MANITOBA 2011 FLOOD REVIEW **TASK FORCE** APPENDICES

What We Heard
Hydrological Characteristics of the 2011 Flood
March 2011 Spring Flood Outlook for Manitoba
Typical Flood Sheets for the Operational Forecasts
Hydrologic Impacts of Praiire Wetland Drainage
HATCH Report

April 2013

A. What We Heard

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What We Heard

1. Introduction

In February 2012, the Province of Manitoba established an independent Task Force to examine many aspects of Manitoba's historic 2011 flood, including preparedness and response, flood forecasting, public communications, operation of flood control infrastructure and flood protection. The work of the Task Force included gaining an understanding and providing an overview of what happened, what worked and did not work, and what could be done better in the future.

The unprecedented scope, magnitude and duration of the 2011 Manitoba flood meant that a huge geographic area and many people, businesses and communities were affected. The Task Force saw Manitobans' participation in the review process as essential to their work and committed to consulting as broadly as possible. This commitment ensured that the experiences, perspectives and feedback of Manitobans would be considered in their final report and recommendations along with technical data, external expertise and the experience of Task Force members.

This "What We Heard" document has been prepared by the consultation team[1] as a record of the consultation activities undertaken, as well as the input received from Manitobans. A significant amount of information was collected from open house feedback forms, online feedback forms, letters, emails, surveys and open house and stakeholder meeting notes. The Task Force report contains a chapter which summarizes the results presented in this document.

A wide range of information was received during the consultation process, with many different perspectives and opinions offered. These comments and ideas were invaluable to the work of the Task Force. While the Task Force appreciates the effort made by the public to attend meetings and open houses, to fill in submission forms and to respond to surveys, it recognizes that many people who are satisfied with how the 2011 Manitoba flood was handled may not have chosen to participate in the consultation process.

It is important to note that the summary presented in Section 5.0 is only a reflection of what was heard by the Task Force. The views, opinions and statements are not those of the Task Force, and so do not necessarily reflect those of the Task Force and of the individual members.

2. Consultation Objectives and Scope

The objectives for this consultation process were to:

- Help the public understand the role of the Task Force and the topics to be considered.
- Hear from, and meet directly with, Manitobans affected by the flood.
- Gather feedback and information relevant to the work of the Task Force.

The Task Force wished to have an open process that would provide multiple opportunities for Manitobans to participate and contribute. The scope of the process needed to be broad in order to achieve the objectives and ensure significant, transparent and meaningful consultation. The process had to address the large geographic scope covered by the 2011 Manitoba flood, the diversity and number of stakeholders affected by the flood, and the breadth of the Task Force's Terms of Reference.

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[1] The consultation team was led by Marr Consulting International Ltd. Other team members were Michelle Holland Consulting Inc., Ashleigh Hall, David Leibl and Barbara Hicks Graphic Solutions.

3. Phases and Timing of Consultation

There were three key phases to the public consultation program.

1. **Initial consultation planning (March – May 2012).**

   This phase included the development of consultation tools, website development and scheduling of consultation activities.

2. **Public consultation activities (May – October 2012).**

   This phase included launching a public website and the consultation activities. While not all Task Force members could attend all consultation events held during this phase, the diversity of the Task Force's experience was always represented.

   During the six-month active public consultation phase there were multiple opportunities for people to participate, whether in person, by mail, email, phone call or online.

3. **Consideration of public consultation findings (November - December 2012).**

   This phase included summary and consideration of public feedback and stakeholder input, and the preparation of this document.

4. Public Consultation Approach

A variety of consultation methods were required to ensure that opportunities to participate were accessible and as convenient as possible for all Manitobans. The tagline "5 Ways to Participate" was used in communicating consultation opportunities available to the public, most of which could be accessed online. In addition, opportunities were provided for municipal and other officials and for the public to meet the Task Force in person and express their thoughts directly through meetings and open houses.

The website provided a venue for the Task Force to communicate to the public and also to receive information from Manitobans. The website had the following elements: homepage; description of the mandate; bios of all the Task Force members; an outline of the public consultation process; and a page which kept the public informed of key activities, for example through the posting of press release announcements. In addition, there were the "5 Ways to Participate":

1. Surveys

Six online surveys (questions provided in Appendix 1) were posted to solicit feedback on specific topics related to the Task Force Terms of Reference, including:

- Environmental and Human Health Impacts of the 2011 Manitoba Flood
- Flood Preparedness, Flood Fighting Capacity and Response
- Impacts of the 2011 Flood on Roads and Bridges
- Flood Forecasting
- The Operation and Adequacy of Existing Flood Control/Protection Infrastructure and the Need for Additional Works
- Communications Regarding Flood Information and the 2011 Spring Flood Disaster Financial Assistance Program.

2. Online Feedback Forms

A freeform online submission form was created to receive input on a range of flood-related topics (Appendix 2).

3. Email and Progress Updates

Progress updates were posted online and circulated, along with other Task Force news, via an email sign up list.

4. Public Open Houses

The public had the opportunity to view materials about the work of the Task Force, meet face to face with Task Force members and provide feedback via feedback forms (Appendix 3) at open houses held in 11 communities across flood-affected areas of the province. Open houses were a drop-in format, held from 4:00p.m. – 8:00p.m. The same information was available at all open houses. Additional technical background data related to the flood was prepared and presented for each geographic area. All technical boards were available for viewing at the final open house in Winnipeg.

5. Online Open House

Public open house materials and feedback forms were posted for online access and viewing by those who could not attend in person.

These opportunities to participate were open to all Manitobans. Hard copy versions of all online forms and surveys were available upon request. Open house materials were also available in French. A Task Force email address, phone number and mailing address were also established for the purpose of receiving public feedback and inquiries.

4.1 Notification of Public Consultation Opportunities

Several means were used to notify the public and stakeholders of the work of the Task Force and how they could participate. These notifications primarily highlighted the "5 Ways to Participate", the website URL, and the dates and locations of Open Houses. Notification included:

- **Individually addressed letters** – introductory letters were sent at the launch of the consultation period to 137 affected municipalities and First Nations.
- **Press releases** – media outlets across the province were notified via press release at the launch of the consultation period and during the periods when open houses were being held.
- **Public service announcements (PSAs)** – prior to public consultation events PSAs were sent to radio stations and local access television stations.
- **Newspaper and radio ads** – Open Houses were announced via newspaper and radio ads, which also were used to remind the public about the website. Ads announcing all open houses were placed several times in the Winnipeg Free Press during the summer and fall. All open houses in the different regions of Manitoba were also advertised in local and regional newspapers and on radio stations.
- **Online calendars, bulletin boards** – Information on public open houses was posted to online event calendars and event listings where possible.
- **E-announcements and email sign-up –** The website included an email sign-up opportunity, which was used to keep stakeholders informed of consultation opportunities. Email blasts were sent out to specifically advertise open houses and to announce the posting of new surveys.
- **Posters, phone calls, direct emails, signage** – Depending on the location, and with input from local officials, a combination of additional methods were used to supplement promotion of public open houses.

4.2 Summary of Consultation Activities

MEETINGS

In addition to the opportunities for the public to share their perspectives and experiences, meetings by invitation occurred with several municipalities and First Nations. In total, the Task Force met with more than 45 municipalities and First Nations during the consultation period in locations across the province. The objective of these meetings was primarily to listen to and learn from local officials. Attendees had the opportunity to present to the Task Force, and the Task Force had the opportunity to ask questions related to their mandate.

Meetings with stakeholders were often conducted as part of other Task Force consultation and research activities in the area, such as open houses and site visits. Task Force members were also able to accommodate several requests from individuals to tour flood damage of homes, farms, cottages or other property. Smaller, informal or impromptu meetings or site visits involving Task Force members and individual stakeholders may not be included in the following list.

Date	Location	Attendees*
May 30, 2012	Portage la Prairie	RM of Portage la Prairie
June 14, 2012	Hartney	Southwest Flood Strategy Group
June 15, 2012	Brandon	City of Brandon
June 26, 2012	The Pas	RM of Kelsey
July 17, 2012	St. Laurent	RM of St. Laurent RM of Coldwell RM of Woodlands
July 25, 2012	Russell	RM of Shellmouth-Boulton RM of Ellice RM of Birtle RM of Russell
July 26, 2012	Ochre River	RM of Ochre River
July 27, 2012	Rorketon - Benyks Point	Benyks Point Cottagers
August 21, 2012	Oak River	RM of Daly RM of Miniota RM of Blanshard RM of Woodworth RM of Wallace
August 21, 2012	Oak River	Manitoba Habitat Heritage Corporation
October 25, 2012	Emerson	Town of Emerson

** In many cases, other municipalities were invited but did not attend.*

OPEN HOUSES

Date	Location
June 19, 2012	Brandon – Keystone Centre
June 21, 2012	Souris – Souris Glenwood Memorial Complex
June 26, 2012	The Pas – Guy Hall
July 25, 2012	Russell – Russell Inn
July 26, 2012	Dauphin – Parkland Recreation Complex
September 11, 2012	St. Laurent – Recreation Centre
September 12, 2012	Fairford – Pinaymootang Arena
September 13, 2012	Ashern – Centennial Hall
September 18, 2012	Portage la Prairie – PCU Centre
September 19, 2012	Langruth – Community Hall
September 26, 2012	Winnipeg – Canad Inns Polo Park

Task Force members discuss flood issues with Open House attendees.

FIRST NATION PARTICIPATION

The Task Force met with First Nations representatives by a variety of means. In some cases the Task Force travelled to the First Nation. Some of these visits were informal and meetings were not held with Chief and Council. The Task Force also invited an extensive list of First Nations to meet with them in Winnipeg.

Date	Location	Attendees or Location Visited
April 11, 2012	Winnipeg	Manitoba Keewatinowi Okimakanak Inc.
May 24, 2012	Winnipeg	Assembly of Manitoba Chiefs (representation on behalf of Grand Chief) Little Saskatchewan First Nation Tootinaowaziibeeng Treaty Reserve (Valley River First Nation) Assembly of First Nations – Regional Chief of Manitoba Ebb and Flow First Nation Peguis First Nation
June 26, 2012	The Pas	Opaskwayak First Nation
July 24, 2012	Valley River	Tootinaowaziibeeng Treaty Reserve (Valley River First Nation)
August 16, 2012	Northern Assoc. of Community Councils AGM – Winnipeg	Dauphin River Crane River Meadow Portage Waterhen Mallard Spence Lake Duck Bay Camperville Red Deer Lake
August 22, 2012	Winnipeg	Pine Creek First Nation Canupawakpa First Nation Sandy Bay First Nation Tootinaowaziibeeng Treaty Reserve (Valley River First Nation) O-Chi-Chak-Ko-Sipi First Nation Ebb and Flow First Nation Lake St. Martin First Nation
September 12-13, 2012	Fairford area	Dauphin River First Nation Fisher River Cree Nation Peguis First Nation Lake Manitoba First Nation

5. What Was Heard

During its extensive consultation, the Task Force met with or heard from hundreds of Manitobans affected by the 2011 flood. In addition to the meetings held with municipalities and First Nations:

- Over 450 people attended one or more of the open houses;
- Approximately 100 open house feedback forms were filled in;
- An additional 36 submissions were received via the online form, mail or email;
- The six surveys had 20-50 participants each;
- 215 people signed up to the Task Force email list; and
- There were 1,892 visits to website (through Nov.15), of which 1,053 were unique visitors.

The following is a description of what the Task Force heard through the entire consultation process, organized by Term of Reference. While most comments are included here, due to the varied and detailed nature of some comments it was not possible to capture absolutely everything below. Appendices 4 through 27 contain summaries of what was heard at specific meetings and of comments heard by Task Force members at the open houses. Appendix 28 is a summary of the submissions received through the online form, mail or email. Appendix 29 summarizes the comments provided by the public on the open house feedback forms. Results from the six surveys are listed in Appendices 30 through 35. For privacy reasons, in most cases quotes have not been attributed to specific individuals.

5.1 The Operation of Flood Control Infrastructure and Ancillary Works

The Task Force received feedback concerning all of its Terms of Reference. One of the topics that was most frequently mentioned was the operation of flood control infrastructure. In particular, people commented on the operation of structures that impact the level of Lake Manitoba and on the Shellmouth Dam and Reservoir. It was clear that these issues were important to respondents, including those who filled out feedback forms and those who spoke with Task Force members in person.

A consistent belief was that people affected by water control structures must be given more consideration. Through a Task Force survey, 23 out of 27 respondents indicated that they were not given the opportunity to provide input into the operation of structures that affect them, and the majority felt that local interests were not well represented in decisions made regarding control structure operation in their area. The Task Force often heard that the major control structures are used for the protection of communities located relatively far away downstream, in particular Winnipeg and Portage la Prairie. It was felt that several reservoirs are kept artificially high, with insufficient storage space available for spring run-off, despite the fact that this causes problems for people in the vicinity of the structures.

> ***"Consideration of those affected by these flood control structures needs to be improved, including timely warning systems, adequate temporary protection measures, compensation packages for those that suffer and land buyouts in areas that are permanently affected."***

Portage Diversion

Many people noted their concern with the impacts of the use of the Portage Diversion on Lake Manitoba, with some stating their belief that operation of the Diversion was directly responsible for the flooding that occurred around the lake in 2011. It was suggested that the Diversion is over-used, with people believing that it was intended to be operated in emergencies only, but has instead been used regularly to keep the level of Lake Manitoba artificially high and/or as a first response to any potential flood water problems. People felt that over-use has caused high water levels on Lake Manitoba for several years, as well as associated problems with shoreline erosion. Some people questioned the validity of the reasons given for operation of the Diversion in recent years, including in the months leading up to the 2011 flood. Questions were asked regarding why the Diversion was used to the extent that it was in 2010, raising the lake level of Lake Manitoba, rather than running the Assiniboine River to its full capacity, which some people believed was an option. The beliefs of some of the people who questioned the operation of the Portage Diversion and are concerned about its impact on Lake Manitoba are illustrated by the following comment made in a submission to the Task Force:

"The attitudes of [Water Stewardship], which do not have them lower the lake to any value below 811 feet, which have them state that all operations of the [Portage Diversion] have a minimal impact on the lake levels, and which have every other potential water problem take precedence over concerns about Lake Manitoba, will result in another massive disaster."

Another issue noted was that use of the Diversion has decreased the amount of flow downstream on the Assiniboine River, which people felt has allowed silt to build up in the river and caused its flow capability to be diminished. It was believed that this in turn has led to an increased need to use the Diversion. Other concerns included that the Diversion causes a decrease in Lake Manitoba's water quality and leads to debris, mud and hay landing on beaches, as well as plugs up the natural drains into the lake around its margins. In addition, there was concern with the sides of the Diversion being shored up, which suggested to some that it will be used to carry higher volumes of water in the future. A recommendation was made for the Portage Diversion to be reviewed to ensure that it is capable of handling 34,000 cubic feet per second (cfs) without leaks should there be another flood of similar or greater magnitude to the 2011 flood.

Through the Task Force survey on this Term of Reference, some respondents suggested that the Diversion should only be operated in conjunction with an outlet at the north end of Lake Manitoba and/or that its flows should be capped at a more manageable level if outflows from the lake are not increased.

Lake Manitoba and the Fairford Control Structure

Several people commented on the lake levels of Lake Manitoba, not necessarily in reference to any specific control works. Respondents felt that lake levels need to be lower and/or better controlled. There was also concern with the potential for a higher upper level to negatively impact economic development around the lake. Those people who suggested specific levels for the lake for the most part felt that the maximum level should be no higher than 812 feet above sea level (ft. asl), with the minimum level around 810 ft. asl. It was suggested that fall target levels for the lake have been too high, but should be 811 ft. asl. Somewhat in contrast, it was also suggested that the range within which the lake is allowed to fluctuate should be relaxed, in order to improve the health of the lake and surrounding ecosystems.

The Task Force received many comments indicating that outputs from Lake Manitoba must be able to equal inputs. In relation to that belief, a few comments were received from people who felt there is a need for the Fairford Control Structure to be opened up to its full capacity, as some people believed that it was not during the flood. Several issues were noted concerning operation of the Fairford Control Structure. These included that it should not have been closed in the winter of 2010, was not opened soon enough in the spring of 2011, and is restrictive in times of high water flow, as its capacity does not increase on pace with increases in the level of Lake Manitoba.

Shellmouth Dam and Reservoir

The detailed comments received on the Shellmouth Dam and Reservoir illustrated the degree to which surrounding landowners are affected by operation of the structure. The Task Force heard that it is poorly managed, causing the flooding of businesses, parks, recreation infrastructure, crops and hay land. It was suggested that the Shellmouth Dam was originally intended for flood protection/control but that as drainage conditions have changed upstream, it now receives too much water. Respondents believed that priorities related to use of the structure have changed, with providing a supply of water for irrigation and recreation now taking precedence over flood control. It was felt that the pressure to have a supply of water for these activities prevents the reservoir from being lowered. Conversely, it was suggested that persistently high reservoir levels and bank erosion compromise recreation potential around Lake of the Prairies. The Task Force also heard that the Shellmouth Reservoir Liaison Committee is not effective because it is comprised of individuals with vested and divergent interests, and certain interests are favoured over others.

Some landowners felt that operation of the Shellmouth Dam actually makes the situation worse than it was under unregulated conditions, as natural floods were higher in magnitude but of shorter duration, while controlled releases are generally lower but last longer, causing serious issues for producers. As such, people suggested there is a need for better operational timing and to notify landowners when the structure is to be operated.

Assiniboine River Dikes and Other Structures

Some comments were received regarding the Assiniboine River and its dikes. It was suggested that the Assiniboine River has lost capacity due to the build up of silt, and so needs to be dredged in order to recover its past capacity. The Task Force also heard that the river's dikes receive poor maintenance. In general, it was suggested that all provincial dikes need more attention.

Other flood control structures commented on included the Red River Floodway, the Mossy River Dam at Dauphin Lake, and the Hoop and Holler controlled breach. It was noted that operation of the Floodway affects communities on the Red River but that meetings of the Floodway Liaison Committee ensure effective communication regarding its operation. Operation of the Mossy River Dam was reported as being contentious during the flood. It was also suggested that the Province could have avoided property damage if a channel had been cut to the Elm River rather than at Hoop and Holler.

5.2 Flood Mitigation

The Task Force received a variety of feedback related to flood mitigation. This included comments on structural forms of flood mitigation, such as sand bags and emergency dikes, as well as non-structural mitigation measures such as wetland restoration. Many of the comments received were very specific in terms of what worked and what did not in certain areas.

Structural Forms of Flood Mitigation

The Task Force often heard that people in flood-affected areas were pleased with the provision of items such as sand bags, but that there was not necessarily sufficient instruction or information regarding how best to use them. Like the individual citizens who commented they did not receive enough instruction, some municipal officials also indicated that they would benefit from more training related to flood mitigation, including when and how to use particular measures, as well as when to take them down. Municipal officials reported that the provincial sand bagging machine is too difficult to operate, in part because it requires so many people to use it. Other issues included that many sand bags were damaged, Aqua Dams and tiger tubes leaked, and in some areas there was insufficient water to fill Aqua Dams. In addition, a concern was raised regarding the potential for sand brought in from outside a region for use in sand bags to be contaminated with noxious weeds such as Leafy Spurge. Despite these concerns, the Task Force did hear of some successes with mitigation efforts. In a submission to the Task Force, one individual from Brandon commented that:

> ***"The earth dike, super-sandbags and last moment aqua-dike saved my home. Brilliant work."***

During the 2011 flood, people around Lake Manitoba and Dauphin Lake in particular found out that small sand bags are not suitable for lakeside property protection. The Task Force heard that in some cases people trusted that building sand bag dikes would protect their property as that is what they were advised to do; after these dikes failed some individuals did not trust any additional mitigation-related information they received from officials. Tiger tubes and Aqua Dams were also found to be ineffective against wave forces, as well as being awkward to install and to remove. It was suggested that the only mitigation measure that worked well on the lake shore was super sand bags. Geotubes were described as being effective in controlling shoreline erosion, but prohibitively expensive. In addition, it was noted that it is very important to get the forecast correct as early as possible because in some cases temporary flood protection works cannot be added to if the forecast changes to indicate a more severe flood is coming. For example, once an Aqua Dam is placed on top of a dike, it is difficult to raise the level of the dike/Aqua Dam complex.

The Task Force heard that people around Lake Manitoba felt that they were left to their own devices, with no help or instruction provided concerning how and to what height to build dikes. Respondents from this area commented that, through the media, they observed resources such as military assistance being sent to areas like the Hoop and Holler breach, but felt that no such assistance was given to people around the lake. It was also felt that mitigation efforts around the lake occurred too slowly. One respondent commented that:

> ***"Having experienced flooding and flood mitigation before [on the Red River], we were surprised by the lack of oversight and provision of adequate flood mitigation measures [for Lake Manitoba]".***

Serious issues with dike-construction were reported in areas including Ashern, Siglunes and Lake St. Martin. It was suggested that in some cases dikes were built by inexperienced officials or contractors, leading to the dikes being improperly constructed and ultimately failing, as well as trees and property being damaged unnecessarily. In some cases dikes also impeded access to the water, which was a problem for fishermen, or kept water in rather than keeping it out. Other issues reported included problems in some communities with the inequitable distribution of resources and equipment, areas where some homes or cottages were too close to the shoreline to construct an adequate dike, and confusion in some areas regarding who was responsible for paying for individual flood protection measures, such as dikes around residences.

Several examples were described of areas where flood mitigation measures worked well, such as in Deloraine and Brandon. It was reported that pumping from inside the dike was an important aspect of flood management in Brandon, and as such officials noted that being prepared with a good supply of pumps was key.

Non-structural Flood Mitigation

The Task Force received many comments regarding non-structural forms of flood mitigation. In particular, people noted their concerns with ongoing illegal or uncontrolled drainage activities and the problems they believed resulted from those activities. Many people commented that there is a need to stop or control drainage and to better manage water upstream. It was also suggested that there is a need for a water management plan that is holistic and recognizes the evolving nature of the watershed.

> ***"It is the view of the Council of the Rural Municipality of Westbourne that long term plans need to be made in terms of the flooding situation rather than reacting and repairing on an almost yearly basis."***

Comments were made noting the connection between wetland loss and flooding, with the suggestion made that there seems to be more incentive to drain wetlands than to protect them. Somewhat in contrast, the Task Force also heard of people in different areas having issues working with Ducks Unlimited. The suggestion was made that Ducks Unlimited projects may be geared more toward periods of drought, and do not include strategies for use during wet cycles.

Several people spoke of drainage issues related to the Shellmouth Dam and Reservoir. It was reported that drainage occurring in Saskatchewan is putting pressure on landowners in Manitoba to do the same. People suggested that drainage-related laws or regulations are not properly enforced, and that since it can take a long time to get a permit to implement drainage properly, it is done illegally and often inappropriately. However, it was also suggested that regulations should be more flexible, with drainage allowed in certain situations and licensing based on common sense.

Several solutions were suggested to address the perceived issue of uncontrolled drainage. For the most part these solutions in some way involved compensating landowners for storing water on their land. Suggested programs included the Alternative Land Use Services project and a nation-wide ecological goods and services approach. Other suggestions mentioned included increased storage of runoff water in Saskatchewan, compensation for landowners adversely impacted by drainage, payments for wetland conservation, buyout of flood-prone Assiniboine River valley bottom lands, increased taxes on lands brought into production through drainage, adoption of a no net loss wetland drainage policy, and a 10-year moratorium on drainage to study the issue and implement mitigative measures. It was also suggested that the Province should be proactive and develop a maintenance program for all drainage ditches.

5.3 Flood Forecasting

The Task Force heard divergent views regarding forecasting. In general, the Province's forecasting efforts in 2011 received primarily unfavourable reviews. Many people commented that forecasting was inaccurate or late and could be improved. Particularly in the Lake Manitoba area, people felt that they should have received more warning in order to better prepare for the flood. It was suggested that little warning was given as to the extent of flooding to expect, even though lake levels had been rising through the winter. One respondent to the open house feedback form commented that:

> *"Flood forecasters should have been able to foresee the large volume of water that was going to impact the Assiniboine River, and steps could have been taken to increase the flow of the Assiniboine to Lake Winnipeg sooner, rather than later."*

In contrast, in some other areas of the province, including the RM of Kelsey and along the Red River, it was indicated that incorrect forecasts, which predicted more water than eventually arrived, caused undue stress and led to unnecessary protection measures being implemented. Other comments suggested to the Task Force that some individuals and municipalities lack confidence in Provincial forecasting.

> *"While the RM of Morris understood the need to ensure a margin of safety in the flood level reporting process, there was unfortunately a lack of confidence in the numbers presented to us by the Province. Local knowledge and understanding of flood levels were probably more useful for us in 2011... More accurate reporting processes are required."*

While forecasting in advance of the flood was described as poor, several comments were received indicating that it improved during the flood, becoming more accurate and timely. In some cases, such as around Dauphin Lake, it was reported that the early forecast was accurate but residents did not believe it and did not act immediately. It was also noted that it can be difficult for municipal officials to put provincial forecasts into a local perspective. Positive comments heard included that Lidar data has helped make predictions more accurate and that the forecasting for Brandon was very accurate.

Through a Task Force survey, information was received regarding people's behaviour in relation to forecasting. 25 out of 26 survey respondents stated that they followed Provincial forecasting before or during the 2011 flood, and most indicated they understood it at least somewhat well. However, only about 35% of the survey respondents indicated that the forecasting was useful in terms of helping them prepare for flooding.

It was indicated that many people obtained forecasting information through multiple sources, such as radio, television and the Internet, and that, while they understood the information, not enough was provided and it was sometimes unclear. It was also indicated that the forecasting changed constantly, with the Province described as being too slow to respond to changing conditions. Most people reported that they took action as a result of forecasting, such as undertaking various types of mitigation work and removing possessions from homes. However, in many cases this action was either not sufficient, with dikes not ending up being high enough, or was too much, with dikes ending up being unnecessary. Many people, including approximately 75% of survey respondents, felt that the communication of forecasts could be improved. One example given of a communication problem was that provincial web pages apparently changed regularly and information moved around, so it was difficult to find information or keep track of where to look for it. It was suggested that communication of forecasts could be improved by determining the best method for delivering the information (whether that is in person, by email, etc.) to citizens and officials depending on the area or situation and ensuring that it is clearly received. One survey respondent illustrated the importance of accurate forecasting to municipalities:

> *"From a Municipal Government perspective the flood forecasting information is absolutely critical in planning our response."*

Suggestions for improving forecasting included that the Province should consider and involve local people and knowledge, as well as gain a better understanding of the increased drainage that is occurring upstream and changes in land use. The concept of incorporating local knowledge is one that the Task Force heard often in relation to several of its Terms of Reference. Officials from the Red River Valley indicated that the joint cooperativeness of Canada and the U.S. is very important, and that organizations such as the Red River Basin Commission allow municipal leaders from both sides of the border to communicate between flood events. It was suggested that cooperation and communication is needed between Manitoba, Saskatchewan and the U.S. to help ensure that information and strategies are shared.

5.4 Flood Preparedness, Flood Fighting Capacity and Response

Comments received by the Task Force regarding flood preparedness and response indicated that in some areas people felt prepared, while in others people did not at all. It was suggested that flood-prone areas were more prepared than those areas not used to major flood events. In particular, people around Lake Manitoba indicated that preparation, response and resources were lacking, while the response was viewed more positively by many people in Brandon and other areas of south-west Manitoba. Some people felt that the focus of response and resources was on Brandon and Souris, while the Lake Manitoba area was poorly prepared with no help provided and insufficient resources available.

> ***"Flood preparedness, fighting capacity and response seems very good in areas prone to flooding, such as around the Red River and Assiniboine, but limited in areas where flooding is less common... Municipalities with flood experience should share knowledge and infrastructure."***

The results of a Task Force survey on this Term of Reference indicated that in most cases officials generally felt at least somewhat well prepared, while the residents of their municipalities did not necessarily agree. Some municipal officials reported that they had undergone flood-related training, such as in dike-building, while others had not. Eight out of 14 municipal officials felt that the Province offered adequate emergency measures training; suggestions for improvement in this area included more training related to flood mitigation work. It was indicated that the Province should provide officials with more direction in general and ensure that all needed information is easily available to municipalities and First Nations, as well as clearly received. Also, it was suggested that officials would benefit from having contact people from whom they can seek advice, and that staff working with the various assistance and recovery programs should be better trained in terms of their knowledge of programs and ability to share information. In addition, it was suggested that there was confusion regarding the responsibilities of various different Provincial offices and staff, and as such roles and responsibilities should be more clearly explained.

Other comments from municipal officials included that materials and equipment were provided by the Province as required and that contractors were used efficiently but needed more supervision. Issues with private security services were reported, as well as with controlling and providing access to flood control areas. The value of consistency in personnel and contractors was noted in the Red River Valley, while in other areas the Task Force heard of municipal concerns regarding the lack of a succession plan in terms of government retention. Positive comments regarding preparedness and response were heard from municipal officials in Brandon, where advanced planning, including early ordering of mitigation materials and prior training, was described as crucial.

Survey comments from people who were not municipal officials indicated that some residents feel it would be beneficial for them to receive training on topics such as flood mitigation work. It was also suggested that it is the Province that has resources and manpower, not municipalities, and that the Province should have provided supplies for mitigation in advance of the flood. In contrast with many of the more negative comments concerning preparedness around Lake Manitoba, one survey respondent from the area indicated that their municipality responded well:

> ***"In the case of Sugar Point/Lundar Beach we were very fortunate that the R. M. of Coldwell had an emergency measures employee with adequate experience... Flood fighting efforts were very well organized, and effective and in fact saved almost all the cottages. All efforts were taken without regards to finances etc., and in my opinion the efforts in Coldwell could be used as a model for flood fighting."***

It was suggested that individual communities are limited in their ability to respond effectively due to their small size and population base. Similarly, it was reported that many of the people with properties around Lake Manitoba are seniors and/or have primary residences away from the lake, both of which were factors limiting their ability to respond. In addition, the Task Force heard that there were issues on a First Nations reserve in terms of perceived nepotism affecting the provision of new homes.

Disaster Financial Assistance

The Task Force repeatedly heard of issues with the Disaster Financial Assistance (DFA) program, as well as the various other assistance and recovery programs. This was one of the most frequently commented on subjects, with respondents providing detailed descriptions of their experiences with the compensation/assistance process. In general, the Task Force heard that municipalities had a better experience with these programs than individuals did, although there were problems for municipalities as well. Too many issues were noted to list them all. However, some examples included:

- Too many government agencies involved, and a lack of coordination between them with no consistency in personnel or information
- Promises made but not being kept, and answers to questions changing from one official/assessor to the next
- A lack of knowledge or training on the part of the employees or officials carrying out the programs
- A lack of support for understanding and completing forms, and then a lack of feedback regarding submitted forms or breakdowns to explain payments
- The process taking far too long, with many still waiting to receive compensation in the fall of 2012
- Policies and the parameters of the programs changing, with no transparency and no consistent application of the rules
- Compensation not covering all flood-related costs
- Compensation paid based on post-flood reduced property values, rather than on pre-flood values
- Neighbours being treated differently depending on whether they were cottagers or permanent residents, and as a result turning against each other
- People being denied compensation for mitigation efforts taken in advance of the flood, leading to the feeling of being penalized as a result of taking pre-emptive action
- The lack of a proper program in place to adequately compensate producers, who are affected by the flood for much longer than just one year
- For municipalities, required engineer assessments caused delays and added costs
- Programs requiring that repairs return damaged property or infrastructure to its prior condition with no improvement, even if that prior condition is inadequate

Seven out of the 10 people who responded to a Task Force survey question about the consistency of DFA information indicated that the information received since the flood was somewhat or very inconsistent. Other respondents, 80% indicated that it had taken several months for them to receive information or answers regarding claims or questions they had submitted, and 80% also rated their overall experience with DFA as poor or very poor. One municipal official who responded to the survey noted that:

> ***"The forms to fill out for compensation are VERY comprehensive and time consuming. We had over 60 sites and I am still trying to work through the forms in order to get some compensation. Our bank account has been sitting at a $300,000 deficit for over a year now while we try to work through the claim forms."***

A number of suggestions were made regarding how the Province could improve these programs and their delivery, including:

- Developing a "one stop shop" for before, during and after major events such as a flood, where different departments are brought together at a single site
- Providing an improved Internet presence and creating a single program and form for flood-related support and compensation
- Implementing a system in which commitments by government representatives can and are made on site and in writing to avoid constant changes
- Offering up-front loans to those who cannot afford to rebuild

- Developing a mechanism to allow for a municipality to recover the costs of a temporary flood mitigation structure (e.g. temporary dike) without having to remove the temporary structure, allowing for the structure to be made permanent after the flood without the municipality having to incur significantly greater costs

In a submission to the Task Force, one person summed up some of these suggested solutions in stating:

> ***"The Province must overhaul procedures for dealing with compensation/reimbursement issues to those who are victims of the flood to end the bureaucratic nightmare and achieve a rapid, effective, consistent, streamlined, single-window approach which will, where possible, return people to their homes quickly."***

5.5 The Adequacy of Existing Flood Protection Infrastructure and the Need for Additional Works

As with the first Term of Reference, concerning the operation of flood control infrastructure, this was one of the most commented on Terms of Reference. Similarly, the majority of what the Task Force heard concerning the adequacy of infrastructure and the need for additional works was focused on Lake Manitoba and the Shellmouth Dam. A general comment suggested that existing flood control infrastructure is too focused on individual areas and does not consider negative impacts to other areas.

Many people indicated that they believe the existing control structures for Lake Manitoba are inadequate and that outflows from the lake must be able to match inflows from the Portage Diversion. It was felt that the Fairford Control Structure is inadequate for dealing with inflows to Lake Manitoba and so a new channel/outlet from Lake Manitoba to Lake Winnipeg is necessary and/or the capacity of the Fairford outlet should be increased. Some people also commented that the Emergency Channel should be kept open, and the suggestion was made that increased capacity is needed from Lake St. Martin to Lake Winnipeg. A common sentiment was that people understood that there is a need to use the Portage Diversion to prevent damage to urban centres, but felt that as a result the Province has a responsibility to develop a new outlet for Lake Manitoba to protect the people around the lake and enable them to feel secure. In addition, concern was expressed regarding the integrity of the Portage Diversion. It was also suggested that, in order to improve the function of the Fairford Control Structure, the opening to the Fairford River should be dredged as it was believed that silt has built up around the structure. A comment from the Reeve of the RM of Lakeview sums up the sentiments of many of the people the Task Force heard from:

> ***"The security for Winnipeg provided by the Red River Floodway and the Portage Diversion has been proven. Lake Manitoba [and] Lake St. Martin deserve security too. Diking farmsteads and raising cottages does not protect farmland. People have to make a living here and feel secure - otherwise our communities will fail."***

Regarding the adequacy of the Shellmouth Reservoir and Dam, it was suggested that drainage conditions upstream have changed since the structure was designed, and as a result there is a problem with too much water entering the reservoir. It was felt that there is not enough space in the reservoir to store the volume of water that enters it and as a result water goes uncontrolled over the spillway and regularly floods land in the valley. The Task Force heard that issues occur in particular during times of high rainfall, and that the system needs to be upgraded, potentially involving the expansion of the reservoir, in order to meet the conditions in the drainage area it controls.

