevations and the emergency measures that are required to protect property was implemented. Maintaining this system later proved too expensive, and it was discontinued. (As will be discussed later in this report, nearly all rural residents in Manitoba have diked, raised or moved their structures to reduce flood risk.) A similar system has been developed on a pilot scale in Minnesota.

Improvements to the hydrometric and climate monitoring networks were made in both countries. The continuing challenge will be to maintain the expanded networks as operating costs increase. There is still a need for improved snow water equivalent, frost penetration and rainfall data. Since the 1997 flood, snowfall monitoring by Environment Canada has been reduced as few meteorological observers for the climate monitoring network remain. (Automatic stations tend to produce poor snowfall information.) Following the 1997 flood, gauging stations in both countries were improved so that they would withstand high water levels. During the 2009 flood, gauging stations continued to operate throughout the flood.

The NWS and Manitoba Water Stewardship have both taken steps to increase public engagement in the spring flood forecasts. A heightened level of collaboration between the two organizations was implemented successfully in 2006 and continued in 2009. This will be continued for future significant events. The challenges of effectively communicating flood forecasts to the public and ensuring the appropriate public response remain.

Forecasting the 2009 flood posed some particular challenges on account of the early snowmelt, which was then followed by several weeks of cold weather. Determining how much snow had melted, how much water lay in temporary storage, and current conditions for soil moisture and frost penetration made forecasting the second peak difficult.

Red River flood forecasts could be further improved through better determination of winter snowfall and improvements to soil moisture modelling

Map modernization. The US Federal Emergency Management Agency (FEMA) has instituted a national map modernization program. The program makes current information available in digital, geographic information system (GIS) compatible form. The Digital Flood Insurance Rate Maps (DFIRM) used in the National Flood Insurance Program replace paper maps and provide greatly enhanced flood-related information. Although some Canadian provinces have digitized flood risk maps, these products are not GIS compatible.

Flood Mitigation

Mitigation can be defined as sustained action that reduces or eliminates long-term risk to people and property from natural hazards and their effects. It encompasses a suite of activity by government and non-government organizations, as well as by individuals, aimed at reducing the occurrence or the effects of a disaster. The recommendations pertaining to mitigation are shown below.

IJC Conclusions	IJC Recommendations	TF Recommendations
2-5,	2-7,9,10,11,12,13,14,16	3-7,10-12,15,23,29

In a floodplain management context, policies and regulations identify the floodplain and determine what may be constructed in a floodplain and under what circumstances. Policies and regulations may also cover the construction of flood mitigation measures aimed at reducing flooding or the effects of flooding. They may therefore be structural or non-structural in their application.

Structural Measures. Many structural measures have been undertaken in all parts of the basin since 1997. The two largest projects were the expansion of the Red River Floodway at Winnipeg and the construction of flood-proofing levees at Grand Forks and East Grand Forks.

In Manitoba south of Winnipeg, 13 community dikes were constructed or raised. A total of 1,742 homes, farmsteads or businesses were raised, diked or relocated under the terms of a federal-provincial agreement. This represents 95 percent of the eligible structures. During the 2009 flood no farmhouses south of Winnipeg were flooded although some out buildings were.

The city of Winnipeg had an extremely close call in 1997. As an interim measure, the Red River Floodway inlet control structure was refurbished, and two notches opened in the east embankment to improve the hydraulic characteristics at the floodway entrance. A preferred option (floodway expansion) for reducing Winnipeg's vulnerability to rare floods was identified and a federal-provincial cost-sharing agreement negotiated. The Manitoba Floodway Authority was established to execute the project. The overall project will cost $665 million and provide protection against the 1:700 flood (KGS Group, 2001).

The floodway expansion project is on track for completion in 2011. The general approach has been to widen rather than deepen the existing floodway because of public concerns regarding effects on groundwater wells. The excavation is complete, railway bridges are nearly complete, two highway bridges remain to be completed by 2010, the West Dyke is 80 percent complete, and the modifications to the inlet structure will be completed in 2011. The completed project will be monitored for eight years to ensure conformance with performance, environmental and social goals. *The Red River Floodway Act*, 2004 contains provisions related to compensating landowners for artificial flooding caused by floodway operations.

In addition, Winnipeg is making about $100 million in improvements to its primary dikes and pumping stations to improve the reliability of the city's internal flood protection system and to protect it to a water level associated with the legislated Flood Protection Level. This work is about 25 percent complete. Some secondary dikes within Winnipeg have been refurbished and new ones constructed.

In the United States, efforts have been directed to increasing storage in the upper basin and to diking. A co-operative storage project with the USACE, North Dakota State Water Commission, Sheyenne River Joint Water Resources District, and local interests for increasing storage at Baldhill Dam on the Sheyenne River and construction of a dry dam on the Maple River have been completed. (A dry dam allows the river to flow freely and impounds water only during floods.) A Natural Resources Conservation Service *Watershed Protection and Flood Prevention Act* (PL 83-566) project will increase storage upstream of Grafton, ND by a dam on the Middle Branch of the Park River. (The act provides technical and financial assistance to states, local governments and tribes for watershed projects.)

The flood protection project for Grand Forks and East Grand Forks consists of 30 miles (48 km) of levees on both banks of the Red River and 3 miles (5 km) of floodwall at East Grand Forks. The East Grand Forks project also protects against the Red Lake River. To accommodate the levee setback and reduce the number of homes and businesses at risk,

over 1,000 structures were removed from the floodplain. The project included stabilizing an existing dam, removal of a former railway bridge, construction of interior flood control features, 24 pump stations, numerous road and railway closures, and two diversion channels. The project, which is essentially complete, cost $409,300,000. The flood protection level is considered to be 1:250. The project has been certified as providing 1:100 year flood protection in accordance with FEMA's National Flood Insurance Program.

The process by which mitigation projects become certified flood-proofing projects in the United States is an important one. Certification is important to the peace of mind of individual homeowners and, because it affects national flood insurance premiums, is financially important. Certification is accomplished at the request of the local community with engineering aspects being covered by the USACE and administrative aspects by FEMA.

Wahpeton, ND and Breckenridge, MN lie at the confluence of the Bois de Sioux and Otter Tail rivers, the beginning of the Red River. Wahpeton had a close call in 1997 but its emergency levee held. On the other hand, Breckenridge's levees were overtopped twice in 1997, first from the north then from the south. Most of the community was flooded causing damages of $30 million. A flood risk management study of the two communities led to two separate but dependent projects. The Breckenridge project consists of a high-flow diversion channel north of the Otter Tail River and two permanent levee reaches that protect all of the community. The Wahpeton project consists of a permanent levee system and flood easements. The flood protection level is considered to be 1:125. The estimated cost of the Breckenridge project is $36.4 million and the Wahpeton project $17.6 million. The diversion at Breckenridge was completed in 2005 and is considered to have prevented $26 million in damages during the 2006 flood. One levee construction project will get underway in 2009; the second will be constructed in subsequent years as funding allows (DNR Waters, 2009). Other works completed at Breckenridge include removal or replacement of 132 flood-prone structures, construction of 14 pumping stations, 3.5 miles of dike and 2 miles of floodwall, relocation of lift stations and protection of the water treatment plant.

At Fargo about 3,500 feet (1,070 m) of USACE levee and three small cutoff channels were constructed in 1963. For the most part, however, the city depended on emergency earthen and sandbag levees for protection against very large floods, like those in 1997 and 2009. Moorhead in 1997 had no permanent federal flood control project. Analyses following the 1997 flood indicated that the 1997 flood was a 1:70 event at Fargo and that the 100-year flood was about eight percent larger than previously determined. There was therefore a need to improve flood protection for both Fargo and Moorhead. Construction of a floodwall to protect the Department of Veterans Affairs hospital is complete. A USACE levee project for a portion of Fargo between 15th and 22nd Avenues North is under construction. Other flood damage mitigation measures that have been completed include the removal of up to 70 flood prone structures, relocation of lift stations, preventing infiltration into the sanitary system, and others.

A feasibility study of flood risk management measures for the entire Fargo-Moorhead area began in September 2008. A $161 million proposed project in Fargo known as the south-side flood control project may be part of that protection. Moorhead has acquired and moved 20 flood-prone structures, raised levees, installed gate valves on storm and sanitary sewers to prevent infiltration, installed seals and valves on flood plain houses, and constructed concrete lined storm sewers to convey internal drainage (Lokkesmoe, 2007). Both a levee project, which would include elements of the south-side project, and a diversion project in Minnesota have been identified as possible options to protect Fargo-Moorhead. The required project will doubtless cost several hundred million dollars.

The Buffalo–Red River Watershed District is managing a project in Oakport Township (north of Moorhead) including acquisition and removal of a number of floodprone structures, construction of a levee, and a water control structure in Oakport Slough. Nearly 350 homes will be protected to at least the 100-year flood level when the project is complete. Land acquisition is nearly complete (26 homes to date) and design, engineering and construction phases of the levee and control structure are ready to commence upon funding availability. State funding to complete the project is estimated to be approximately $12 million (DNR Waters, 2009).

The entire city of St. Vincent, MN (across the Red River from Pembina, ND) is in the 100-year floodplain. The city has completed levee repairs and is completing geotechnical and design work on a proposal to raise and partially relocate an existing levee. It is estimated that an additional $2.5 million in state funding will be required to complete construction (DNR Waters, 2009).

A Natural Resources Conservation Service PL 83-566 project was recently completed for the city of Warren, MN on the Snake River and is operational. It consists of an upstream, off-channel impoundment, dikes, and a high flow diversion channel rerouting flood flows around the city, protecting 520 homes and businesses to at least the 100-year flood level (DNR Waters, 2009).

Since the 1997 flood, North Dakota has spent $291,444 on residential/farmstead ring dikes. The state provides a 50 percent share of the cost of such projects up to $40,000. Rural diking projects aimed at protecting individual land holdings have been completed in the Rush River, Walsh County, Richland County and Grand Forks County water resources districts in North Dakota. Renewed interest has been showed in the Maple River, Southeast Cass and Traill County water resources districts. Several communities along the Red River (including Pembina, Drayton, Grand Forks, Fargo, Briarwood, Oxbow, and Wahpeton) took advantage of Hazard Mitigation Grant Program funding following the 1997 flood to purchase and remove homes from the floodplain.

In Minnesota some $4.5 million has been made available on a 50 percent cost share basis for the construction of farmstead ring dikes. Construction of 265 rural ring dikes protects farmsteads, livestock, machinery and stored agricultural commodities. Since the 2009 flood there has been a renewed interest in farmstead ring dikes, particularly in the upper

basin. Small-scale impoundment projects have been constructed in Minnesota. Some of those include the Agassiz Valley, North Ottawa, Brandt- Angus, Euclid East, Riverton Township, Manston Slough, Hay Creek-Norlund projects. Several more are in the planning/feasibility stages.

In summary, significant projects have been completed or are under development in virtually all of the flood prone communities in the Minnesota portion of the basin. The USACE has substantially completed construction for a Cookston, MN flood control project, currently completing design of a Roseau, MN project, and completing a feasibility and environmental study for a levee project at Ada, MN. Additionally, there are a number of ecosystem restoration projects that have been completed through the Red River mediation process--North Ottawa impoundment, Aggasiz impoundment, and Hay Creek - that have incidental flood damage reduction benefits.

At this time, the only larger communities lacking in significant structural mitigation measures are Fargo-Moorhead, Drayton, ND and Grafton, ND. Some other towns on tributaries, including Valley City and Lisbon, proved to be vulnerable in 2009. Given the magnitude of the 2009 flood, there will be a need to review flood risk calculations including the determination of the current 1:100 year flood. There are as well a number of community dikes in the United States that have not been certified as flood protection dikes for flood insurance purposes. Neche, ND is one such example.

Given the recent flooding history on the Red River, structural measures have provided enormous benefits. The levee project at Oslo, MN, for example, cost two million dollars in 1984 and has prevented thirty-one million dollars in damages since, not including the 2009 flood.

Non-Structural Measures. In its study of Red River flooding, the IJC observed that, unlike the United States, Canada has no continuing mitigation policies or programs. Since that time the Canadian Department of Public Safety has developed a National Disaster Mitigation Strategy (NDMS). The Public Safety Minister and his provincial/territorial counterparts approved a National Mitigation Strategy in January 2008. The strategy commits the federal government to using the *Building Canada Fund* (BCF) to support structural mitigation and research. The BCF, administered by Infrastructure Canada, allocates $8.8 billion over seven years to infrastructure projects. The safe and strong communities component includes disaster mitigation. Mitigation projects therefore must compete with a host of other municipal infrastructure priorities. Thus far, the only Canadian flood mitigation project to receive funding from this program is the Red River Floodway expansion.

A key element of non-structural approaches to floodplain management is the definition of a regulatory floodplain and the institution of regulations for the occupancy of that floodplain. In Manitoba the regulatory floodplain is legislated as that occupied by the 1997 flood, which was approximately a 1:100-year flood. The safe building elevation adds 0.6 m (two feet) of freeboard. In North Dakota and Minnesota the regulatory

floodplain is that of the 100-year flood, plus one foot (0.3 m) of freeboard for residential structures.

The 1:100 year flood is considered a reasonable minimum regulatory flood in both the United States and Canada. (Some Canadian provinces use more severe floods at the regulatory flood.) In its review of the 1997 flood the IJC observed that it would be useful to define a larger flood, the 1:500 flood, and use that flood to assist in locating critical facilities such as schools and hospitals. The 1:500 year flood has been defined for the Red River mainstem, but the water surface elevation and flooded area pertaining to that flood is not as well known to basin residents as that pertaining to the 1:100 flood.

All jurisdictions have removed at least some severely at-risk structures from the floodplain. Minnesota is committed to acquiring and removing flood damaged or flood prone structures from the floodplain and to protecting remaining structures. Sixty-three of the most vulnerable structures in Manitoba south of Winnipeg were purchased from owners and removed from high hazard areas. Following the ice jam floods north of Winnipeg in 2009, some 200 flood-prone properties have been identified as potential buy-out candidates (Free Press, 2009).

At the same time that vulnerable dwellings were being removed from the Red River floodplain, some were being added in areas such as Oakport Township near Moorhead, MN. It would be useful to examine the number of new dwellings constructed since the 1997 flood and identify how many of these required emergency flood protection in 2009. In the United States portion of the basin, the degree to which flood insurance had been taken up by homeowners in the Red River Valley may be instructive. This analysis would point to any floodplain policy gaps.

Another non-structural measure was a project by the Red River Basin Commission, with cost sharing from the Red River Basin Commission, Province of Manitoba, ND Red River Joint Water Resources District, ND State Water Commission, and MN Red River Watershed Management Board aimed at implementing a single Mike-11 unsteady flow model from the headwaters of the Red at Lake Traverse to Lake Winnipeg. The Mike-11 model is one of several proprietary models developed by the Danish Hydraulics Institute.