Multiple people commented on the Assiniboine River and the condition of its dikes. It was indicated that the river should be dredged and its dikes built up and then maintained and monitored. People suggested that a lack of maintenance on these dikes has kept the river from being able to meet its past capacity. In addition, the comment was made that efforts to raise the Assiniboine's dikes over the winter of 2010/11 were a waste of money because the clay would not compact properly due to it being frozen. It was suggested that the breach at Hoop and Holler would not have been necessary if the Assiniboine's capacity had been greater.

Other comments indicated that flood control infrastructure, work or maintenance is needed in several other areas. The Task Force heard that a new control structure is needed at the north end of Dauphin Lake, in addition to the existing Mossy River channel, as the Mossy River is insufficient for dealing with a flood such as the one in 2011. The need for ongoing maintenance of dikes along the Red River was mentioned, with officials from Emerson noting their concern that the Province no longer conducts rodent control on the dikes and that that, along with weed and tree growth, is compromising the dikes' integrity. Other needs mentioned in other areas included dredging of the mouth of the Dauphin River at Lake Winnipeg, control structures or other work at the Shoal Lakes and the Salt Lakes, a solution concerning high water levels on Whitewater Lake, a dike in Brandon and drainage work on several First Nations reserves.

5.6 The Environmental, Social, Water Quality and Human Health Impacts Related to Flooding

Comments the Task Force received regarding the impacts of flooding tended to focus on the physical and emotional toll caused by the 2011 flood, as well as the environmental damage. Many people indicated that they have suffered significant stress as a result of dealing with the flood and its aftermath. It was suggested that it is particularly difficult for older people to recover from an event such as the 2011 flood.

> ***"My wife and I had the home of our dreams and flooding of this magnitude never entered our minds. We have basically lost two or three years of our life, trying to get back to where we were physically and emotionally. At our age physically is a bit harder. Emotionally, we hope to get back there."***

A variety of environmental issues were described to the Task Force, for the most part related to flood impacts on private properties. These included wells flooded or destroyed, holding tanks overflowing and ending up in the lake, oil, paint and chemicals being swept into the lake or left standing on properties for months, and sewage lagoons being overrun. Concern was also noted regarding the possibility of flood-damaged appliances having been disposed of improperly. One person described the following experience:

> ***"Our home is located a short distance from the Hoop and Holler breach. The water from the breach flooded our septic field and in turn pushed the contents of our septic tank into our basement. There was enough water in our basement to float and tip an old furnace oil tank into the water already in the basement. This toxic water mixture remained in our basement for several weeks. We called in environmental testers ... and they indicated that we could not remain in our home for any longer than 10 minutes. They recommended a respirator for anyone to remain in the house longer than 10 minutes."***

Several people asked questions regarding what, where and when water quality testing was being conducted, and it was indicated that in some communities the flood affected the availability of fresh water. A survey respondent from Lake Manitoba First Nation stated that:

> ***"During the flood and after, members of Lake Manitoba First Nation couldn't drink or use the water. Band members had to get water from the store and the amount of water that was given to each household was put at a limit. The water that flooded the community was dirty, filthy and there was plenty of garbage that came with it... The community no longer has a beach and the people couldn't fish."***

In addition, the Task Force heard that the RM of Kelsey's water supply is located in the middle of a low area, rendering it inaccessible during the flood and for a significant period of time afterward. Responses to a Task Force survey on this Term of Reference were mixed regarding whether or not people were aware of any mitigation measures put in place before the flood to protect the wells, holding tanks or other sites they listed.

In addition to what the Task Force heard concerning impacts to people's homes and properties, several people commented on the amount of damage to ranch land caused by the flood. It was reported that soil salinity levels were much increased due to the flood and will potentially stay that way for some time, impacting the productivity of the land. It was indicated that it will be years before some farmland becomes usable again and existing resources to address the issue of degraded lands are inadequate. As such, the mental health of many farmers has been negatively impacted and it was suggested that no plan or form of assistance to deal with this has been put in place by the government.

The Task Force heard from a number of people who were concerned with the impact of the flood on wildlife. People noted a perceived reduction in wildlife and waterfowl numbers around Lake Manitoba, and several respondents were concerned for Delta Marsh and for marshland in general. It was noted that in Lake Manitoba's south basin, the lake and swamps/lagoons are filled with refrigerators, plastic and other debris. Municipal officials indicated that they were unsure whose responsibility it was to clean this up. In addition, the Task Force heard that the loss of trees and significant amount of erosion and sedimentation that took place will have continuing effects and lead to more issues in the future.

5.7 Land Use Policies and Zoning Criteria Relative to Areas of the Basin that are Vulnerable to Flooding

The Task Force heard from several municipal officials and residents regarding land use and zoning guidelines and policies, although fewer comments were received on this Term of Reference than the others. General comments suggested that regulations should be based on common sense, not bureaucracy, and that development of management standards needs to be a joint effort between municipalities, First Nations and the Province.

Several people from the Lake Manitoba area commented on the Provincial policy requiring them to raise their home or cottage to above the 2011 flood level. Many issues were noted with this requirement, such as people not knowing how they were to go about doing this, not having the necessary information, and finding out about the requirement from neighbours. The Task Force also heard that some people cannot afford the upfront costs needed to comply with the requirement and others were having difficulty finding contractors to do the work. In addition, it was suggested that some people around the lake do not want to rebuild their homes or cottages until they know how lake levels will be controlled in the future. One senior citizen living alone on Lake Manitoba who was evacuated during the flood commented that:

> ***"I am being told I must raise my house 1.5 ft. and the garage 3.5 ft. which suggests the water will be back. Implied in that message is the need to move out again to have it raised and then move back home when it is again deemed safe. I cannot move four times in two years."***

Some individuals and municipal officials felt that the new policies are premature and inconsistent. It was suggested by some that land use and zoning policy changes are not needed so long as water is properly managed and/or a new outlet is built from Lake Manitoba. However, it was also suggested that greed for tax dollars led to building being allowed in areas that should never have been developed, and as such policies are needed to prevent this from happening in the future.

It was suggested that the new water level based zoning criterion is too high, as cottages and other buildings must be raised above that level but not roads. People did not think it makes sense to protect buildings to a certain level when the roads leading to those buildings would potentially end up under water. In addition, it was felt that the Provincial policy is focused on the protection of permanent structures, but there is no consideration given for the protection of agricultural lands. It was suggested that land use guidelines for agricultural land need to be established in relation to land capability, so that, for example, good land is preserved for agriculture and poor land is used for water storage. In addition, the Task Force heard that land use regulations must be well thought out in terms of what is financially viable, sustainable and defensible.

The Task Force heard from municipal officials in the Red River Valley that current guidelines in that area, which require new residences or buildings in the Valley to be padded or diked to 1997 levels plus two feet, are adequate. However, it was suggested that land use planning in and around the Red River should be revisited, in order to examine possible ways to enable more development. The Task Force also heard that Manitoba lacks the digital geomatics data that municipalities need for effective planning.

5.8 Communications

The Task Force received a variety of comments on communications before, during and after the flood. Some of those comments relate to the Task Force's other Terms of Reference and have been touched on in those sections of this report. Generally, communications during the flood received mixed reviews, with comments from the Red River Valley and south-west Manitoba areas tending to be more positive, but comments from the Lake Manitoba area tending to be more negative. Municipal officials also tended to view Provincial communications more favourably than did residents. It was suggested that, for the most part, municipalities around Lake Manitoba did what they could, but flood-related warnings did not arrive soon enough. In addition, there seemed to be little communication between different governing bodies.

Individuals identified many communications-related issues. General issues included a lack of information being made available, few answers and confusing direction being provided, and people feeling like they were not being listened to. A respondent to the open house feedback form suggested that "a lack of information provided by [the] province creates [the] opportunity for people to create/speculate about the real reasons" for events or actions. In Delta Beach specifically, it was suggested that the order to evacuate was unclear, no warning system was in place, and it was difficult to find information about lake levels on the Internet.

The majority of people who completed a Task Force survey on communications felt that flood-related communications before, during and after the flood were poorly timed or late, not helpful, and inaccessible. In a separate survey question, 80% of respondents indicated that communication was poor or very poor before the flood, 70% rated communication as poor or very poor during the flood, and 60% rated communication as poor or very poor after the flood. Other issues highlighted through the surveys included a seeming lack of leadership, a sense of chaos and people receiving different answers to the same question from different departments. Nine out of 11 survey respondents indicated there was information they did not receive that would have been helpful. Information received that was described as helpful included that on flood mitigation sources and materials, and on what was going on in the community. At the same time, it was suggested that it would have been helpful to receive more information on flood mitigation, and that in some cases this information was provided, but too late so it was of no use.

From a municipal perspective, the Task Force heard that municipal leaders are responsible for the land in their municipalities yet feel like they are not listened to by any other levels of government. Some municipal officials indicated that they experienced issues related to their communications with the Province, with noted problems including not having enough information to make decisions and receiving unclear direction. Through the open house feedback form, an official from the RM of Lakeview indicated that:

> ***"The provincial and federal government provided very little information in order for us to make decisions; council did the best job to protect its residents but we never knew [until] afterwards if this would be paid for."***

Major communication issues were reported by some municipalities. For example, the RM of Portage la Prairie indicated that they were not given the opportunity to contribute to decision-making processes and did not receive up-to-date information from the Province in a timely fashion. In addition, it was reported that there was miscommunication between different levels of government and the RCMP, and that residents were provided with incorrect information by Provincial or contracted staff who did not have the appropriate authority to be giving out information. Another serious communication issue was reported by officials from the RM of Ochre River, where poor cell phone service in some areas led to problems with on-site communication as well as a safety issue. In contrast, it was indicated that communication worked well in Brandon, with twice-daily reports from council representatives helping to keep the public positive. Also, some people found municipal web pages to be helpful tools for communicating updates to residents.

It was felt that there was a lack of empathy on the part of the government in terms of appreciating and considering the stress levels and emotional impacts people were experiencing due to the flood. It was also suggested that people within Winnipeg and on the Red River had very little interest in the 2011 event. The Task Force heard from some people who were displeased with the media coverage the flood received, with the suggestion made that the breach at Hoop and Holler was a "photo op" for publicity for the Province and a planned distraction away from the problems on Lake Manitoba. Some municipal officials noted that media management during the flood was an issue, with local authorities having to spend too much time dealing with the media.

Several communications issues were described that were specific to the compensation/assistance programs, some of which were touched on earlier. Compensation forms were described as disorganized, long-winded and full of legal jargon, and it was indicated that forms and guidelines seemed to be revised constantly. Communication accompanying delivered compensation was also lacking, with limited or no breakdowns explaining the payments. Most survey respondents believed they had at least some understanding of the DFA program, but it was indicated that it would have been helpful to receive specific information such as that on the rules and regulations regarding what should be claimed, what was allowed or what qualified, and when the money would be available.

A variety of suggestions were provided to the Task Force concerning how the Province could improve general flood-related communications. Some of these included:

- Implement a flood oversight management group which would provide clear, simple, up-to-date and consistent communications during the aftermath of the flood and during the recovery period
- Directly provide people with information rather than requiring them to get it from the media
- Share information with residents via the Internet rather than by mail, which is too slow, but be sure that it is received
- Improve communications to those people without Internet service or in areas without reliable cell phone service
- Contact municipal councils in person to enable discussion and ensure municipalities have the information they require
- Give more consideration to local people and their knowledge
- Improve communication and cooperation between different government departments, as well as jurisdictions and between First Nations, municipalities and the Province

5.9 Impacts on the Road Networks and Bridges to Businesses and Public Access

The Task Force received comments on this Term of Reference from across Manitoba, with many focused on specific impacts or needs. Comments identified damaged sites that required or still require repair, bridges and highways that needed to be raised so that access will not be compromised in the future, and areas where replacement culverts are still needed. The comments showed that the flood continues to have a huge effect on municipal infrastructure.

It was indicated that roads and bridges in the south-west corner of Manitoba were greatly affected by the flood, but municipalities dealt well with this and Manitoba Infrastructure and Transportation did a good job returning the highways to travel conditions. However, some municipalities described several issues they faced, including engineer assessments required by the Province adding costs and delays to the repair process, the approval and licensing processes for replacing culverts taking a long time, and public works staff being unable to carry out regular maintenance activities due to flood-related needs. Some First Nations reserves also face ongoing issues regarding surface runoff being impeded by improperly located or inadequately maintained road culverts, or roads being soft and difficult to drive on at certain times of the year. In addition, it was felt that increased drainage is increasing flood flows in many areas, resulting in much higher water levels. Some municipal officials indicated that, as a result, there is a need in some cases to replace culverts with higher-capacity culverts or bridges, but they were under the impression that the rules for damage claims require culverts to be replaced with those of an equivalent size.

The Task Force heard many examples of the road and bridge damage and access issues communities faced due to the flood. One such example is found in the town of Emerson, which can quickly become isolated during a flood if certain bridges are lost. Another issue there is that Emerson's King Street is repaired after nearly every flood, but due to damage claim rules, only to its pre-flood, and therefore flood-prone, condition. In the RM of Westbourne, approximately 200 damaged sites were repaired in 2011, with more to be repaired in 2012 and beyond, and plugged culverts and debris on road allowances were still being discovered. One individual from the RM of Ochre River indicated that they had to evacuate during the flood not because their home was below the flood level, but because the road to their home would not support emergency vehicles. The bridge over the Qu'Appelle River in St. Lazare was damaged for two to three weeks, resulting in a 40-50 kilometre detour and no access for emergency vehicles. This small sample of examples demonstrates how widespread these issues were across Manitoba during and after the flood.

Aside from the more obvious damage caused to roads and bridges that were directly impacted by flood waters, the Task Force heard that many secondary roads in municipalities were damaged due to being used as alternate routes during and after the flood and as a result receiving much heavier traffic than they were designed for. It was suggested that some damage may have been avoided if roads were better monitored in order to make sure use restrictions were adhered to. Regardless, in many cases these roads had not yet been repaired as of the summer or fall of 2012, with little or no funding available to do so.

Through the Task Force survey on this subject, many people described damaged or inaccessible roads and bridges. The impacts of this damage/lack of access on businesses and the public were most often rated as extremely significant. In approximately 45 percent of these cases, people indicated that access had still not been restored and/or damage not repaired as of the summer or fall of 2012. In some other cases, access was reported as being restored as a result of the use of mitigation measures such as sand bags. Survey respondents described many issues resulting from the lack of access and damage to roads. These included:

- The need to take long detours
- Service delivery interrupted
- Businesses unable to access customers and farmers unable to access fields
- Schools closed or bus routes affected
- Access problems for emergency services
- Safety issues caused by high amounts of traffic condensed onto those roads that remained open

One particularly detailed example of the impacts of flooded roads on a community was provided by a survey respondent from Dauphin River First Nation. This individual indicated that access to approximately 34 kilometres of Highway 513 from Gypsumville to Dauphin River was lost due to the flood:

> ***"The flood isolated the community of Dauphin River as this is the only access into the community and First Nation. We travelled 60 km by boat to get in and out. We had to travel on the Dauphin River which was very fast flowing, [debris-filled] and extremely treacherous. Only a few people stayed behind to monitor and protect the community, everyone else was evacuated and [is] still evacuated today [in August, 2012]. Highway 513 is only now being reconstructed. This road remains closed 21 months after it was originally declared closed by MIT... All businesses in Dauphin River have been closed since March 2011. 62 commercial fishers are affected since we could not get our [product] to market. [Four] tourist operations have been closed. The lakeside fish plant is closed and the transport truck sits idle. Every person from our community and the surrounding area has been affected."***

The Task Force heard several suggestions for how issues regarding impacts to roads and bridges should be addressed. It was indicated that the Province should develop a province-wide emergency roads system for all communities, including First Nations, that better use should be made of local knowledge in terms of locating and sizing road drainage structures, and that municipalities should be provided with compensation to address soft roads and the damage caused by additional traffic on secondary roads used as detours. It was also suggested that the Province should provide the public with more information regarding road closures.

Other Comments

The Task Force received a few comments that were unrelated to any particular Term of Reference. General comments included those from a few people who felt the Province was responsible for the flood and should be held accountable for that and apologize. Comments were also made suggesting that the people of Lake Manitoba were sacrificed to protect communities downstream, specifically Winnipeg. Some indicated they understood why the Province had to take that action, but did not understand why the people affected had to pay financially and suffer as a result. Regarding the Task Force, it was suggested that the online surveys and open houses were a great way to collect public opinion.

6.0 Appendices (Available on request)

1. Survey Questionnaires
2. On-line Feedback Forms
3. Open House Feedback Forms
4. Debrief Notes: Ashern Open House September 13/2012
5. Debrief Notes: Assiniboine Valley Producers Meeting September 25/2012
6. Debrief Notes: Benyks Point Meeting July 27/2012
7. Debrief Notes: Brandon Meeting June 15/2012
8. Debrief Notes: Brandon Meeting September 25/2012
9. Debrief Notes: Brandon Open House June 19/2012
10. Debrief Notes: Dauphin Open House July 26/2012
11. Debrief Notes: Emerson Meeting October 29/2012
12. Debrief Notes: Fairford Open House and site visits September 12-13/2012
13. Debrief Notes: Langruth Open House September 19/2012
14. Debrief Notes: Northern Association of Community Councils AGM August 16/2012
15. Debrief Notes: Oak River Meeting August 21/2012
16. Debrief Notes: Portage la Prairie Open House September 18/2012
17. Debrief Notes: The Pas Meeting June 26/2012
18. Debrief Notes: Ochre River Meeting July 26/2012
19. Debrief Notes: Portage la Prairie Meeting May 30/2012
20. Debrief Notes: Russell Meeting July 25/2012
21. Debrief Notes: Russell Open House July 25/2012
22. Debrief Notes: Souris Open House June 21/2012
23. Debrief Notes: St. Laurent Meeting July 17/2012
24. Debrief Notes: St. Laurent Open House September 11/2012
25. Debrief Notes: South West Flood Group Meeting June 14/2012
26. Debrief Notes: Valley River Meeting July 24/2012
27. Debrief Notes: Winnipeg Open House September 26/2012
28. Summary of Online and Mailed Submissions
29. Summary of Open House Feedback Forms
30. Survey Report TOR# 1 + 5
31. Survey Report TOR# 3
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35. Survey Report TOR# 9

B. Hydrological Characteristics of the 2011 Flood

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Hydrologic Characteristics of the 2011 Flood

Background

Three main river systems ***(Figure 1)*** drain the prairie and boreal plains regions of western Canada and north central United States – the Saskatchewan River, the Assiniboine River, and the Red River of the North (known in Canada as the Red River). Runoff from these large basins ultimately accumulates in Lake Winnipeg before continuing on its way eastward and northward to Hudson Bay through the Nelson River system. During periods of high flow, a portion of the flow on the Assiniboine River near Portage la Prairie is also diverted into Lake Manitoba to provide flood protection downstream. In addition, runoff from local sources that include the Red Deer River, the Swan River, and numerous streams that drain the Porcupine, Duck, and Riding Mountains also finds its way to Lake Manitoba via Dauphin Lake, Lake Winnipegosis, and the Waterhen River. The Whitemud River drains the area between Riding Mountain and Lake Manitoba, emptying into the lake on its southwest shore. In addition, a number of small streams that rise in the Interlake region of Manitoba contribute inflow to both Lake Manitoba and Lake Winnipeg but flows on these streams are relatively small compared to those from the three major river systems.

Saskatchewan River

The Saskatchewan River and its many tributaries ***(Figure 2)*** rises on the eastern slopes of the Rocky Mountains and conveys water across Alberta and Saskatchewan before crossing into northern Manitoba and discharging into Lake Winnipeg at Grand Rapids. The Pas, located about 35 km east of the Saskatchewan/Manitoba border, is the most populated community on the river within Manitoba. The Saskatchewan River is heavily regulated for both water supply and hydro-electric power in Alberta and Saskatchewan, and the flows at The Pas reflect a wide range of climatic inputs and physiographic and anthropogenic effects. Overall, hydro-electric operations at the E. B. Campbell Generating Station at Tobin Lake near Nipawin, Saskatchewan have the most effect on the flows at The Pas because of the extensive storage in the reservoir and its close proximity to the town. The Saskatchewan River is also regulated for hydro-electric power at Grand Rapids. However, the effects of this regulation are confined more or less to Cedar Lake, which is immediately upstream of the regulation structure, and do not extend upstream to The Pas.

Assiniboine River

The Assiniboine River ***(Figure 3)*** is a prairie stream that rises in central Saskatchewan and flows south and east through Brandon and Portage la Prairie to its confluence with the Red River at Winnipeg. The Assiniboine is compose of three main tributaries – the Qu'Appelle River, the Upper Assiniboine River, and the Souris River. Each of the three main tributaries are heavily regulated for both water supply and flood control. Water is diverted from Lake Diefenbaker on the South Saskatchewan River near Swift Current, Saskatchewan into the Upper Qu'Appelle River system to augment water supplies. There are a number of water supply reservoirs along the entire Qu'Appelle River. The Lake of the Prairies on the Upper Assiniboine provides regulation for a variety of uses including flood control, water supply, and recreation. The Souris River is regulated in Saskatchewan primarily for water supply and cooling water for thermal electric generation stations, and to a lesser degree for flood control. The Souris River in North Dakota is regulated to a limited degree to improve riparian habitat. During high flows, there also is a significant diversion of water from the Lower Assiniboine River to Lake Manitoba at Portage la Prairie to provide a measure of flood control for the City of Winnipeg.

Red River

The Red River ***(Figure 4)*** rises in South Dakota and flows northward to Lake Winnipeg. Major cities along the Red include Fargo and Grand Forks in North Dakota and Winnipeg in Manitoba. The basin extends over areas of North and South Dakota, Minnesota, and Manitoba. The river is fed by numerous small tributaries from both the east and the west. The two largest tributaries are the Sheyenne River that derives most of its flow from North Dakota and the Pembina River that drains a portion of southern Manitoba. The Red River basin generally occupies the bottom of glacial Lake Agassiz. As a result, it is a relatively flat landscape with the result that there is considerable storage of water on the landscape and runoff is slow to develop. Never the less, the basin is relatively productive in terms of water supply relative to the more arid Assiniboine River basin.

Conveyance Across Manitoba

The elevations of the rivers and lakes that convey flows across Manitoba vary from west to east and from north to south. Lake Winnipeg – the most downstream large body of water – is at a nominal elevation of 217.6 m. This is about six metres lower than the Red River at Winnipeg, due mainly to the difference in water levels across the falls at Lockport. The level of Lake Winnipeg is also about 26 m lower than the level of Lake St. Martin which itself is only four metres lower than Lake Manitoba. Most of the elevation difference between Lake Manitoba and Lake Winnipeg occurs along the relatively steep Dauphin River. For additional perspective, the water level on the Assiniboine River at Portage la Prairie averages about 256.0 m – or some eight metres above the level of Lake Manitoba and almost 33 m above the level of the Red River at Winnipeg.

Near the north end of Lake Winnipeg there is about a 38 m drop in water levels across Grand Rapids from Cedar Lake to Lake Winnipeg, while there is only a three metre difference in water levels on the Saskatchewan River between The Pas and Cedar Lake. The nominal water level of Dauphin Lake is 260.5 m which is about seven metres above the level of Lake Winnipegosis which in turn is about six metres above the level of Lake Manitoba. ***Figure 5*** provides a map of these salient lakes and waterways, along with their respective elevations and Table 1 summarizes typical water elevations along the lakes and waterways.

Table 1: Water elevations along salient lakes and waterways

Water Body	Nominal Elevation (m)
Saskatchewan River at The Pas	258.5
Cedar Lake	255.5
Dauphin Lake	260.5
Lake Winnipegosis	253.0
Waterhen Lake	252.1
Assiniboine River at Portage la Prairie	256.0
Lake Manitoba	247.5
Lake St. Martin	243.5
Red River at Winnipeg	223.5
Lake Winnipeg	217.6

Runoff volumes and lake levels vary with precipitation, but because the overall system is so large is takes a sequence of dry or wet years to produce a dramatic change in runoff and consequently, to adversely affect lake levels and/or flood peaks. The 1930s, early 1960s, and early 2000s are examples of dry periods, while wet periods with above average flood peaks were evident in the mid 1950s, late 1970s and the late 2000s. Water levels on Lake Winnipegosis and peak flows on the Red River at Emerson provide a good representation of the cyclic nature of the runoff patterns.

Regional Aspects of the 2011 Flood – Historical Context

The 2011 flood was one of the most widespread flood events ever experienced in Manitoba. While its severity varied from location to location, its extent and duration was such that its management became problematical. The following discussion describes the general conditions leading up to the flood event and the subsequent flood characteristics on seven salient water bodies within Manitoba, including the Saskatchewan River, Dauphin Lake, the Assiniboine River, the Souris River, the Whitemud River, Lake Manitoba/Lake St. Martin, and the Red River.

General Antecedent Conditions

The manifestation of runoff and related flooding is a complex hydrologic process that depends on a number of factors, including (i) the physiographic characteristics of the basin, (ii) the amount of precipitation (either snow or rain) that is available to be converted into runoff, and (iii) the amount of storage available in the basin (generally defined on the basis of antecedent moisture levels) that could limit how much of the precipitation actually runs off. While the physiographic characteristics of a basin are more or less the same from year-to-year (not withstanding the effects of land drainage), the year-to-year variability in the precipitation and the antecedent moisture levels can have dramatic effects on runoff volumes and subsequent flood levels.

In 2011, the antecedent conditions, the winter snowpack, and the summer rains all conspired to produce one of the largest recorded flood events ever experienced in Manitoba. Falling within a somewhat wet cycle, 2011 was preceded by a very wet 2010 fall when fall precipitation averaged about 175 percent of normal over a wide area in Manitoba and Saskatchewan ***(Figure 6)***. This produced extremely high regional antecedent moisture conditions whereby moisture levels were 100 to 250 percent of normal – or 1.5 to 2.5 times the long term average ***(Figure 7)***. Added to this, the winter snowpack ***(Figures 8 and 9)*** was relatively high, varying spatially in the range of 50 to 150 percent of normal. Finally, after all that, unprecedented rainfall volumes were experienced in the region throughout the months of May, June, and July. On a regional basis rainfall amounts approached 200 percent of normal ***(Figure 10)*** and in some local areas the rainfall exceeded 350 percent of normal.

It was clear in early January of 2011 that Manitoba was in for relatively severe snowmelt flooding, given typical melt rates, and that there should be concern about both local and general flooding. However, what was not clear, and could not have been known at any time during the spring and summer, was the amount of rain in addition to the winter snowpack that the region would experience, and the effects that the rain had on the intensity and duration of the summer flooding.

Saskatchewan River at The Pas

The Pas is situated on the Saskatchewan River just inside the Saskatchewan/Manitoba border. The drainage area at that point is about 347,000 km^2. The river carries runoff from the North and South Saskatchewan rivers – both of which are highly regulated for hydro-electric power and irrigation purposes in Alberta and Saskatchewan. The river is also regulated for hydro-electric power production downstream of The Pas at Grand Rapids, but operations there do not affect flows or water levels at The Pas. In terms of water storage, Lake Diefenbaker would have the largest effects on flood volumes at The Pas while Tobin Lake would affect flood peaks in the reach between the E. B. Campbell Generating Station and The Pas.

The Carrot and Pasquia Rivers are major tributaries that add to the flows released from Tobin Lake, but these inflows are offset by the large amount of storage in numerous wetlands/lakes adjacent to the Saskatchewan River. Both open water and ice-related flooding is a major concern along the margins of the Saskatchewan River, particularly at Ralls Island at The Pas. Extensive drainage of farmland and the creation of polders south of the river requires significant pumping during wet periods and a rather intensive management of water levels in the area between the Carrot and Pasquia rivers.

Long-term precipitation records at The Pas ***(Figure 11)*** suggest that both the winter snowfall and the summer rainfall in 2010-11 was about average and well below the highest recorded values in 2009-10. The precipitation pattern ***(Figure 12)*** during the spring and summer in 2011 essentially reflected the historical average. The precipitation totals were slightly below normal in early July, but 75 mm of rain in the period between mid-July and mid-August increased the total precipitation to somewhere in the range of 35 to 40 percent above normal. A relatively dry fall offset the summer precipitation so that by the end of October, the accumulated precipitation was only about 10 percent above normal. While the 2011 precipitation alone was close to normal, the two-year running average for 2009-10 and 2010-11 was the highest on record – about a 100-year event ***(Figure 13)*** – and the cumulative total likely contributed to the high groundwater and surface water levels in the area.

Outflows from Tobin Lake in 2011 followed their normal patterns ***(Figure 14)***. The flows through the turbines were relatively low during the winter to produce hydro-electricity. Outflows began to rise in the spring as the reservoir began to fill, with a peak outflow of about 3300 m^3/s in late June. With the exception of a brief period of high flow that was related to breakup and ice jamming in late April (note that the flows at breakup are subject to confirmation), the flows at The Pas tracked the outflows from Tobin Lake in a systematic way. The Saskatchewan River peaked at about 2300 m^3/s in early July – some 20 days after the peak at Tobin Lake ***(Figure 14***). The Tobin Lake peak was attenuated by about 30 percent due to channel and floodplain storage between Tobin Lake and The Pas. This type of attenuation would occur in most years and is one reason why the post-regulation flood peaks are lower than the pre-regulation peaks.

The water levels at the Water Survey of Canada (WSC) gauge (located three kilometres downstream of the highway bridge on PTH #10) more or less followed the discharge as would be expected ***(Figure 15)***. Winter water levels ranged between 257.5 and 258.0 m. During breakup, a short-lived ice-related peak level of 260.8 m occurred on April 23. After the ice cleared the water level dropped by about 1.2 m to elevation 259.6 m before rising in response to increasing flows. A peak water level of 261.1 m for the year occurred on July 13. Water level fluctuations in November are related to ice effects, with water levels rising about 0.5 to 0.6 m when an ice cover forms, even though the flow does not change.

The flood peaks on the Saskatchewan River are more or less independent of the local precipitation and influenced more by precipitation in Alberta and Saskatchewan, and by the operation of the reservoirs upstream. Since regulation by Tobin Lake in the early 1960s, there has been a systematic reduction in flood peaks. The average peak has decreased by about 20 percent. The 2011 flood peak ***(Figure 16)*** was the third largest since regulation but within the historical context it would have been exceeded in at least seven preceding years. If it had not been for the flood threat due to ice jamming, the flood in 2011 would have been quite benign.

In retrospect, the 2011 peak on the Saskatchewan River had a return period of about 20 years (it was a 20-year flood or alternatively there would have been a five percent chance that it would be equaled or exceeded in any year) if it was compared to other flood peaks in the post-regulation era ***(Figure 17)***. Compared to pre-regulation flows, the peak would have been characterized as a 5-year event – much more benign – and it likely would have been contained within the banks of the river.

Dauphin Lake

Dauphin Lake has a surface area of about 500 km^2 and receives inflow from a drainage area of about 8700 km^2 – an area that is about 17 times the surface area of the lake ***(Figure 18)***. The basin that drains into the lake encompasses parts of the south slope of the Duck Mountain and parts of the north slope of the Riding Mountain. However, most of the drainage area is located between those uplands west and south of the lake. The major water courses that contribute runoff to the lake include the Valley River, which drains the area between the Duck and Riding mountains, the Vermilion and Ochre Rivers, which rise in the Riding Mountain, and the Turtle River, which also has its source in the Riding Mountain but also represents inflow from the lower portions of the basin south of the lake.

The Mossy River is the only outlet from the lake and it ultimately flows into Lake Winnipegosis. WSC records indicate that the lake has been regulated since the early 1930s by a weir located on the Mossy River near the lake outlet. A lake management plan developed in 1992 indicated that nutrient and sediment loadings were the main issues on the lake. A stream rehabilitation study was undertaken in 1992-93 to classify stream corridors and to identify potential projects to reduce nutrient and sediment yields in the basin. Subsequent to this, a number of projects were initiated – mostly to do with sediment reduction, including stream channel stabilizations and some shoreline armoring on Dauphin Lake. No follow-up was undertaken to assess the effectiveness of these measures

Long-term precipitation records at Gilbert Plains provide a reasonable analogue of the precipitation over the basin. The data ***(Figure 19)*** suggests a somewhat cyclic pattern in the annual precipitation with highs in the mid 1970s and late 1990s and lows in the early 1960s, mid 1990s, and early 2000s. Indications are that the early 2010s would correspond to a period of above average precipitation. Winter precipitation (snow) makes up about 25 percent of the annual precipitation, and in some years it can be as much as 50 percent. Generally, in years when the winter snowfall is above average, the annual runoff also tends to be above average. Neither the snowfall nor the annual precipitation was particularly severe in 2011 at Gilbert Plains.

The precipitation pattern during the spring and summer in 2011 more or less reflected the historical average ***(Figure 20)***. At the end of June, the precipitation at Dauphin was about normal while at Gilbert Plains it was about 40 percent above normal. By the end of October, the precipitation at Gilbert Plains was about normal while at Dauphin it was about 30 percent below normal. Statistical analysis ***(Figure 21)*** of annual precipitation for 53 years of record from 1959 to 2011 suggests that 2011 was about a 5-year event at Gilbert Plains – somewhat less than what occurred in 1975 and 1998. From consideration of only the seasonal precipitation, high lake levels would not have been expected.

The pattern of annual runoff more or less follows the precipitation pattern – albeit with a significantly greater differential between the high and low periods. In spite of the 2010-11 precipitation being only slightly above average, runoff on the Valley River ***(Figure 22)*** was the third largest in record – exceeded only in 1995 and 2007. It is clear that the antecedent moisture levels in the basin (likely due to the high 2009-10 precipitation) contributed to a higher than average proportion of the precipitation running off. The magnitude of the 2011 event was almost the same as the 2007 event and only slightly lower than the 1995 event – all three having a return periods of about 50 years ***(Figure 23)***.

While inflow into Dauphin Lake can vary widely from year to year due to variations in precipitation and antecedent moisture conditions, the outflow via the Mossy River is controlled by the characteristics of the outlet channel and the configuration of the weir at the lake exit. Inflows can be as high as 500 m^3/s while outflows rarely exceed 90 m^3/s – the difference being made up by rising lake levels. During the winter the outflows are limited by the effects of the ice cover on the Mossy River so that outflows are reduced substantially – to about half of what they would be in the summer – even at high lake levels.

For a majority of time over the period of record water levels on Dauphin Lake have been in the range of 260.0 to 261.0 metres with brief excursions above that range in the mid 1950s, mid 1970s, and early 2010s ***(Figure 24)***. Low lake levels were experienced in the early 1960s. As would be expected, the lake levels tend to follow the precipitation and runoff patterns. Not withstanding the effects of wind and subsequent wave and lake setup, the 2011 lake levels are the highest on record by about 0.3 to 0.4 metres. Lake levels can be simulated reasonably well ***(Figure 25)*** using standard hydrologic techniques and measured flows on key streams in the basin so that lake levels can be forecast and/or reasonably defensible lake level management options can be evaluated.

Assuming that the operational characteristics of the weir at the outlet of the lake have not changed in a systematic way over the period of record, a statistical analysis of lake levels ***(Figure 26)*** suggests that the 2011 level was about a 175-year event (slightly more than a 0.5 percent chance of being equaled or exceeded each year). On the average, it is expected that in 50 percent of the years the peak lake level would be less than 260.7 metres and in 10 percent of the years it would be greater than 261.5 metres. Prior to 2011, the highest water level occurred in 1974 which, within the context of the 2011 frequency curve, would be about a 50-year event (2 percent chance of being equaled or exceeded each year).

Assiniboine River

It is difficult to succinctly characterize the Assiniboine River as a single entity. It is convenient to differentiate the river into distinct reaches on the basis of where the river is regulated and on the locations of major tributaries. From this perspective one can designate four separate reaches:

- The Russell Reach from the upstream end of Lake of the Prairies to the confluence of the Qu'Appelle River at St. Lazare. The gauging station at Russell provides a reasonable indication of the flows in this reach.
- The Brandon Reach from St. Lazare to the mouth of the Souris River at Wawanesa. The WSC gauge at Brandon represents the flows in this reach.
- The Holland Reach from the mouth of the Souris River to Portage la Prairie. The Holland gauge represents the flows in this reach.
- The Lower Reach from downstream of the Portage Diversion to Winnipeg. The WSC gauge at Headingly would represent the flow in this reach.

Lake of the Prairies and the Russell Reach

Flows in the Russell Reach are affected significantly by operations at Shellmouth Dam and storage in Lake of the Prairies. The reservoir was created in 1969 following the construction of the dam to provide storage for downstream flood control, water supply and to augment downstream low flows. Considerations are also given currently to recreation and environmental concerns. The dam is 1,270 m long and 22 m high. The reservoir is about 60 km long and more or less contained within the valley of the Assiniboine River. The surface area of the reservoir is about 60 km^2 and its total storage volume is about 480,000 dam^3 – equivalent to about the average annual inflow.

The reservoir levels generally fluctuate within an elevation range of 425 to 430 m ***(Figure 27)*** except in times of severe inflows when the water levels exceed the upper bound of that range and during periods of severe droughts or when the lake is drawn down to maximize storage with the expectation of experiencing a severe flood, such as in 2011. The highest reservoir level on record is 431.3 m and this occurred on May 3, 1995. As a comparison, the peak water level in 2011 was 431.1 m, occurring also in early May. The lowest water level on record is 421.8 m. This occurred in late March and early April, 2011 as the water levels were drawn down in anticipation of the 2011 snowmelt flood.

The drainage area above the reservoir is 17,900 km^2 ***(Figure 28)***. Most of the inflow is derived from the Upper Assiniboine River basin (gauged at Kamsack) in Saskatchewan and from the Big Boggy Creek and Shell River basins in Manitoba. While the reservoir effectively controls outflows from the upper part of the Assiniboine River basin and provides flood relief along the Lower Assiniboine, inflows from the Qu'Appelle River can still produce severe flood conditions at St. Lazare, Miniota, and Brandon.

Annual precipitation in the basin upstream of Lake of the Prairies is highly variable, ranging between 350 and 650 mm ***(Figure 29).*** The water equivalent of the winter snowpack varies between 70 and 240 mm. The snowpack that would have contributed to spring runoff into the reservoir in 2010-11 was about 160 mm. This was not unusual and was seventh largest on record. Evidently the high antecedent moisture conditions left over from the record high precipitation in 2010 contributed to the high spring runoff. From April 2011 and throughout the summer, the cumulative precipitation ***(Figure 30)*** at Roblin and Langenburg was not unduly high – about 25 to 40 percent above normal at various times throughout the summer, but ending up virtually normal by the end of October. It appears that the summer inflow into the reservoir was not as a severe as the spring event.

Peak inflows into the reservoir were in the range of 475 to 600 m^3/s, according to MIT calculations after accounting for peaks on the Assiniboine and Shell rivers and allowing for the ungauged parts of the contributing basin. Analysis by MIT further suggests that the peak outflow would have been about 350 m^3/s. After accounting for local inflows, the peak at the WSC gauge near Russell was about 400 m^3/s. Reservoir storage reduced the 2011 peak at the WSC gauge by 22 percent, which was equivalent to a water level reduction of about 0.55 m.

In 2011 the reservoir was drawn down to an elevation of 421.8 m – about one metre lower than provided for in the operating protocols – in anticipation of a severe runoff event. On April 28 water levels rose to the level of the spillway and the spillway continued to operate until about June 6. In that period the peak outflow was between 340 and 400 m^3/s, corresponding to a peak water level in the reservoir of 431.1 m. When the reservoir level receded to below the crest of the spillway, outflows through the low level conduit were maintained at about 100 m^3/s until late July when the outflows were set to 10 to 20 m^3/s to match the inflows. Reservoir levels in the late fall and early winter remained in the range of 426.5 to 427.5 m.

Water levels on the Assiniboine River below Lake of the Prairies are a function of the outflows from the reservoir and the condition of the river channel. With an ice cover, the channel capacity would be between 40 and 45 m^3/s. In open water, the capacity would increase to about 85 m^3/s. For operational purposes, a water level of 409.5 m at the WSC gauge represents the adopted incipient flood level in the reach at Russell. In 2011, this water level was exceeded for about 75 days in January, February and March when the reservoir was being drawn down and for about 100 days in April through to July when reservoir levels were above the spillway crest.

During the periods in 2011 when water levels in the reservoir were below the crest of the spillway, and outflows could be controlled by adjusting the gate(s) in the low level conduit, peak water levels in the river were limited to between 410.2 and 410.4 m at the WSC gauge. This was close to bankfull but low enough not to produce significant inundation of the floodplain. The peak water level at the gauge occurred over a period of about seven days in early May, 2011 when water levels hovered between 412.2 and 412.3 m.

The Brandon Reach

The drainage area of the Assiniboine River at Brandon is approximately 94,000 km^2 and includes the Qu'Appelle and Assiniboine River drainage basins. River flows at Brandon are significantly affected by operations at the Shellmouth Dam. While the dam controls only about 20 percent of the total drainage area above Brandon, it passes on average roughly 40 percent of the total surface water runoff water that reaches the city via the Assiniboine River. Conversely, the Qu'Appelle River basin in Saskatchewan comprises about 65 percent of the drainage basin at Brandon, but on average contributes only about 20 percent of the runoff. Runoff from the south facing slopes of the Riding Mountain via Birdtail Creek, Little Saskatchewan River and Oak River also contributes to the flow at Brandon.

Spatial representation of precipitation in the basin upstream of Brandon is problematical due to missing data at many stations and the discontinuance of long-term meteorological stations. Long-term precipitation records at Roblin/Inglis ***(see Figure 29)*** suggest that 2010-11 winter snowfall was more or less normal and the annual precipitation was about the fifth largest on record – exceeded in 1975, 1991, 1996, and 2010. However, the back-to-back high precipitation in 2009-10 and 2010-11 would have contributed significantly to the large amount of runoff and the resulting high water levels.

In 2011, the precipitation in the basin upstream of Brandon was highly variable ***(Figure 31)***. While the amount of snow/rain at Roblin was more or less normal throughout the spring and summer, Elkhorn experienced almost twice the normal amount of precipitation by the end of June. This intensified the spring peak in late April and contributed to the long drawn-out flooding over the entire summer. Limited rainfall from August to September resulted in more or less normal precipitation amounts for the April to September period.

The flood peak at Brandon occurred in early May due to almost coincidental flood peaks at Shellmouth and on the Qu'Appelle River ***(Figure 32)***. Those two sources contributed to about 80 percent of the peak – the rest of the water came from areas north of Brandon. The 2011 regulated flood peak of about 1,030 m^3/s is by far the largest on record – about 70 percent greater than the previous historical highs in 1922, 1976 and 1995 ***(Figure 33)***. The corresponding peak water level at the WSC gauge was about 363.8 m – an increase of about 4.5 m from the pre-flood water level. Water levels stayed high until early August when there appeared to be a marked reduction in upstream runoff due to lower precipitation amounts in July. The return period of the 2011 flood peak is about 450 years ***(Figure 34)***.

Regulation at Shellmouth has reduced past flood peaks by about 20 percent on average and has cut flood risks by about 50 percent (transforming the 50-year flood into the 100-year flood, for example). In 2011, storage upstream of Shellmouth Dam in Lake of the Prairies reduced the spring flood peak at Brandon by 10 percent ***(Figure 35)***, a reduction in the peak water level of about 0.2 m. Once the peak passed in early May, Lake of the Prairies could provide only limited flood reduction at Brandon because there was little storage available in the reservoir and much of the runoff was being produced from the Qu'Appelle River and drainage areas downstream of Shellmouth Dam.

The natural channel capacity of the Assiniboine River at Brandon is about 170 m^3/s before the banks begin to overflow ***(Figure 36)***. In 2011, the river would have been in "flood stage" for about 100 days. The pre-2011 dike heights in the area of First Street would have protected against the 1976 flood with very little freeboard but would not have provided protection for a 100-year flood. In 2011 the dikes were raised by about 1.4 m to protect against the expected flood peak.

Holland Reach

The drainage area of the Assiniboine River at Holland is about 152,000 km^2. Flows at Holland are derived from the Upper Assiniboine River which has its source in Saskatchewan, the Qu'Appelle River which also rises in Saskatchewan and enters the Assiniboine River at St. Lazare, and the Souris River which enters the Assiniboine River near Wawanesa after flowing through North Dakota from its source in Saskatchewan. The system is heavily gauged with at least ten WSC gauges in operation on or near the Assiniboine River between Shellmouth and just downstream of Portage.

In 2011 the entire basin contributed almost equally to the runoff volume at Holland – confirming the widespread nature of the flood event. For example, the Shellmouth Dam controls about 12 percent of the basin area above Holland and that area produced about 15 percent of the runoff. The Qu'Appelle River basin in Saskatchewan comprises about 35 percent of the basin and it contributed about 35 percent of the flow volume. The Souris River comprises 40 percent of the area and it contributed about 45 percent of the runoff volume. The flood peak of 1470 m^3/s occurred at Holland on May 17 ***(Figure 37)***. The total volume of runoff experienced in the April to October period was about 11,800,000 dam^3, the largest on record and equivalent to about a 350-year event ***(Figure 38)***.

The Portage Diversion and the Lower Reach

Flows downstream of Portage la Prairie are affected by diversions via the Portage Diversion to Lake Manitoba during severe flood events. The Portage Diversion was completed in 1970. It is one component of the works constructed in the 1960s to prevent flooding in Winnipeg. The Diversion consists of two separate control structures: one which controls the flows down the Assiniboine River and another which diverts some of the flow in the Assiniboine River into a 29 km long diversion channel that empties into Lake Manitoba near Delta Beach.

The design capacity of the system to accommodate floods downstream of Portage la Prairie amounted to 700 m^3/s on the Diversion Channel and at least 650 m^3/s on the Lower Assiniboine River for a total of 1,350 m^3/s. The actual flow volume diverted into Lake Manitoba depends on the severity of the floods at Holland. Prior to 2011, the annual diversion volumes have ranged from zero to a high of 1,760,00 dam^3 in 1976 ***(Figure 39)*** - averaging about 325,000 dam^3 during the 1970 to 2010 period.

In 2011, forecasts indicated that the flood peak could approach 1,590 m^3/s. To prevent the Assiniboine River dikes from breaching and flooding much of the prairie between Portage la Prairie and Winnipeg, the Manitoba authorities, under a state of emergency, increased the capacity of the diversion channel to about 1,000 m^3/s by raising dikes and reinforcing drop structures thereby requiring the Lower Assiniboine to accommodate about 590 m^3/s. During its operating period in 2011, the diversion flow averaged about 710 m^3/s over a period of about 130 days, peaking at about 980 m^3/s on May 14. About 5,900,000 dam^3 or about 50 percent of the incoming flood volume was diverted from the Lower Assiniboine River into Lake Manitoba. This was more than three times the next highest diverted volume that occurred in 1976 ***(Figure 39)***.

Souris River

The drainage area of the Souris River at Wawanesa, near its confluence with the Assiniboine River, is approximately 61,100 km^2 ***(Figure 40)***. About 45 percent of the basin is located in Saskatchewan, 35 percent in North Dakota, and the remaining 20 percent is in Manitoba. Runoff due to precipitation can find its way into Manitoba from Saskatchewan and North Dakota through the main stem of the Souris River or by a large number of local tributaries that enter the Souris River from the west in the area between Melita and Wawanesa. In some years these tributaries will produce more runoff than that carried by the main stem of the river, although clearly this was not the case in 2011.

The Boundary, Rafferty, and Alameda reservoirs in Saskatchewan regulate outflow from about 30 percent of the basin. There are a number of water storage facilities in North Dakota – the largest being Lake Darling – but these do not contribute significantly to a controlled storage of water. There is little significant man-made storage in Manitoba, but Oak, Plum, and Maple lakes store runoff produced in the Pipestone Creek and Stony Creek catchments.

Spatial representation of precipitation in the Souris River basin is problematical due to missing data at many stations and the discontinuance of long-term meteorological stations. Long-term precipitation records at Fertile, Saskatchewan suggest that 2010-11 winter snowfall ***(Figure 41)*** was on the high end of normal but that the annual precipitation (not withstanding missing data) was about average – exceeded by a significant margin in 1975, 1991, 1998, and 2004. Evidently the high November-April precipitation in 2010-11 and the high antecedent pre-flood moisture levels in the fall of 2010 contributed to the high spring runoff.

Precipitation everywhere in the Souris River basin was above normal in May and June of 2011 ***(Figure 42)***. For example, parts of the basin experienced between 240 and 310 mm of rain over that period - between 170 and 230 percent of normal. This exacerbated the spring peak in late April and resulted in very high flood volumes and corresponding high flood peaks at Minot, North Dakota and downstream at Westhope, North Dakota, Melita, Souris and Wawanesa in late June and early July. Limited rainfall from July through to September reduced the seasonal precipitation quantities to more manageable levels – 20 to 50 percent above normal.

Streamflow records on the Souris River go back the furthest at Wawanesa, although records are currently kept at a number of locations along the river. At Wawanesa, the larger flood peaks are typically between 200 and 300 m^3/s, but with two notable outliers – 1976 and 2011 ***(Figure 43)***. Historically, the peaks at Wawanesa are between 40 and 100 percent greater than those at Westhope. However, in 2011 the flood peaks were essentially identical. This suggests that either the flows at Westhope were not accurately estimated or water storage in the floodplain between Westhope and Wawanesa served to reduce the flood peak as it travelled downstream.

In 2011, storage in the Saskatchewan reservoirs significantly reduced inflows into North Dakota in mid-April, while significantly higher flows were evident elsewhere in the basin ***(Figure 44)***. However, towards the end of May the flows at Westhope and Melita were almost entirely derived from reservoir releases in Saskatchewan, and flows at Souris and Wawanesa were exacerbated by runoff from Jackson, Stony, and Pipestone creeks. In early June, the entire Souris River basin contributed to flows on an almost equal basis until late June when a huge deluge of rain on the main stem of the Souris River in Saskatchewan lead to unprecedented flood peaks at all locations downstream of the Saskatchewan/North Dakota border. It took 12 days for the peak to travel from the Saskatchewan/North Dakota border to the North Dakota/Manitoba border – a distance of some 550 km, while the peak travelled the 200 km from Melita to Wawanesa over a period of three days.

The 2011 flood at Westhope was much larger than any other previous flood, while at Wawanesa the 2011 flood would have been comparable to what was experienced in 1976. Both the 1976 and 2011 floods confound the statistical analysis at Wawanesa. Depending on how those two floods are treated, the 2011 flood could have a return period of between 350 and 500 years. At Westhope the 2011 flood would have been at least a 500-year event ***(Figure 45)***.

After the spring peak in the second week of April, three subsequent peaks were evident at both Souris and Wawanesa as river levels responded to individual rain events ***(Figure 44)***. The highest recorded water levels occurred in early July with peak levels exceeding the late winter ice level by 6.5 m and 5.0 m ***(Figure 46)*** at Souris and Wawanesa respectively. The water level at the PTH #3 bridge at Melita was about 1.4 m higher than the 1996 level and 0.50 m higher than the highest previous peak which occurred in 1976. The water level rose to more or less the elevation of the pavement on the bridge and the water levels were in range of the superstructure for almost three months. This put tremendous pressure on the bridge structure, piers, and abutments and washed out the east approach of the highway.

Lake Manitoba

Lake Manitoba has a surface area of 4,740 km^2 ***(Figure 47)***. It drains an area of 79,900 km^2 that includes the east side of the Riding Mountain and most of the Duck and Porcupine mountains. Runoff from the Duck and Porcupine mountains finds its way into Lake Manitoba via the Waterhen River after passing through Lake Winnipegosis and Waterhen Lake. Water from the catchment area immediately adjacent to the lake also adds to the inflow. The Whitemud River provides a reasonable analogue for the contribution of the ungauged catchments around the southern extent of the lake. Lake Manitoba also receives inflow via the Portage Diversion when flows are high on the Assiniboine River and high flood levels are imminent at Winnipeg. Total inflows into Lake Manitoba can be well reconciled by considering flows on the Waterhen and Whitemud rivers and by accounting for flows at the Portage Diversion at Portage la Prairie. This makes it feasible to simulate lake levels to assess the efficacy of any potential water management strategy.

The Fairford River provides the only outflow from Lake Manitoba, and it is regulated by the Fairford River Water Control Structure. It conveys flows into Lake St. Martin (surface area of 345 km^2) which connects to Lake Winnipeg via the 50 km long Dauphin River. Outflows on the Fairford River are severely limited due to the need to account for water levels on Lake St. Martin which in turn are affected by the winter capacity of the Dauphin River. An emergency channel has been constructed between Lake St. Martin and Lake Winnipeg to augment the capacity of the Dauphin River and there are considerations to construct a channel between Lake Manitoba and Lake St. Martin to add to the capacity of the Fairford River.

Waterhen River

The Waterhen River is the main tributary to Lake Manitoba. It drains an area of about 55,000 km^2, or about 70 percent of the total Lake Manitoba drainage basin. However, flows on the Waterhen River are naturally regulated by storage in Lake Winnipegosis. The Waterhen River shows multi-year cycles of dry and wet periods ***(Figure 48)*** that are also reflected in the plot of Lake Manitoba levels before 1960. Waterhen River flows from Lake Winnipegosis were above average every year from 2005 to 2010. By the fall of 2010, Lake Winnipegosis levels were the highest in 50 years, thereby guaranteeing above average Waterhen River flows in 2011. The high Lake Winnipegosis levels in 2010 coupled with the record high inflows to Lake Winnipegosis in 2011 resulted in the highest annual Waterhen River flow volumes on record ***(Figure 49)***.

Whitemud River

The Whitemud River basin encompasses an area of about 6,220 km^2. It mostly drains a prairie-type landscape located south of Riding Mountain and north of the Assiniboine River. Precipitation in the Whitemud River basin in 2011 ***(Figure 50)*** was about 550 mm - slightly above the long-term average and corresponded to something less than a five-year return period ***(Figure 51)***. Previous years with the large amounts of precipitation were 1956 and 1975.

The annual runoff volume in 2011 was the largest on record – some 850,000 dam^3 ***(Figure 52)***. This eclipsed the 1970 and 2001 runoff volumes by about 30 percent. The wet periods in the early 1970s, the mid 1990s, and the 2010s (extending into 2011) are evident in the record, along with the dry periods in the early 1960s and the early 1980s. In 1975, only about five percent of the precipitation was converted to runoff. In 2011, it was about 23 percent - likely in part due to high antecedent moisture conditions that resulted in a high percentage of the precipitation being converted to runoff due to a lack of storage in the basin. The 2011 runoff volume from the Whitemud River basin represented about a 100-year event ***(Figure 53***).

Lake Manitoba in 2011

In 2011, inflows to Lake Manitoba were the highest on record for both the Waterhen River and Portage Diversion ***(Figure 54)***. Between January and early April, lake levels were relatively steady as outflows at Fairford kept pace with the winter inflows derived primarily from the Waterhen River. In the second week of April, levels began to increase rapidly due to rising inflows from the Waterhen River, the Whitemud River, and the Portage Diversion ***(Figure 55)***.

Inflows peaked in early June at about 1450 m^3/s. Outflows through the Fairford River Water Control Structure peaked at about 650 m^3/s in late July ***(Figure 56)***, coincident with peak lake levels, and receded after that well into 2012. In 2011, ambient levels on Lake Manitoba peaked at 249.1 m in late July. Instantaneous peaks due to wind effects were typically about 0.25 to 0.50 m above the ambient lake level, and these occurred virtually in every month.

Given the predominantly northwesterly winds that are experienced in the region, there is potential for high wind-related water levels to occur along the southern margins of Lake Manitoba due to both lake setup and wave runup. Wind and water level data indicates that there is a strong correlation between (i) wind speed in the direction along the lake and (ii) water level differences between Steep Rock near the north and Westbourne in the south ***(Figure 57)***. Sustained winds of 20 km/hr can produce a water level differential of 0.2 to 0.4 m.

On May 31, severe winds in excess of 100 km/hr from the northwest produced a setup of 0.65 m at Westbourne, raising the lake level there to 249.35 m ***(Figure 58)***. The instantaneous peak level at Twin Lakes Beach reached 250.04 m, almost 1.5 m above the calm lake level. Waves as high as 2.1 m were reported against dikes and buildings. Areas around the lake that were hardest hit include the rural municipalities of St. Laurent, Woodlands, Alonsa, and Portage la Prairie, and the First Nation communities of Lake Manitoba and Sandy Bay ***(Figure 59)***.

Red River

The Red River drains large portions of Saskatchewan, Manitoba, and North Dakota with contributions from South Dakota and Minnesota. At Winnipeg the drainage area is about 287,000 km^2, with the Upper Red River and the greater Assiniboine River basin comprising 134,000 and 153,000 km^2 in area respectively. About 35 percent of the basin or 104,000 km^2 of its total area is located upstream of Emerson. The Upper Red River basin comprises about 47 percent of the area upstream of Winnipeg, but it is responsible for about 75 percent of the runoff. Clearly, the greater Assiniboine River basin is not that productive in terms of water yield.

Flows in the entire Red River basin are regulated to some extent – starting from the headwaters of the Souris and Qu'Appelle rivers in Saskatchewan, the Shellmouth Dam in Manitoba, the Portage Diversion from the Assiniboine River into Lake Manitoba, and the Red River Floodway. Regulation in Saskatchewan is primarily for water supply.

The Red River Floodway was constructed in 1968 to provide flood relief for the city of Winnipeg in response to the disastrous floods of the early 1950s. The floodway is about 47 km long and it extends from St. Norbert to just downstream of Lockport. Water is diverted into the floodway by a set of gates on the Red River just downstream of its inlet. The capacity of the floodway was upgraded in the late 2000s from about 2550 m^3/s to 4000 m^3/s. The combined effects of the floodway, the diking throughout the city, the Shellmouth Dam, and the Portage Diversion now protect the city against about a 700-year flood.

The 2011 flood peak on the Red River occurred in late April ***(Figure 60)***. The flood was primarily driven by snowmelt in the upper basin (North Dakota) with the peak occurring after the completion of runoff in many of the local contributing catchments in Manitoba. The estimated peaks at Emerson and Ste. Agathe were about 2240 and 2140 m^3/s respectively. The lower peak at Ste. Agathe was due to the effects of floodplain storage. The Assiniboine River flows at Headingly peaked slightly after those on the Red River, but they were kept in the range of 500 to 550 m^3/s by diverting water to Lake Manitoba, due to concerns about the stability of the dikes on the Lower Assiniboine River.

The 2011 flood peak at Emerson was the fifth largest since 1913 and at Ste. Agathe it was the fourth largest since 1959 ***(Figure 61).*** The largest flood on record at Emerson was in 1997, followed in descending order by 1950, 1979, and 2009. The 1997 "flood of the century" is estimated to be about a 250-year event at Emerson ***(Figure 62)***. In comparison, the 2011 event was about a 25-year event at Emerson and a 10-year event at Ste. Agathe ***(Figure 63)***.

In 2011, floodway operation began on April 9 and continued into the first week of June. Peak flows down the floodway amounted to about 1000 m^3/s – reducing the Red River peak within the city of Winnipeg by 50 and 30 percent respectively in the reaches upstream and downstream of the confluence with the Assiniboine River. Water levels on the Red River peaked at about 235.2 m at Ste. Agathe, at about 232.9 m just upstream of the inlet to the floodway, and at 229.5 m just downstream of the inlet to the floodway ***(Figure 64)***. At Selkirk, the peak water level was affected by ice conditions in the river with a peak water level of about 221.7 m occurring on April 8, just prior to the start of gate operations at the floodway. Water levels at James Avenue were reduced by about 3.5 metres at the peak of the flood due to diversions into the floodway.

Summary

The 2011 flood was one of the most widespread flood events ever experienced in Manitoba. While its severity varied from location to location, its extent and duration was such that management of the flood became problematical. In 2011, the antecedent conditions, the winter snowpack, and summer rains all combined to produce one of the largest flood events on record at many locations throughout the province.

Falling within a somewhat wet cycle, 2011 was preceded by a very wet fall in 2010 fall that produced extremely high regional antecedent moisture conditions. The winter snowpack was highly variable across the southern portions of Saskatchewan and Manitoba, ranging between 50 to 150 percent of the long term average. This created areas of local concern in small watersheds that made it difficult to generalize to the larger basins. Finally, after all that, unprecedented rainfall volumes were experienced in the region throughout the months of May, June, and July.

It was clear in early January of 2011 that Manitoba was in for relatively severe snowmelt flooding, given typical melt rates, and that there should be concern about both local and general flooding. However, what was not clear, and could not have been known at any time during the spring and summer, was the amount of rain in addition to the winter snowpack that the region would experience, and the effects that the rain had on the intensity and duration of the summer flooding.

The most severe flooding occurred in the Souris and Assiniboine Rivers, and around Dauphin Lake, Lake Manitoba, and Lake St. Martin. The Red River was spared because the expected runoff from North Dakota did not materialize. Furthermore, even though many watersheds in southern Manitoba experienced record floods, runoff from small tributaries between Emerson and Winnipeg also did not appear to be significant. Flood flows on the Saskatchewan River at the Pas were also relatively benign likely due to the extensive storage in Cumberland Lake, although some of the larger tributaries such as the Carrot River were affected by backwater from the Saskatchewan River. Much of the landscape south of the Saskatchewan River in the vicinity of The Pas was, and still is, saturated.

Difficulties on the Souris and Assiniboine Rivers appear to have resulted from very high runoff in Saskatchewan both during the spring period and later in the summer. Portions of these basins that are located in Saskatchewan had been subjected to very high precipitation for at least two years prior to 2011 and they were primed to produce significant runoff volumes for even marginal additional precipitation amounts. While the amount of precipitation that was experienced in the May to July period of 2011 certainly had an effect on the runoff volumes and flood severity, the effects of the high antecedent moisture conditions in all the basins cannot be understated.

Water levels on Dauphin Lake were the highest on record due to large runoff volumes from the Duck and Riding Mountains. Lake Manitoba reached record levels due to high inflows from the Waterhen River and the Portage Diversion. The former were due to above average precipitation in 2010 and 2011 which ultimately contributed to high water levels on Lake Winnipegosis, and the latter arose out of the huge runoff volumes produced mostly by the Souris and Qu'Appelle River basins. Lake St. Martin also experienced record high water levels because of the high outflows from Lake Manitoba at Fairford.

Table 2 summarizes the severity of the flood peaks and volumes at selected locations throughout Manitoba. The table provides an indication of the return period or the annual probability of experiencing a flood equal or larger than what occurred in 2011. It should be noted that Lake Manitoba and Lake St. Martin are not included in the table. Due to rigid controls of lake levels on Lake Manitoba, the peak water levels on both lakes are not amenable to a straightforward statistical analysis – especially because of the confounding effects of winds on both lake setup and wave heights.

Table 2: Severity of the 2011 flood event at salient locations in Manitoba

River/Lake	Location	Parameter	Value	Approximate Return Period (years)
Saskatchewan River	The Pas	Discharge	2285 m^3/s	25 [(1)]
Valley River	Dauphin	Runoff Depth	149 mm	50
Dauphin Lake	-	Water Level	262.33 m	175 [(2)]
Assiniboine River	Brandon	Discharge	1245 m^3/s	450 [(3)]
Assiniboine River	Holland	Volume	11,800,000 dam^3	350
Souris River	Westhope	Discharge	850 m^3/s	500
Souris River	Wawanesa	Discharge	830 m^3/s	350-500
Waterhen River	Waterhen	Volume	8,350,000 dam^3	250
Whitemud River	Westbourne	Volume	789,000 dam^3	100
Red River	Emerson	Discharge	2240 m^3/s	25
Red River	Ste. Agathe	Discharge	2140 m^3/s	15

Notes: *[(1)] The return period is given for the post-regulation period. If the flood peak was evaluated within the context of the pre-regulation peaks the return period would be about five years.*

[(2)] May include some wind effects.

[(3)] The return period is given for regulated conditions over the entire flood record as computed by MWS. If the regulated flows are naturalized the 2011 flood peak would have been 1250 m^3/s and it would have had the same 450-year return period. Within the context of the natural flood series, regulation reduced the return period of the 2011 flood to just less than 200 years.

It is clear that the 2011 flood was an extreme event at many locations. The Souris and Assiniboine Rivers were particularly hard hit and both the flood peaks and flood volumes were well above what would be considered in the design of flood management infrastructure. Care must be taken to evaluate these floods within the context of what might constitute a reasonable design event. If these floods are meant to be used as a design benchmark it is important to review their genesis in considerable detail and reflect on what precedent such a choice would make. With respect to the flood risks on Lake Manitoba and Lake St. Martin, a rigorous statistical analysis is required to take into account the effects of regulation on the ambient lake levels in order to provide perspective for the 2011 flood. Also, an appropriate probability analysis is needed to assess the joint probabilities of high ambient lake levels and high wind-related lake setup in order to develop an understanding of the confounding effects of the winds.

Within the context of the analysis carried out herein, the 2011 floods in the Assiniboine River basin (including Lake Manitoba and Lake St. Martin) and those in the Souris River basin may qualify as outliers in any statistical analysis. This could be confirmed through statistical analysis and the application of the appropriate criteria for the classification of outliers.

Figure 1: Major drainage basins that contribute runoff into Manitoba.

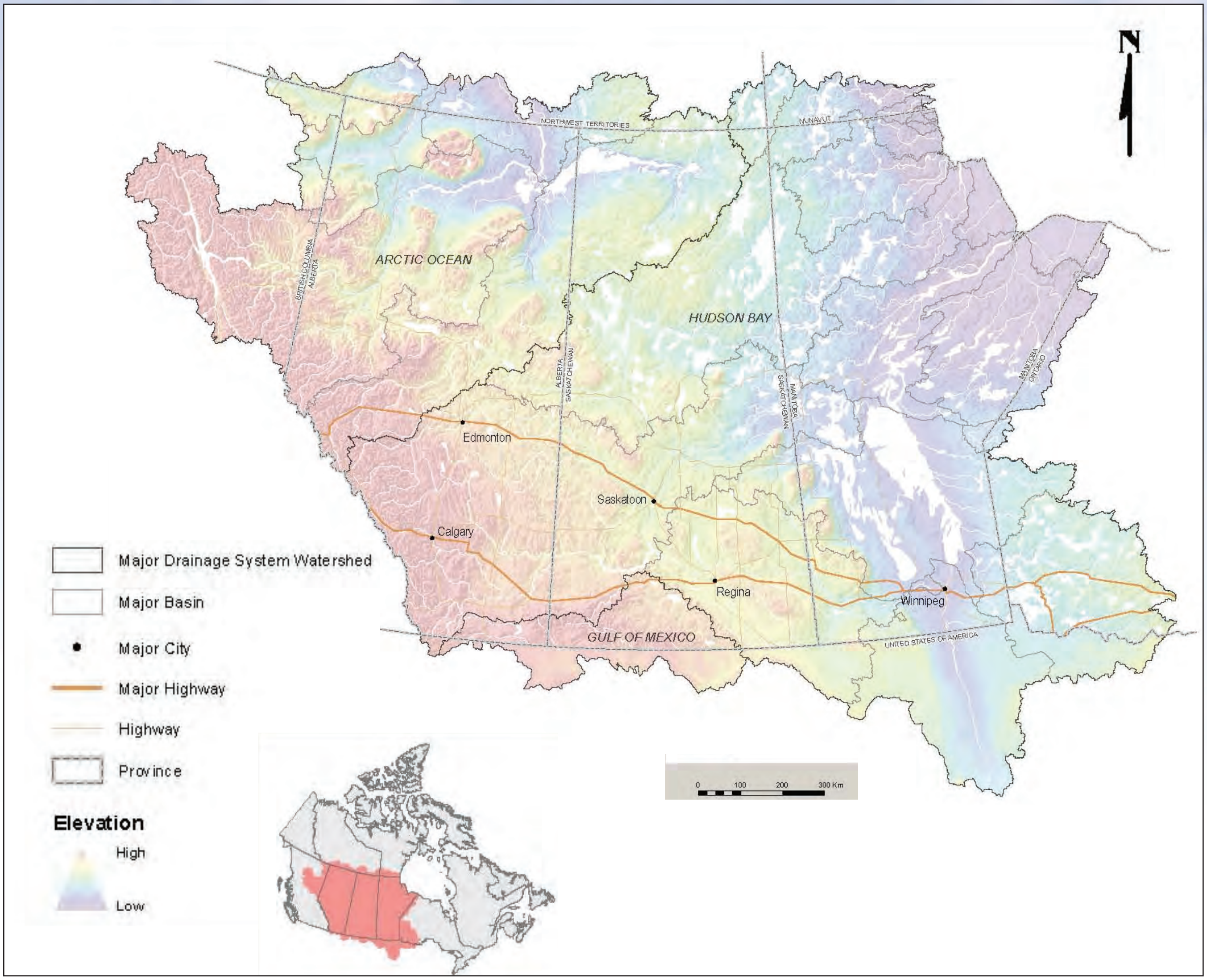


Figure 2: Saskatchewan River basin.

Figure 3: Assiniboine River basin.