An unsteady flow HEC-RAS model of the Red River mainstem has also been developed. The HEC-RAS model was developed by the USACE as a public domain model and is widely used in both the United States and Canada.

Under a federal-provincial agreement, a more complex unsteady flow model was developed to examine wind set-up and wave uprush in the 'Red Sea' – the 40 km (25 mile) wide floodplain south of Winnipeg. The Telemac-2D model extends from the international boundary to Winnipeg. It was used to calculate the effects of wind and waves at the Red River Floodway inlet control structure and the effects of existing dikes on local water levels. Another Telemac 2-D model is now being applied to the lower Pembina River basin from Walhalla to the Red River to study the flooding problems in that area.

These models may be used for planning studies for flood control projects. The effects of tributary storage on main stem flood levels will be a primary application. Such models allow an analysis of tributary peak timing on mainstem water levels, analysis of the effects of various structural measures such as dikes on local water levels, and a determination of the increase in water levels due to encroachment on the floodplain by, say, fill for residential construction.

One specific application of the hydraulic model was an examination of the Waffle® project. The project modelled distributed storage options using a SWAT hydrological model and determined peak flow reductions using HEC-RAS (Kurz *et al*., 2008).

Response/Recovery

Response involves the coordinated actions taken during or immediately following a flood when people may have been injured or lives lost, major damage has occurred to public and private property, and essential utilities and supply sources are disrupted. Emergency response takes place at the level appropriate to the emergency. The first line of response is local government, then state/provincial, then federal. Response/recovery recommendations are shown below.

IJC Conclusions	IJC Recommendations	TF Recommendations
	15	25

Following a disaster, the recovery phase attempts to restore all systems to normal or near normal condition. Long-term recovery from a disaster may go on for years until the entire disaster area is completely redeveloped; either as it was in the past or for entirely new purposes that are less vulnerable to disaster. The cornerstone of the recovery process is disaster financial assistance. This alleviates an unreasonable financial burden and is generally provided to help local governments, individuals, full-time farmers, small businesses and some non-profit organizations. There is, off course, a human cost in all disasters and the focus of any recovery program must be to promote community resiliency so that individuals and communities are better able to cope with the next disaster.

For the most part, government agencies charged with response and recovery, have not made major changes as a direct result of the 1997 flood. The emergency plans developed in the years following the 1997 flood have enabled more timely and co-ordinated responses to disasters. Efforts have been made to deliver financial assistance in a more timely fashion.

There has been a hiatus in Canada-United States consultation on civil emergency planning and management pertaining to natural hazards following a meeting of the Prairie Region Emergency Management Advisory Committee (PREMAC) in December 2001. More recently, two exploratory meetings were held in the last 18 months.

The current 'hardening' of the international boundary makes it more difficult to move personnel and materiel across the boundary to seamlessly respond to flood fighting needs. On the other hand, the stationing of a Predator drone aircraft in Grand Forks may provide new opportunities for real time flood monitoring.

Environment

Some IJC and Task Force recommendations apply specifically to the environment. These may also have a bearing on public health and well-being. The recommendations are shown below.

IJC Conclusions	IJC Recommendations	TF Recommendations
4	23	32,34

Lake Traverse. The risk of biota transfer through the hydraulic connection between the Little Minnesota River and Red River systems at Lake Traverse continues. This is a natural connection between the Hudson Bay and Mississippi basins. The USACE dam safety reconnaissance study for the White Rock Dam, which controls the pool elevation of Lake Traverse during large flood events, has considered the potential for inter-basin flows. Although this is a high priority item from a transboundary perspective, there has been little recent activity. Resolution of the problem is linked to flood control measures for Browns Valley, MN.

Groundwater. The IJC identified a problem with the contamination of groundwater wells in Manitoba. Since the 1997 flood, an inventory of active and abandoned wells in Manitoba was completed and the wells subject to surface flooding were sealed. Minnesota and North Dakota had regulations concerning abandoned wells in place prior to 1997 (Scherer and Johnson, 2007).

Hazardous Goods. Storage of hazardous goods, even banned substances, in the floodplain was another issue of concern after the 1997 flood. Manitoba Environment is undertaking consultations concerning on-farm storage of hazardous chemicals and safe disposal of household hazardous waste. The province maintains inventories of many types of contaminants and has consolidated these into a single database.

Prior to the 1997 flood Manitoba based its regulations concerning dikes around sewage lagoons and other hazards on a previously-defined 100-year flood. The regulations are now based on the area inundated in 1997 – a higher elevation.

The ND Division of Emergency Services (DES) has had discussions with the North Dakota-based chemical industry with emphasis on awareness of the inventory of hazardous chemicals in the floodplain, encourage reduction of chemical inventory in the floodplain, encourage flood protection efforts, and encourage relocation of hazardous chemicals in anticipation of flood events. DES has coordinated with ND Department of

Agriculture to hold periodic collection and disposal efforts for getting rid of banned and obsolete chemicals in flood-prone areas under Project Safe Send. Some 91,000 lbs. of chemicals were collected in the months following the 1997 flood. A brochure has also been produced on flood-proofing of above-ground storage tanks. The MN Department of Agriculture regulates storage of farm chemicals.

Lake Winnipeg. The 1997 flood led to a significant loading of nutrients into Lake Winnipeg. Several programs are aimed at improving scientific understanding of Lake Winnipeg and to reducing nutrient loadings to the lake. In 2003 Manitoba announced a plan to reduce nitrogen and phosphorous loads to Lake Winnipeg to pre-1970s levels. The plan is aimed at protecting riparian growth along the Red and Assiniboine rivers, ensuring appropriate fertilizer application, introducing new effluent regulations, reducing shoreline erosion on Lake Winnipeg, and engaging other jurisdictions in Lake Winnipeg nutrient management. As a federal contribution to meeting the challenges to the sustainability of Lake Winnipeg ecosystems, recent federal budgets have allocated $18 million to a Lake Winnipeg Basin Initiative. Through federal-provincial mechanisms, federal funding will be directed to reduction of harmful algae blooms, improved recreational water quality, restoration of the ecological integrity of Lake Winnipeg, and a sustainable fishery. Federal funding will support research, information and monitoring, and facilitate governance and stewardship.

During the 1997 flood, a quantity of a banned substance, toxaphene, was released from storage. Manitoba Water Stewardship in partnership with Fisheries & Oceans Canada have been monitoring toxaphene concentrations in fish tissue for Lake Winnipeg for a number of years. Concentrations have declined since 2002 and are now less than Manitoba Water Quality Standards, Objectives and Guidelines for both human and wildlife consumers.

Riparian Zones. The IFMI process has led to a renewed interest in preserving and enhancing riparian zones. Several developments throughout the basin are pertinent. The Greenway on the Red Inc. has been organized to "promote the development of a greenway system on the Red River of the North and its tributaries that mitigates floods and protects people through education and partnerships that enhance the economy, environment and communities of the Red River Basin."

The greenway will provide multiple on-the-ground benefits through riparian restoration; water quality enhancement; farmer/landowner incentives; community strengthening; and increased recreation, tourism, and economic development. The greenway project is supported in the United States by, among others, grants from the USEPA and FEMA. Winnipeg has an on-going program to acquire riverbank property for greenway and park purposes. This sometimes involves the removal of structures (houses and businesses) from the floodplain.

Examples are greenway development in Grand Forks and East Grand Forks, proposals for considerable urban park development along the Red River Floodway at Winnipeg, and the interest in set-back levees for the lower Pembina River. The new Dean C. Hildebrand

Wildlife Management Area located on the Red River near Drayton provides two miles (three kilometres) of shoreline habitat management. Greenway on the Red Inc. is a multi-state and international effort to establish a greenway from Lake Traverse to Lake Winnipeg. The task is about one-quarter complete. The Canadian partner is Rivers West, a Manitoba organization aimed at conserving natural, cultural and heritage resources. The entire Red River in Canada became part of the Canadian Heritage Rivers System in 2007 (Hilderman, Thomas, Frank, Cram, 2005).

The USACE is pursuing several environmental and flood damage reduction projects that protect or enhance the floodplain environment. These include fish passage over existing dams on the Red River and several tributaries; partial restoration of hydrological and floodplain conditions along the lower reaches of Hay Creek in Roseau County; establishment of an urban greenway with the construction of the Grand Forks/East Grand Forks flood control project; and the restoration/ enhancement of floodplain functions along 15 miles (24 km) of the Wild Rice River below Ada through the setback of existing agricultural protection levees and re-meandering of the channelized river.

The Red River Basin Commission has assisted various groups in Minnesota and North Dakota in developing a Red River Conservation Reserve Enhancement Program (CREP). Measures such as buffer strips, wetland restoration, river corridor restoration and setback levees are contemplated. Minnesota has applied these types of programs more than North Dakota.

The Minnesota Mediation Agreement, signed December 9, 1998, is the product of eight months of consensus-based, mediated negotiations by the Red River Basin Flood Damage Reduction Work Group. The agreement is intended as the framework for a new, collaborative approach to implementing both flood damage reduction and natural resource protection and enhancement in the Red River Basin in ways that will benefit all Minnesota's citizens. The keys to this new approach are clearly identified goals related to both prevention and reduction of damage, comprehensive watershed planning, early consultation and collaboration on flood damage reduction projects among stakeholders, and a cooperative approach to state-level permitting of those projects.

The Red River Basin Riparian Project, funded by a USEPA grant, is a land management and water quality project that seeks to improve riparian areas through influencing land management decisions. Eight demonstration sites are being established in the basin. Manitoba has also announced tax reduction measures for landowners in riparian zones as a water quality improvement measure aimed at reducing agricultural runoff.

The Louisville/Parnell Impoundment project in the Red Lake Watershed District controls breakout flows and assists wetland restoration. The project consists of an earthfill structure and three wetlands units.

Winnipeg's standard tender document requires adherence to specified environmental protection measures, as well as best management practices for such things as fuel handling and storage, waste handling and disposal, dangerous goods, emergency spill

response, protection of trees, sediment control, etc. Re-vegetation of riverbank and construction of pool and rifle structures on streams are two examples of the types of "compensation" works that are undertaken to meet the requirements of the federal Department of Fisheries and Oceans (DFO) for flood protection works and associated riverbank works that are considered as "harmful alteration, disruption or destruction of fish habitat".

CURRENT STATUS, CHALLENGES AND VULNERABILITIES

More than ten years after the 1997 flood it is evident that much has been accomplished to increase awareness of flood threats in the basin, determine specific flood risks, and mitigate the effects of large floods. This section of the report will provide a status report on each of the IJC Recommendations. It will then go on to discuss the remaining challenges and vulnerabilities.

Status of Recommendations

The IJC made 28 recommendations to governments in *Living with the Red* and endorsed and did not restate a further 30 Task Force Recommendations. In framing its recommendations the IJC stated not only what should be done but also who should do it, and sometimes when it should be done. The IJC also drew seven Conclusions and endorsed a further two Conclusions by the Task Force. All of these have been accepted, some with qualifications, and the status of that acceptance has not changed.

Making an overall determination of progress on some recommendations is also confounded by, in some cases, differing achievements in each country. A five-point scale has been used to identify progress. The scale used in defining progress on the recommendations is as follows:

- Superceded. This applies to a few recommendations that appear to have been overtaken by events and are no longer being pursued.
- Little or No Progress. This applies to cases where a required policy decision does not appear to have been made, where no discernable progress has been reported, or perhaps where meetings have been held but with little effect.
- Some Progress. This applies where there has been activity to meet the recommendation but significant impediments remain before the recommendations can be completed. This includes cases where policies directions are clear but where substantial financial impediments remain.
- Significant Progress. This applies where the completion of the recommendation can be reasonably foreseen.
- Complete. The recommendation appears to have been accepted and implementation is complete. In cases where completion is immanent a completion year is given.
- Ongoing. The recommendation will live forever and is being pursued

Table 1 summarizes the progress on the IJC recommendations, while Figure 1 illustrates the progress. Each recommendation is covered in more detail in Appendix Two. Needless to say the status represents a value judgment by this writer.

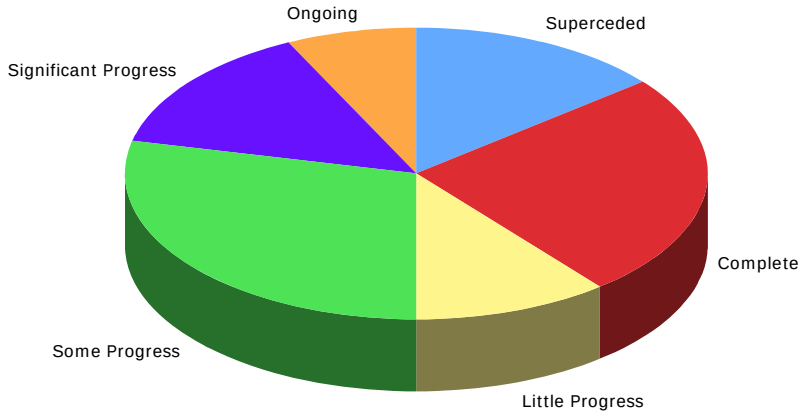

Figure 1. Status of IJC Recommendations.