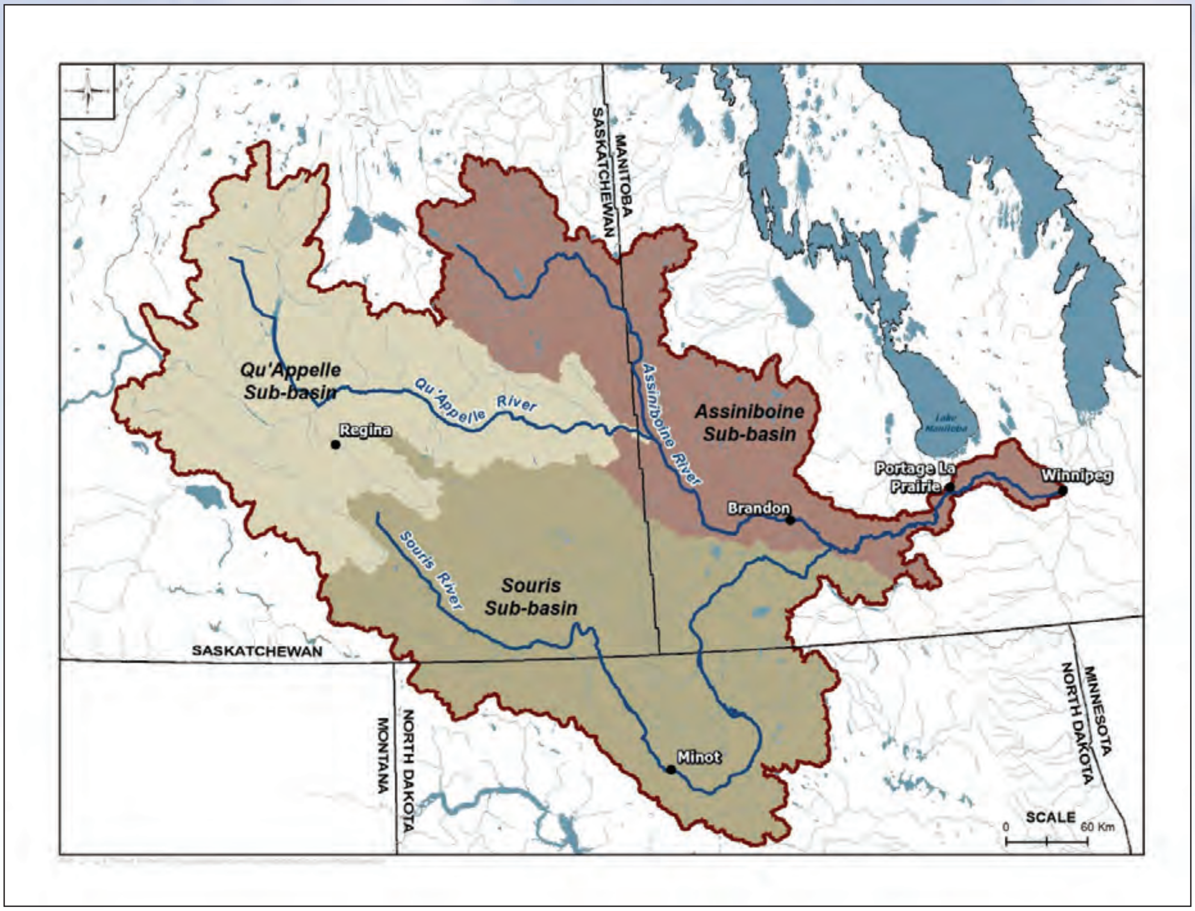


Figure 4: Red River basin.

Figure 5 Spatial runoff patterns in the Red River and Lake Manitoba drainage systems. All the runoff eventually finds its way into Hudson Bay after passing through Lake Winnipeg.

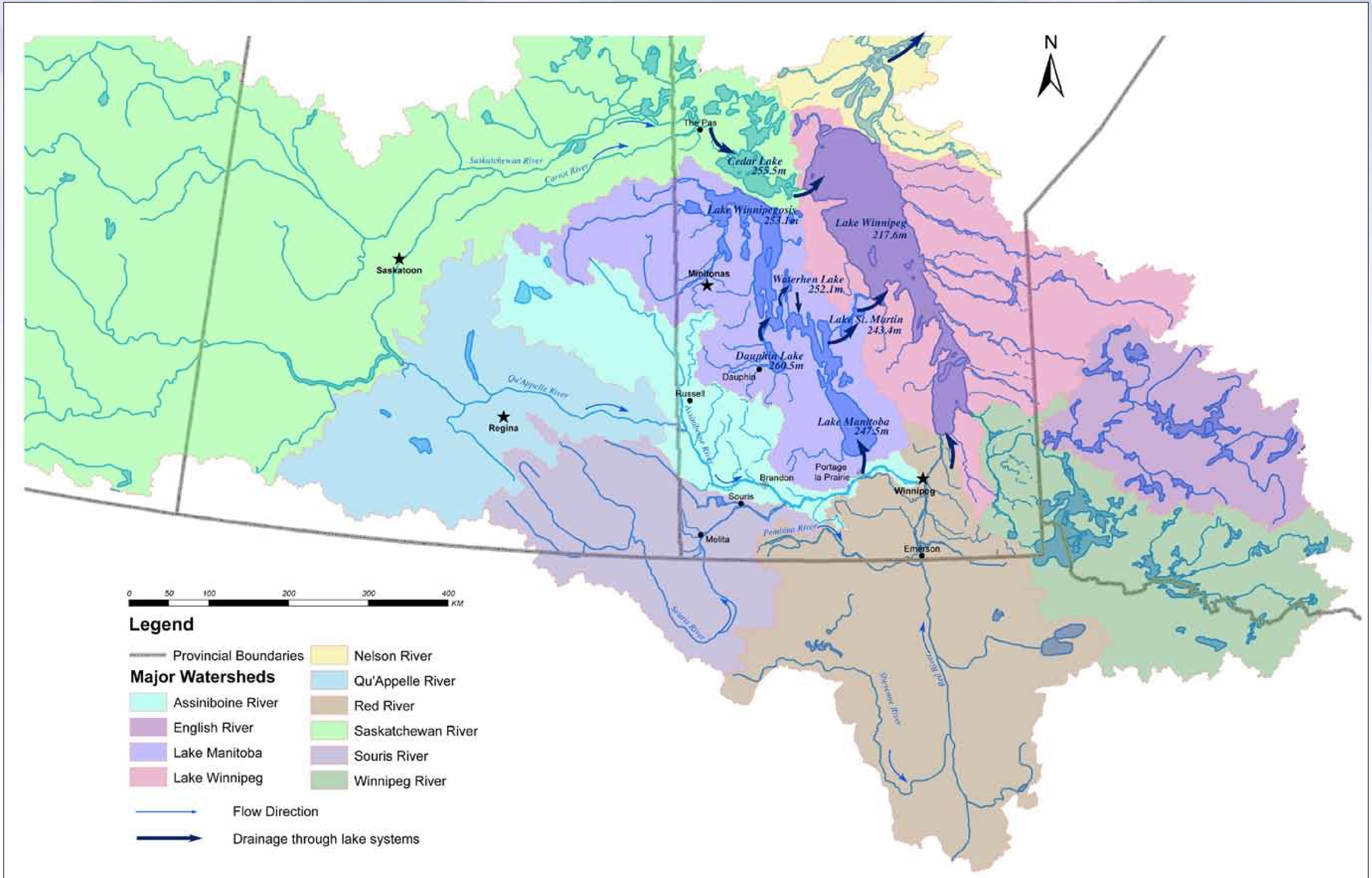


Figure 6: Prairie antecedent precipitation (August to October, 201-11inclusive) as a percent of normal

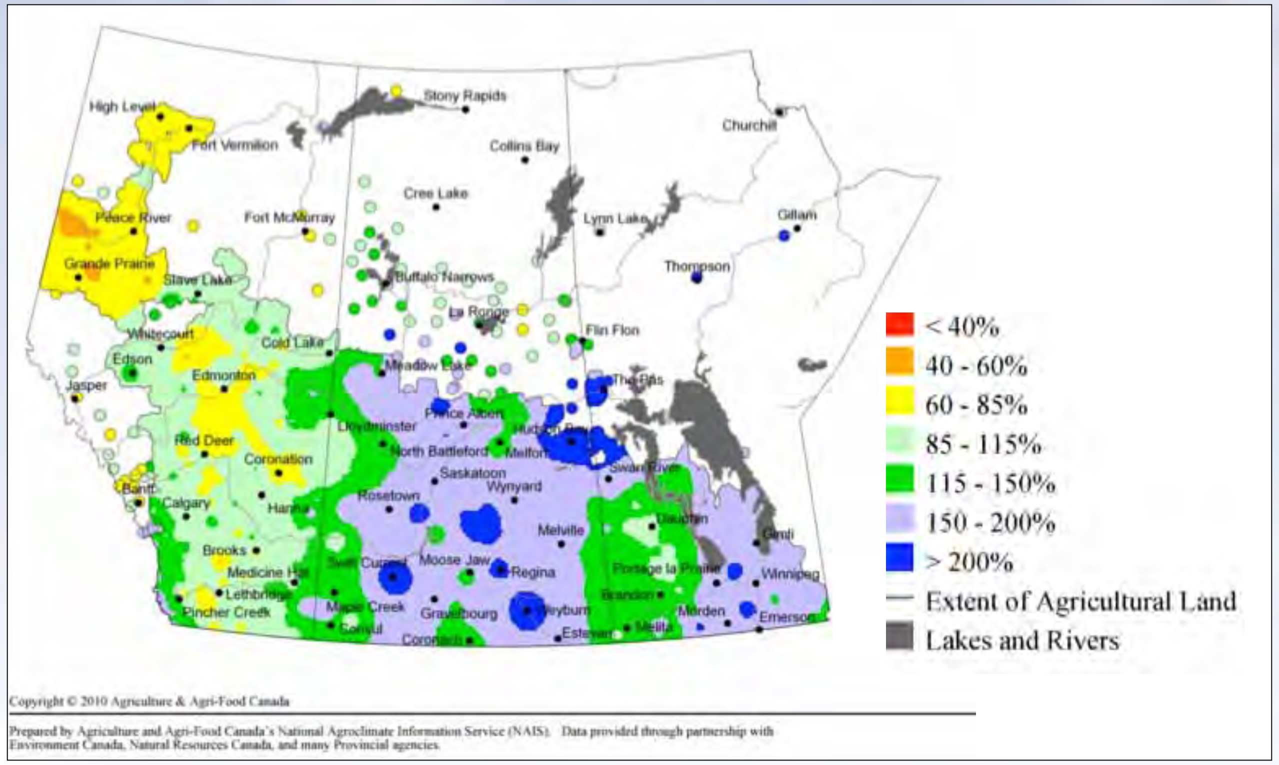


Figure 7: Antecedent soil moisture levels as a percent of normal in 2010 prior to arrival of snow.

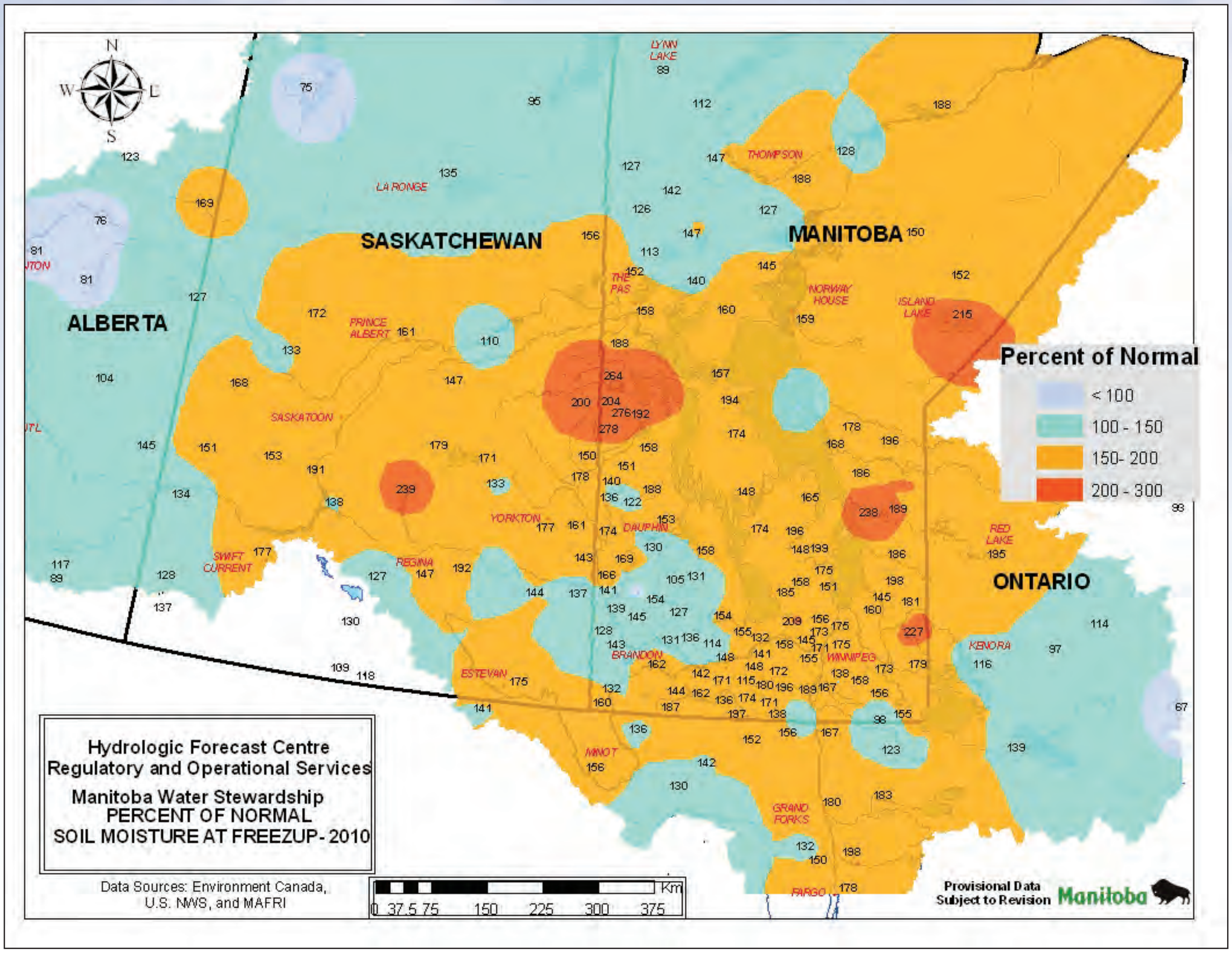


Figure 8 Prairie winter/spring precipitation (November to April, inclusive) as a percent of normal, 2010-11. Winter snowfall appeared to be well below or just average over much of Manitoba and Saskatchewan.

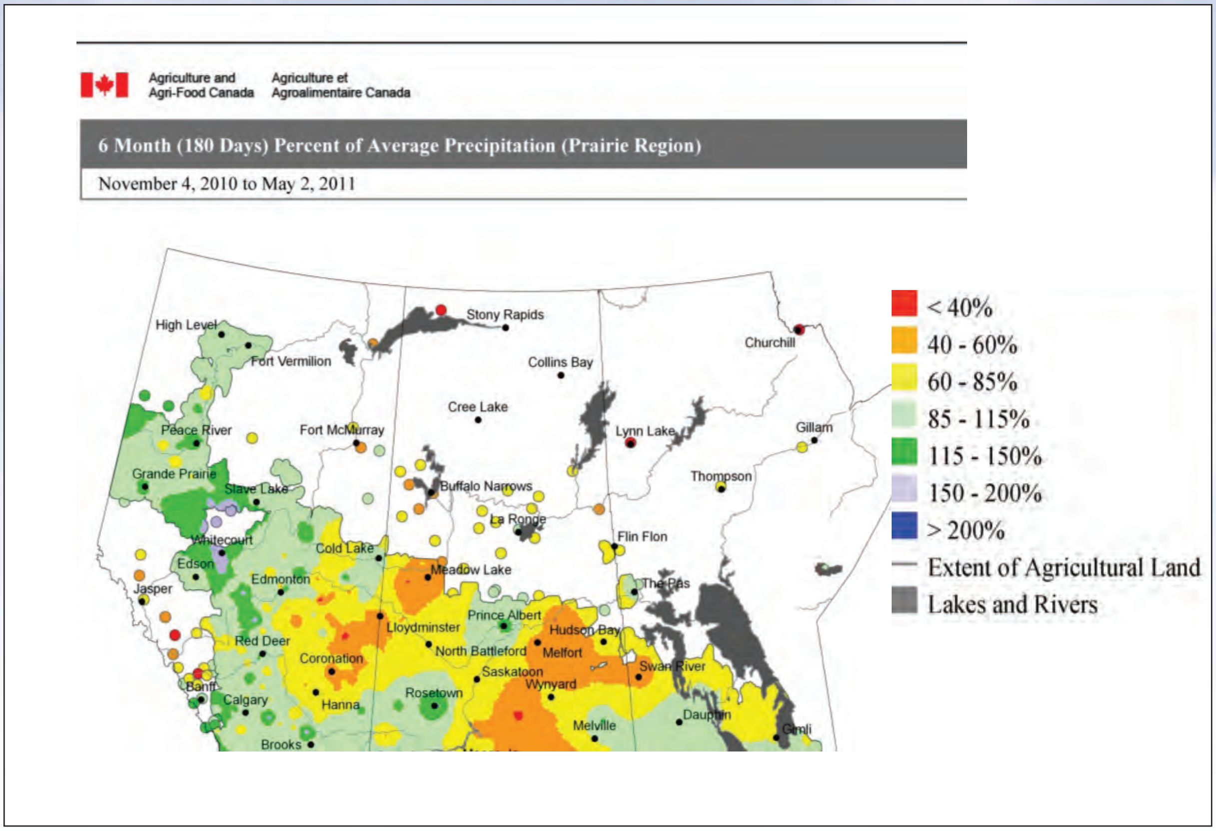


Figure 9: Water content of snowpack on the Prairies, April 8, 2011. Much of the Souris and Upper Assiniboine basins were exhibiting more than 100 mm of water primed to runoff during the snowmelt period. The estimates reconcile reasonably well with those by Manitoba Water Stewardship compiled from a number of data sources.

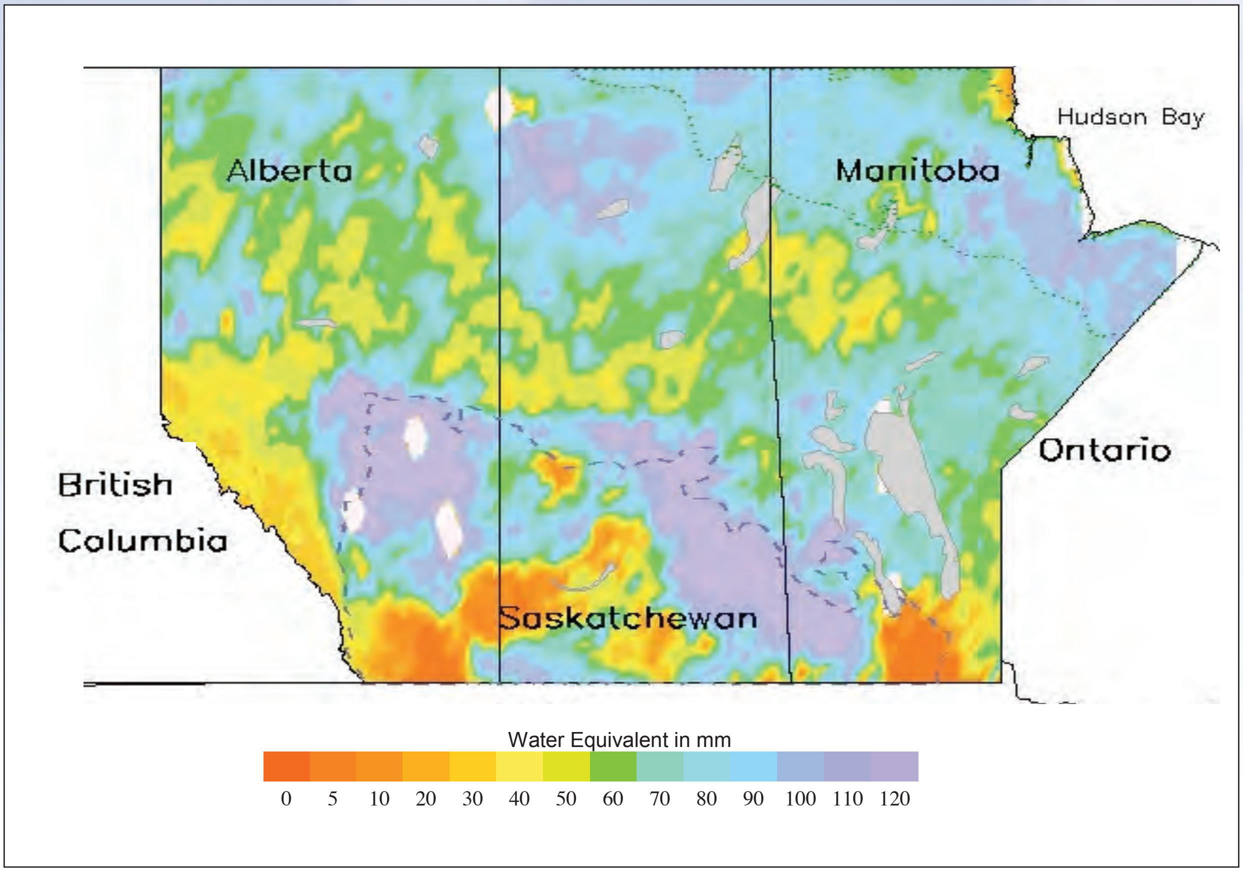


Figure 10: Prairie summer precipitation (May to June, inclusive) as a percent of normal, 2011. Summer precipitation west of the Red River ranged from just below normal to almost twice the amount normally experience.

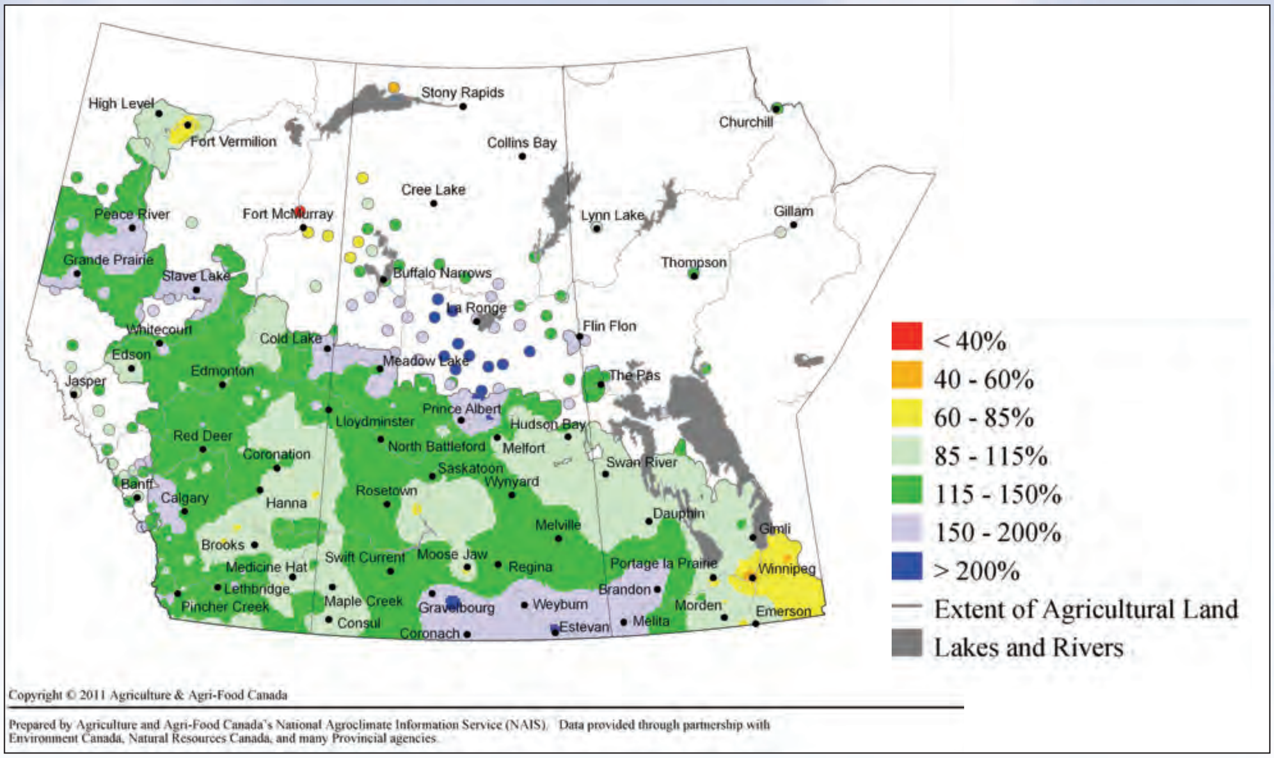


Figure 11: Annual and winter precipitation at The Pas.

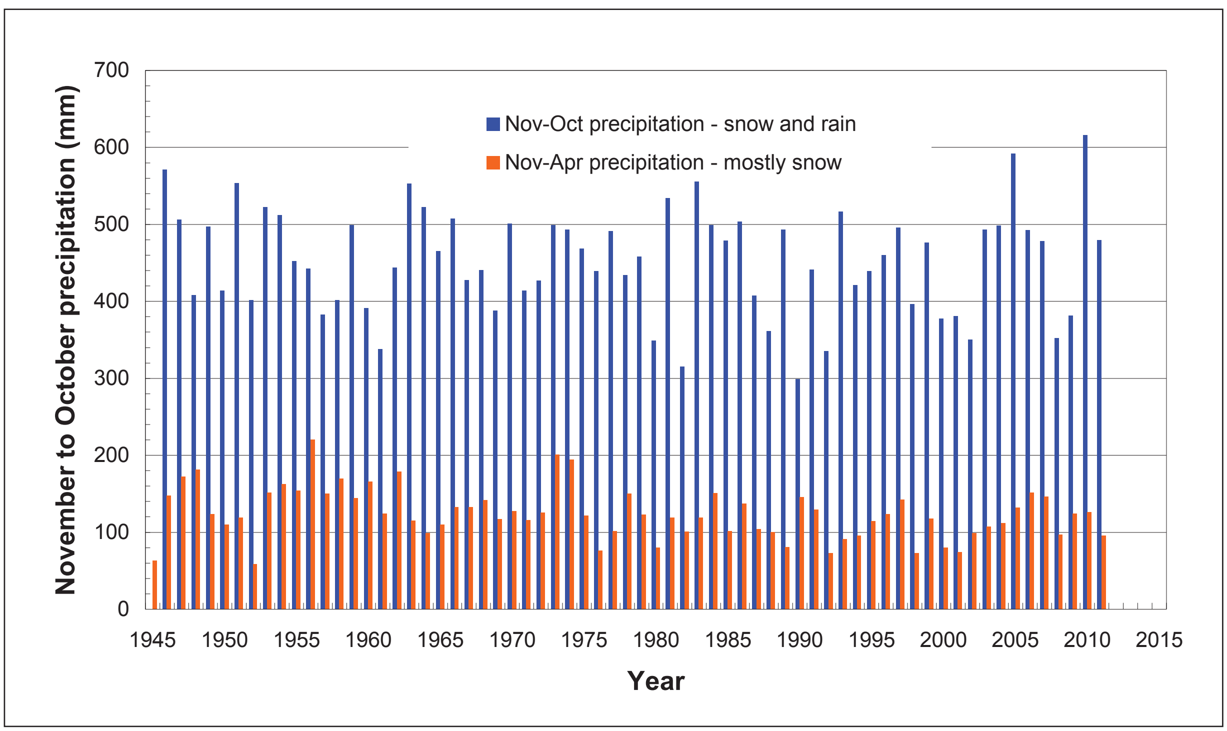


Figure 12: Cumulative precipitation at The Pas, 2011

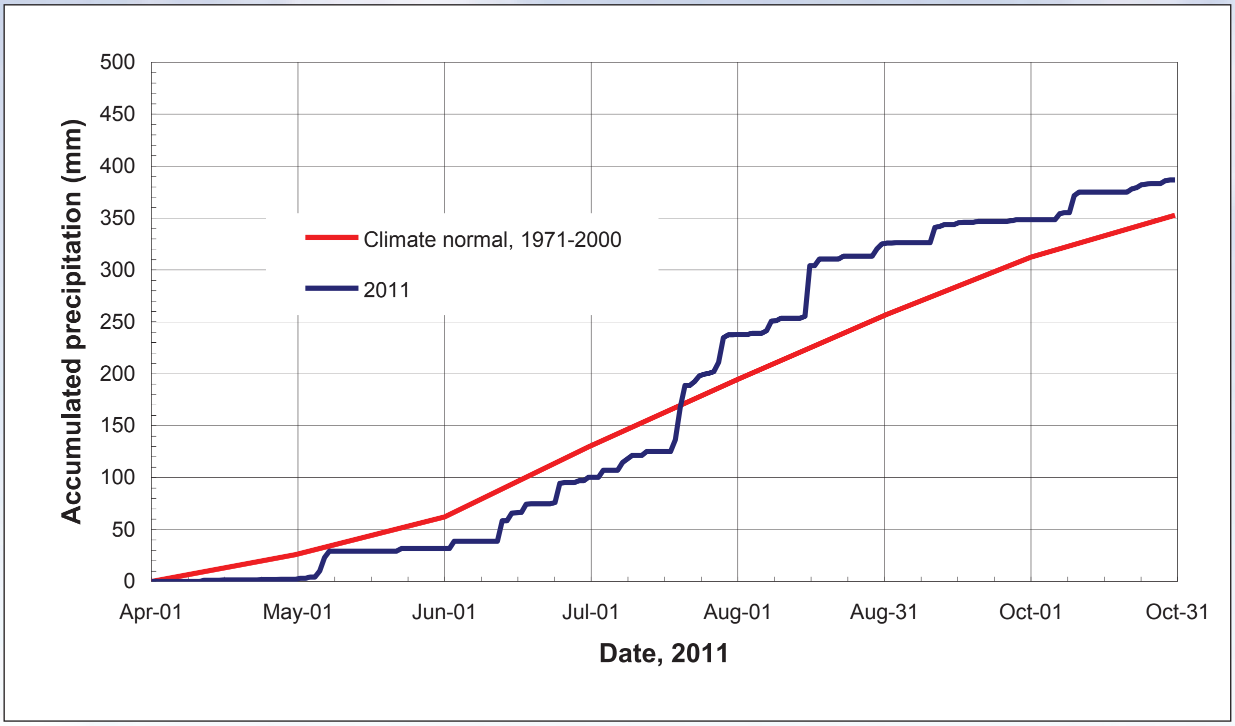


Figure 13: Frequency curves of precipitation at The Pas, 1946-2011

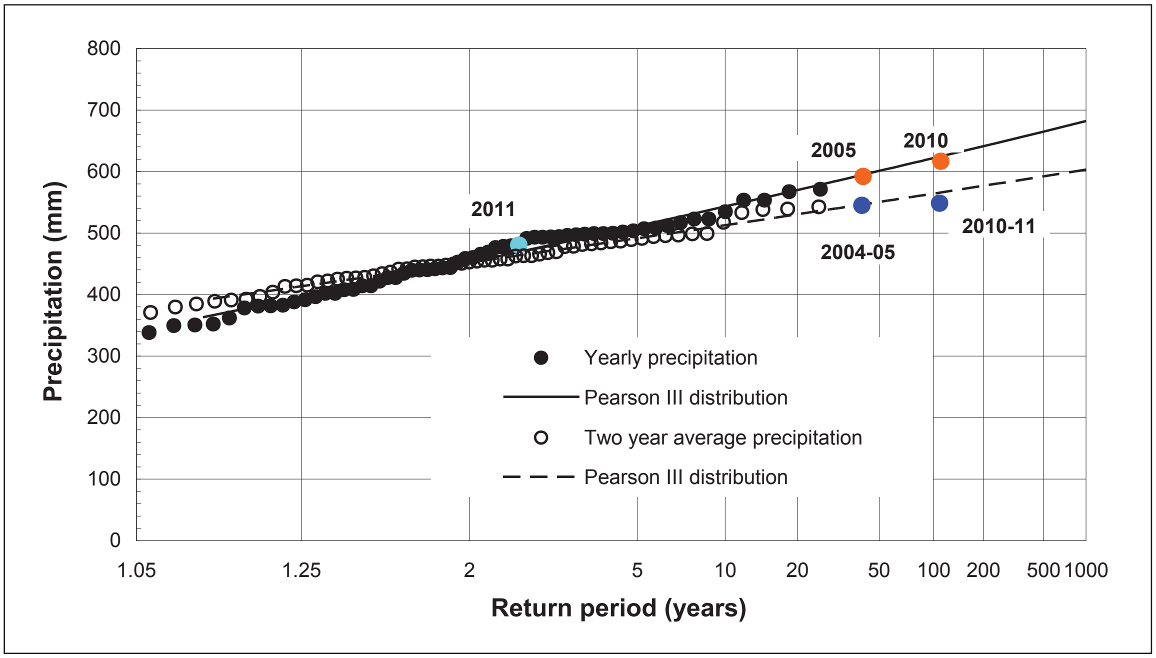


Figure 14: Attenuation of Saskatchewan River flows between Tobin Lake and The Pas.

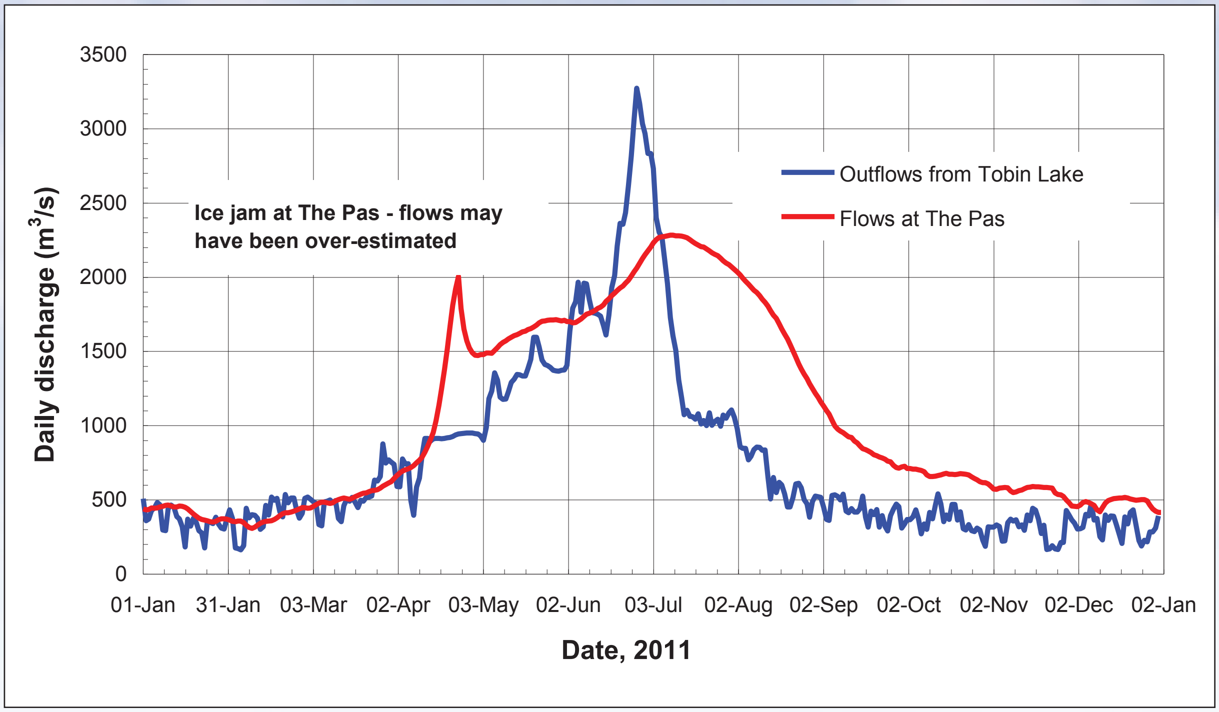


Figure 15: Water levels on the Saskatchewan River at The Pas at the Water Survey of Canada gauge.

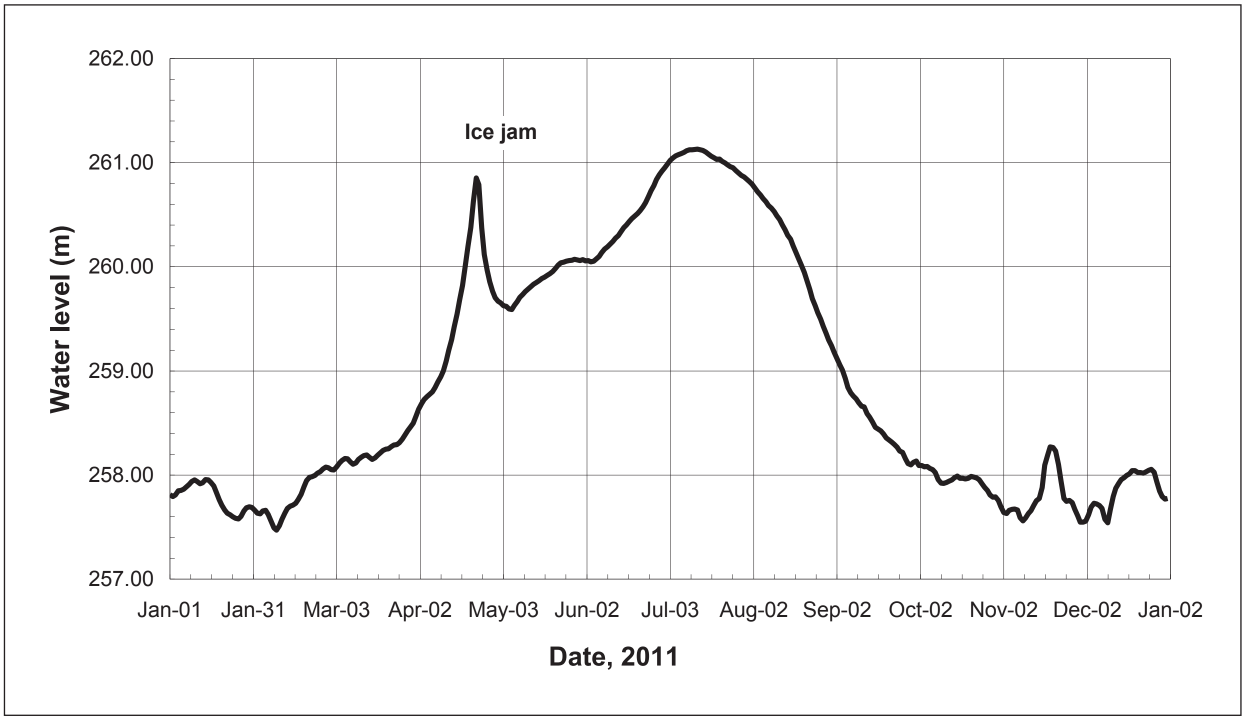


Figure 16: Historical series of measured flood peaks on the Saskatchewan River at The Pas.

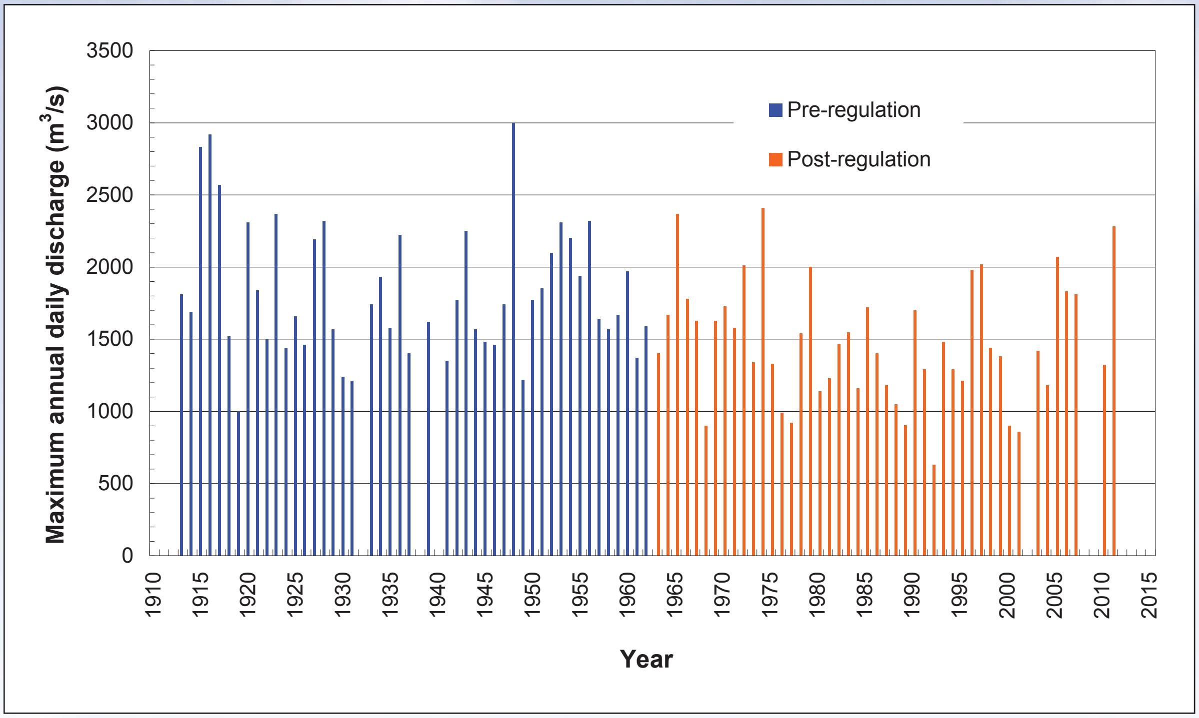


Figure 17 Flood frequency curves for the Saskatchewan River at The Pas - pre and post regulation by Tobin Lake, 1913-2011. The statistics are noted for the post regulation flood peaks.

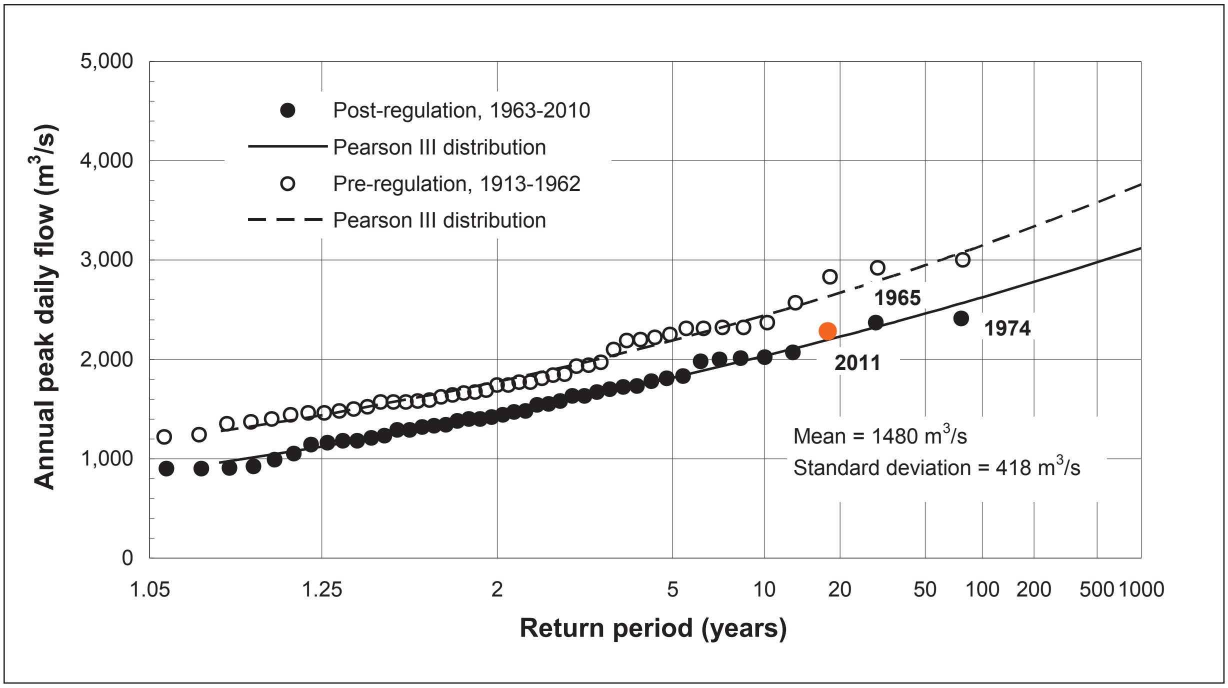


Figure 18: Dauphin Lake basin.

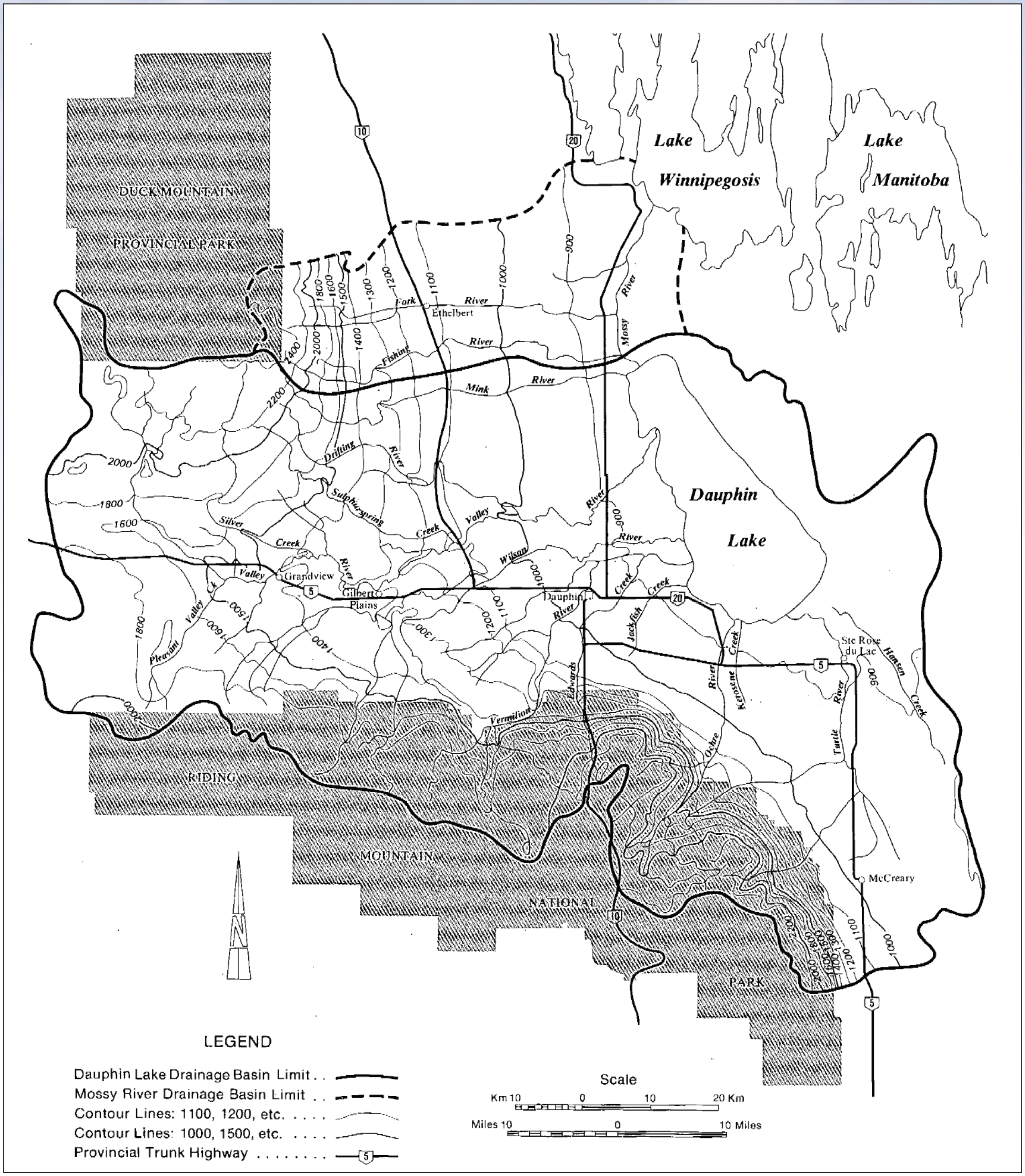


Figure 19: Annual and winter precipitation at Gilbert Plains. These precipitation data provide an indication of the potential for inflows into Dauphin Lake.

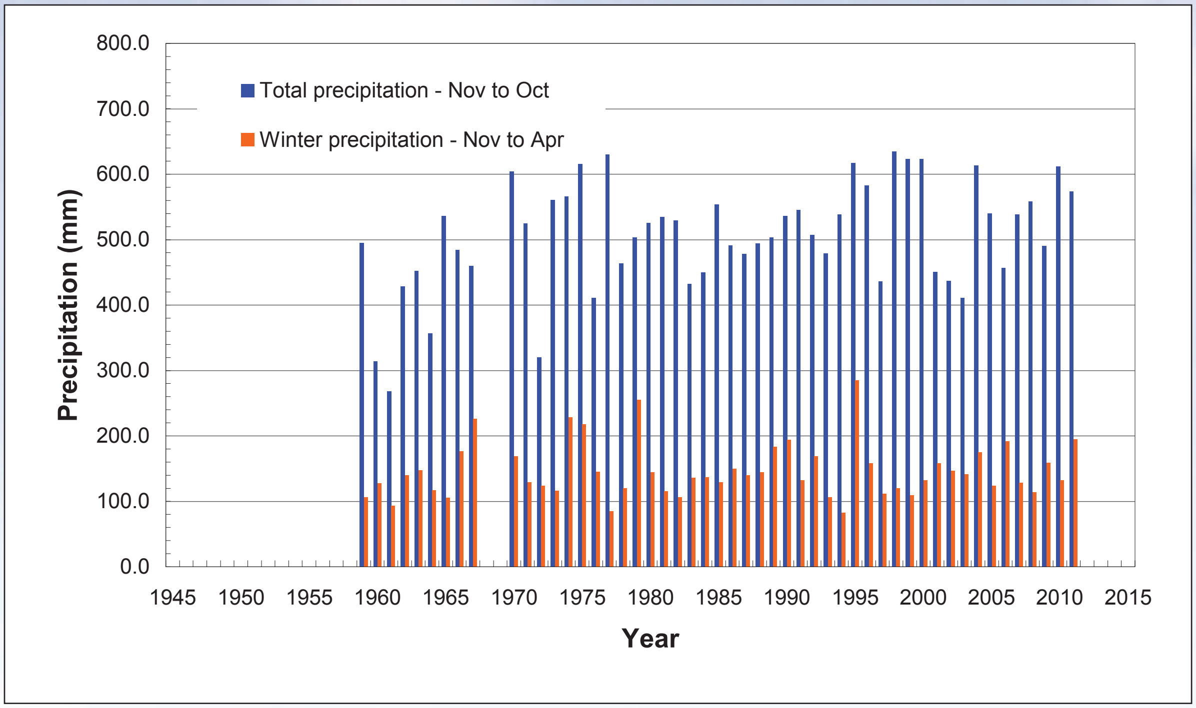


Figure 20: Cumulative precipitation in the Dauphin Lake basin, 2011.

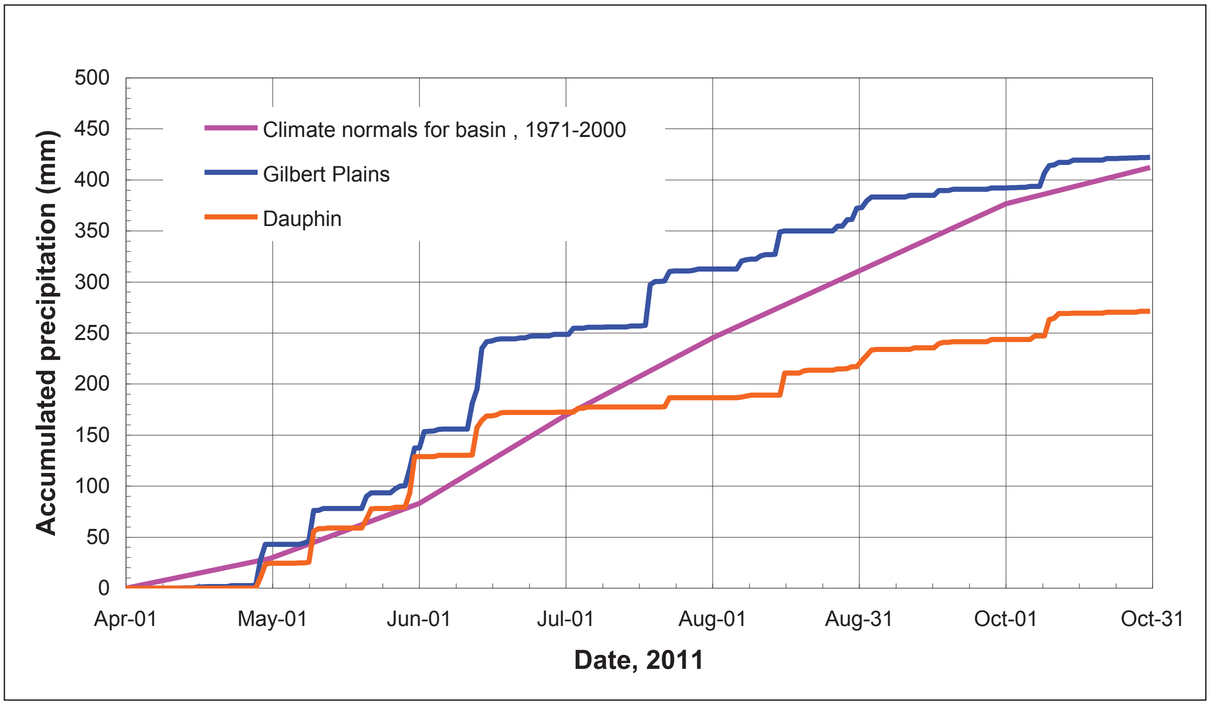


Figure 21: Frequency curve of November-October precipitation at Gilbert Plains, 1959-2011.

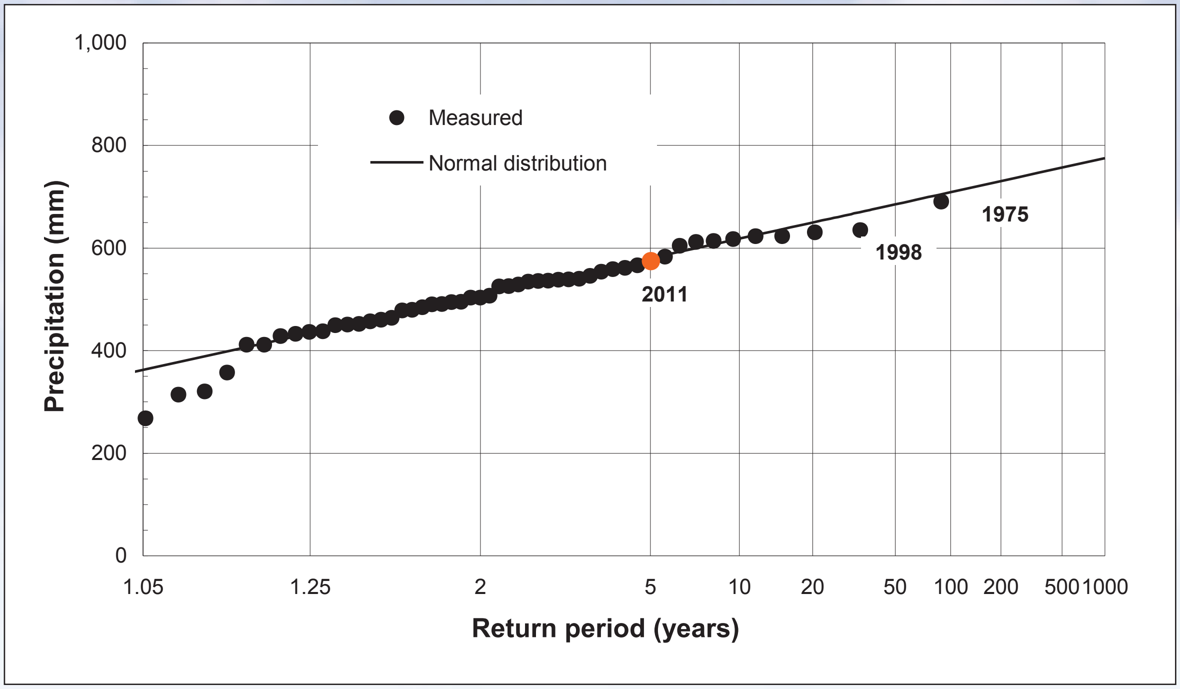


Figure 22: Summer runoff depths from the Valley River watershed.

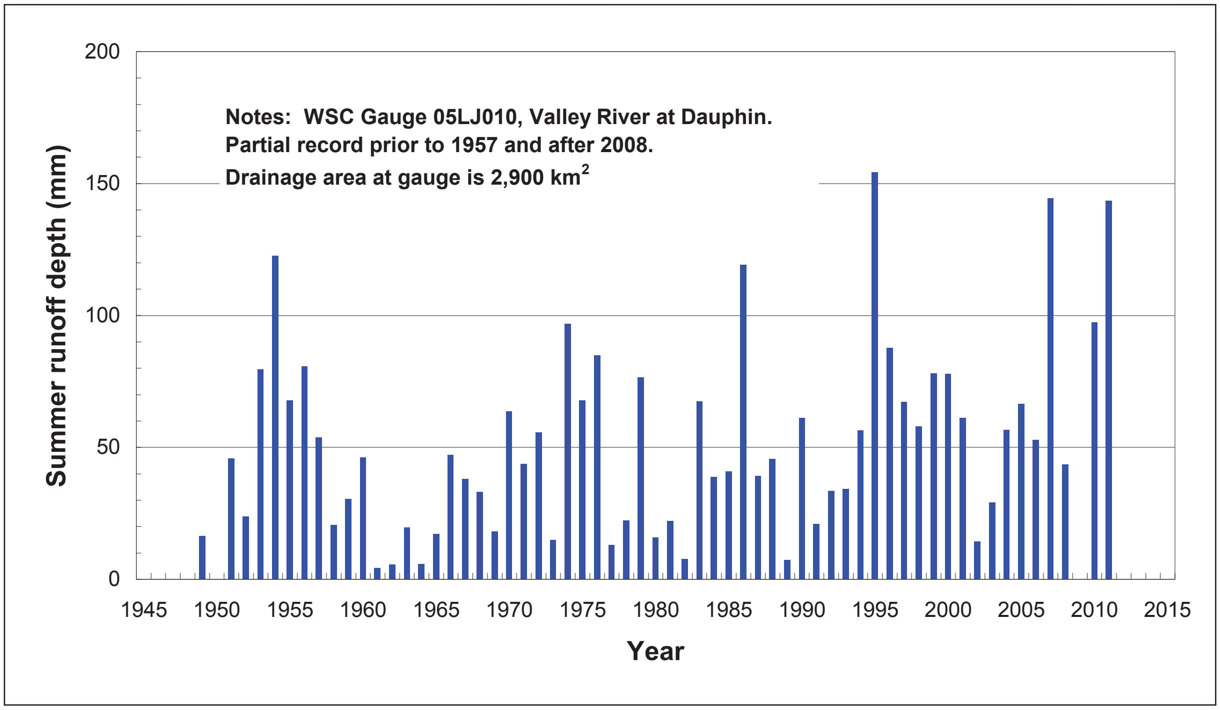


Figure 23: Frequency curve of summer runoff depths - Valley River, 1948-2011.

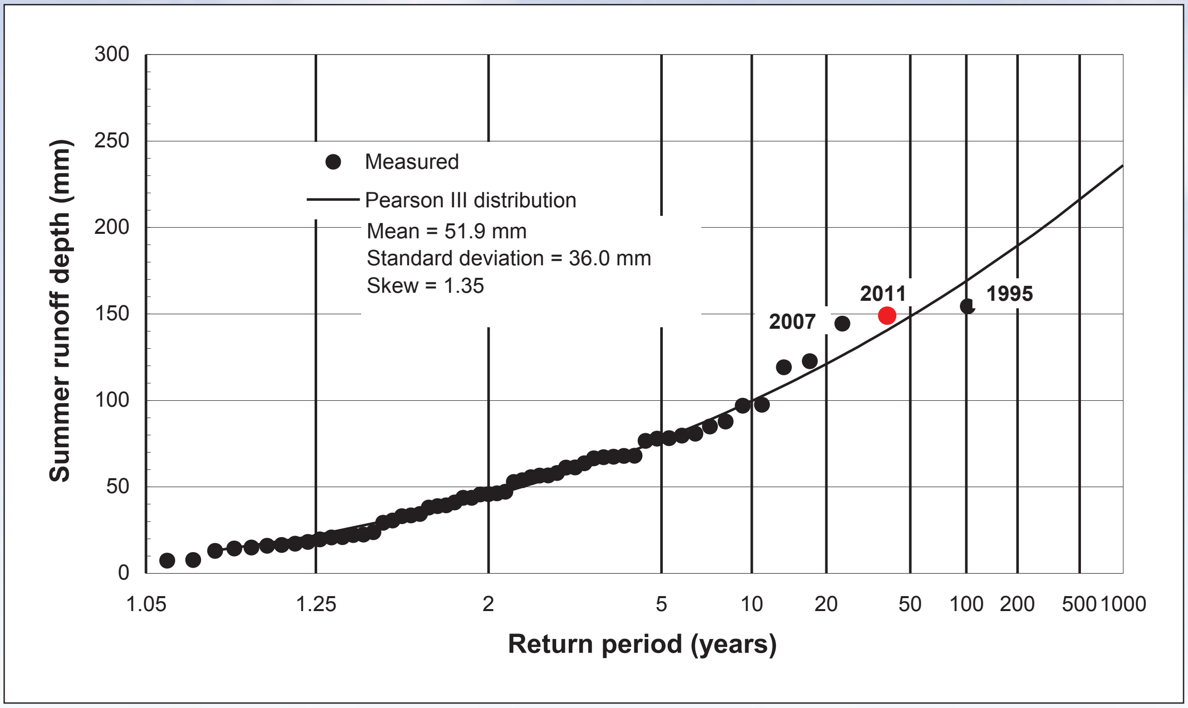


Figure 24: Historical record of daily water levels on Dauphin Lake.

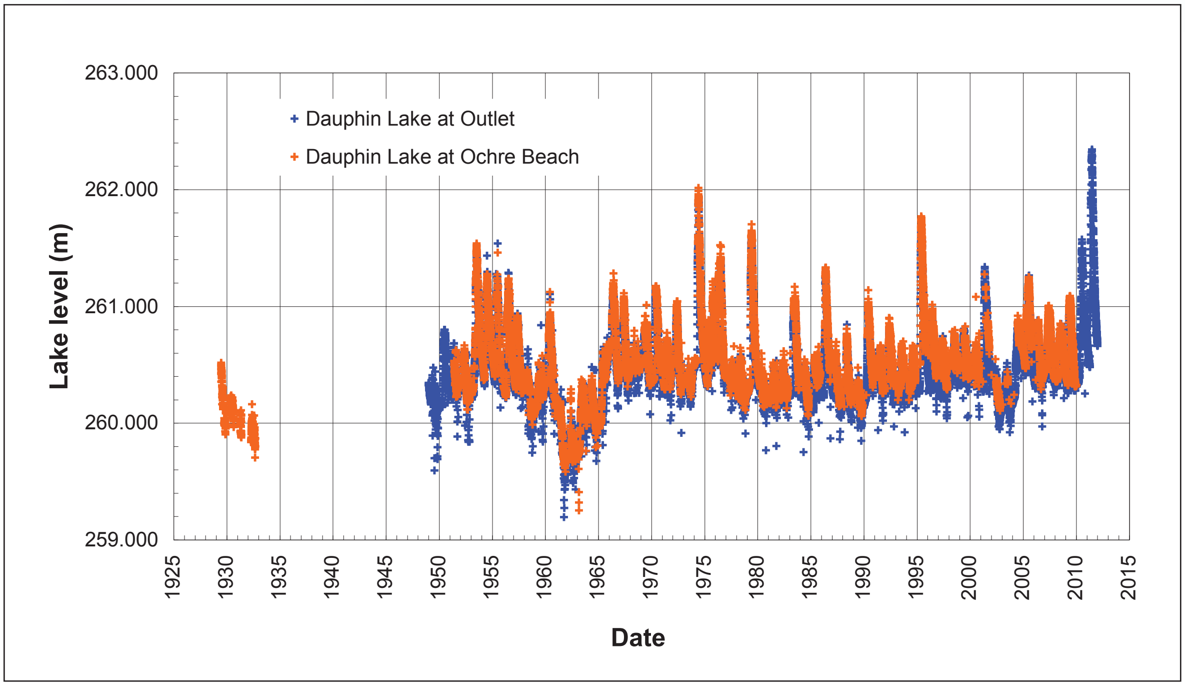


Figure 25: Comparison of 2011 measured and simulated water levels on Dauphin Lake.

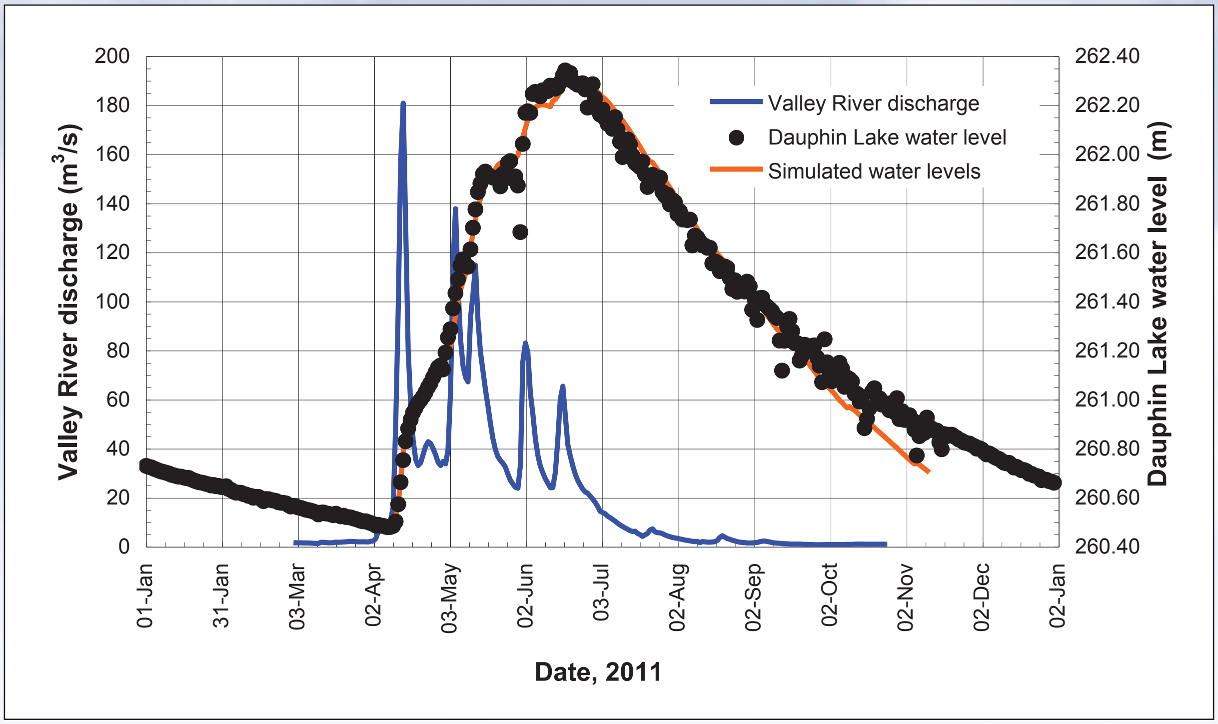


Figure 26: Frequency curve of peak annual lake levels - Dauphin Lake, 1949-2011.