Table 1. Status of IJC Recommendations

Recommendations from IJC Report		Status
1	The federal governments should convene a meeting of senior federal, provincial and state officials in 2002 to undertake policy discussions and an examination of the 1997 flood, with emphasis on review of emergency plans, evacuation procedures and mitigation measures underway.	Super-ceded
2	The design flood used as the standard for flood protection works for Winnipeg should be the highest that can be economically justified or, at a minimum, the flood of record, the 1826 flood.	Complete
3	The city, province and the Canadian 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.	Complete in 2011

4	The government of the United States, in cooperation with the cities of Fargo and Moorhead and the states of North Dakota and Minnesota, should expedite the study of flood risk potential and implement plans for flood protection measures for the Fargo–Moorhead area.	Some Progress
5	The government of the United States, in cooperation with the cities of Grand Forks and East Grand Forks and the states of North Dakota and Minnesota, should ensure that the planned flood protection works are promptly and expeditiously completed.	Complete
6	The government of the United States, in cooperation with the cities of Wahpeton and Breckenridge and the states of North Dakota and Minnesota, should expedite approval and implementation of flood protection plans to reduce the risk of flooding at Wahpeton–Breckenridge.	Complete in 2010
7	The province of Manitoba and city of Selkirk should expedite studies of flood-risk potential in the Selkirk area.	Complete
8	To improve resiliency in the basin, governments should support enhanced research into the various social dimensions of the flood, including economic, psychological, public health and sociological impacts.	Little Progress
9	Governments at all levels should ensure that in the development of flood mitigation strategies for the basin the needs of small communities, individual isolated farmsteads and agriculture are not overlooked.	Signif. Progress
10	Federal government agencies, in cooperation with the state of North Dakota and the province of Manitoba, should establish a consultative group to work with local interests, including the Pembina River Basin Advisory Board, to resolve the lower Pembina River flooding issue, provide necessary resources for the group, and act to achieve a solution.	Some Progress
11	Governments should develop a binational integrated approach to mitigation initiatives at all political levels, based on a comprehensive mitigation strategy for the entire basin. In the United States, the strategy should be integrated within the overall national framework.	Some Progress
12	The Canadian federal government should establish a national flood mitigation strategy, or a broader disaster mitigation strategy, and support it with comprehensive mitigation programs.	Some Progress
13	Governments should use, at a minimum, the 100-year (1 percent) flood as the basis for floodplain regulations and revise their estimates of the 100-year flood levels based on 1997 and new data that become available.	Complete
14	State, provincial and other appropriate authorities should review the effectiveness of and compliance with the floodplain management regulations in the basin and take steps as needed to improve enforcement.	Signif. Progress
15	Within the current context of Canada–United States cooperation for civil emergency planning and management, governments should develop more detailed bilateral emergency planning and management arrangements with specific adaptations to Red River flooding.	Little Progress
16	Development of the digital elevation model for the Red River basin, with high resolution in appropriate high flood risk areas, should be pursued and completed through collaborative initiatives of federal, state, provincial and local governments.	Signif. Progress

17	Federal, state and provincial governments should develop and implement a binational agreement to establish an appropriate network of hydrological and meteorological stations and data exchange for floodplain management and flood forecasting in the Red River basin.	Super-ceded
18	The governments should authorize the Commission to establish a binational Red River Flood Forecasting Liaison Committee under the International Red River Board to improve interjurisdictional coordination and to help ensure that clear, understandable and compatible forecasts are issued to the public.	Super-ceded
19	As a long term priority, government agencies responsible for flood-forecasting and mitigation measures should develop basin-wide models rather than separate but coordinated models for each country.	Super-ceded
20	The Canadian government should review its data and information management policies to ensure that topographic, hydrometeorological, and other flood related data collected under government programs are made available without restrictions or conditions that limit their accessibility.	Signif. Progress
21	Governments should ensure that progress continues in building a binational, virtual network linking the people, data, and models for the Red River basin.	Some Progress
22	Federal, state, and provincial governments should work with basin organizations to complete in a timely manner the development of a prototype decision support system and establish a cooperative mechanism for coordination and funding its further development and implementation.	Some Progress
23	Governments should take immediate steps to ensure that all banned materials such as toxaphene are removed from the Red River basin. Governments should also ensure that potentially hazardous materials are not stored in the 500-year floodplain, although reasonable quantities of such substances could be maintained in the floodplain for immediate use.	Some Progress
24	Flood protection projects focus not only on reduction of flood damage but also on protection and enhancement of the floodplain environment.	Some Progress
25	Governments immediately take steps, on a binational basis, to begin development of a comprehensive flood damage reduction plan for the Red River basin.	Little Progress
26	Governments at all levels should undertake the following measures: [eight items]	Ongoing
27	Governments should assign the following functions to the International Joint Commission for implementation by the International Red River Board: [eleven items]	Complete
28	The federal governments, in cooperation with the state and provincial governments should work with the Commission and its International Red River Board, as well as with existing and emerging bilateral organizations, to ensure that appropriate arrangements are in place to coordinate and implement measures for flood preparedness and mitigation activities and to implement recommendations of the Commission.	Ongoing

In several cases the IJC endorsed recommendations from its Task Force without re-stating them. The status of these recommendations is shown in Table 2 and illustrated in Figure 2. Each is discussed in more detail in Appendix Two.

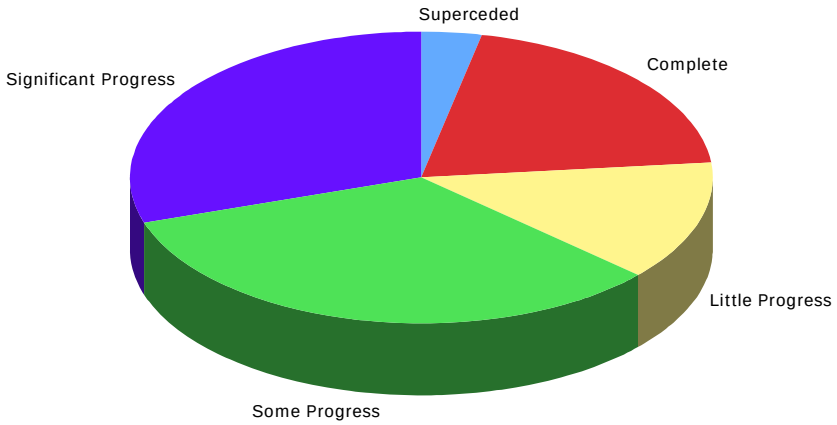

Figure 2. Status of Task Force Recommendations Endorsed by the IJC.

Table 2. Status of Task Force Recommendations Endorsed by the IJC.

Recommendations from IJC Task Force		Status
2	Future ice jam information from the entire basin should be incorporated into the CRREL Ice Jam Database so that ice problems in the basin can be analyzed further. Where feasible, historic ice jams from the Canadian portion of the basin should be entered.	Little Progress
3	Communities in the United States portion of the Red River basin should ensure that community-built flood damage reduction projects are certified by FEMA for 100-year or greater protection, or should participate in the Non-Federal Flood Control Works Inspection Program.	Some Progress
5	Based on results from hydraulic model studies, modify the east embankment of the Floodway to improve the performance of the Floodway entrance to lower upstream water levels and increase capacity.	Complete
6	The west dike should be raised to allow a water level elevation of 778 feet at the Floodway inlet structure with appropriate freeboard.	Complete in 2009
7	The primary diking system should be raised where economically feasible to the elevation specified in existing legislation.	Signif. Progress

Recommendations from IJC Task Force		Status
10	Modifications to the sewer and land drainage systems should be optimized and undertaken once the overall plan for Winnipeg flood protection is determined.	Signif. Progress
11	The city of Winnipeg should give immediate high priority to the preparation of a detailed emergency preparedness and response manual.	Complete
12	Operating rules for new flood control measures should be designed to accommodate all flow regimes, even those beyond design capacity. The public should be consulted on any proposed new operating rules.	Signif. Progress
15	The 500-year flood (0.2 percent flood) should be defined throughout the Red River basin and used to inform the public of the potential risks of flooding from rare events, including the need to buy flood insurance in the United States, and as the basis of regulations for siting and floodproofing critical facilities.	Some Progress
16	Both North Dakota and Minnesota should consider adopting the new International Building Code that includes requirements for design and construction in flood hazard areas.	Complete
17	The National Building Code of Canada should specify design and construction standards for buildings in flood hazard areas such as the Red River basin. Floodplain construction requirements should be incorporated into the Manitoba code when available.	Little Progress
18	Federal, state, provincial and local governments in the Red River Basin, in conjunction with the private sector, should continue to develop, refine and implement effective strategies to improve the disaster resiliency in both communities. Efforts should be made to increase public awareness of flood risks throughout the basin.	Signif. Progress
21	The Canadian federal government should include in the Disaster Financial Assistance Arrangements provisions to allow for the permanent removal of structures in areas subject to repeated flooding.	Little Progress
25	Recovery, rebuilding, and mitigation expertise and information should be widely shared across the border in advance of flooding.	Some Progress
26	Measures of flood resilience should be developed, and a system should be established to monitor resilience in the Red River basin.	Little Progress
28	Given the transboundary nature of the basin and the potential for federal involvement in funding and monitoring any agreement, federal agencies from both countries should be engaged in this process as well	Some Progress
29	Changes in the road network and diking system in the Lower Pembina Basin should be modeled by the hydrodynamic model prior to implementation of any plan to ensure that there are no unintended consequences.	Signif. Progress
30	The virtual database and decision support system prototype that the Task Force has begun to develop for the Pembina Basin should be continued by relevant agencies in Canada and the United States.	Some Progress

32	Any modification to existing operating plans or physical structures associated with Lake Traverse that could increase pool elevation must be accompanied by features that eliminate the southward movement of water into the Little Minnesota River.	Some Progress
34	Governments should continue to monitor toxaphene in the Lake Winnipeg ecosystem until concentrations decline to pre-1997 levels.	Signif. Progress
35	Hydrometric and meteorological data networks necessary for flood forecasting should be improved and maintained in a state of readiness to forecast future floods.	Signif. Progress
36	New geographically related data collection in the United States should be in accord with the North American Vertical Datum of 1988.	Some Progress
37	For consistency and accuracy data used in models should take into account the differences in data at the border. Because datum conversions can affect data accuracy, any conversions between standards should be noted and reported along with the data.	Some Progress
38	U.S. National Geodetic Survey and the Geodetic Survey of Canada should convene a forum of datum experts in the year 2000 to discuss Red River Basin datum issues and develop a long-term transition plan.	Super-ceded
39	All key data providers in Canada should make available at no cost and with no restriction the data sets necessary for the Red River floodplain management and emergency response, and regional or basin-wide modelling activities.	Signif. Progress
40	Data providers should remain responsible for maintaining and replicating the data sets.	Complete
44	The U.S. National Weather Service should implement its Advanced Hydrologic Prediction System in the Red River basin as an early priority.	Complete
46	Confirm the flood peak reduction findings of Chapter 3 for large floods and examine reductions for smaller floods by implementing distributed models on tributaries such as the Mistinka, Wild Rice and Maple Rivers.	Some Progress
48	Conduct surveys of secondary roads, particularly in the central portion of the basin, with differential global positioning systems, and incorporate the results into the hydraulic models.	Some Progress
50	Measures should be taken to ensure that data supporting the operation of the hydraulic models and model outputs can be made widely available.	Signif. Progress

As can be appreciated from Tables 1 and 2, there has been significant attention paid to implementing the recommendations to governments made by the IJC. The expenditures made in the last 10 years exceed one billion dollars on flood mitigation works alone. Additional expenditures will be made. No recommendations have been formally rejected but some have been overtaken by events or essentially ignored.

The recommendations that have achieved the most success are those that involve construction of a structural measure identified in the IJC report, even if that work requires collaboration at the federal, state or province, and local level. A second group of successful recommendations relate to specific recommendations aimed at a specific agency. The improvements to flood forecasting are an example. A third group of

recommendations are those regarding binational approaches to resolving Red River flooding issues. These are complex and difficult and will be discussed in the following section.

Challenges and Vulnerabilities

If present trends in implementing the IJC recommendations continue, within a few years the mainstem communities and individual farmsteads of the Red River Valley will be able to withstand a flood equivalent to the 1997 (2009 in the upper basin) without extensive damage. Based on advanced modelling, residents of the basin will have sufficient warning to protect lives and property. This does not mean that the repetition of such a flood would be a "non-event". There would be interruptions in business on account of transportation and other disruptions, agricultural losses would still take place, and the cost of preparing for very large floods would be significant.

This outcome would be the result of relentless adherence to IJC recommendations related to structural mitigation measures, building databases and improving models. In effect the basin will have been 'hardened' to withstand the 1997 flood or, in the cases where 1:100 year flood is larger than the 1997 event, the 1:100 flood. This would be a remarkable achievement, but could more be accomplished?

The ultimate goal of floodplain management in the Red River basin must be to make the people, infrastructure and institutions of the basin as resilient as possible in the face of damaging floods. One certainty is that, at some time in the future, the basin will face a flood that is larger than the present-day 1:100 year flood. Such a flood could take place on the mainstem or on one or more tributaries. In addition, climate change could lead to damaging ice jam floods, either in the spring or fall, and to summer rain-driven floods. Preparing for the last flood is wise, but may be insufficient. Considering the IJC recommendations that have not been completely adopted may be useful.

The recommendations that have achieved relatively little success are those that involve multiple agencies and, perhaps, multiple objectives. It could be that these sorts of tasks could be deemed to be more difficult and could naturally be expected to take longer. It could also be said that public expectations for structural measures supercede all other post-flood needs and that those expectations need to be met before proceeding with "softer" projects. Most of the media discussion following the 2009 flood has concentrated on flood protection for Fargo-Moorhead, for example.

One particular impediment to progress is the advent of lawsuits among various jurisdictions, for example related to the lower Pembina River. Lawsuits tend to inhibit the free exchange of information and have a profound effect on the ability or willingness of parties to reach consensus on a course of action that could resolve the issue in question.

This writer is of the view that it will take considerable effort to achieve the level of integration and cohesion on flood management that the IJC envisaged. This integration is difficult because individual agencies are confined by their mandates. Processes akin to the IFMI process but dealing with a short list of issues could be required (IFMI, 2000). Significant interagency and intergovernmental cooperation will be needed. It is fortunate that residents of the basin and their political leaders are still seized by the flooding issue. If the Red River basin experiences a decade or more in which no serious flooding occurs, flood preparedness could decline in favour of other priorities.

The 2009 flood, which was the second largest in the instrumental record for much of the basin and a record flood at Fargo-Moorhead, serves two purposes. First, it enables agencies and individuals to evaluate the degree to which measures taken following the 1997 achieved their objectives. In general one can say that these measures have been successful. Secondly, the 2009 flood brought a realization that improving flood resiliency in the Red River basin is a journey, not a destination. Each flood has its unique characteristics and the relatively early timing of the 2009 flood meant that ice played a larger role than in some previous floods. The Red River thus tended to stage higher than usual for a given flow.

Another somewhat unusual characteristic of the 2009 was that, following the first peak, a second major peak was forecast for the upper basin. Had a large peak materialized, it would have found all available storage filled and thus would have provided further stress on emergency measures.

The 2009 flood has made it clear that there are still tasks left undone if flood resiliency in the Red river basin is to be improved. The IRRB may wish to consider a number of next steps. Through the support of members of the IRRB, it should be possible to examine the effects of recent floods on the magnitude of the 1:100 year floods in the basin, review the extent to which post-1997 structures were damaged in the 2009 flood, or verify which communities in the US portion of the basin do indeed have certified flood-proofing levees. These are all actions that flow from the findings of this report.

The IRRB should continue to devote attention to the resolution of the long-standing lower Pembina River flooding issue. In general, because of the transboundary nature of the Pembina and Roseau river tributaries, any matters pertaining to these tributaries are fundamental to the work of the IRRB and to the IJC itself.

Some longer term actions could be addressed through the International Water Initiative as funding will be required. The IRRB could document the nature of flooding in the Red River basin, and whether that nature is changing. This would include consideration of flooding and the environment and of land use issues in the entire basin. The IRRB could consider issues related to flood management governance as a means of examining matters where bilateral approaches would be particularly effective. The IRRB could also consider the development of specific measures of flood resiliency.