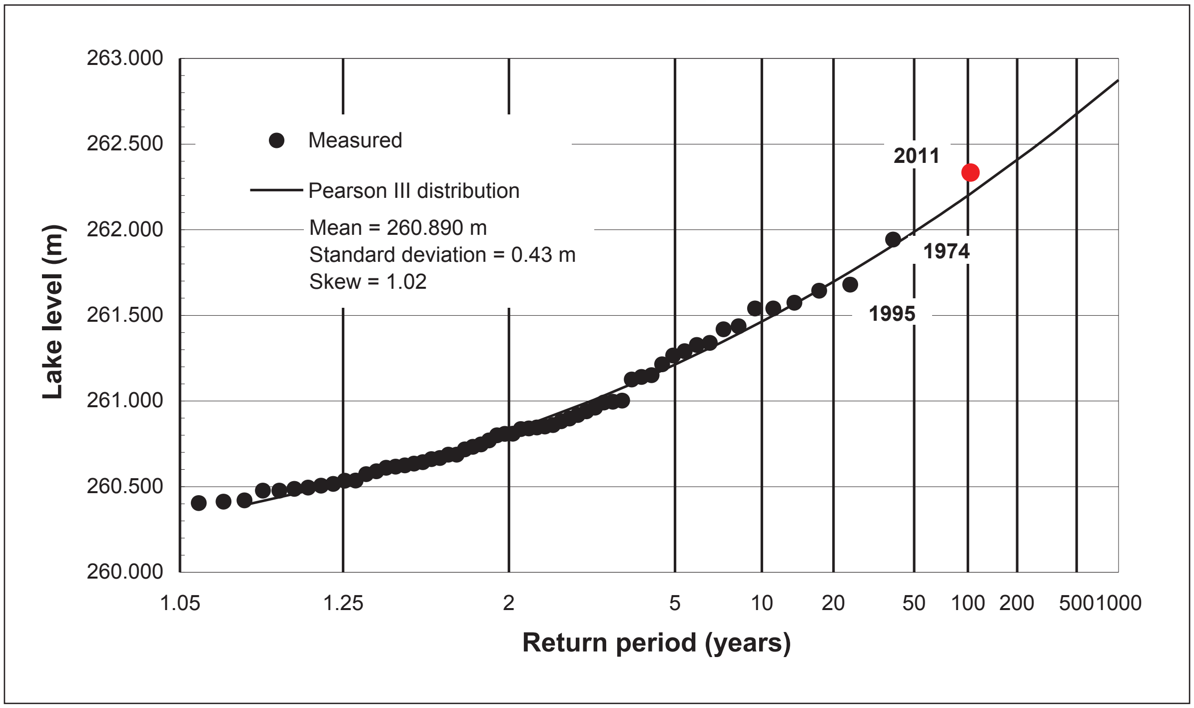


Figure 27: Historical water levels on Lake of the Prairies.

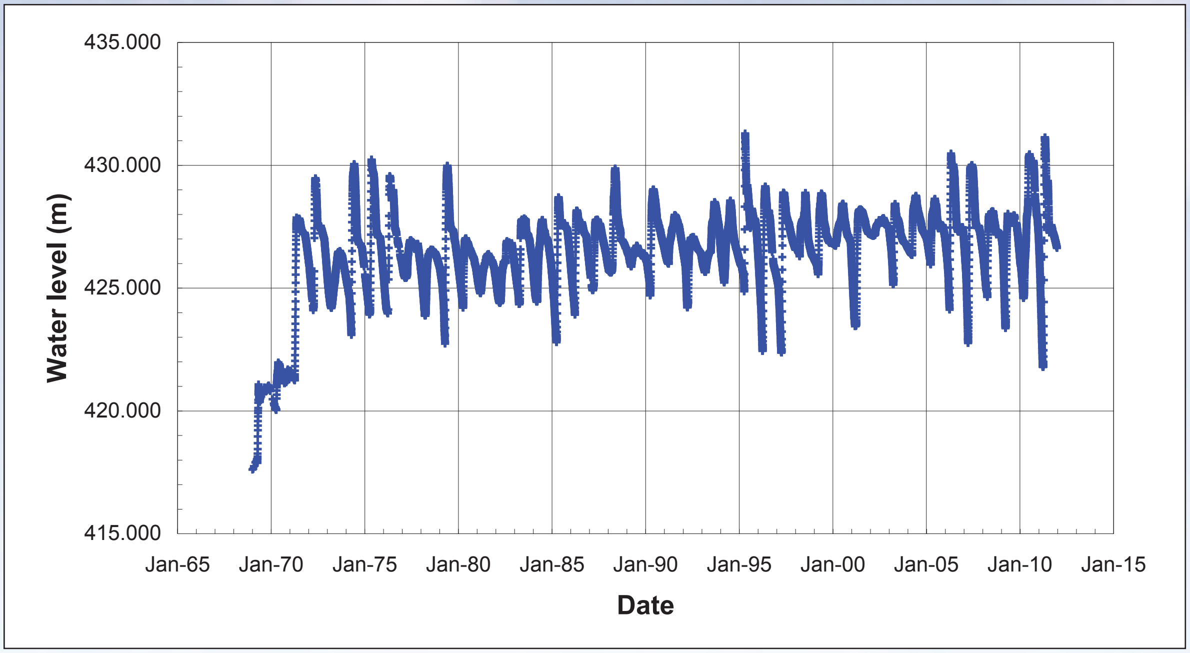


Figure 28: Drainage basin upstream of Lake of the Prairies.

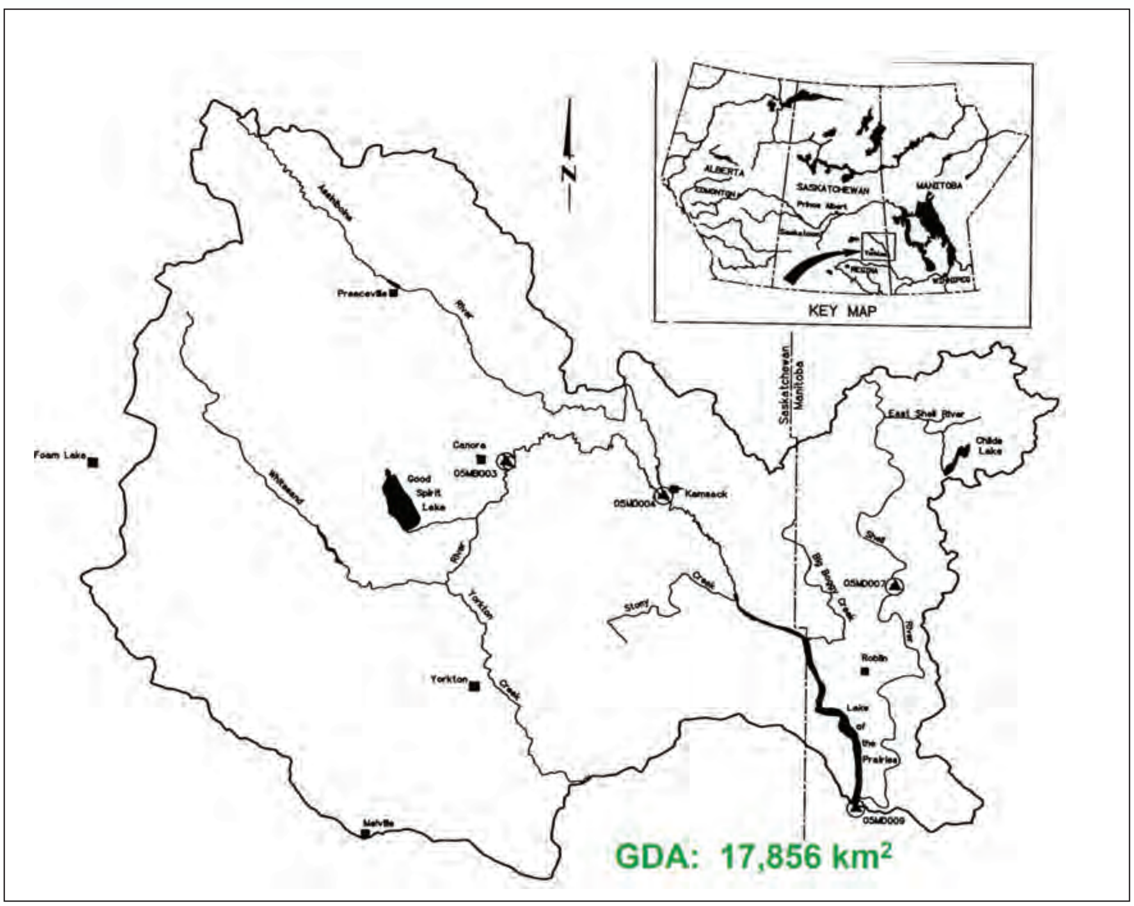


Figure 29: Comparison of 2011 Roblin precipitation to historical values.

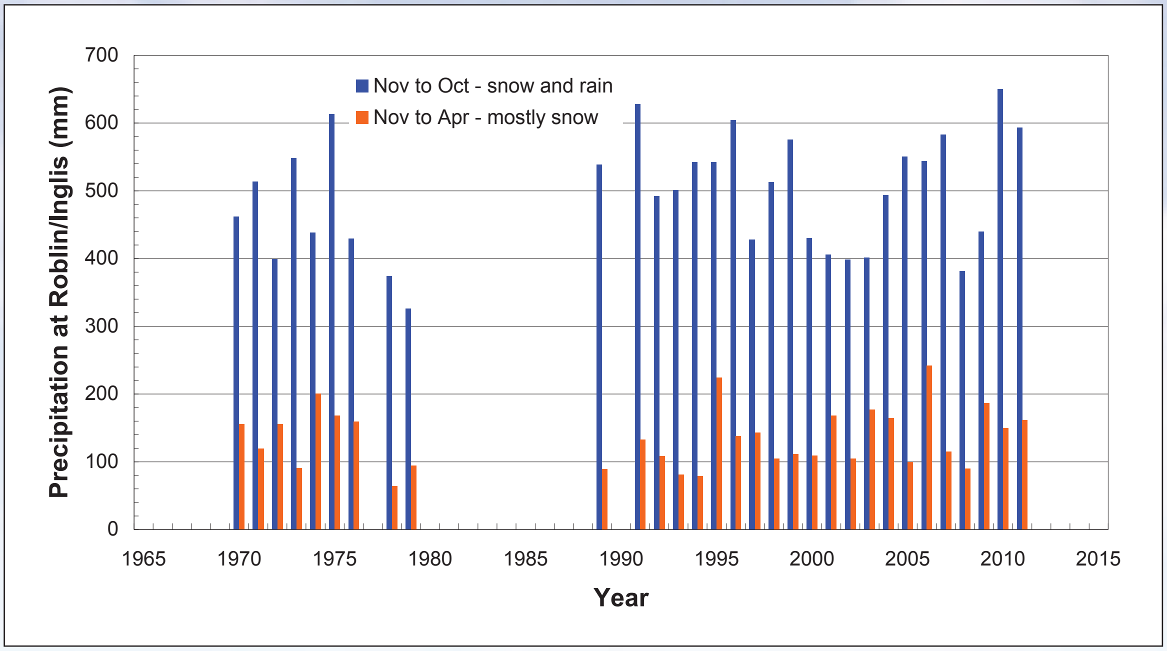


Figure 30: Cumulative Precipitation in vicinity of Lake of the Prairies, April to November , 2011.

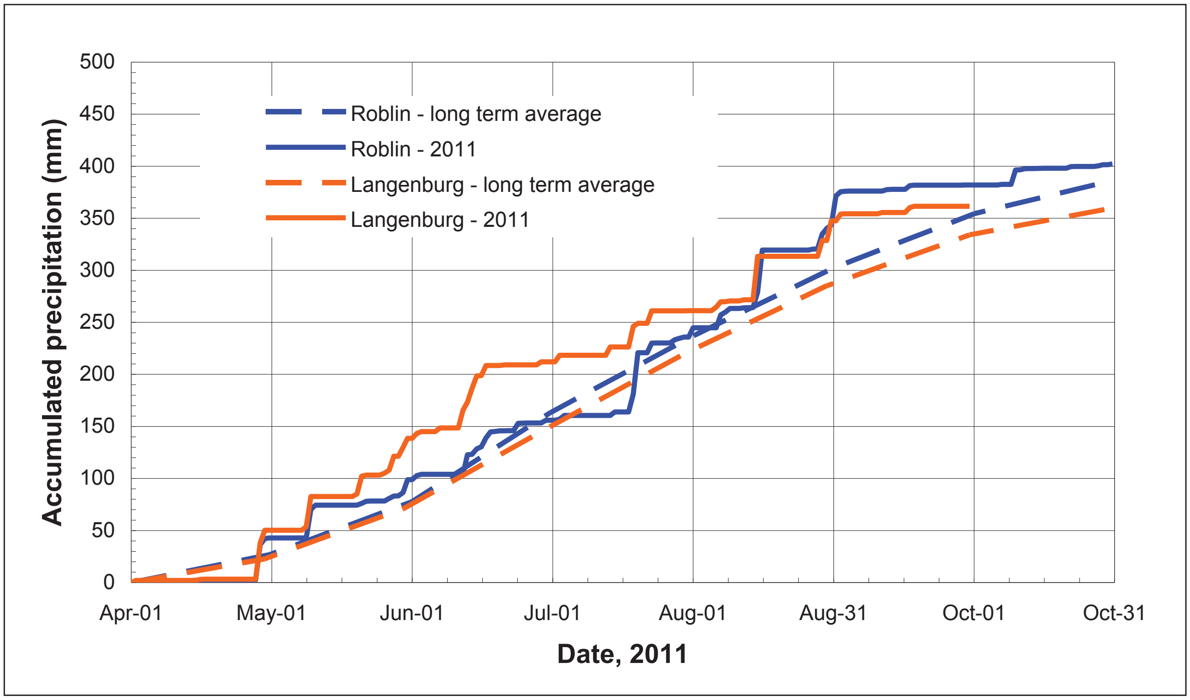


Figure 31: Cumulative precipitation at Roblin and Elkhorn, April to November, 2011. This would be indicative of the precipitation in the Assiniboine River basin upstream of Brandon.

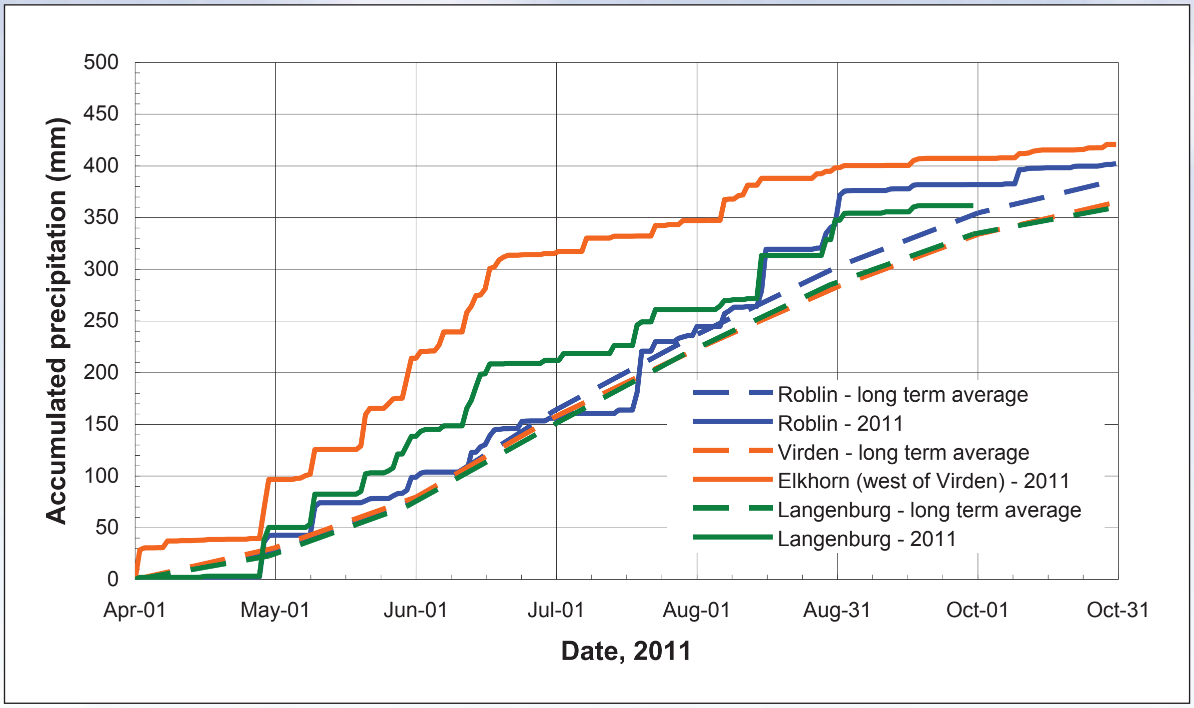


Figure 32: Flows and water levels - Assiniboine River at Brandon, 2011.

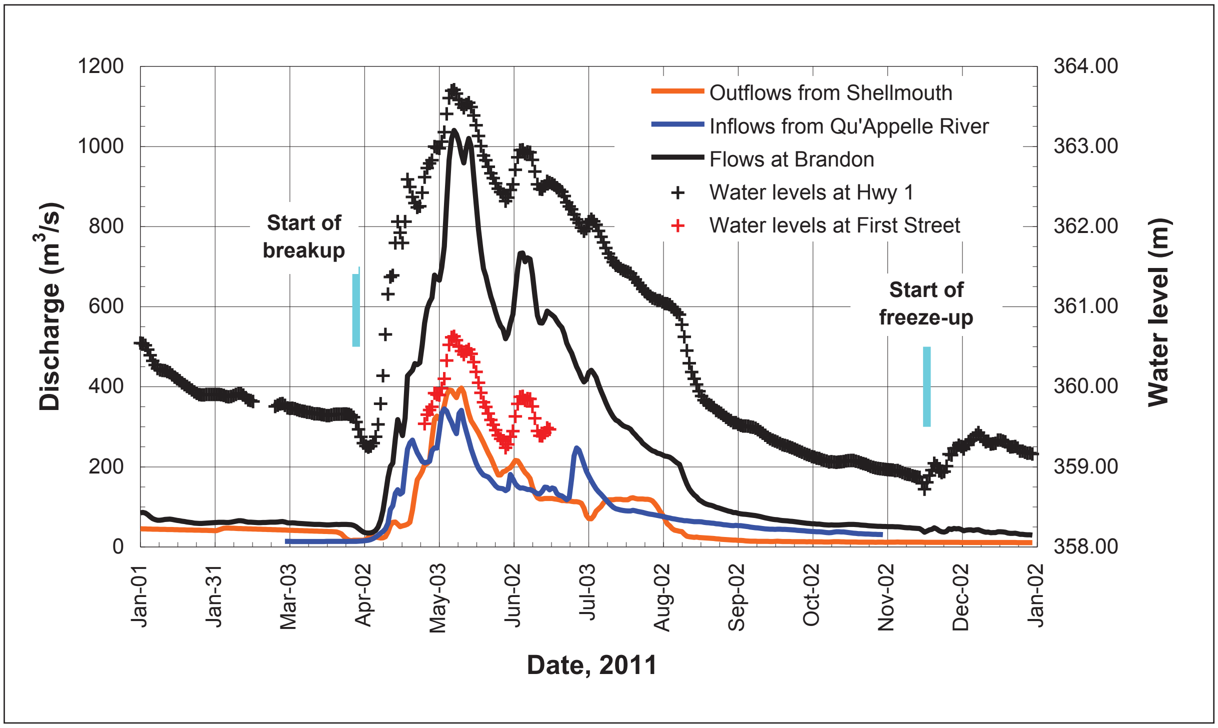


Figure 33: Peak Flows on Assiniboine River at Brandon for period of record, 1906-2011.

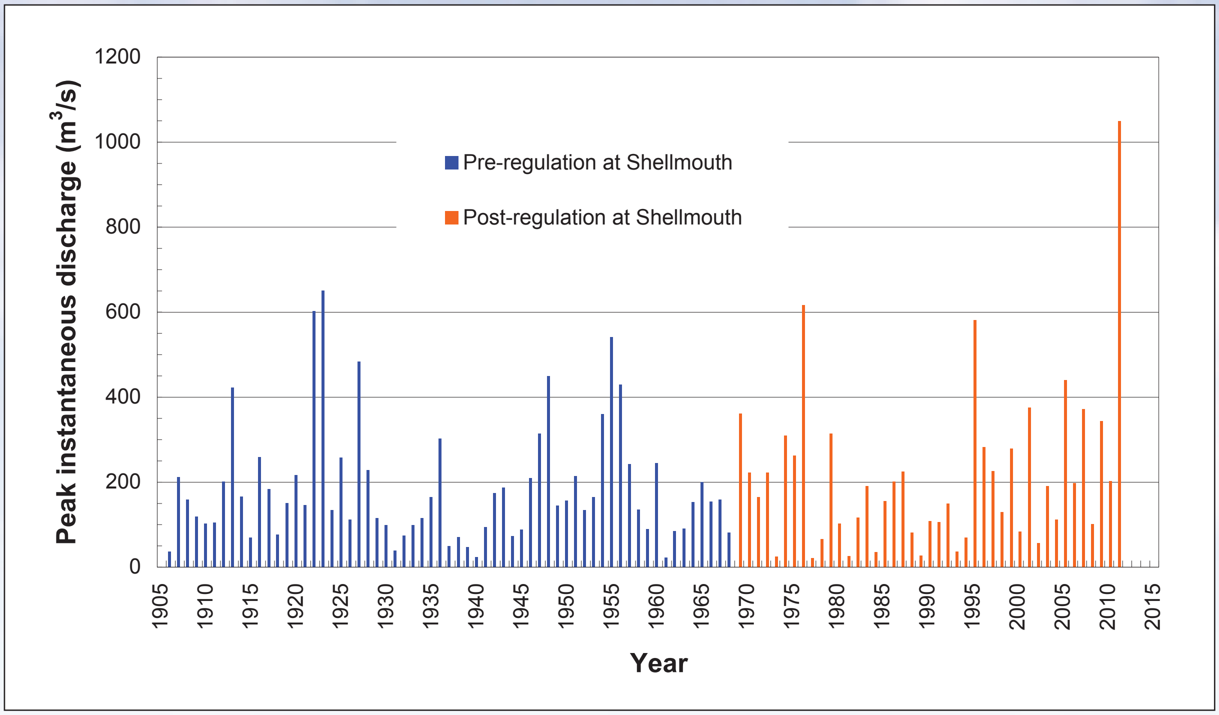


Figure 34: Comparison of regulated and unregulated frequency curves of annual peak flows at Brandon for period of record, 1906-2011.

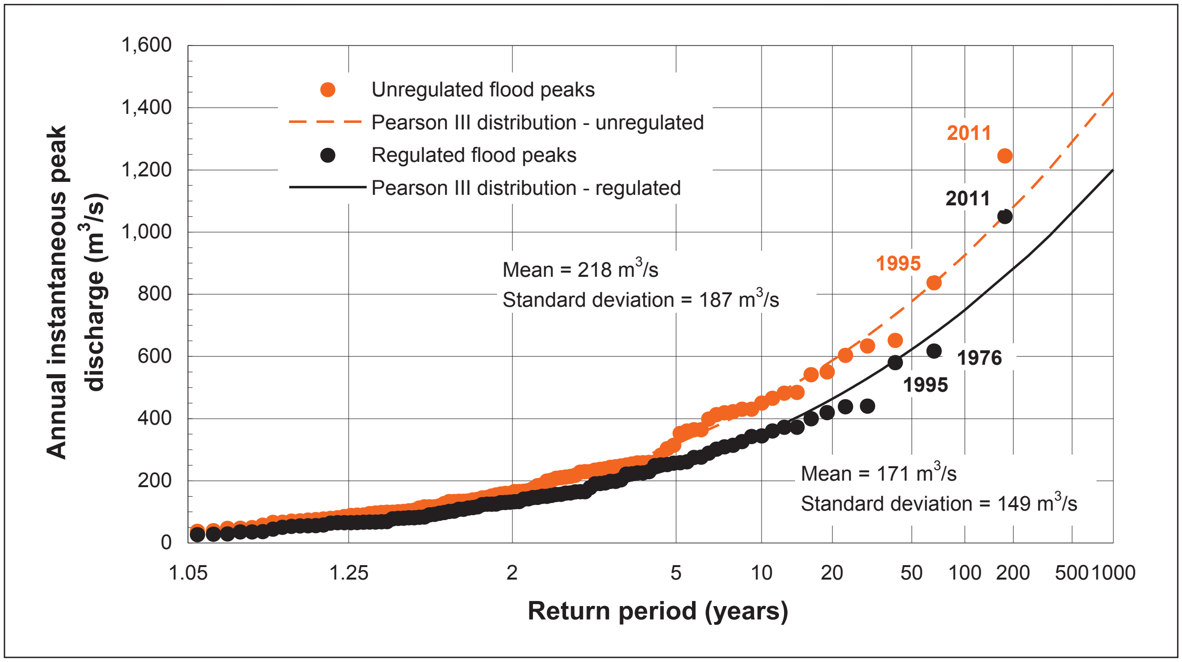


Figure 35: Effects of regulation at Shellmouth on 2011 flows at Brandon.

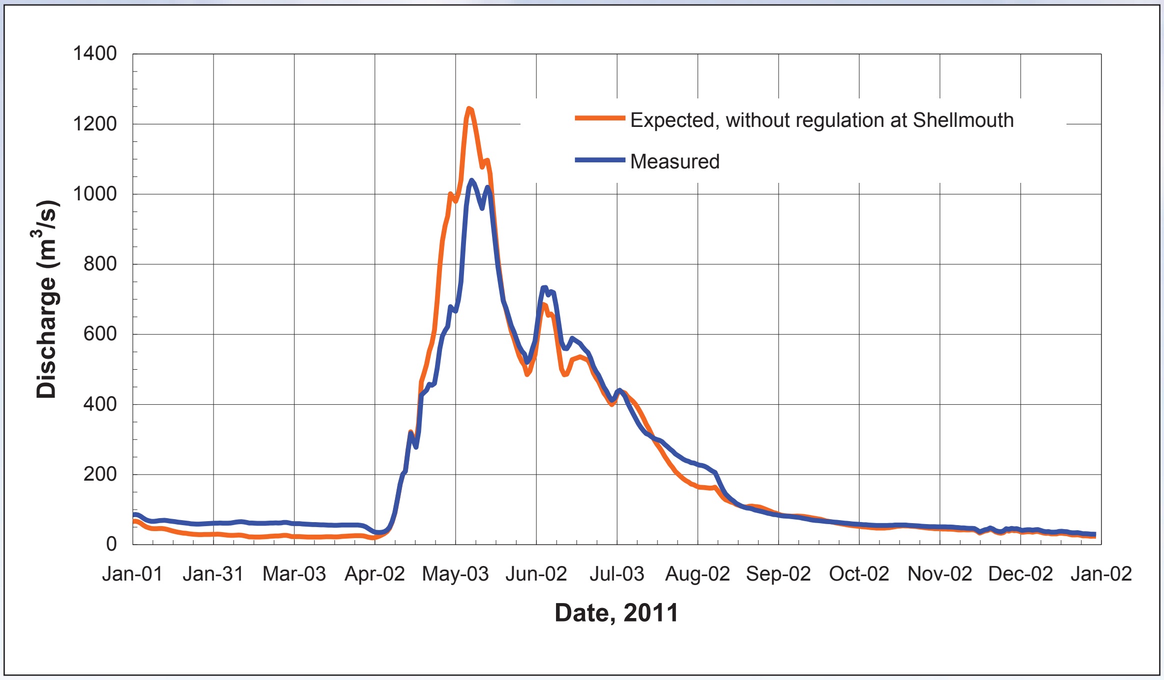


Figure 36: Flood levels on the Assiniboine River at Brandon, just upstream of bridge at First Street.

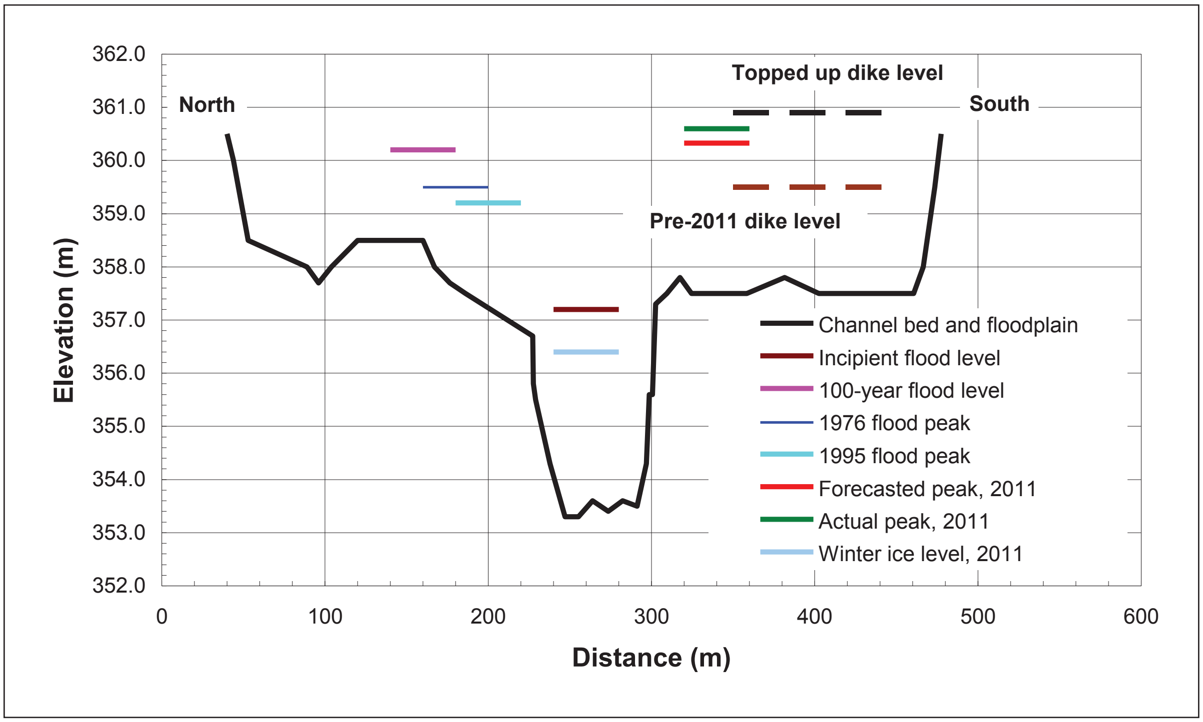


Figure 37: Flows on the Assiniboine River at Holland with corresponding flows at Brandon and inputs from the Souris River , 2011.

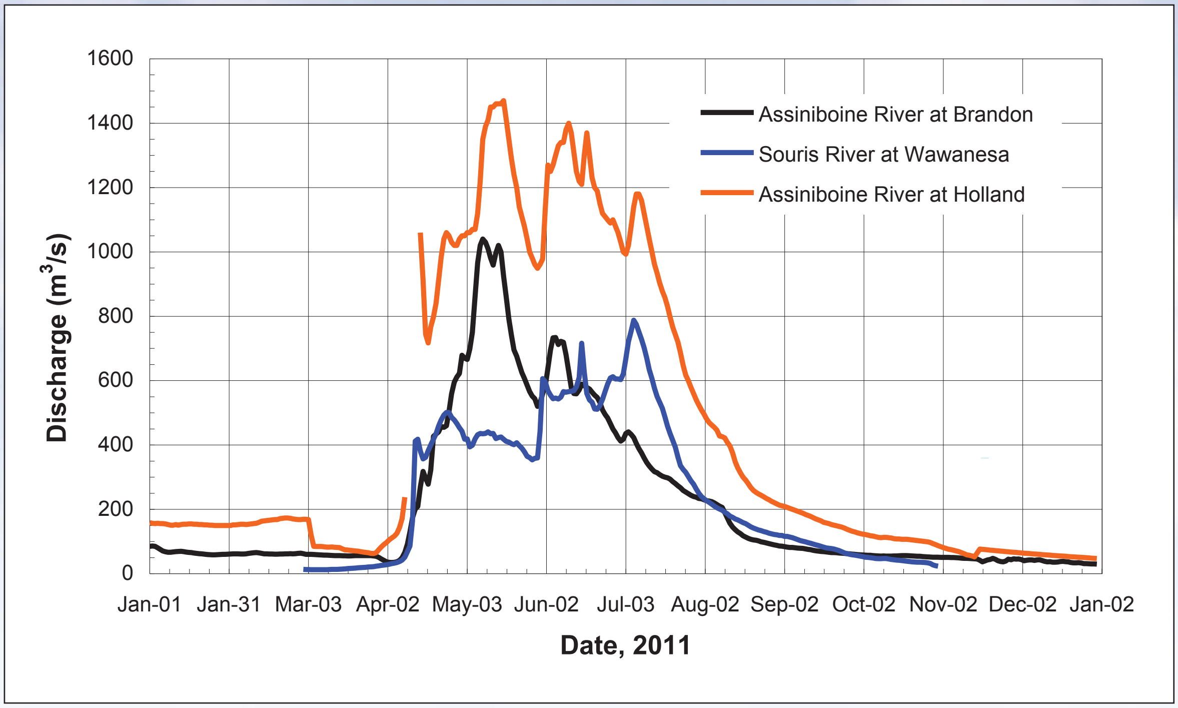


Figure 38: Frequency curve of April to October runoff volumes at Holland, 1961-2011.

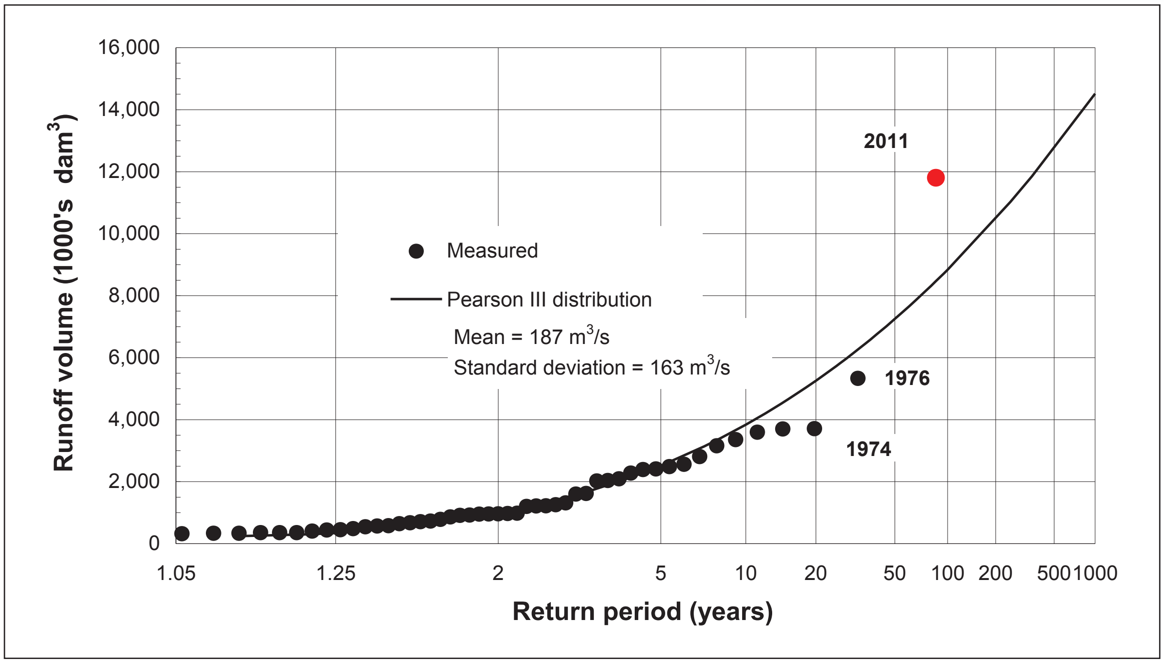


Figure 39: Annual diversion volumes to Lake Manitoba via the Portage Diversion.

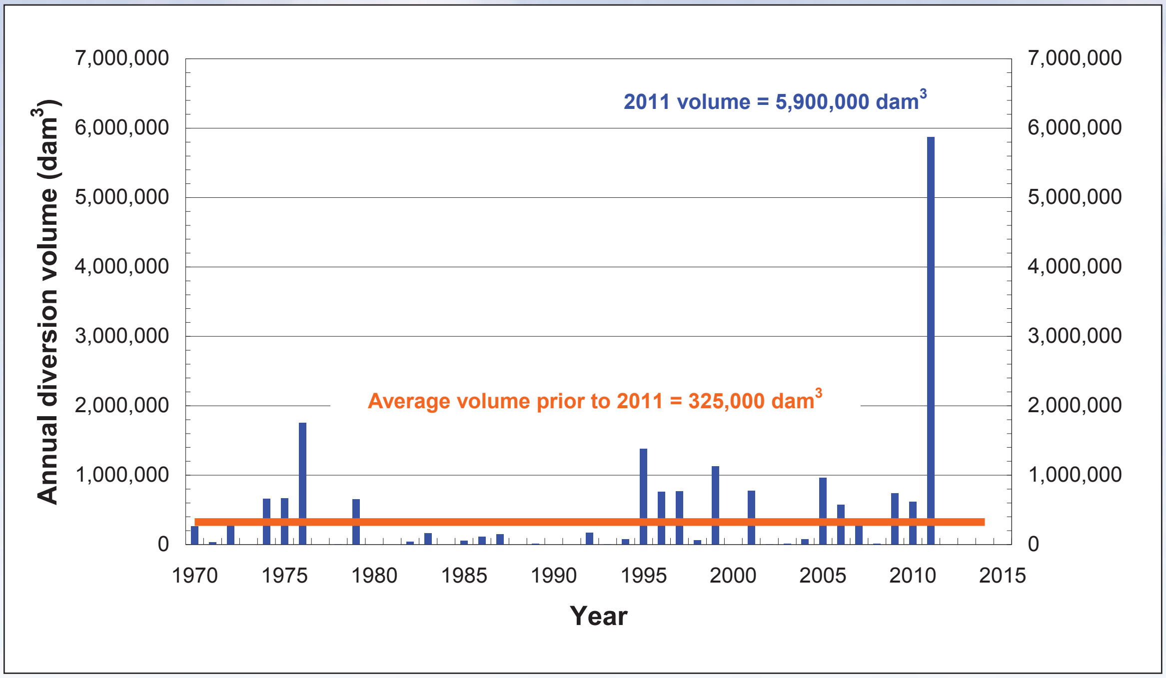


Figure 40: Souris River basin map.

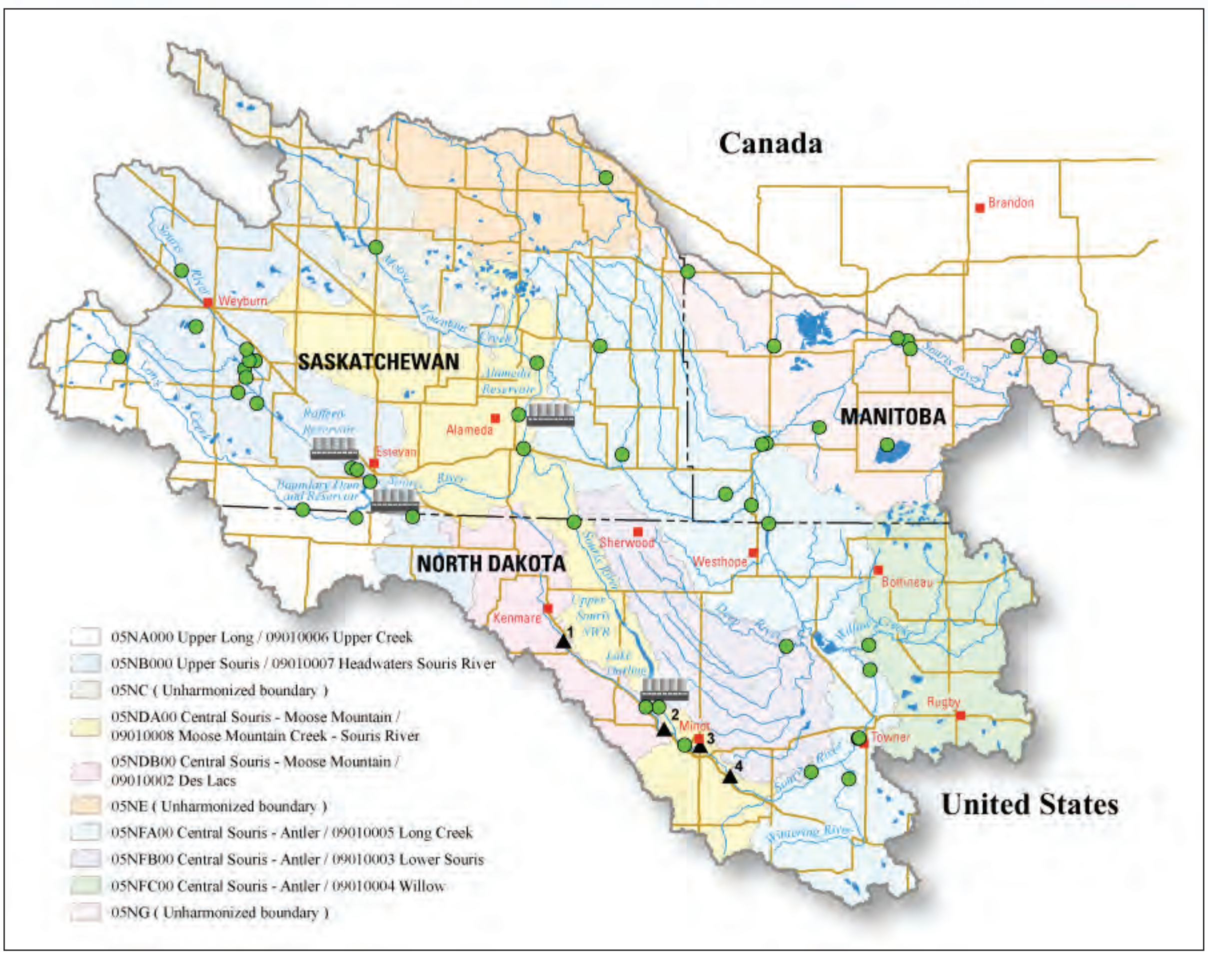


Figure 41: Comparison of 2011 precipitation in Souris River basin to historical values

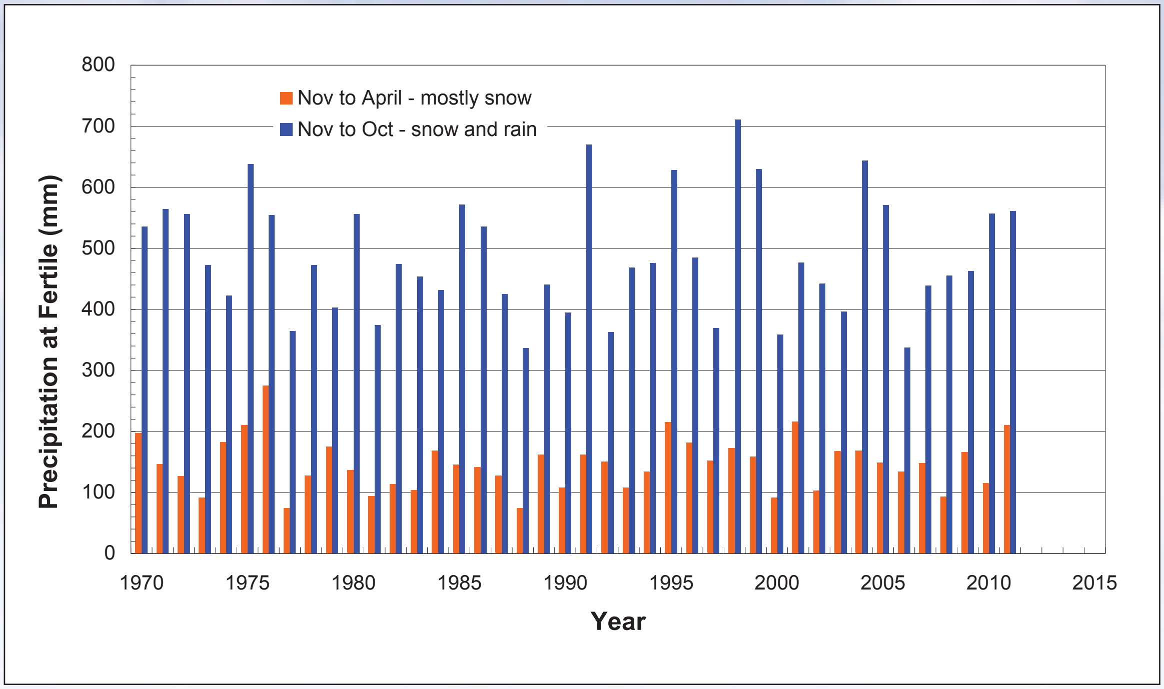


Figure 42: Cumulative precipitation at selected locations in Souris River basin, 2011.

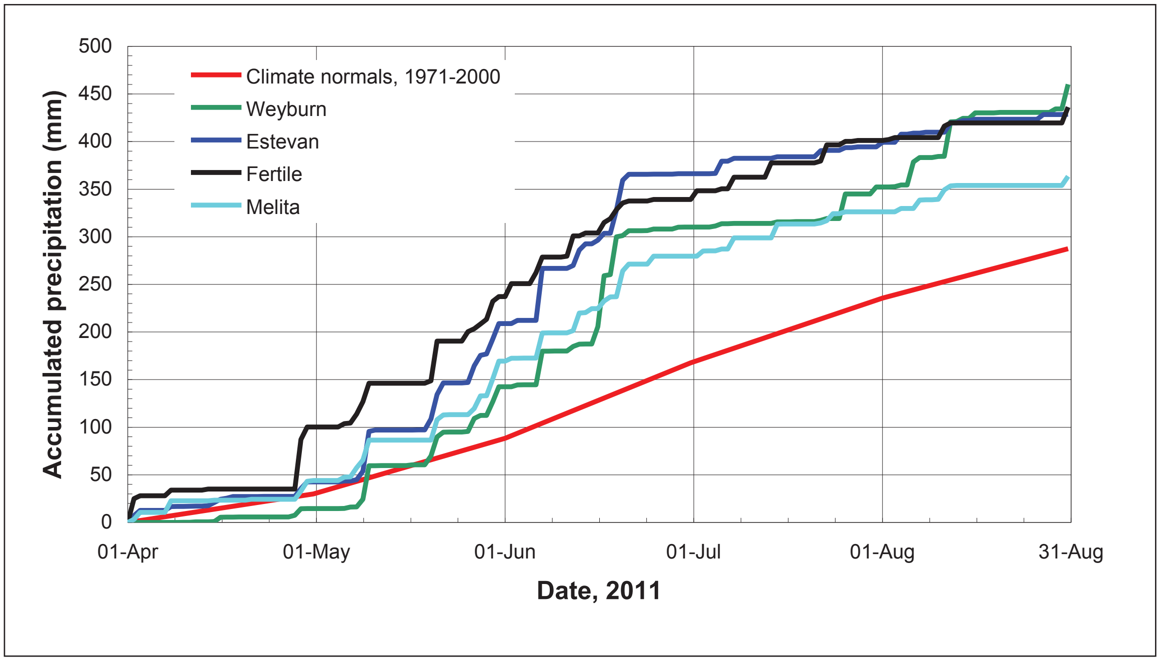


*Figure 43:	Historical flood peaks on the Souris River at Westhope and Wawanesa.*

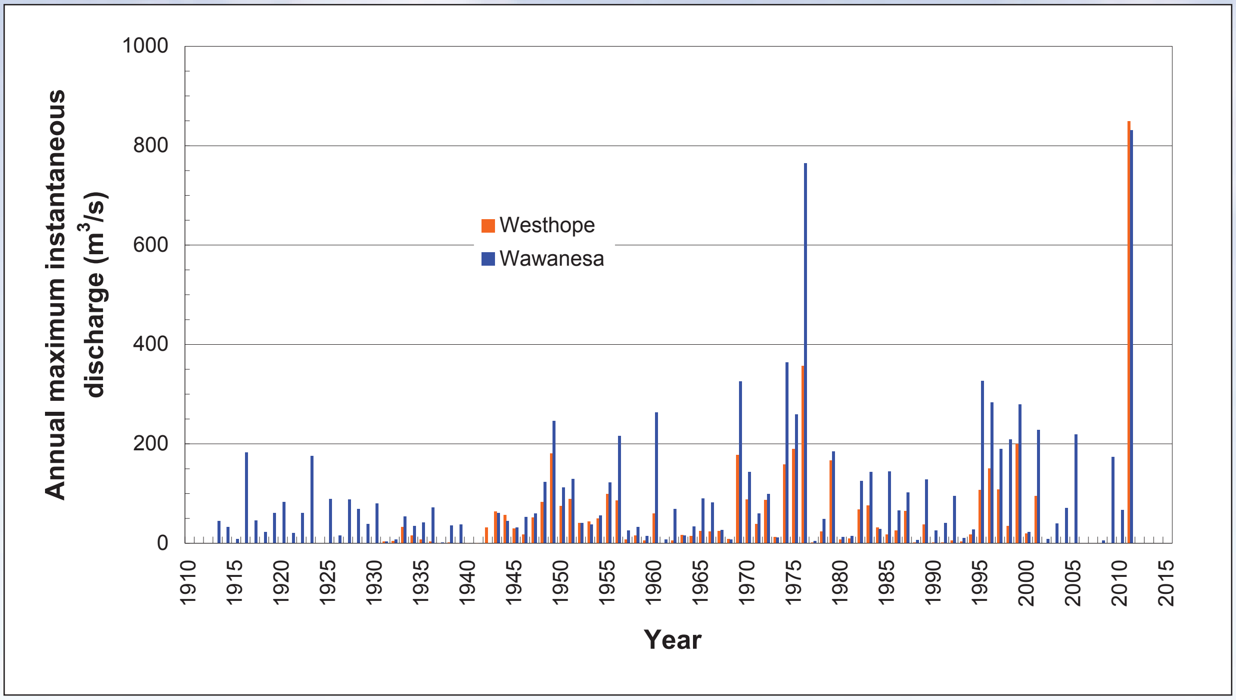


*Figure 44:	Flow hydrographs at various locations along the Souris River, 2011.*

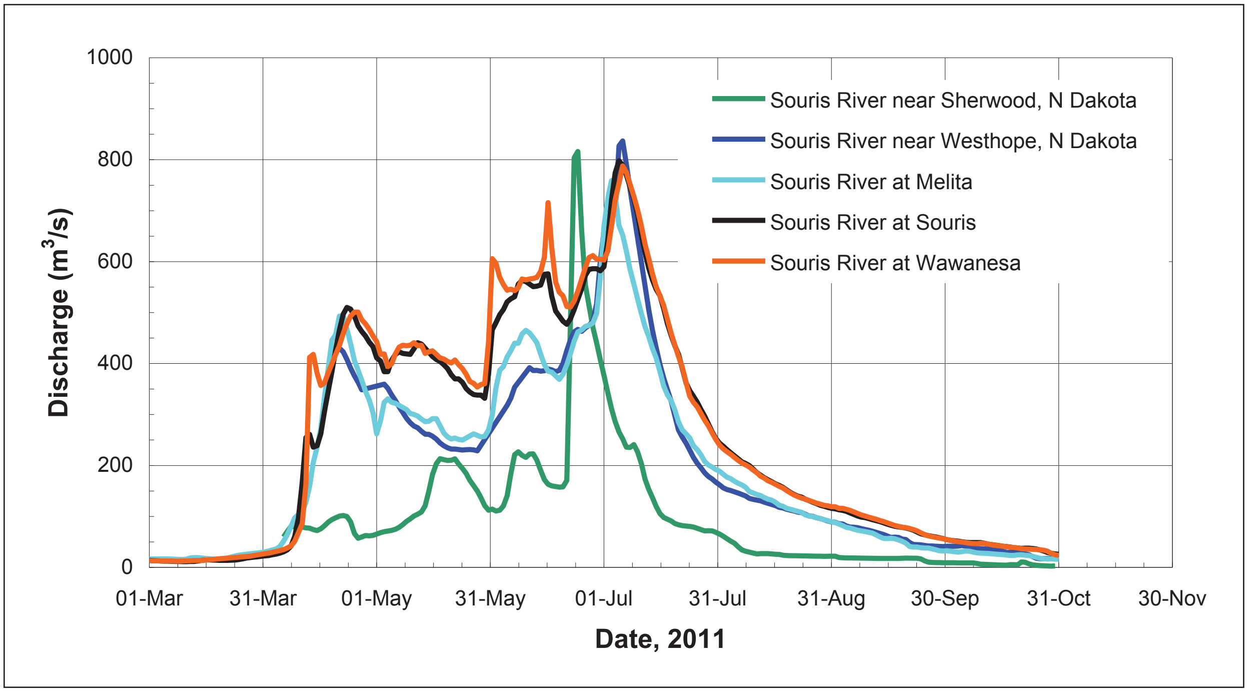


Figure 45: Frequency curves of annual peak flows on the Souris River at Wawanesa and Westhope.

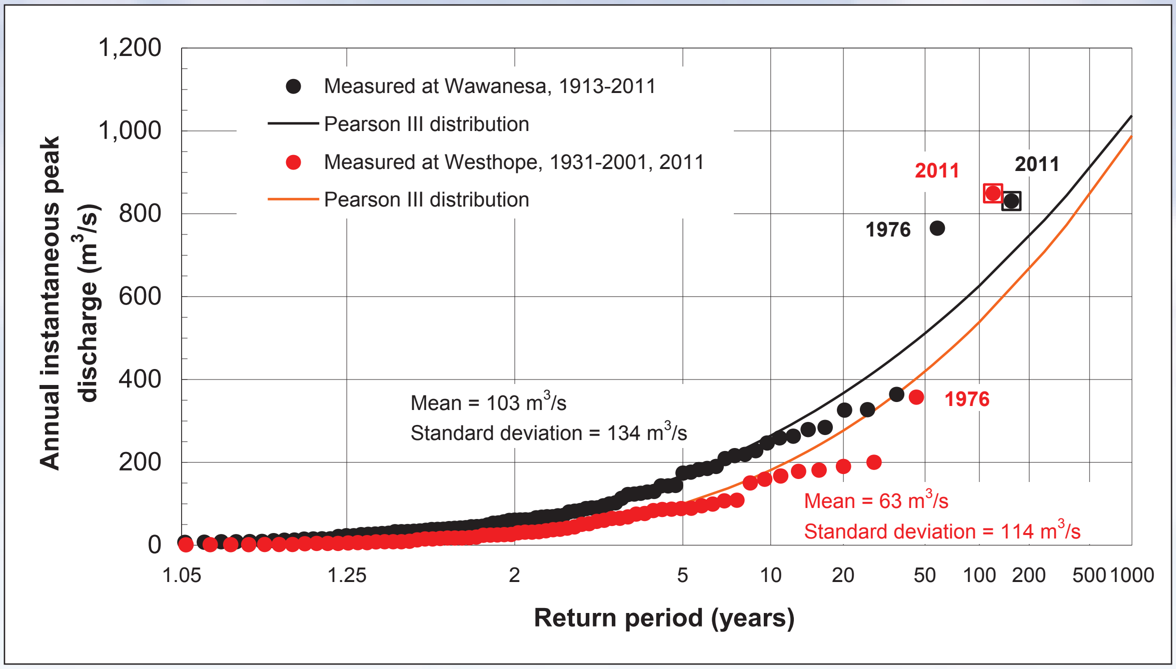


Figure 46: Water levels on the Souris River at Souris and Wawanesa, 2011.

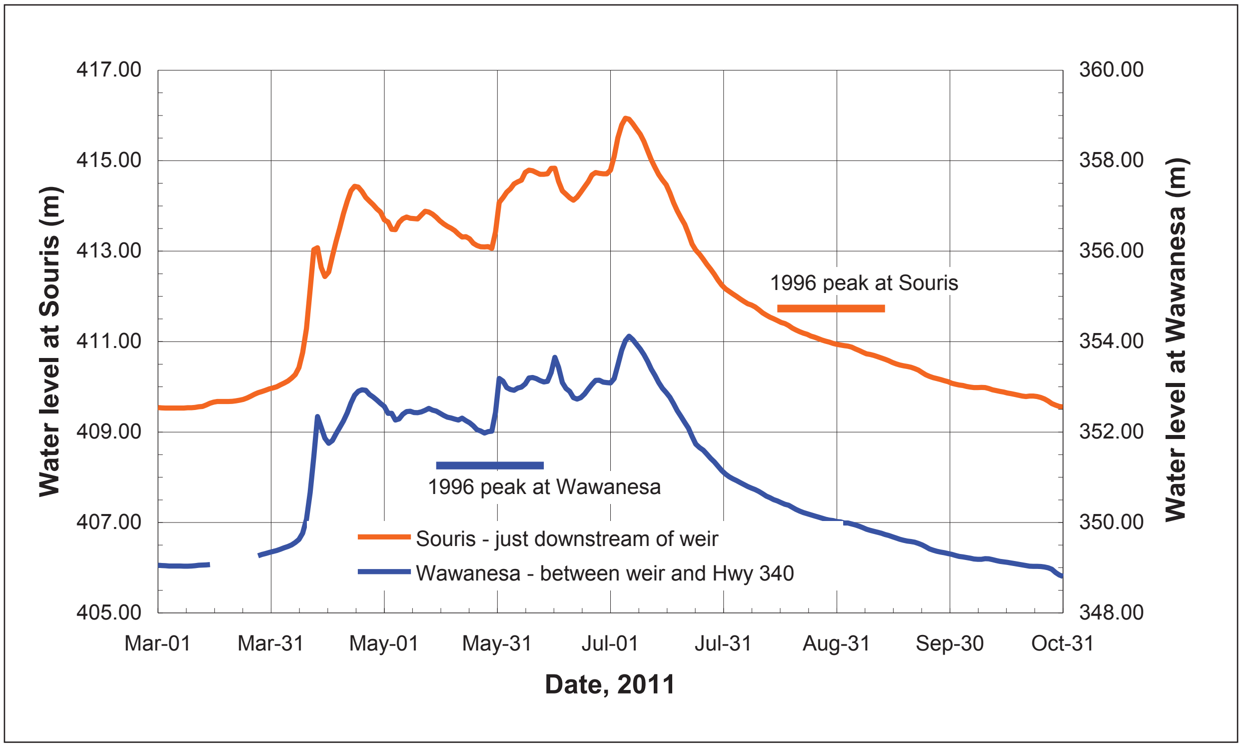


Figure 47: Lake Manitoba drainage basin.

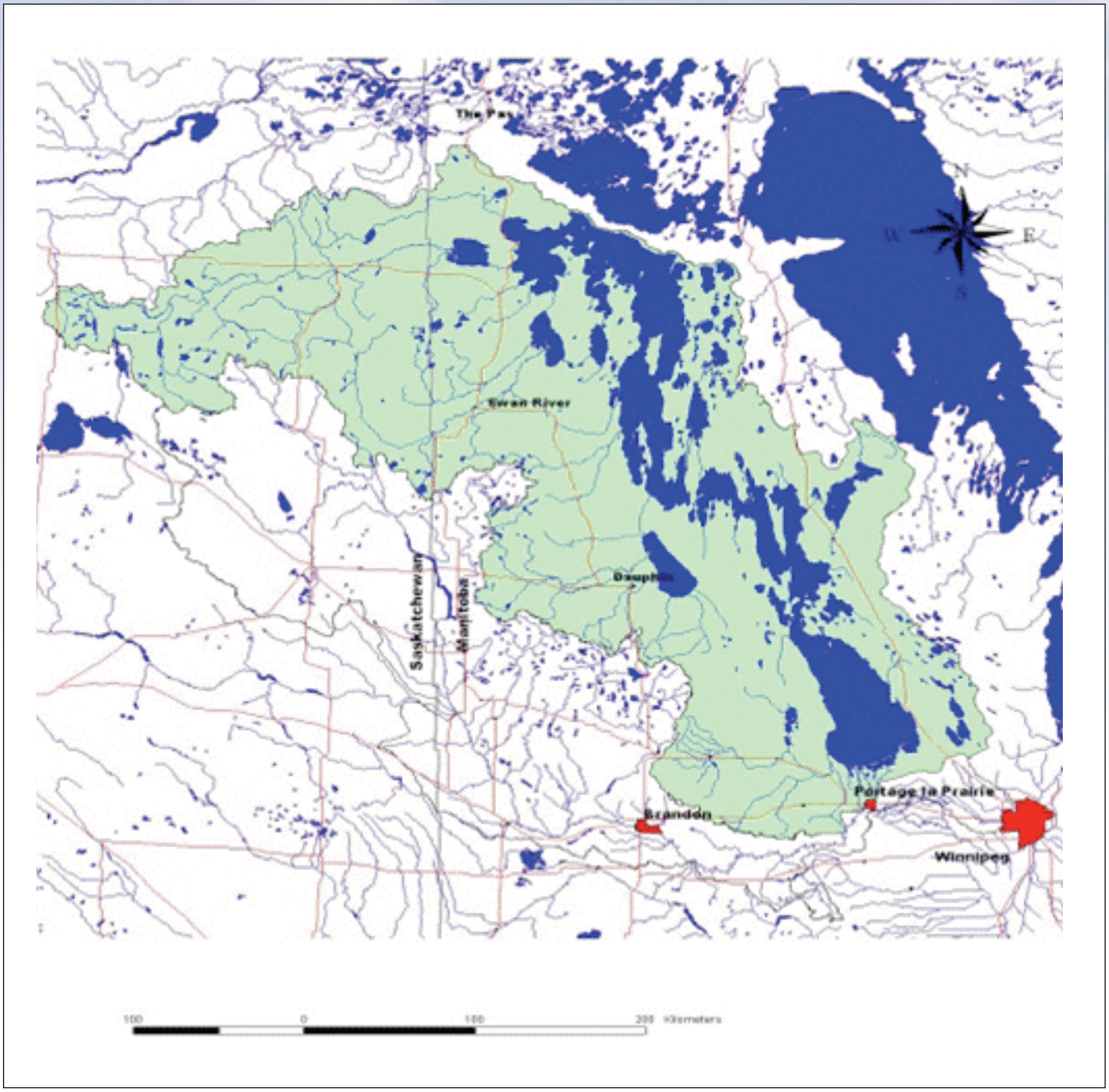


Figure 48: Historical annual runoff volumes - Waterhen River.

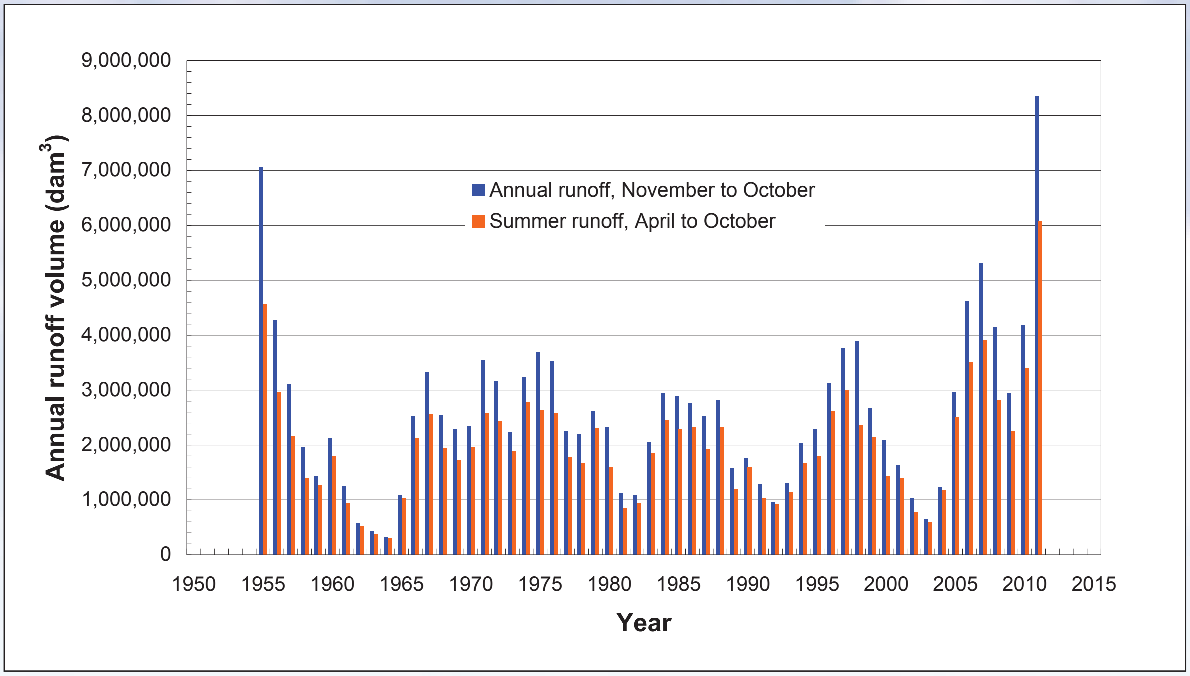


Figure 49: Frequency curve of annual runoff volume - Waterhen River, 1955-2011.

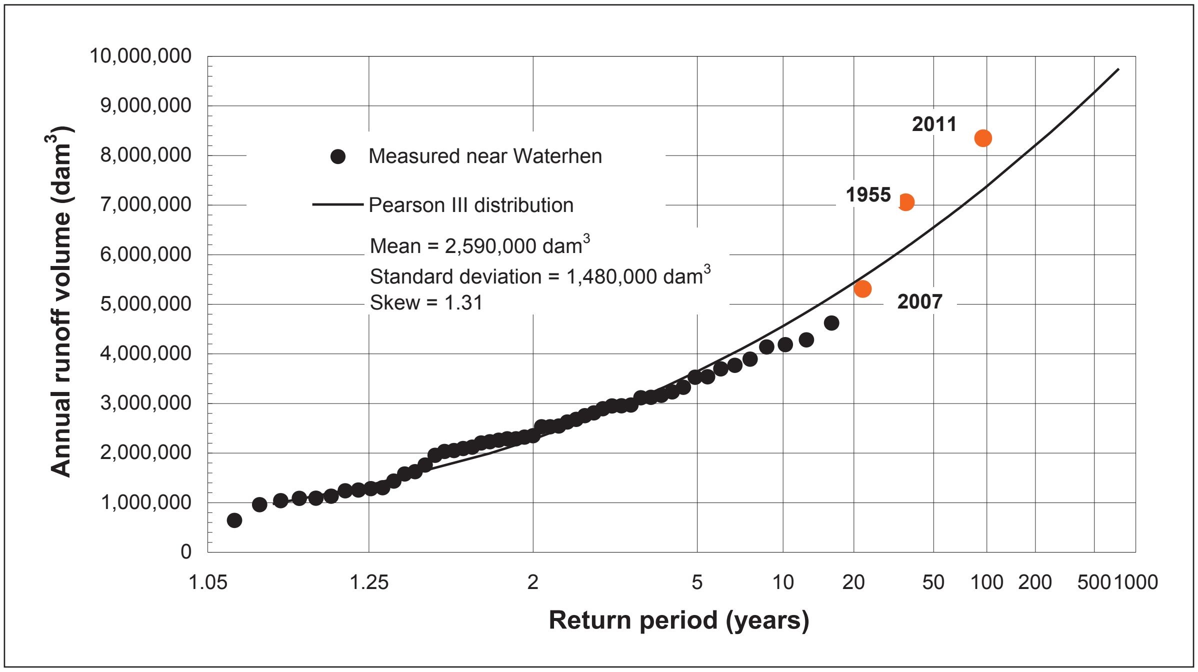


Figure 50: Historical precipitation in the Whitemud River basin.

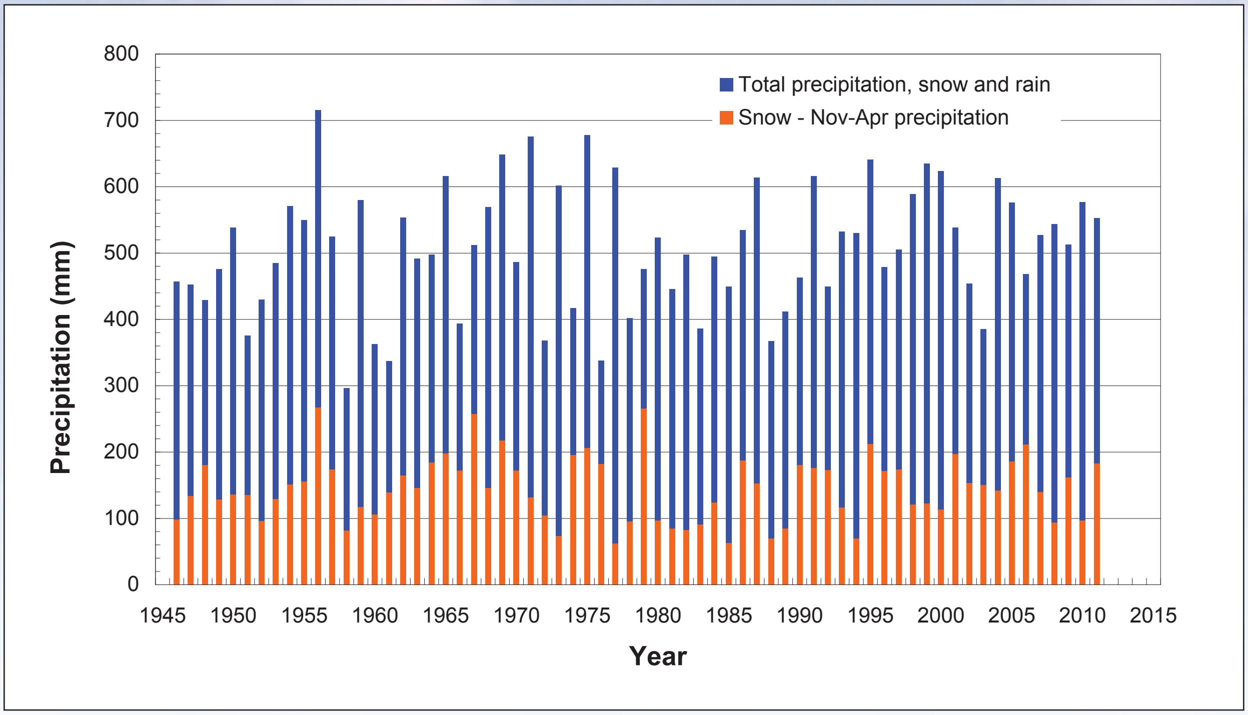


Figure 51: Frequency curve of historical precipitation in the Whitemud River basin, 1946-2011.