Some of the IJC recommendations will not gain traction without a 'champion', or in a select few cases, until the responsible agency agrees to adopt the recommendation. Examples of the latter are the adoption of flood proofing measure in Canada's National Building Code or adoption of a new vertical datum in Canada. In some cases where a champion is needed for broad multi-agency recommendations, the IJC may wish to pursue that role. For example, the IJC should continue to encourage the free flow of environmental data and information in Canada and the United States and to advocate for high quality distributed databases. As well, the IJC should continue to encourage the role of sound science in decision-making.

In considering the way forward, the IJC's International Red River Board (IRRB) should continue to review progress on implementing the recommendations from *Living with the Red* by periodically updating the information in Appendix Two of this report. It is understood that the IJC will make this report available on its website. Consideration could be given to making the headings, Category, Location and Status in Appendix 2 searchable fields so that users could retrieve only the recommendation summaries they are interested in.

The apocryphal quote that the Red River basin has two problems, "too much water and too little" has a firm foundation in reality. In attempting to deal with concerns related to flooding, it is important to determine the consequences of any proposed measures during times of drought. Integrated water resources planning should be the overarching goal for the basin.

ACKNOWLEDGEMENTS

This report was made possible through funding provided by the International Joint Commission's International Water Initiative. Many people provided their insights and assistance in its preparation. Any errors, of course, are the responsibility of the author. The contributions of the following are gratefully acknowledged: Nicole Armstrong, Bob Bezek, Don Brennan, Cameron Buchanan, Craig Evans, Dennis Fewless, Pat Fridgen, Randy Gjestvang, Bob Harrison, Lee Klapprodt, Kent Lokkesmoe, Doug McNeil, Scott Jutila, Mike Renouf, Paul Swenson, Steve Topping, Alf Warkentin and Ted Yuzyk.

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APPENDIX ONE

Acronyms and Abbreviations

AHPS	Automated Hydrologic Prediction System (USNWS)
BCF	Building Canada Fund
CD-ROM	Compact Disk - Read Only Memory
CREP	Conservation Reserve Enhancement Program
DEM	Digital Elevation Model
DES	Division of Emergency Services (North Dakota)
DFA	Designated Flood Area (Manitoba)
DFO	Department of Fisheries and Oceans (Canada)
EERC	Energy & Environmental Research Center (UND)
FEMA	Federal Emergency Management Agency (United States)
FGDC	Federal Geographic Data Committee (United States)
GPS	Global Positioning System
GRT	Greenway on the Red Trust
IFMI	International Flood Mitigation Initiative
IJC	International Joint Commission
IRRB	International Red River Board (IJC)
IRRBTF	International Red river Basin Task Force (IJC)
IWI	International Water Institute (Tri-colleges)
JEPP	Joint Emergency Preparedness Program (Canada)
Lidar	Light detection and ranging
MB	Manitoba
MEMO	Manitoba Emergency Measures Organization
MN	Minnesota
ND	North Dakota
NDMS	National Disaster Mitigation Strategy (Canada)
NRCS	Natural Resources Conservation Service (United States)
PRBAB	Pembina River Basin Advisory Board
PFRA	Prairie Farm Rehabilitation Administration (Canada)
PREMAC	Prairie Region Emergency Management Advisory Committee
PSC	Public Safety Canada
RRBB	Red River Basin Board (now RRBC)
RRBC	Red River Basin Commission
RRBDIN	Red River Basin Disaster Information Network
RRWRC	Red River Water Resources Council (now RRBC)
TIC	The International Coalition (now RRBC)
UNET	Unsteady NETwork
US	United States of America
USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
USNWS	United States National Weather Service
WET	Water Education for Teachers

APPENDIX TWO

Status of IJC Recommendations

IJC Recommendation 1: Senior Officials Meeting		
The federal governments should convene a meeting of senior federal, provincial and state officials in 2002 to undertake policy discussions and an examination of the 1997 flood, with emphasis on review of emergency plans, evacuation procedures and mitigation measures underway.		
Category: preparedness	**Location:** basin	**Status:** superceded
Background: While the governments have been responsive to many IJC recommendations, there is still a need for additional cross-border co-ordination and co-operation on matters such as data enhancement and model development. A senior officials meeting was seen as one step in this process.		
Progress to Date: No single meeting of senior officials was held. One outcome from the International Flood Mitigation Initiative process was to draw governors of Minnesota and North Dakota together with the premier of Manitoba to discuss matters pertaining to flooding. This led to the signing of a Memorandum of Understanding in November 2000. The RRBC has organized further meetings of senior elected officials from the three jurisdictions. In April 2004 the governors of North Dakota, Minnesota, and South Dakota, and the premier of Manitoba signed a Memorandum of Understanding for Flood and Drought Mitigation on the Red River.		
Related Recommendations:		
References: IFMI 2000. *International Flood Mitigation Initiative for the Red River Basin.* Final Report and Executive Summary. The Consensus Council, Bismarck.		
Date: February, 2009		**Revised:**

IJC Recommendation 2: Design Flood for Winnipeg		
The design flood used as the standard for flood protection works for Winnipeg should be the highest that can be economically justified or, at a minimum, the flood of record, the 1826 flood.		
Category: mitigation	**Location:** Manitoba	**Status:** complete
Background: The city of Winnipeg had an extremely close call in 1997. Shortly after the flood the Red River Floodway inlet control structure was refurbished and two notches opened in the east embankment to improve the hydraulic characteristics at the Floodway entrance. A federal-provincial study examined options for improving flood protection for Winnipeg and identified two feasible options: expansion of the existing Red River Floodway and a detention structure at Ste. Agathe. A preferred option (Floodway expansion) for reducing Winnipeg's vulnerability to rare floods was identified. The expanded floodway will provide protection against a 1:700 year year flood, a rarer event than the 1826 flood, which is considered to be a 1:300 year flood.		
Progress to Date: Selection of the Winnipeg flood protection level is complete. For the status of the floodway expansion project, see IJC Recommendation 3.		
Related Information: The 1997 flood was deemed to be a 1:100 year flood at Winnipeg. The large number of inhabitants of the city and the importance of the city to the provincial economy led to the IJC recommendation. The IJC, while agreeing that the Ste. Agathe option would provide the required flood protection level for Winnipeg, considered that this option would not meet tests of public acceptability.		
Related Recommendations: 3-7, 9-14, 16 and TF 3-7, 10-12, 15, 23, 29		
References: KGS Group 2001. *Flood Protection Studies for Winnipeg*. A report to the Government of Canada, Manitoba Conservation and the City of Winnipeg. KGS Group, Winnipeg, MB.		
Date: February, 2009		**Revised:**

Recommendation 3: Flood Protection for Winnipeg

The city, province and the Canadian 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.

Category: mitigation	**Location:** Manitoba	**Status:** complete 2011

Background: The city of Winnipeg had an extremely close call in 1997. The IJC recommended that the city be protected against floods at least as great as that of 1826. A federal-provincial study examined options for improving flood protection for Winnipeg and identified two feasible options: expansion of the existing Red River Floodway and a detention structure at Ste. Agathe. The federal and provincial governments agreed that the Red River Floodway be expanded to provide protection against the 1:700 year flood. (The 1826 flood is considered to be a 1:300 year flood.) The initial cost-sharing agreements for Floodway expansion were signed in 2003.

During the IJC study and other subsequent studies of flood protection for Winnipeg, there was considerable public concern about the social, environmental and human effects of enhancing Winnipeg's flood protection. This related, in particular, to the upstream effects of Floodway operation and the possible effects downstream where the Floodway channel rejoins the Red River.

Progress to Date: The floodway expansion project is on track for completion in 2011. The $665 million project is fully funded by the federal and provincial government. The general approach has been to widen rather than deepen the existing floodway because of public concerns regarding groundwater wells. The excavation is complete, railway bridges are nearly complete, two highway bridges remain to be completed by 2010, the West Dyke is 80 percent complete, and the modifications to the inlet structure will be completed in 2011. The completed project will be monitored for eight years. *The Red River Floodway Act*, 2004 contains provisions related to compensating landowners for artificial flooding caused by floodway operations. In addition the City of Winnipeg is making about $100 million in improvements to its primary dykes and pumping stations.

Related Recommendations: 2, 4-7, 9-14, 16 and TF 3-7, 10-12, 15, 23, 29

References:

KGS Group 2001. *Flood Protection Studies for Winnipeg*. A report to the Government of Canada, Manitoba Conservation and the City of Winnipeg. KGS Group, Winnipeg, MB.

Date: February, 2009		**Revised:**

IJC Recommendation 4: Flood Protection Measures – Fargo-Moorhead		
The government of the United States, in cooperation with the cities of Fargo and Moorhead and the states of North Dakota and Minnesota, should expedite the study of flood risk potential and implement plans for flood protection measures for the Fargo–Moorhead area.		
Category: mitigation	**Location:** North Dakota, Minnesota	**Status:** some progress
Background: At Fargo about 3,500 feet (1,070 m) of USACE levee and three small cutoff channels were constructed in 1963. For the most part, however, the city depended on emergency earthen and sandbag levees for protection against very large floods, like those in 1997 and now 2009. Moorhead in 1997 had no permanent federal flood control project. Analyses following the 1997 flood indicated that the 1997 flood was a 1:70 event at Fargo and that the 100-year flood was about eight percent larger than previously determined. There was therefore a need to improve flood protection for both Fargo and Moorhead.		
Progress to Date: Construction of a floodwall to protect the Department of Veterans Affairs hospital is complete and a project for the Ridgewood neighborhood between 15th and 22nd Avenues North is under construction. A feasibility study of flood risk management measures for the entire Fargo-Moorhead area began in September 2008. A $161 million proposed project in Fargo known as the south-side dike and diversion may be part of that protection. Moorhead has acquired and moved 20 flood-prone structures, raised levees, installed gate valves on storm and sanitary sewers to prevent infiltration, installed seals and valves on homes, and constructed concrete lines to storm sewers to convey internal drainage. Fargo has removed about 70 flood prone structures and made other improvements such as relocating lift stations. The USACE has identified two options for overall Fargo-Moorhead flood protection: a diversion channel through MN from the confluence of the Red and Wild Rice rivers north to a point northwest of Kragnes or a levee plan that would include aspects of the south-side project. Either option would cost several hundred million dollars.		
Related Recommendations: 2-3, 5-7, 9-14, 16 and TF 3-7, 10-12, 15, 23, 29		
References: Lokkesmoe, K. 2007. "Disaster Recovery Following the 1997 Spring Floods in Minnesota." *Water Resources Impact*, November. Sisco, G. and T. McAdams (eds.) 2001. *Flood Damage Reduction: What Minnesota has Done and Still Needs to Do.* Minnesota Department of Natural Resources, St. Paul, MN. US Army Corps of Engineers 2009. *Red River of the North*, Corps of Engineers Fact Sheet. US Army Corps of Engineers, St. Paul, MN.		
Date: February, 2009		**Revised:**

IJC Recommendation 5: Flood Protection for Grand Forks and East Grand Forks		
The government of the United States, in cooperation with the cities of Grand Forks and East Grand Forks and the states of North Dakota and Minnesota, should ensure that the planned flood protection works are promptly and expeditiously completed		
Category: mitigation	**Location:** North Dakota, Minnesota	**Status:** complete 2009
Background: The cities of Grand Forks and East Grand Forks were devastated by the 1997 flood. In East Grand Forks only 27 residential properties had no damage. Temporary levees were overtopped and the cities evacuated. Flood damages were estimated to be $3.6 billion. Many houses and other buildings were total losses. The 1997 flood was determined to be a 1:210 event at Grand Forks.		
Progress to Date: The flood protection project consists of 30 miles (48 km) of levees on both banks of the Red River and 3 miles (5 km) of floodwall at East Grand Forks. To accommodate the levee setback and reduce the number of homes and businesses at risk, over 1000 structures were removed from the floodplain. The project included stabalization of an existing dam, removal of a former railway bridge, construction of interior flood control features, 24 pump stations, numerous road and railway closures, and two diversion channels. The total project cost was $409,300,000. The flood protection level is considered to be 1:250. The project is essentially complete. Only project close out and miscellaneous repairs remain to be accomplished.		
Related Information: The project has been certified as providing a 1:100 level of flood protection in accordance with FEMA's national flood insurance program. This benefits householders protected by the levee by significantly reducing flood insurance premiums.. The project has recreation features including 24 miles (39 km) of trails and channels.		
Related Recommendations: 2-4, 6-7, 9-14, 16 and TF 3-7, 10-12, 15, 23, 29		
References: Lokkesmoe, K. 2007. "Disaster Recovery Following the 1997 Spring Floods in Minnesota." *Water Resources Impact*, November. Sisco, G. and T. McAdams (eds.) 2001. *Flood Damage Reduction: What Minnesota has Done and Still Needs to Do.* Minnesota Department of Natural Resources, St. Paul, MN. US Army Corps of Engineers 2009. *Red River of the North*, Corps of Engineers Fact Sheet. US Army Corps of Engineers, St. Paul, MN.		
Date: February, 2009		**Revised:**

IJC Recommendation 6: Flood Protection Measures – Wahpeton-Breckenridge		
The government of the United States, in cooperation with the cities of Wahpeton and Breckenridge and the states of North Dakota and Minnesota, should expedite approval and implementation of flood protection plans to reduce the risk of flooding at Wahpeton–Breckenridge.		
Category: mitigation	**Location:** North Dakota, Minnesota	**Status:** complete 2010
Background: Whapeton, ND and Breckenridge, MN lie at the confluence of the Bois de Sioux and Otter Tail rivers, the beginning of the Red River. Wahpeton had a close call in 1997 but its emergency levee held. On the other hand, Breckenridge's levees were overtopped twice in 1997, first from the north then from the south. Most of the community was flooded causing damages of $30 million. A flood risk management study of the two communities led to two separate but dependent projects. The Breckenridge project consists of a high-flow diversion channel north of the Otter Tail River and two permanent levee reaches that protect all of the community. The Wahpeton project consists of a permanent levee system and flood easements. The flood protection level is considered to be 1:125. The estimated cost of the Breckenridge project is $36.4 million and the Wahpeton project $17.6 million.		
Progress to Date: The diversion at Breckenridge was completed in 2005. Levee construction will get underway in 2009. Other works completed at Breckenridge include removal or replacement of 132 flood-prone structures, construction of 14 pumping stations, 3.5 miles of dike and 2 miles of floodwall, relocation of lift stations and protection of the water treatment plant. Interior flood control features at Wahpeton have been completed and the first of three stages of levee construction began in June 2008.		
Related Recommendations: 2-5, 7, 9-14, 16 and TF 3-7, 10-12, 15, 23, 29		
References: Lokkesmoe, K. 2007. "Disaster Recovery Following the 1997 Spring Floods in Minnesota." *Water Resources Impact*, November. Sisco, G. and T. McAdams (eds.) 2001. *Flood Damage Reduction: What Minnesota has Done and Still Needs to Do.* Minnesota Department of Natural Resources, St. Paul, MN. US Army Corps of Engineers 2009. *Red River of the North*, Corps of Engineers Fact Sheet. US Army Corps of Engineers, St. Paul, MN.		
Date: February, 2009		**Revised:**

IJC Recommendation 7: Flood Risk Studies – Selkirk		
The province of Manitoba and city of Selkirk should expedite studies of flood-risk potential in the Selkirk area.		
Category: mitigation	**Location:** Manitoba	**Status:** complete
Background: Although Selkirk experienced some flooding of water front properties in 1997, its susceptibility to ice jam flooding has been known for many years. Prior to 1997, the flood protection level at Selkirk was considered to be the 1:160 year flood. Subsequent analysis indicated the flood protection level was about 1:100. Residents in the Selkirk area believe they may be affected by downstream impacts of Red River Floodway expansion. There was therefore a need to quantify the flood risk and consider mitigation measures.		
Progress to Date: The province has confirmed that the present infrastructure provides 1:100 year flood protection. Studies have confirmed that water levels will only increase marginally for the 1 in 700 year flood downstream of the outlet structure. The design of the Red River Floodway expansion includes bank erosion protection of the river bank opposite the outlet structure. The province has purchased two Amphibex AE-400 amphibious excavators and three ice cutting saws for use in the Selkirk area and other locations where ice jams are a concern. This new equipment was used in 2009 for the first time with partial success.		
Related Recommendations: 2-6, 9-14, 16 and TF 3-7, 10-12, 15, 23, 29		
References: Fleming, Sandford. 1880. "Documents in Reference to the Bridging of Red River", *Report and Documents in Reference to the Canadian Pacific Railway, Appendix No. 16.* Ottawa.		
Date: February, 2009		**Revised:**

IJC Recommendation 8: Socio-economic Research		
To improve resiliency in the basin, governments should support enhanced research into the various social dimensions of the flood, including economic, psychological, public health and sociological impacts.		
Category: preparedness	**Location:** basin	**Status:** little progress
Background: Many floodplain residents experienced some degree of collective trauma in recovering from the 1997 flood. This human toll was particularly evident in the flooded area immediately south of the Red River Floodway inlet. Further research concerning the human aspects of flooding and recovery from flooding is required.		
Progress to Date: Although some social and economic studies are being undertaken at universities using government and other funding concerning topics raised by the 1997 flood, the level of funding support, and hence the research effort, is still modest.		
Related Recommendations: 17-19, 22, 26 and TF 2, 16-19, 26,30, 35-40, 44, 46, 50		
References:		
Date: February, 2009		**Revised:**

IJC Recommendation 9: Flood Mitigation Strategies for Small Communities		
Governments at all levels should ensure that in the development of flood mitigation strategies for the basin the needs of small communities, individual isolated farmsteads and agriculture are not overlooked.		
Category: mitigation	**Location:** basin	**Status:** significant progress
Background: Many small communities and individual farmsteads were affected by the 1997 flood. In the United States small communities may be protected by non-federal levees but the exact level of protection is unknown.		
Progress to Date: In Manitoba south of Winnipeg 13 community dikes were constructed and 1742 homes, farmsteads or businesses were raised, diked or relocated under a federal-provincial agreement. This represents about 95 percent of the eligible structures. Increased storage has been added to Baldhill Dam on the Sheyenne River and a dry dam has been constructed on the Maple River, both in North Dakota. North Dakota raised funding support level for rural ring dikes to 50 percent in 2001. Minnesota has supported the construction of 225 rural ring dikes. Small scale remediation projects have been constructed in Minnesota. The USACE has substantially completed construction for a Cookston, MN flood control project, initiated design of a Roseau, MN project and started a feasibility study at Ada, MN. Drayton and Grafton, ND flood control is still required. Smaller communities such as Valley City and Lisbon are also in need of additional protection. Since the 2009 flood there has been renewed interest in farmstead ring dikes in the United States.		
Related Recommendations: 2-7, 10-14, 16 and TF 3-7, 10-12, 15, 23, 29		
References: Sisco, G. and T. McAdams (eds.) 2001. *Flood Damage Reduction: What Minnesota has Done and Still Needs to Do.* Minnesota Department of Natural Resources, St. Paul, MN.		
Date: February, 2009		**Revised:**

IJC Recommendation 10: Lower Pembina River Basin Flooding

Federal government agencies, in cooperation with the state of North Dakota and the province of Manitoba, should establish a consultative group to work with local interests, including the Pembina River Basin Advisory Board, to resolve the lower Pembina River flooding issue, provide necessary resources for the group, and act to achieve a solution.

Category: mitigation	**Location:** Pembina basin	**Status:** some progress

Background: For more than 50 years unilateral road and dike building on both sides of the international boundary has been a source of tension among basin residents and between the governments of North Dakota and Manitoba. Certain levees along the lower Pembina River have been deemed to be illegal and have been removed. Manitoba has cost-shared with North Dakota some improvements to drainage through the road-dike that parallels the international boundary. The road dike, however, is now the source of litigation between North Dakota and Manitoba.

Progress to Date: A report in 2004 reviewed the lower Pembina basin flooding issue and made recommendations for further action. This included an examination of flood measures protection at Pembina and Neche, flood-proofing of rural farmsteads and further study of spring and summer floods. In August 2008 the USACE and the State of North Dakota began developing an HEC-RAS model of the lower Pembina basin and the Red River from Drayton ND to the international boundary. This task included acquisition of additional lidar topographic data in the lower Pembina basin using PFRA funding. Previously the IJC had funded a detailed survey of the culverts in the road-dike. The USACE has developed a proposal for improvements to Neche's flood protection, but the plan is on hold. A USACE reconnaissance study of lower Pembina flooding is also on hold pending identification of a non-federal sponsor.

The IRRB endorsed the formation of the Lower Pembina River Task Team in January 2008. The objective of the Task Team is to oversee technical work to determine methods to minimize flooding on the lower Pembina River and adjacent watersheds. Technical work to date has been the enhancement of the Mike-11 model and development of the Telemac-2D by NRC-CHC.

Related Recommendations: 2-7, 9, 11-14, 16 and TF 3-7, 10-12, 15, 23, 29

References:

Halliday, R., R. Bowering and R. Gjestang 2004. *Lower Pembina River Flooding*. A Report to the International Red River Board. Winnipeg

US Army Corps of Engineers 2009. *Red River of the North*, Corps of Engineers Fact Sheet. US Army Corps of Engineers, St. Paul, MN.

Date: February, 2009		**Revised:**

IJC Recommendation 11: Mitigation Strategy for the Basin		
Governments should develop a binational integrated approach to mitigation initiatives at all political levels, based on a comprehensive mitigation strategy for the entire basin. In the United States, the strategy should be integrated within the overall national framework.		
Category: mitigation	**Location:** basin	**Status:** some progress
Background: Red River basin residents have a right to expect that governments at all levels will show leadership and work together to reduce the damaging effects of flooding. The United States has a framework for dealing with flooding and flood damages through instruments such as the National Flood Insurance Program, statutory programs of the USACE, and other instruments. Canada does not, depending on *ad hoc* post event programs.		
Progress to Date: The Red River Basin Commission has developed a natural resources framework plan that includes aspects of flood mitigation. The RRBC does have representatives from all levels of government but the process itself is not government led. The IJC with its IRRB has developed a draft document on developing a comprehensive flood mitigation strategy. This remains a priority of the IRRB.		
Related Recommendations: 2-7, 9-10, 12-14, 16 and TF 3-7, 10-12, 15, 23, 29		
References: Red River Basin Commission 2005. *Red River Basin Natural Resources Framework Plan.* Red River Basin Commission, Moorhead, MN.		
Date: February, 2009		**Revised:**

IJC Recommendation 12: National Mitigation Strategy – Canada		
The Canadian federal government should establish a national flood mitigation strategy, or a broader disaster mitigation strategy, and support it with comprehensive mitigation programs.		
Category: mitigation	**Location:** Canada	**Status:** some progress
Background: Flood mitigation in Canada tends to be event driven. With the demise of the federal-provincial flood-damage reduction program there is no common program or framework tying activities together. Some provincial governments continue to update flood risk maps, conduct hydrological and hydraulic studies, and construct mitigation works. These programs, however, are often a response to a specific event.		
Progress to Date: The Public Safety Minister and his provincial/territorial counterparts approved a National Mitigation Strategy in January 2008. Mitigation programs to support the strategy are yet to come. The strategy commits the federal government to using the *Building Canada Fund* (BCF) to support structural mitigation and research. The BCF, administered by Infrastructure Canada, allocates $8.8 billion over seven years to infrastructure projects. The safe and strong communities component includes disaster mitigation. Mitigation projects therefore must compete with a host of other municipal infrastructure priorities. Thus far, the only flood mitigation program to receive funding from this program is the Red River Floodway expansion (Recommendation 3).		
Related Recommendations: 2-7, 9-11, 13-14, 16 and TF 3-7, 10-12, 15, 23, 29		
References: Public Safety Canada 2008. *Canada's National Mitigation Strategy*. Public Safety Canada, Ottawa, ON. Infrastructure Canada 2007. *Building Canada*. Infrastructure Canada, Ottawa, On.		
Date: February, 2009		**Revised:**

IJC Recommendation 13: Regulatory Flood		
Governments should use, at a minimum, the 100-year (1 percent) flood as the basis for floodplain regulations and revise their estimates of the 100-year flood levels based on 1997 and new data that become available.		
Category: mitigation	**Location:** basin	**Status:** complete
Background: Communities and individuals need to understand the flood risks they face and need to be assured that flood risk information is up-to-date. The 100-year (1:100) floodplain extent is one such measure. A 500-year floodplain definition is useful for design of critical infrastructure or where flooding may be deemed unacceptable.		
Progress to Date: All jurisdictions have defined the applicable 100- and 500-year floods. In North Dakota and Minnesota the states have adopted a safe building elevation of the 100-year flood elevation plus one foot. In Manitoba south of Winnipeg, the province has adopted a safe building elevation and regulatory level of 1997 plus 0.6 m. This is higher than the 100-year flood elevation.		
Related Recommendations: 2-7, 9-12, 14, 16 and TF 3-7, 10-12, 15, 23, 29		
References:		
Date: February, 2009		**Revised:**

IJC Recommendation 14: Floodplain Management Regulations		
State, provincial and other appropriate authorities should review the effectiveness of and compliance with the floodplain management regulations in the basin and take steps as needed to improve enforcement.		
Category: mitigation	**Location:** basin	**Status:** significant progress
Background: The 1997 flood pointed out the need to enforce or improve regulations aimed at reducing flood damages in the Red River basin. The need to enforce regulations pertaining to building codes, zoning and other matters was identified.		
Progress to Date: More than 400 cities and counties in Minnesota enforce floodplain zoning ordinances that state no new buildings shall be placed in the path of floodwaters and that buildings experiencing substantial flood damage shall be removed. The required safe building elevation is the 1:100 level plus one foot of freeboard. Ninety percent of Minnesota jurisdictions participate in the National Flood Insurance Program. North Dakota defines the 1:100 floodway on the basis of a one-foot rise criterion and does not allow structures in the floodway. Structure in the floodway fringe must be flood-proofed. Manitoba uses the 1997 level plus 0.6 m as a safe building elevation. The province has a two step inspection process, once after the foundation is built and again when the project is completed, to ensure compliance. A review of flood damages in 2009 to houses and other structures constructed since 1997 would useful in demonstrating the effectiveness of the post-197 regulations. As well, a review of flood frequency calculations that includes 2009 data would also indicate whether regulations need further revision.		
Related Recommendations: 2-7, 9-13, 16 and TF 3-7, 10-12, 15, 23, 29		
References: North Dakota 2007. Chapter 61-16.2, Floodplain Management, in *Century Code*. State of North Dakota, Bismarck, ND. Sisco, G. and T. McAdams (eds.) 2001. *Flood Damage Reduction: What Minnesota has Done and Still Needs to Do.* Minnesota Department of Natural Resources, St. Paul, MN.		
Date: February, 2009		**Revised:**

IJC Recommendation 15: Binational Civil Emergency Planning		
Within the current context of Canada–United States cooperation for civil emergency planning and management, governments should develop more detailed bilateral emergency planning and management arrangements with specific adaptations to Red River flooding.		
Category: response, recovery	**Location:** basin	**Status:** little progress
Background: The Canada-United States Agreement on Cooperation in Comprehensive Civil Emergency Planning and Management provides a framework for joint response to civil emergencies. The likelihood of continued Red River flooding makes specific binational arrangements for the basin desirable. One mechanism for this is the Prairie Region Emergency Management Advisory Committee (PREMAC). This organization is comprised of representatives from Public Safety Canada, FEMA (Region 8), the three prairie provinces, North Dakota and Montana. An analogous organization includes FEMA (Region 5) and Minnesota, but tends to deal with Great Lakes issues. One outcome from such arrangements would be the facilitation of movement of personnel and materiel across the international boundary to assist in flood-fighting efforts as required. The current international co-operation on forest fire fighting is an example of what might be achieved.		
Progress to Date: There has been a hiatus in Canada-United States consultation on civil emergency planning and management pertaining to natural hazards from a meeting of the PREMAC in December 2001 to two recent meetings in the last 18 months.		
Related Recommendations: TF 25		
References:		
Date: February, 2009		**Revised:**

IJC Recommendation 16: Digital Elevation Model		
Development of the digital elevation model for the Red River basin, with high resolution in appropriate high flood risk areas, should be pursued and completed through collaborative initiatives of federal, state, provincial and local governments.		
Category: mitigation	**Location:** basin	**Status:** significant progress
Background: The 1997 Red River flood occupied a floodplain that was as much as 40 km-wide in southern Manitoba. Modelling flood paths through this flat landscape requires high resolution digital elevation models (DEM). The IJC study funded the development of lidar-based digital elevation models for a portion of the Red River floodplain from Winnipeg to Ste. Agathe and for the lower Pembina basin.		
Progress to Date: A lidar DEM has been prepared for the entire Red River floodplain from the international boundary to Winnipeg and from Winnipeg to the Red River delta. In the United States lidar DEMs are available for the lower Pembina basin, Wahpeton, an extensive area south of Fargo, the Sheyenne River valley and an area in the lower Wild Rice River near Ada MN, and a small area in Wilkin county, MN. The International Water Institute is working with partners to develop a non-proprietary high resolution DEM for the entire United States portion of the basin. About one-half of the required lidar data have been acquired, but not processed.		
Related Recommendations: 2-7, 9-14 and TF 3-7, 10-12, 15, 23, 29		
Date: February, 2009		

IJC Recommendation 17: Flood Forecast Data		
Federal, state and provincial governments should develop and implement a binational agreement to establish an appropriate network of hydrological and meteorological stations and data exchange for floodplain management and flood forecasting in the Red River basin.		
Category: preparedness	**Location:** basin	**Status:** superceded
Background: Hydrological and meteorological data are an essential element of flood forecasts. It is essential that the improvements to observing networks carried out following the 1997 flood be maintained and that information sharing continue to improve. A binational agreement was seen as the best way to accomplish this.		
Progress to Date: The hydrometeorological monitoring network has been improved considerably since 1997, and data are routinely shared between forecast agencies in both countries and with other interests. Significant progress has been made in Canadian data distribution. The Canadian Wheat Board on-line weather centre is a recent development. The monitoring activity is not supported by any basin-specific binational agreement, however. As costs of network operation increase, additional pressure is put on operating and funding agencies to maintain the present level of service. Environment Canada's abandonment of observer-operated climate stations makes snow monitoring more difficult.		
Related Recommendations: 8, 18-19, 22, 26 and TF 2,16-19,26,30,35-40,44,46,48,50		
Date: February, 2009		**Revised:**

IJC Recommendation 18: Flood Forecasting Liaison Committee		
The governments should authorize the Commission to establish a binational Red River Flood Forecasting Liaison Committee under the International Red River Board to improve interjurisdictional coordination and to help ensure that clear, understandable and compatible forecasts are issued to the public.		
Category: preparedness	**Location:** basin	**Status:** superceded
Background: There is a long-standing and successful bilateral arrangement for sharing flood forecasting information in the Red River basin. A more formal interjurisdictional coordination would be useful.		
Progress to Date: This recommendation pertaining to the establishment of a Flood Forecasting Liaison committee under the aegis of the IRRB has not been implemented. Flood forecasting agencies have taken steps to improve coordination and dissemination of forecasts. The 2009 flood demonstrated well-established coordination/communications between all government agencies concerned with flood issues. Daily conference calls provide opportunity to learn and share information.		
Related Recommendations: 8, 17, 19, 22, 26 and TF 2,16-19,26,30,35-40,44,46,48,50		
References:		
Date: February, 2009		**Revised:**

IJC Recommendation 19: Basin-wide Models		
As a long-term priority, government agencies responsible for flood forecasting and mitigation measures should develop basin-wide models rather than separate but coordinated models for each country.		
Category: preparedness	**Location:** basin	**Status:** superceded
Background: Although the forecast models used in the Red River basin share datasets and are calibrated to provide similar results at the international boundary, a basin-wide problem merits a basin-wide model.		
Progress to Date: The National Weather Service has implemented a detailed FLDWAV model for the Red River mainstem and the lower Sheyenne River. Basin-wide hydrodynamic models (Mike-11 and HEC-RAS) for the Red River mainstem have been developed under a task led by the Red River Basin Commission. These models can be used for evaluating flood mitigation measures. It is extremely unlikely the flood forecast entities, the National Weather Service and Manitoba Water Stewardship, would support a common forecast model on account of the administrative complexities and the need to demonstrate due diligence to their respective governments. A one-dimensional hydrodynamic model of the entire Red River mainstem has been developed and can be used for mitigation studies.		
Related Recommendations: 8, 17-18, 22, 26 and TF 2,16-19,26,30,35-40,44,46,48,50		
References:		
Date: February, 2009		**Revised:**

IJC Recommendation 20: Canadian Data Holdings		
The Canadian government should review its data and information management policies to ensure that topographic, hydrometeorological, and other flood-related data collected under government programs are made available without restrictions or conditions that limit their accessibility.		
Category:	**Location:** Manitoba	**Status:** significant progress
Background: Following the 1997 flood there were a number of roadblocks pertaining to Canadian data that inhibited the development of a common searchable database for the basin. Government data holdings tended to be inaccessible, access to internal computer networks constrained by security requirements, and cost-recovery policies made access expensive. This placed public safety in jeopardy by constraining public and agency access to data.		
Progress to Date: This recommendation was directed at Canadian data management policies. Policy decisions have now been taken by the Canadian and Manitoba governments that will lead to unfettered access to Canadian data. The federal government has significantly improved access to data holdings through programs such as Natural Resources Canada's GeoConnections and the Environment Canada's Water Survey of Canada's data portal. Environment Canada's Meteorological Service has also improved access to meteorological and climate data. Similarly, Manitoba Water Stewardship has improved access to its data holdings. There remains a need to transfer some paper files to digital files and to improve digital access.		
Related Recommendations:		
References:		
Date: February, 2009		**Revised:**

IJC Recommendation 21: Binational Virtual Network		
Governments should ensure that progress continues in building a binational, virtual network linking the people, data, and models for the Red River basin.		
Category: preparedness	**Location:** basin	**Status:** some progress
Background: Work on a distributed (or virtual) database linking flood-related data holdings across the basin led to conceptual plan for a decision support system linking both data and models.		
Progress to Date: Several measures have been introduced to continue the work on a binational virtual network linking people, data and models for the Red River basin. One has been the RRDDIN project, supported for the most part by the USACE. There have also been significant agency-level initiatives aimed at making data, tools and model output more available. Manitoba created a decision support system linking forecast water levels, cadastral data and sandbag requirements. It proved too expensive to maintain and was wound down. (Almost all the dwellings in the Manitoba floodplain were flood-proofed following the 1997 flood therefore reducing the need for this sort of information.) Minnesota has implemented a similar pilot project.		
Related Recommendations: 8, 17-19, 22, 26 and TF 2,16-19,26,30,35-40,44,46,48,50		
References:		
Date: February, 2009		**Revised:**

IJC Recommendation 22: Decision Support System		
Federal, state, and provincial governments should work with basin organizations to complete in a timely manner the development of a prototype decision support system and establish a cooperative mechanism for coordination and funding its further development and implementation.		
Category: preparedness	**Location:** basin	**Status:** some progress
Background: Work on a distributed (or virtual) database linking flood-related data holdings across the basin led to conceptual plan for a decision support system linking both data and models.		
Progress to Date: As indicated for Recommendation 21 there have been some developments related to decision support systems. Binational interagency approaches are lacking however.		
Related Recommendations: 8, 17-19, 26 and TF 2,16-19,26,30,35-40,44,46,48,50		
References:		
Date: February, 2009		**Revised:**

IJC Recommendation 23: Hazardous Materials		
Governments should take immediate steps to ensure that all banned materials such as toxaphene are removed from the Red River basin. Governments should also ensure that potentially hazardous materials are not stored in the 500-year floodplain, although reasonable quantities of such substances could be maintained in the floodplain for immediate use.		
Category: preparedness, environment	**Location:** basin	**Status:** some progress
Background: During the 1997 flood a banned pesticide, toxaphene, was released to the aquatic environment. Increased concentrations were detected in fish tissue in Lake Winnipeg. In Minnesota and North Dakota, the state agriculture departments regulate storage of chemicals in the floodplain while in Manitoba this is regulated by the environment department. It is not clear that the 500-year floodplain is the basis for regulations.		
Progress to Date: The US Environmental Protection Agency worked with North Dakota to distribute information on storage of chemicals in flood prone areas. Some 91,000 lbs. of chemicals were collected and removed. The work was accomplished under Project Safe Send, a non-regulatory state-wide program for safe disposal of unusable pesticides. North Dakota has also produced a brochure on flood-proofing of above ground storage tanks,		
Related Recommendations: TF 32, 34		
References:		
Date: February, 2009		**Revised:**

IJC Recommendation 24: Floodplain Environment		
Flood protection projects focus not only on reduction of flood damage but also on protection and enhancement of the floodplain environment.		
Category: mitigation	**Location:** basin	**Status:** some progress
Background: Flood mitigation projects provide an opportunity to restore wetlands, enhance fish or wildlife, or otherwise compensate for the effects of human activity in the basin.		
Progress to Date: In addition to building flood mitigation projects in conformance with federal, state or provincial laws, there have been developments that provided additional environmental values as part of a mitigation project. Examples are greenway development in Grand Forks and East Grand Forks, proposals for considerable urban park development along the Red River Floodway at Winnipeg, and the interest in set-back levees for the lower Pembina River. Greenway on the Red is a multi-state and international effort to establish a greenway from Lake Traverse to Lake Winnipeg. The task is about one-quarter complete. The Canadian partner is Rivers West, a Manitoba organization aimed at conserving natural, cultural and heritage resources. The entire Red River in Canada became part of the Canadian Heritage Rivers System in 2007.		
Related Recommendations:		
References: Hilderman, Thomas, Frank, Cram, 2005. *Canadian Heritage Rivers System: Nomination Document for the Red River in Manitoba.* Report prepared for Rivers West and Manitoba Conservation, Winnipeg, MB.		
Date: February, 2009		**Revised:**

IJC Recommendation 25: Comprehensive Flood Damage Reduction Plan		
Governments immediately take steps, on a binational basis, to begin development of a comprehensive flood damage reduction plan for the Red River basin.		
Category: mitigation	**Location:** basin	**Status:** little progress
Background: The nature of flooding in the basin means that basin residents will remain at risk until a multifaceted solution is developed for the full range of flood problems. This can best be accomplished on a binational basis.		
Progress to Date: There has been almost no attention devoted to a comprehensive flood damage reduction plan, as such, by government agencies. Individual agencies nonetheless have made enormous efforts to improve flood management in the Red River basin since 1997. The aggregate result of these efforts, while not a plan, represents a significant improvement in flood resiliency in the basin. The work currently being undertaken by the RRBC (Recommendation 19) could ultimately contribute to such an overall plan, however.		
Related Recommendations: 11		
References:		
Date: February, 2009		**Revised:**

IJC Recommendation 26: Flood Management Measures		
Governments at all levels should undertake the following measures: *a. Develop and implement comprehensive, multi-faceted plans for concurrently reducing flood damage and protecting and enhancing the natural environment;* *b. Ensure ongoing institutional support and full multi-jurisdictional participation in further development and maintenance of the Task Force's legacy projects;* *c. Implement Commission and Task Force recommendations designed to ensure basin wide flood preparedness and community resiliency;* *d. Promote a culture of flood preparedness and flood resiliency in the basin;* *e. Enhance technology and monitoring systems to provide early warnings and early action in the face of impending major floods;* *f. Ensure binational coordination of flood forecasting and communications of forecasts to the public;* *g. Provide opportunities for multi-jurisdictional problem solving and the exchange of best practices information; and* *h. Integrate floodplain management activities into the broader field of watershed and basin management.*		
Category: preparedness, education	**Location:** basin	**Status:** ongoing
Background: Although agencies throughout the basin can carry out the many flood-related tasks within their respective mandates, this transboundary watershed also requires binational approaches to achieving flood resiliency.		
Progress to Date: This recommendation directed eight measures to governments for action. All are long-term and will require sustained activity over many years. The work already initiated meets the intent of the recommendation, but this is a very long-term recommendation. One indicator of success is that the 2006 Red River flood, although it was then the fifth largest flood in the instrumental record was considered a 'non-event' in the basin, except for road closures and restricted access to properties. Nonetheless the 2009 flood, the second largest in the instrumental record (and the largest in the headwaters) demonstrated that large floods can still cause considerable disruption and damage.		
Related Recommendations: 8, 17-19, 22 and TF 2, 16-19, 26, 30, 35-40, 44, 46, 48, 50		
References:		
Date: February, 2009		**Revised:**

IJC Recommendation 27: Functions of the International Red River Board		
Governments should assign the following functions to the International Joint Commission for implementation by the International Red River Board: *a. Monitor progress by the governments (federal, state, provincial, municipal) in implementing the recommendations of the Commission's report on Red River basin flooding, and in maintaining and advancing the work of the Task Force's legacy projects;* *b. Encourage governments to develop and promote a culture of flood preparedness in the Red River valley;* *c. Encourage government efforts to develop and implement a long-term strategy for flood mitigation and emergency preparedness;* *d. Encourage the sharing of accurate and timely transboundary information to support the development of improved flood forecasting techniques and procedures for early flood warnings and to improve communication of flood forecasts;* *e. Provide through the activities of the Board a forum for the exchange of best practices and for other flood-related information on preparedness, mitigation, response, and recovery, to assist in transboundary problem solving;* *f. Promote the application of innovative technologies for supporting flood modelling and mapping;* *g. Monitor the adequacy of data and information collection networks (meteorological, hydrometric, water quality) for flood preparedness, forecasting and mitigation, within the larger context of overall water management needs in the basin;* *h. Monitor potential transboundary effects of flood mitigation and other works in the basin, and encourage cooperative studies necessary to examine these effects;* *i. Encourage governments to integrate floodplain management activities in watershed and basin management;* *j. Interact with all levels of government to help decision makers become aware of transboundary flood-related and associated water management issues; and* *k. Assist in facilitating a consultative process for resolution of the lower Pembina River flooding issue.*		
Category:	**Location:** basin	**Status:** complete
Background: There are many flood-related functions and tasks that need to be pursued by out by government agencies and others. The IRRB can assist this task by assuming some functions for the transboundary area.		
Progress to Date: This recommendation identified 11 flood-related functions that the IRRB should be asked to perform on behalf of the IJC. These are included in the directive to the Board. The tasks themselves are continuing tasks.		
Related Recommendations:		
References:		
Date: February, 2009		**Revised:**

IJC Recommendation 28: Coordination and Implementation: Preparedness and Mitigation		
The federal governments, in cooperation with the state and provincial governments, should work with the Commission and its International Red River Board, as well as with existing and emerging bilateral organizations, to ensure that appropriate arrangements are in place to coordinate and implement measures for flood preparedness and mitigation activities and to implement recommendations of the Commission.		
Category: preparedness, mitigation	**Location:** basin	**Status:** ongoing
Background: There is a need for coordinated bilateral action on measures aimed at improving flood resiliency in the Red River basin. This is in addition to measures taken by agencies.		
Progress to Date: There is activity on a number of fronts related to preparedness and mitigation. The approach tends to be agency specific and progress on measures taken by various agencies is reported by the International Red River Board and the Red River Basin Commission.		
Related Recommendations:		
References:		
Date: February, 2009		**Revised:**

Task Force Recommendations

(endorsed but not restated by the International Joint Commission)

Task Force Recommendation 2: Flow Management		
Future ice jam information from the entire basin should be incorporated into the CRREL Ice Jam Database so that ice problems in the basin can be analyzed further. Where feasible, historic ice jams from the Canadian portion of the basin should be entered.		
Category: prepardness	**Location:** basin	**Status:** little progress
Background: Ice jams occur at many locations on the Red River and its tributaries. At times these jams can lead to damaging floods. Systematic documentation of ice jam incidents may encourage additional research specific to the Red River basin.		
Progress to Date: There was a significant ice jam flood on the Red River at Selkirk in 2007. Because of an ice jam north of the city, the crest in 2007 was the highest on record. It exceeded the 1996 crest, also caused by an ice jam, and that of 1997. Ice jamming was also a major factor in the 2009 flood. Intact ice covers persisted at higher than usual flows. Record high water levels were obtained in areas north of Winnipeg. The only historic Red River ice jam added to the CRREL database since 1997 is one at Fargo in April 2005.		
Related Recommendations: IJC **7,**8, 17-19, 22, 26 and 16-19,26,30,35-40,44,46,48,50		
References: Beltaos, S., R. Pomerleau and R. A. Halliday (2000). *Ice Jam Effects on Red River Flooding and Possible Mitigation Methods.* Report for the International Red River Basin Task Force, International Joint Commission.		
Date: February, 2009		**Revised:**

Recommendation: TF 3 Communities at Risk		
Communities in the United States portion of the Red River basin should ensure that community-built flood damage reduction projects are certified by FEMA for 100-year or greater protection, or should participate in the Non-Federal Flood Control Works Inspection Program.		
Category: mitigation	**Location:** North Dakota, Minnesota	**Status:** some progress
Background: Many communities have constructed dikes and levees under emergency conditions. These structures may or may not meet federal standards. Some emergency levees remain in place after the flood event. When a levee can be certified as flood-proofing, homes and other structures can be removed from the 1:100 floodplain protected by the levee for National Flood Insurance Purposes.		
Progress to Date: The US Non-Federal Flood Control Works Inspection Program is now known as the Rehabilitation Inspection Program (RIP). Most communities in the basin with non-federal levees do not participate in the program. Thus far ten communities have applied, six met requisite engineering and maintenance standards, and three rehabilitation projects have been completed.		
Related Recommendations: IJC 2-7, 9-14, 16 and 4-7, 10-12, 15, 23, 29		
References:		
Date: February, 2009		**Revised:**

Recommendation: TF 5 Winnipeg at Risk		
Based on results from hydraulic model studies, modify the east embankment of the Floodway to improve the performance of the Floodway entrance to lower upstream water levels and increase capacity.		
Category: mitigation	**Location:** Manitoba	**Status:** complete
Background: Winnipeg faces a number of threats from damaging floods. The city was fortunate in 1997; with more severe weather conditions at the time of the peak the existing flood defenses may have failed. Modifications to the east embankment were considered an interim measure pending design of a floodway expansion project.		
Progress to Date: The work on improving the performance of the floodway inlet is complete. Two notches were cut in the east embankment.		
Related Recommendations: IJC 2-7, 9-14, 16 and 3-4, 6-7, 10-12, 15, 23, 29		
References: KGS Group 2001. *Flood Protection Studies for Winnipeg*. Report prepared for the governments of Canada, Manitoba and Winnipeg. KGS Group, Winnipeg, MB.		
Date: February, 2009		**Revised:**

Recommendation: TF 6 Winnipeg at Risk		
The west dike should be raised to allow a water level elevation of 778 feet at the Floodway inlet structure with appropriate freeboard		
Category: mitigation	**Location:** Manitoba	**Status:** complete 2010
Background: Winnipeg faces a number of threats from damaging floods. The city was fortunate in 1997; with more severe weather conditions at the time of the peak the existing flood defenses may have been insufficient. This work was considered an interim measure pending design of a floodway expansion project.		
Progress to Date: Modifications to the West Dike as part of the floodway expansion project are 80 percent complete. The work should be completed in 2009.		
Related Recommendations: IJC 2-7, 9-14, 16 and 3-5, 7, 10-12, 15, 23, 29		
References: KGS Group 2001. *Flood Protection Studies for Winnipeg*. Report prepared for the governments of Canada, Manitoba and Winnipeg. KGS Group, Winnipeg, MB.		
Date: February, 2009		**Revised:**

Recommendation: TF 7 Winnipeg at Risk		
The primary diking system should be raised where economically feasible to the elevation specified in existing legislation		
Category: mitigation	**Location:** Manitoba	**Status:** significant progress
Background: Winnipeg faces a number of threats from damaging floods. The city was fortunate in 1997; with more severe weather conditions at the time of the peak the existing flood defenses may have been insufficient. This work was considered an interim measure pending design of a floodway expansion project.		
Progress to Date: Winnipeg continues to improve its primary diking system. The design of this work has been harmonized with the floodway expansion project. The total cost of dike and other in-city improvements is estimated at $100 million. This is in addition to floodway expansion costs.		
Related Recommendations: IJC 2-7, 9-14, 16 and 3-6, 10-12, 15, 23, 29		
References: KGS Group 2001. *Flood Protection Studies for Winnipeg*. Report prepared for the governments of Canada, Manitoba and Winnipeg. KGS Group, Winnipeg, MB.		
Date: February, 2009		**Revised:**

Recommendation: TF 10 Winnipeg at Risk		
Modifications to the sewer and land drainage systems should be optimized and undertaken once the overall plan for Winnipeg flood protection is determined.		
Category: mitigation	**Location:** Manitoba	**Status:** significant progress
Background: Winnipeg faces a number of threats from flooding. Even with an expanded floodway attention must be paid to improving internal drainage within the city.		
Progress to Date: Winnipeg continues to improve its internal drainage system. The design of this work has been harmonized with the floodway expansion project. The total cost of drainage and dike improvements is estimated at $100 million. This is in addition to floodway expansion costs.		
Related Recommendations: IJC 2-7, 9-14, 16 and 3-7, 11-12, 15, 23, 29		
References: KGS Group 2001. *Flood Protection Studies for Winnipeg*. Report prepared for the governments of Canada, Manitoba and Winnipeg. KGS Group, Winnipeg, MB.		
Date: February, 2009		**Revised:**

Recommendation: TF 11 Winnipeg at Risk		
The City of Winnipeg should give immediate high priority to the preparation of a detailed emergency preparedness and response manual.		
Category: preparedness	**Location:** Manitoba	**Status:** complete
Background: Although Winnipeg performed well in responding to the 1997 flood, the need for improvements to its emergency plan became evident. Under provincial law all communities are required to have an emergency response plan that is subject to periodic review and testing.		
Progress to Date: A detailed flood emergency manual for the city of Winnipeg has been completed.		
Related Recommendations: IJC 2-7, 9-14, 16 and 3-7, 10, 12, 15, 23, 29		
References:		
Date: February, 2009		**Revised:**

Recommendation: TF 12 Winnipeg at Risk		
Operating rules for new flood control measures should be designed to accommodate all flow regimes, even those beyond design capacity. The public should be consulted on any proposed new operating rules.		
Category: mitigation	**Location:** Manitoba	**Status:** significant progress
Background: During normal floodway operation, operating rules specify that the upstream water levels be held at or below the elevation that would have occurred in a state of nature. When the design capacity of the floodway is exceeded as in 1997, upstream water levels can be raised above those that would occur naturally. This results in artificial flooding of upstream residents.		
Progress to Date: This recommendation regarding operating rules for mitigation works has been accepted and is being taken into account in Red River Floodway expansion. New floodway operating rules were prepared in 2005 and a compensation program introduced in 2006. Public consultation is continuing.		
Related Recommendations: IJC 2-7, 9-14, 16 and 3-7, 10-11, 15, 23, 29		
References: Red River Floodway Operation Review Committee 1999. *A Review of the Red River Floodway Operating Rules.* Manitoba Conservation, Winnipeg, MB. Manitoba Water Stewardship 2006. *Implementation and Administration of Compensation Program For Damages Caused by Rule 4 Operation of the Red River Floodway.* Manitoba Water Stewardship, Winnipeg, MB.		
Date: February, 2009		**Revised:**

Recommendation: TF 15 Flood Preparedness and Resiliency		
The 500-year flood (0.2 percent flood) should be defined throughout the Red River basin and used to inform the public of the potential risks of flooding from rare events, including the need to buy flood insurance in the United States, and as the basis of regulations for siting and floodproofing critical facilities.		
Category: mitigation	**Location:** basin	**Status:** some progress
Background: Critical infrastructure such as hospitals, fire stations, etc. should be exposed to minimal flood risks. The 1:500 floodplain is delineated on US National Flood Insurance rate maps and can be used in siting critical infrastructure.		
Progress to Date: The 500-year floodplain is being defined in flood frequency analyses conducted by the USACE, but there is little evidence of regulatory agencies incorporating this floodplain into regulations. The 500-year floodplain has been defined in Manitoba south of Winnipeg as part of the floodway expansion project.		
Related Recommendations: IJC 2-7, 9-14, 16 and 3-7, 10-12, 23, 29		
References:		
Date: February, 2009		**Revised:**

Recommendation: TF 16 Flood Preparedness and Resiliency		
Both North Dakota and Minnesota should consider adopting the new International Building Code that includes requirements for design and construction in flood hazard areas.		
Category: preparedness	**Location:** North Dakota, Minnesota	**Status:** complete
Background: At the time of the 1997 flood the United States model building code was in transition from the Uniform Building Code to the International Building Code. Adoption of the new code was deemed desirable on account of its inclusion of flood-proofing requirements. Both Minnesota and North Dakota adopted new building codes based on the 2000 International Building Code.		
Progress to Date: The North Dakota State Building Code, effective November 1, 2007, adopts the 2006 edition of the International Building Code without appendices. The Minnesota Building Code, adopted July 10, 2007, is also based on the 2006 International Building Code. In both North Dakota and Minnesota, enforcement of the building code is the responsibility of local jurisdictions. Jurisdictions that elect to adopt and enforce a building code must adopt the state building code, but may amend the code further to conform to local needs. In Minnesota such amendments must be more stringent than the state code. In 2008 the Minnesota Building Code became the minimum construction standard throughout the state although it is not enforceable by municipalities unless adopted by local ordinance.		
Related Recommendations: IJC 8, 17-19, 22, 26 and 2,17-19,26,30,35-40,44,46,48,50		
References:		
Date: February, 2009		**Revised:**

Recommendation: TF 17 Flood Preparedness and Resiliency		
The National Building Code of Canada should specify design and construction standards for buildings in flood hazard areas such as the Red River basin. Floodplain construction requirements should be incorporated into the Manitoba code when available.		
Category: preparedness	**Location:** Manitoba	**Status:** little progress
Background: Unlike the US model code the Canadian model code contains no information on flood-proofing requirements.		
Progress to Date: No steps have been taken to incorporate flood-proofing information into the Canadian National Building Code. Canadian officials take the view that people should not live in floodplains and therefore should not be encouraged by the inclusion of flood-proofing information in the code. This position ignores the fact that thousands of Canadians do live in floodplains.		
Related Recommendations: IJC 8, 17-19, 22, 26 and 2,16, 18-19,26,30,35-40,44,46,48,50		
References:		
Date: February, 2009		**Revised:**

Recommendation: TF 18 Flood Preparedness and Resiliency		
Federal, state, provincial and local governments in the Red River Basin, in conjunction with the private sector, should continue to develop, refine and implement effective strategies to improve the disaster resiliency in both communities. Efforts should be made to increase public awareness of flood risks throughout the basin.		
Category: preparedness	**Location:** basin	**Status:** signif. progress
Background: Continuing public education on flood risks is an important component of improving disaster resiliency. The International Flood Mitigation Initiative, initiated by FEMA and financially supported by Manitoba, was one part of this public education process.		
Progress to Date: Measures undertaken to mitigate the effects of damaging floods in the Red River basin have undoubtedly led to increased resiliency in the areas flooded in 1997. The continuing discussions of floods and flood risks have increased public awareness. Post-1997 flood events, most recently in 2006, have also maintained awareness.		
Related Recommendations: IJC 8, 17-19, 22, 26 and 2,16-17,26,30,35-40,44,46,48,50		
References: IFMI 2000. *International Flood Mitigation Initiative for the Red River Basin.* Final Report and Executive Summary. The Consensus Council, Bismarck.		
Date: February, 2009		**Revised:**

Recommendation: TF 21 Flood Preparedness and Resiliency		
The Canadian federal government should include in the Disaster Financial Assistance Arrangements provisions to allow for the permanent removal of structures in areas subject to repeated flooding.		
Category: preparedness	**Location:** Manitoba	**Status:** little progress
Background: The Canadian Disaster Financial Assistance Arrangements financially supports the replacement of a damaged building with one that is identical, except that current safe building elevations and building codes must be respected. There is no provision for compensation for structures subject to repetitive losses through buy-outs.		
Progress to Date: The Canadian Disaster Financial Assistance Arrangements were revised effective January 1, 2008. The new arrangements require replacement structures in designated flood risk areas to be floodproofed and allow some flexibility for additional costs aimed at reducing future damages. They do not specifically permit buy-outs of high-risk structures. Some Canadian buy-outs following the 1997 flood were made, however, using a separate arrangement.		
Related Recommendations: TF 15-18, 25-26		
References: Public Safety Canada 2007. *Guidelines for the Disaster Financial Assistance Arrangements.* Public Safety Canada, Ottawa, ON.		
Date: February, 2009		**Revised:**

Recommendation: TF 25 Flood Preparedness and Resiliency		
Recovery, rebuilding, and mitigation expertise and information should be widely shared across the border in advance of flooding.		
Category: recovery, mitigation	**Location:** basin	**Status:** some progress
Background: The international boundary can become an impediment to timely sharing of expertise and wisdom. Having arrangements in place prior to a disaster improves flood resiliency.		
Progress to Date: There is considerable sharing of recovery, mitigation and re-building expertise and information across the international boundary. For the most part, this has been on an informal agency to agency basis.		
Related Recommendations: TF 15-18, 21, 26		
References:		
Date: February, 2009		**Revised:**

Recommendation: TF 26 Flood Preparedness and Resiliency		
Measures of flood resilience should be developed, and a system should be established to monitor resilience in the Red River basin		
Category: preparedness	**Location:** basin	**Status:** little progress
Background: Although one may subjectively feel that the post-1997 efforts have led to a more flood resilient basin, the improvements in resiliency cannot be quantified, nor can desired further improvements be compared and evaluated. Development of specific measures of resiliency would help this task.		
Progress to Date: The experiences of the 2006 and 2009 floods provide an indication that resiliency has improved. There has been no activity specifically directed to developing measures of flood resiliency for the basin.		
Related Recommendations: IJC 8, 17-19, 22, 26 and 2,16-19, 30, 35-40, 44, 46, 48, 50		
References:		
Date: February, 2009		**Revised:**

Recommendation: TF 28 Lower Pembina Flooding		
Given the transboundary nature of the basin and the potential for federal involvement in funding and monitoring any agreement, federal agencies from both countries should be engaged in this process as well		
Category: preparedness	**Location:** Pembina basin	**Status:** some progress
Background: For more than 50 years unilateral road and dike building on both sides of the international boundary has been a source of tension among basin residents and between the governments of North Dakota and Manitoba. Certain levees along the lower Pembina River have been deemed to be illegal and have been removed. Manitoba has cost-shared with North Dakota some improvements to drainage through the road-dike that parallels the international boundary. The road dike, however, is now the source of litigation between North Dakota and Manitoba.		
Progress to Date: The US Section of the IJC has provided financial assistance for data acquisition along the international boundary. The ND State Water Commission and USACE are directly involved in developing an HEC-RAS unsteady flow model of the lower Pembina. The USACE has examined flood protection needs at Neche ND, and has considered a reconnaissance study of the basin. Agriculture Canada, PFRA has provided financial assistance for lidar mapping of the lower basin.		
Related Recommendations: IJC 10, TF 29-30		
References:		
Date: February, 2009		**Revised:**

Recommendation: TF 29 Lower Pembina Flooding		
Changes in the road network and diking system in the Lower Pembina Basin should be modeled by the hydrodynamic model prior to implementation of any plan to ensure that there are no unintended consequences.		
Category: mitigation	**Location:** lower Pembina basin	**Status:** signif. progress
Background: Flooding in the lower Pembina basin is sensitive to existing roads and dikes. Solutions to the existing problems could involve new construction. Because of the situation, a careful examination of the effects of new works is required.		
Progress to Date: The modelling task currently underway is based on up-to-date data on the roads and dikes. There will be a need to confirm that any models used to examine flooding in the lower Pembina basin employ the same configuration of roads and dikes in order to build confidence in the results.		
Related Recommendations: IJC 2-7, 9-14, 16 and 3-7, 10-12, 15, 23		
References:		
Date: February, 2009		**Revised:**

Recommendation: TF 30 Lower Pembina Flooding		
The virtual database and decision support system prototype that the Task Force has begun to develop for the Pembina Basin should be continued by relevant agencies in Canada and the United States.		
Category: preparedness	**Location:** lower Pembina basin	**Status:** some progress
Background: Some effort has been devoted to improving databases and to developing decision support in the lower Pembina basin. More work is necessary to realize the benefits of this effort.		
Progress to Date: The work on databases and decision support related to the Pembina River is being continued to some extent by the PRBAB and RRBDIN. A binational research project also examined some data issues related to the Pembina. The current hydrodynamic model development for the lower Pembina basin supports this activity.		
Related Recommendations: IJC 8, 17-19, 22, 26 and 2, 16-19, 26, 35-40, 44, 46, 48, 50		
References: Vantage Point International, Houston Engineering and R. Halliday & Associates (2002). *Joint Canada/US Framework for the Red River Basin.* Report to the Geoconnections Secretariat, Natural Resources Canada and the US Federal Geographic Data Committee, Ottawa and Washington.		
Date: February, 2009		**Revised:**

Recommendation: TF 32 Hydraulic Connection at Lake Traverse		
Any modification to existing operating plans or physical structures associated with Lake Traverse that could increase pool elevation must be accompanied by features that eliminate the southward movement of water into the Little Minnesota River.		
Category: preparedness, environment	**Location:** Minnesota	**Status:** some progress
Background: Hydraulic connections are one means by which non-native invasive species may be propagated across the major continental river basin divides. The flat terrain and the proximity of the Little Minnesota River in the Mississippi basin to Lake Traverse in the Red river headwaters make this a potential point of transfer. There is a need to consider movement of water in either direction, southward or northward.		
Progress to Date: The potential for biota transfer at Lake Traverse was considered as part of the dam safety study at White Rock Dam. In general, however, there is little progress on this recommendation. A flood protection project for Browns Valley, MN is part of the solution.		
Related Recommendations: TF 34		
References:		
Date: February, 2009		**Revised:**

Recommendation: TF 34 Lake Winnipeg Water Quality		
Governments should continue to monitor toxaphene in the Lake Winnipeg ecosystem until concentrations decline to pre-1997 levels.		
Category: environment	**Location:** Manitoba	**Status:** signif. progress
Background: During the 1997 flood a banned pesticide, toxaphene, was released to the aquatic environment. Increased concentrations were detected in fish tissue in Lake Winnipeg.		
Progress to Date: Manitoba Water Stewardship in partnership with Fisheries & Oceans Canada have been monitoring toxaphene concentrations in fish tissue for Lake Winnipeg for a number of years. Concentrations have declined since 2002 and are now less than Manitoba Water Quality Standards, Objectives and Guidelines for both human and wildlife consumers.		
Related Recommendations: IJC 23 and TF 32		
References: International Red River Board 2007. *Eighth Annual Report to the International Joint Commission.* International Joint Commission, Washington and Ottawa.		
Date: February, 2009		**Revised:**

Recommendation: TF 35 Data and Decision Support		
Hydrometric and meteorological data networks necessary for flood forecasting should be improved and maintained in a state of readiness to forecast future floods.		
Category: preparedness	**Location:** basin	**Status:** significant progress
Background: Hydrological and meteorological data are an essential element of flood forecasts. It is essential that the improvements to observing networks carried out following the 1997 flood be maintained and that information sharing continue to improve.		
Progress to Date: The initial task of improving hydrometric and meteorological networks used in flood forecasting has been completed. Maintaining these networks in the long term as operating costs increase remains a challenge. Forecasts could be further improved with additional snow water equivalent, frost penetration and soil moisture data. Environment Canada's curtailment of manned climate observing sites has reduced snowfall data availability.		
Related Recommendations: IJC 8, 17-19, 22, 26 and 2, 16-19, 26, 30, 36-40, 44, 46, 48, 50		
References:		
Date: February, 2009		**Revised:**

Recommendation: TF 36 Data and Decision Support		
New geographically related data collection in the United States should be in accord with the North American Vertical Datum of 1988.		
Category: preparedness	**Location:** North Dakota, South Dakota, Minnesota	**Status:** some progress
Background: The United States adopted a new gravity-based vertical datum in 1988. This new datum is naturally compatible with global positioning system output. The previous datum, NGVD 1929, is widely used in the basin and often documents do not specify the datum. Given the flat terrain and the difference between the two datums in the Red River basin, this can lead to potential problems.		
Progress to Date: Data collected by US federal agencies are being collected using the new US vertical datum (NAVD 1988). This is frequently not the case for city and county entities. The IJC's International Water Initiative has provided funding for an international data harmonization pilot project based in the lower Pembina basin.		
Related Recommendations: IJC 8, 17-19, 22, 26 and 2, 16-19, 26, 30, 35, 37-40, 44, 46, 48, 50		
References: Harkness, R. E. 1999. *Datum Issues in the Red River of the North Basin.* Water Resources Division, US Geological Survey, Bismarck, ND.		
Date: February, 2009		**Revised:**

Recommendation: TF 37 Data and Decision Support		
For consistency and accuracy, data used in models should take into account the differences in data at the border. Because datum conversions can affect data accuracy, any conversions between standards should be noted and reported along with the data.		
Category: preparedness	**Location:** basin	**Status:** some progress
Background: The United States adopted a new gravity-based vertical datum, NAVD 1988, in 1988. This new datum is naturally compatible with global positioning system output. The previous datum, NGVD 1929, is widely used in the basin and is similar to the Canadian CGVD28. Given the flat terrain and the difference between NAVD 1988 and CGVD28 at the international boundary, this can lead to potential problems.		
Progress to Date: There now appears to be a greater likelihood of the datum used in specific projects being reported, but this is not always the case. Natural Resources Canada has developed a conversion algorithm for converting between US and Canadian vertical datums.		
Related Recommendations: IJC 8, 17-19, 22, 26 and 2, 16-19, 26, 30, 35-36, 38-40, 44, 46, 48, 50		
References: Harkness, R. E. 1999. *Datum Issues in the Red River of the North Basin.* Water Resources Division, US Geological Survey, Bismarck, ND.		
Date: February, 2009		**Revised:**

Recommendation: TF 38 Data and Decision Support		
U.S. National Geodetic Survey and the Geodetic Survey of Canada should convene a forum of datum experts in the year 2000 to discuss Red River Basin datum issues and develop a long-term transition plan.		
Category: preparedness	**Location:** basin	**Status:** superceded
Background: The United States adopted a new gravity-based vertical datum, NAVD 1988, in 1988. This new datum is naturally compatible with global positioning system output. The previous datum, NGVD 1929, is widely used in the basin and is similar to the Canadian CGVD28. Given the flat terrain and the difference between NAVD 1988 and CGVD28 at the international boundary, this can lead to potential problems.		
Progress to Date: Natural Resources Canada, together with provincial agencies, is examining issues related to adopting a Canadian vertical datum that is compatible with the US NAVD 1988 as part of the Height Reference System Moderization Project. In the meantime the official Canadian vertical datum is CGVD28. NRCan has a goal of converting to a new gravity-based vertical reference system that would be compatible with the US reference system at the international boundary. This has been discussed with the U.S. National Geodetic Survey but there has been no expert binational examination of datum issues specifically related to the Red River basin since the IJC study. The IJC's International Water Initiative has provided funding for an international data harmonization pilot project based in the lower Pembina basin. The project will examine datum issues.		
Related Recommendations: IJC 8, 17-19, 22, 26 and 2, 16-19, 26, 30, 35-37, 39-40, 44, 46, 48, 50		
References: Harkness, R. E. 1999. *Datum Issues in the Red River of the North Basin.* Water Resources Division, US Geological Survey, Bismarck, ND.		
Date: February, 2009		**Revised:**

Recommendation: TF 39 Data and Decision Support		
All key data providers in Canada should make available at no cost and with no restriction the data sets necessary for the Red River floodplain management and emergency response, and regional or basin-wide modelling activities.		
Category: preparedness	**Location:** Manitoba	**Status:** significant progress
Background: Following the 1997 flood there were a number of roadblocks pertaining to Canadian data that inhibited the development of a common searchable database for the basin. Government data holdings tended to be inaccessible, access to internal computer networks constrained by security requirements, and cost-recovery policies made access expensive. This placed public safety in jeopardy by constraining public and agency access to data.		
Progress to Date: Substantial improvements in data availability for both Canadian and American data have been made since the flood. Canadian cost-recovery policies have been changed significantly. More work on making data available by means of the Internet continues to be needed including conversion of paper records and development of data portals.		
Related Recommendations: IJC 8, 17-19, 22, 26 and 2, 16-19, 26, 30, 35-38, 40, 44, 46, 48, 50		
References:		
Date: February, 2009		**Revised:**

Recommendation: TF 40 Data and Decision Support		
Data providers should remain responsible for maintaining and replicating the data sets.		
Category: preparedness	**Location:** basin	**Status:** complete
Background: The Task Force saw the distributed (or virtual) database as the preferred model for data distribution in the basin. The other model was the data warehouse. Having data providers retain responsibility for their data is a necessary pre-condition to development of distributed databases.		
Progress to Date: There is general acceptance of the concept of data providers being responsible for maintaining and replicating data sets, as opposed to this being done by third parties.		
Related Recommendations: IJC 8, 17-19, 22, 26 and 2, 16-19, 26, 30, 35-39, 44, 46, 48, 50		
References:		
Date: February, 2009		**Revised:**

Recommendation: TF 44 Hydrologic and Hydraulic Modelling		
The U.S. National Weather Service should implement its Advanced Hydrologic Prediction System in the Red River basin as an early priority.		
Category: preparedness	**Location:** North Dakota, Minnesota	**Status:** complete
Background: At the time of the 1997 flood the NWS had embarked on significant changes in its flood forecast systems. These changes had not been incorporated into Red River forecasts and for much of the United States in 1997.		
Progress to Date: The National Weather Service has implemented the AHPS forecast system and new modelling for the US portion of the basin. A detailed FLDWAV model for the Red River mainstem was implemented in 1999 and updated in 2005. Further improvements will be made by adding additional cross-sections.		
Related Recommendations: IJC 8, 17-19, 22, 26 and 2, 16-19, 26, 30, 35-40, 46, 48, 50		
References:		
Date: February, 2009		**Revised:**

Recommendation: TF 46 Hydrologic and Hydraulic Modelling		
Confirm the flood peak reduction findings of Chapter 3 for large floods and examine reductions for smaller floods by implementing distributed models on tributaries such as the Mustinka, Wild Rice and Maple Rivers.		
Category: preparedness	**Location:** basin	**Status:** some progress
Background: The Task Force made some basic calculation of the effect of upstream storage on downstream water levels. These calculations could be refined using sub-basin scale distributed hydrological models.		
Progress to Date: The flood peak reduction analysis performed during the IJC studies can be re-examined a hydrodynamic model of the entire Red River main stem. A distributed hydrologic model for the Mustinka River has been prepared by the USACE. Similar models for the Wild Rice and Maple Rivers have not been developed. The Waffle Project®, based at the University of North Dakota has also examined flood peak reduction.		
Related Recommendations: IJC 8, 17-19, 22, 26 and 2, 16-19, 26, 30, 35-40, 44, 48, 50		
References: Kurz, B.A., X. Wang, L. de Silva, S.K. Hanson, M.D. Kurz, W.D. Peck, T. K. Simonsen, E.N. Steadman 2008. *An Evaluation of Basinwide, Distributed Storage in the Red River Basin: The Waffle® Concept.* Energy & Environmental Research Center, University of North Dakota, Grand Forks, ND		
Date: February, 2009		**Revised:**

Recommendation: TF 48 Hydrologic and Hydraulic Modelling		
Conduct surveys of secondary roads, particularly in the central portion of the basin, with differential global positioning systems, and incorporate the results into the hydraulic models.		
Category: preparedness	**Location:** basin	**Status:** some progress
Background: Accurate modelling the movement of flood waters in the flat landscape of the Red River Valley requires very detailed topographic data. As roads and railways can influence the accuracy of the models, inclusion of this information in the model is important.		
Progress to Date: As higher resolution digital elevation models are being prepared for the basin, some attention is being given to precise surveys of secondary roads. There is a need to consolidate surveys by many agencies into one seamless best available DEM. In the United States this task is being managed by the International Water Institute. In Canada, Manitoba Water Stewardship is best positioned to carry out this task.		
Related Recommendations: IJC 8, 17-19, 22, 26 and 2, 16-19, 26, 30, 35-40, 44, 46, 50		
References:		
Date: February, 2009		**Revised:**

Recommendation: TF 50 Hydrologic and Hydraulic Modelling		
Measures should be taken to ensure that data supporting the operation of the hydraulic models and model outputs can be made widely available.		
Category: preparedness	**Location:** basin	**Status:** significant progress
Background: Operation of the hydraulic models used in the Red River basin requires a considerable amount of topographic and hydrometric data. As different models are developed they must be calibrated and verified. Using common datasets assists the development of new models and the intercomparison of model results.		
Progress to Date: The data supporting the operation of hydraulic models and the output from those models are becoming more widely available. There is a significant need for the preparation of metadata in accordance with a standard such as the FGDC standard to facilitate this process.		
Related Recommendations: IJC 8, 17-19, 22, 26 and 2, 16-19, 26, 30, 35-40, 44, 46, 48		
References:		
Date: February, 2009		**Revised:**