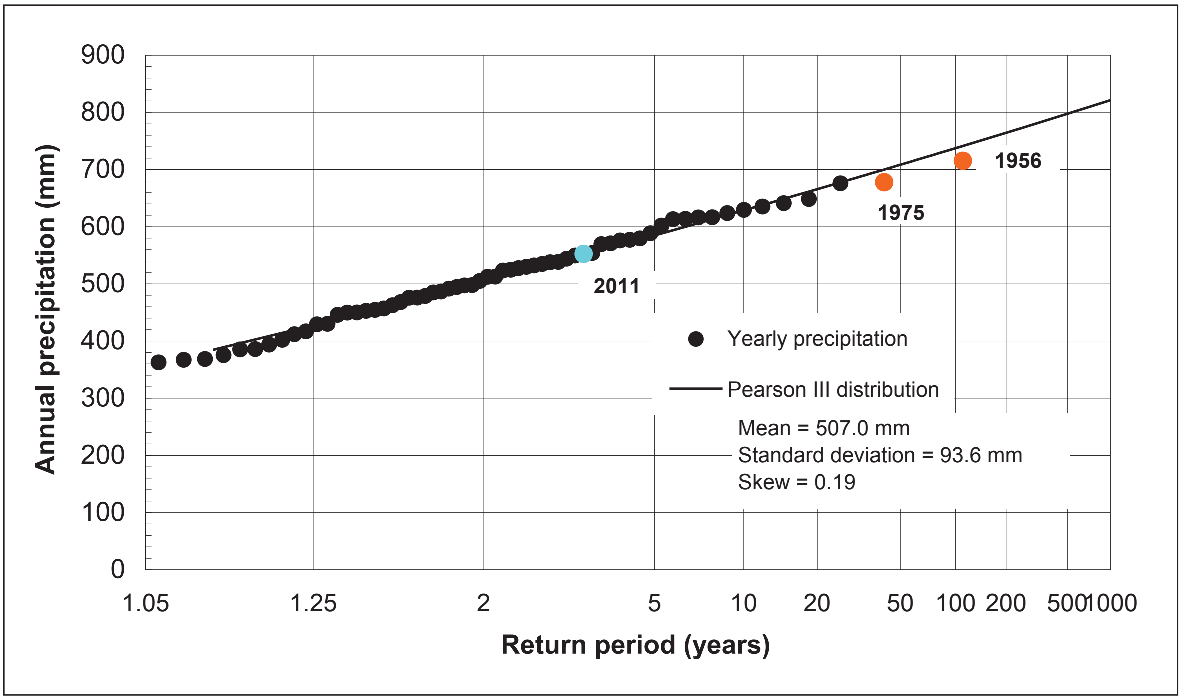


Figure 52: Historical runoff volumes - Whitemud River.

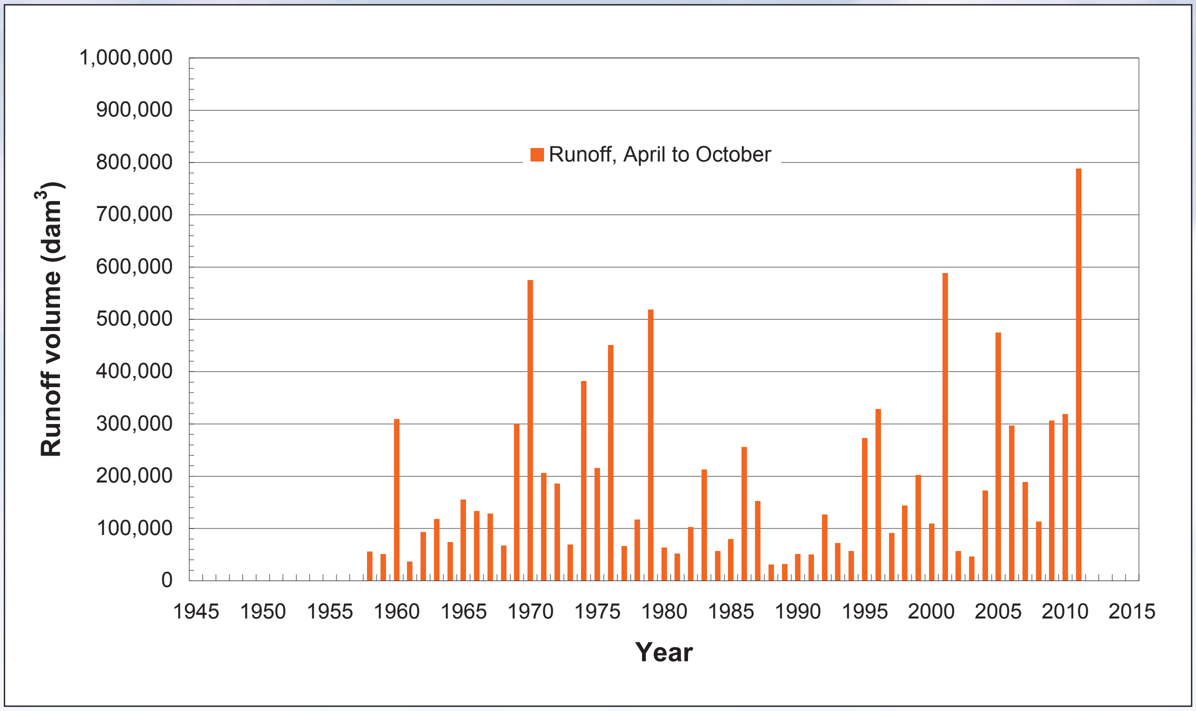


Figure 53 : Frequency curve of runoff volume from the Whitemud River basin, 1958-2011.

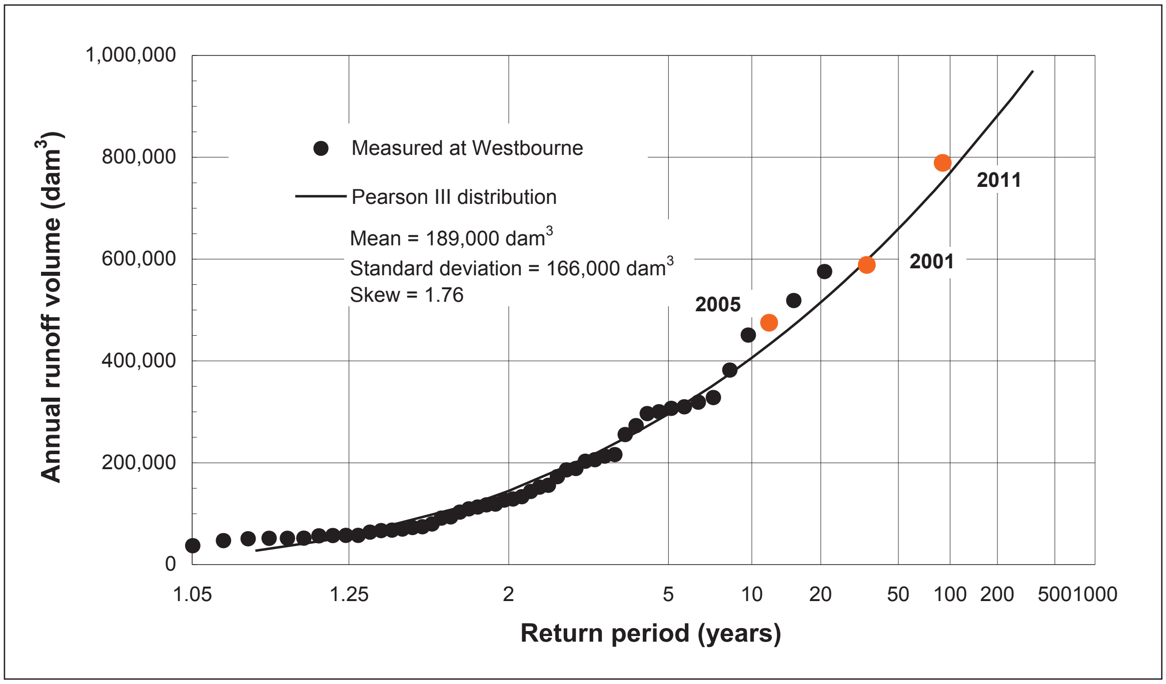


Figure 54:   Annual inflows Into Lake Manitoba since the implementation of the Portage Diversion in 1970.

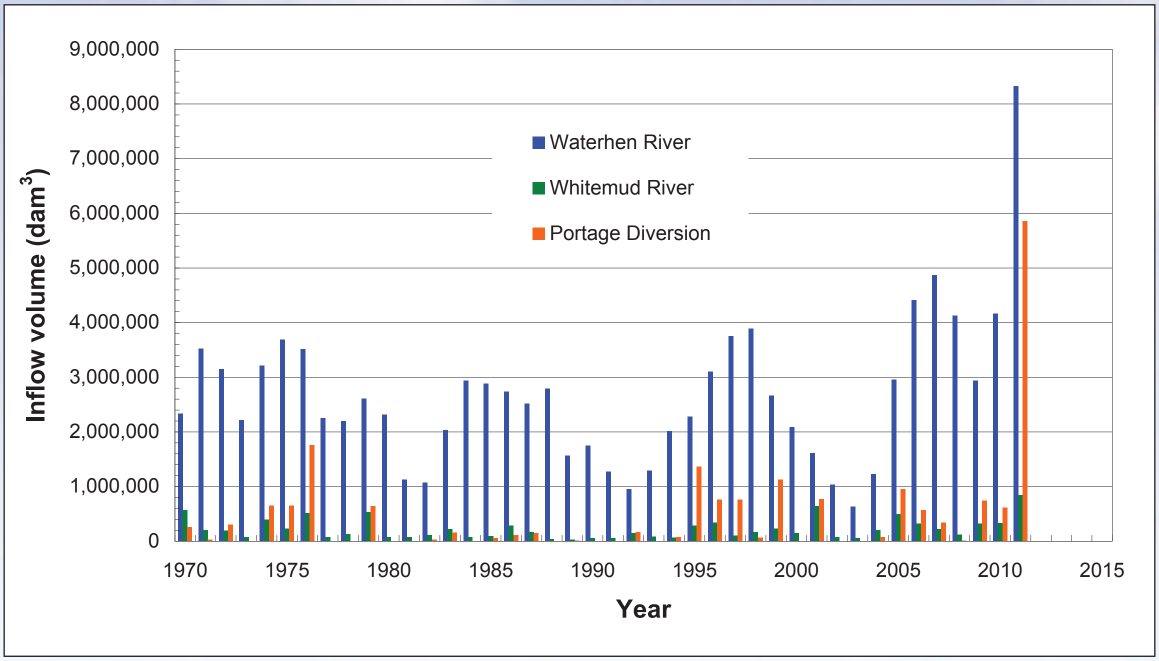


Figure 55:   Water levels on Lake Manitoba, 2011.

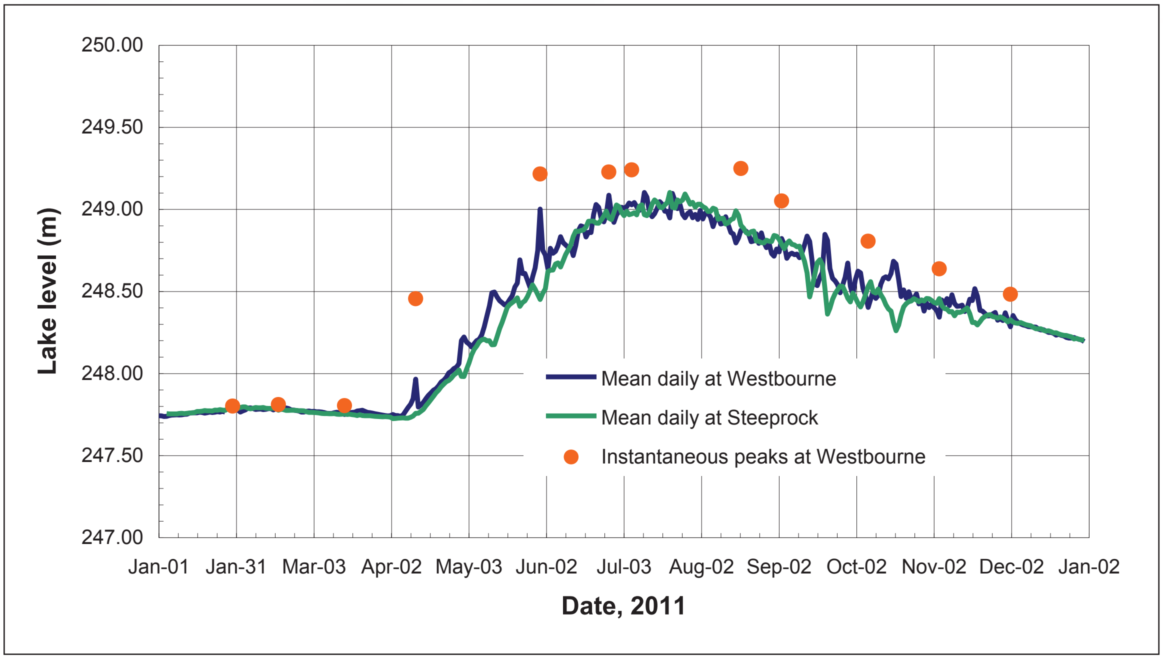


Figure 56: Lake Manitoba inflows and outflows, 2011.

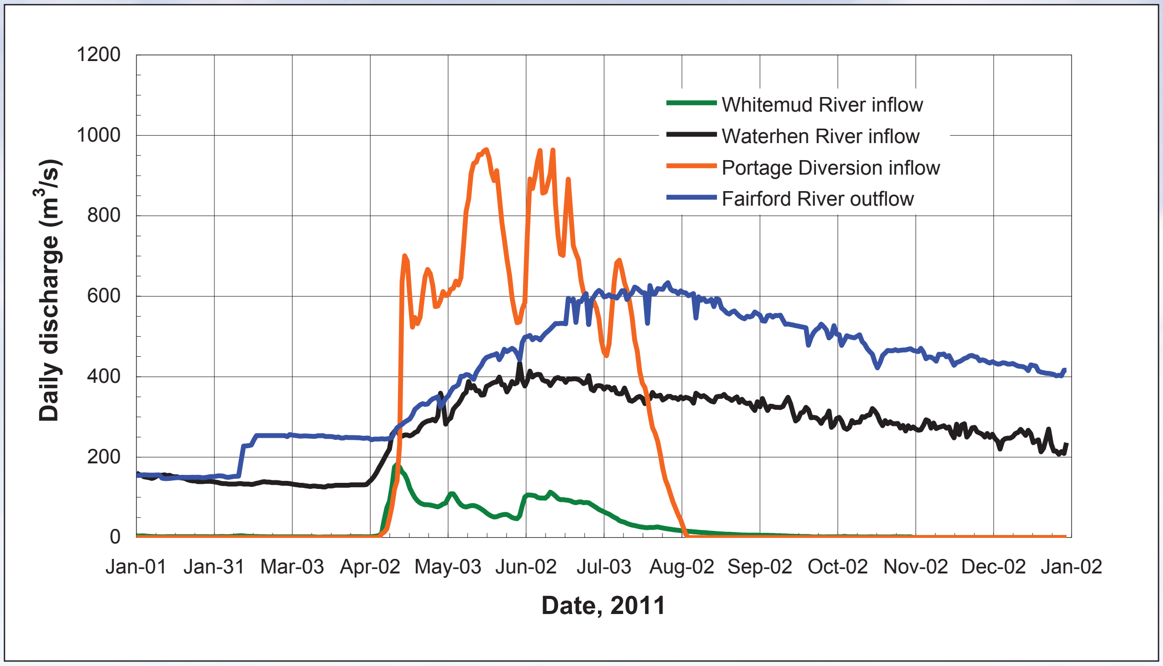


Figure 57: Relationship Between daily wind speed and water level setup on Lake Manitoba, 2011.

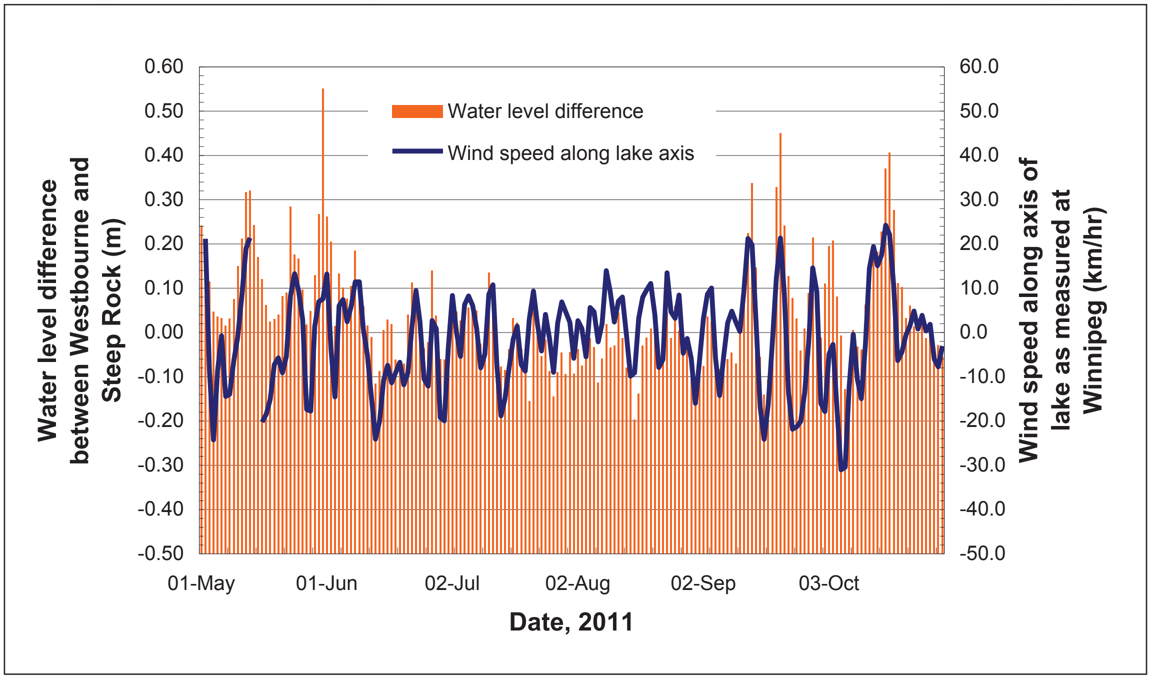


Figure 58: Effects of May 31, 2011 storm on the Lake Manitoba water level differential between Steeprock and Westbourne.

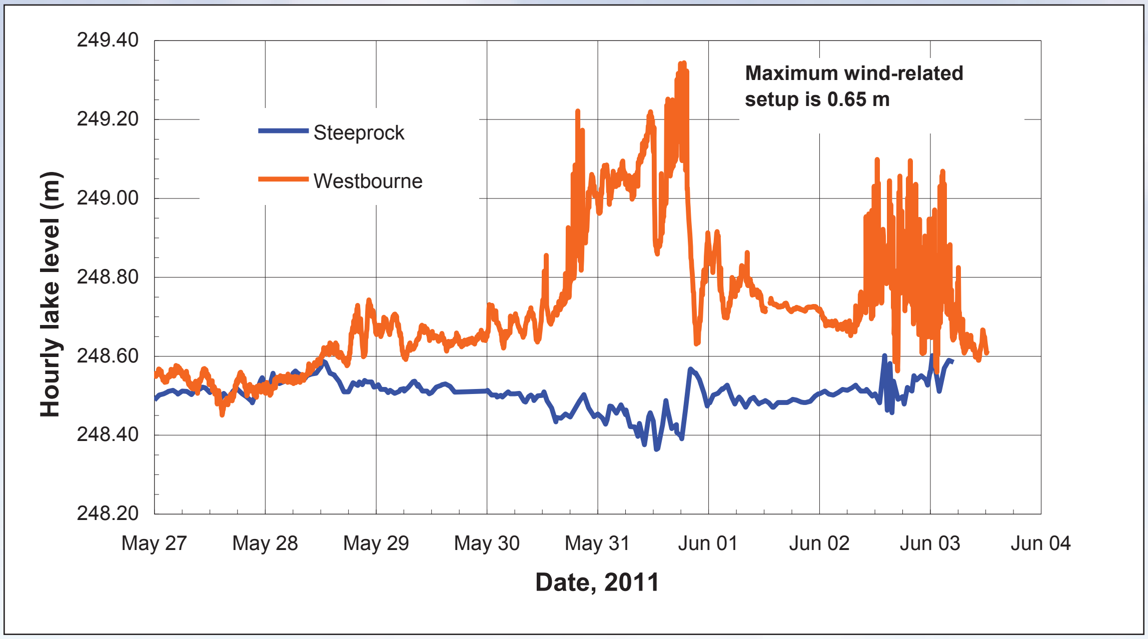


Figure 59: Flood area around the margins of Lake Manitoba in 2011.

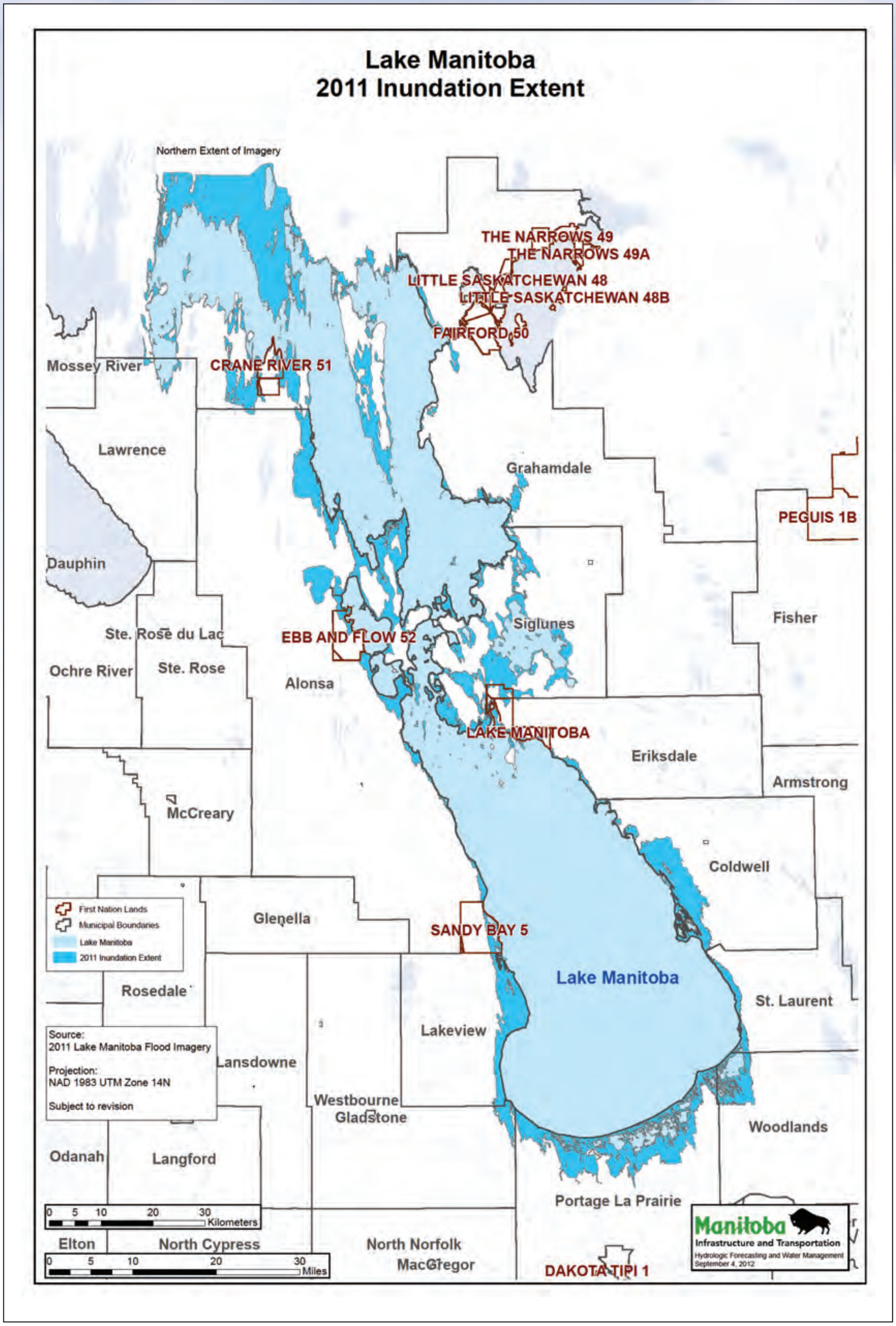


Figure 60: Flows on the Red River at Emerson and Ste. Agathe, 2011.

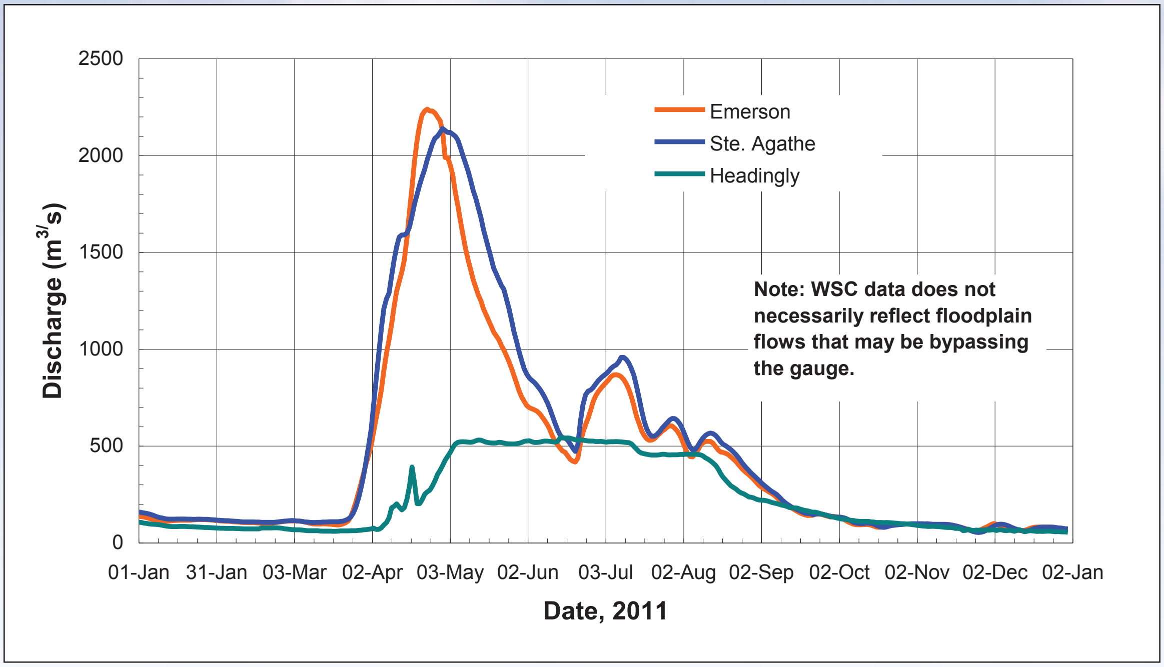


Figure 61: Historical flood series on the Red River at Emerson and Ste. Agathe.

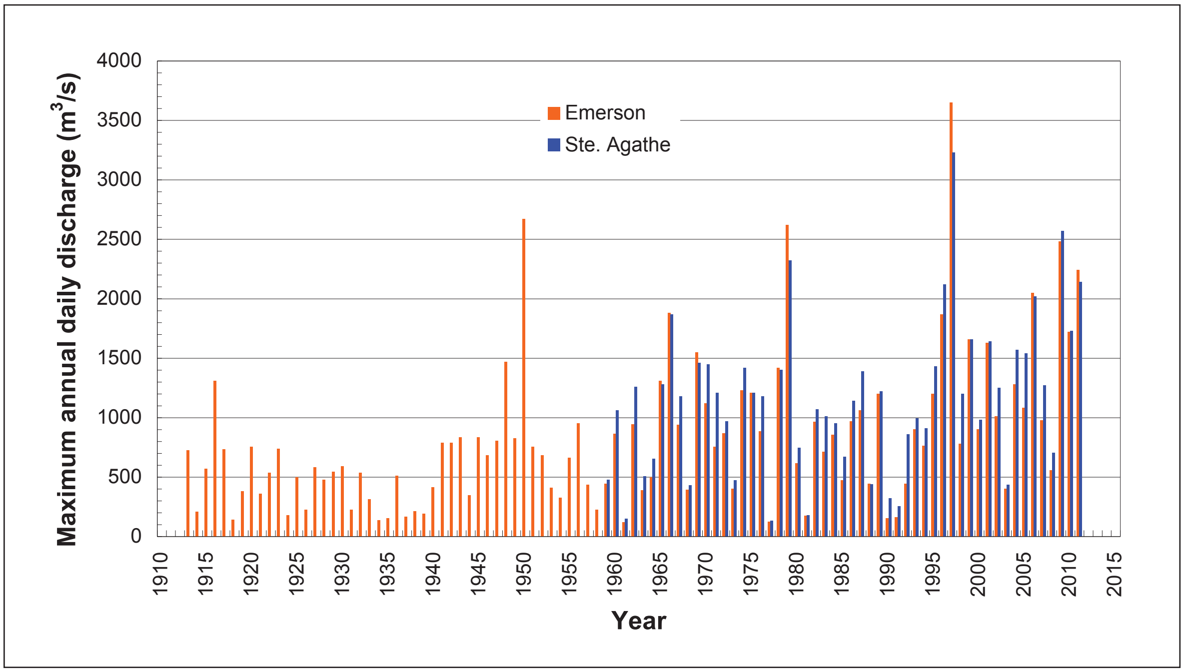


Figure 62: Frequency curve of flood peaks on the Red River at Emerson, 1913-2011.

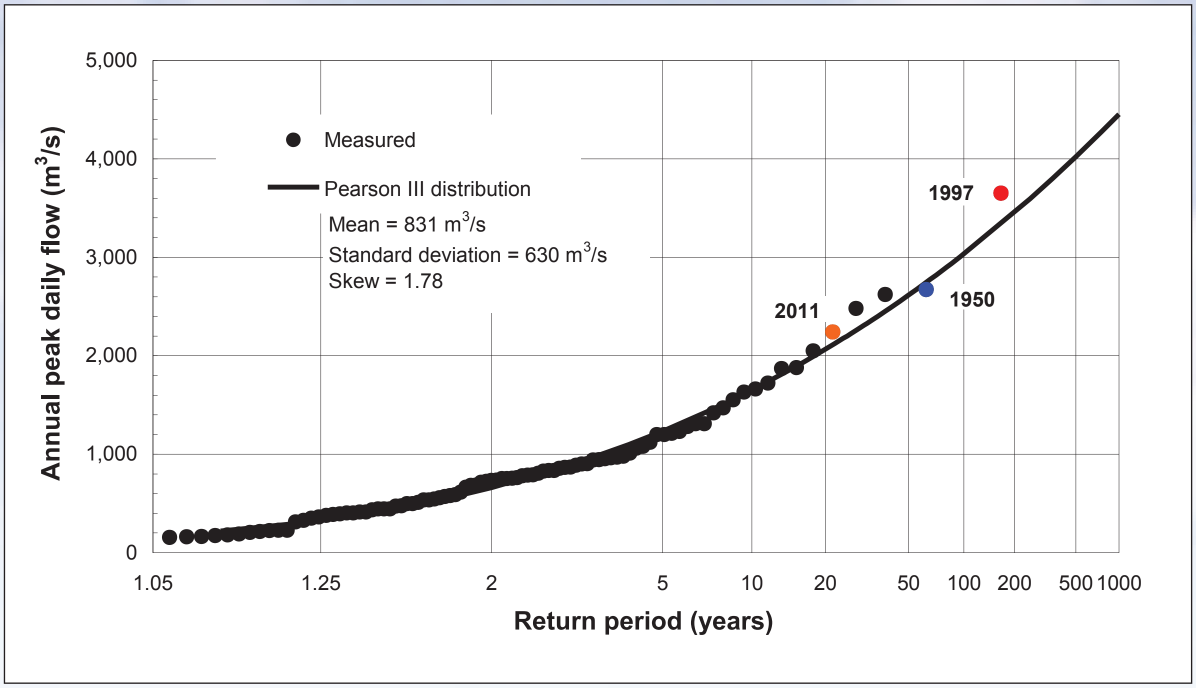


Figure 63: Frequency curve of flood peaks on the Red River at Ste. Agathe, 1959-2011.

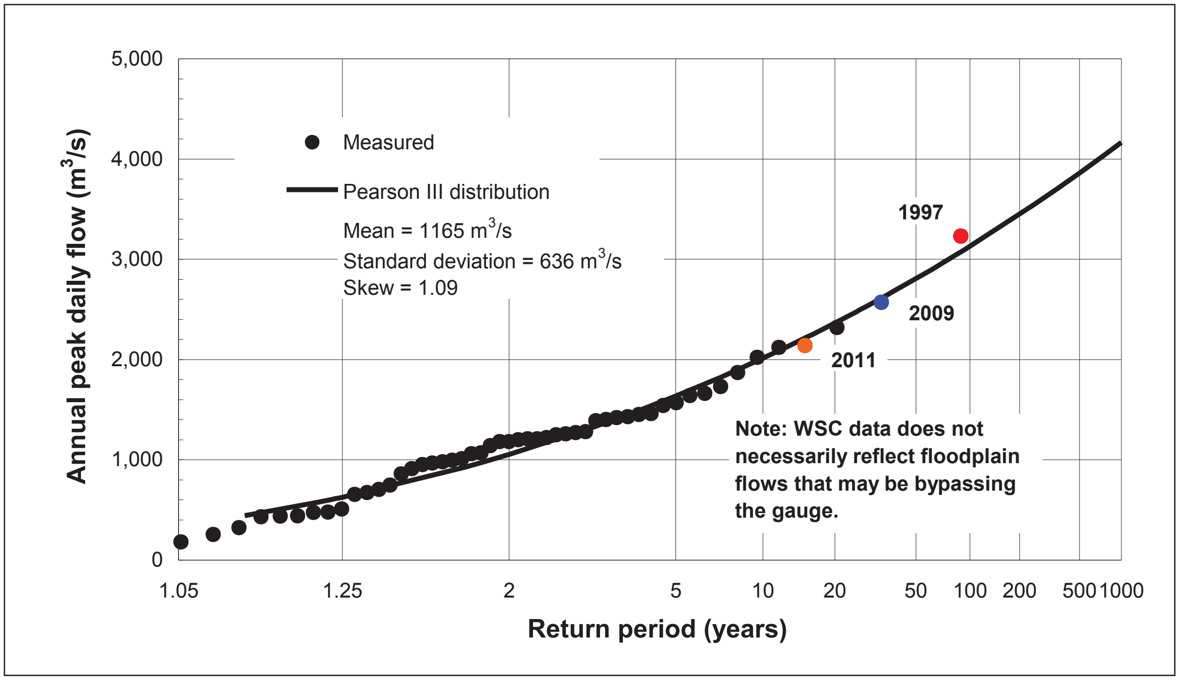
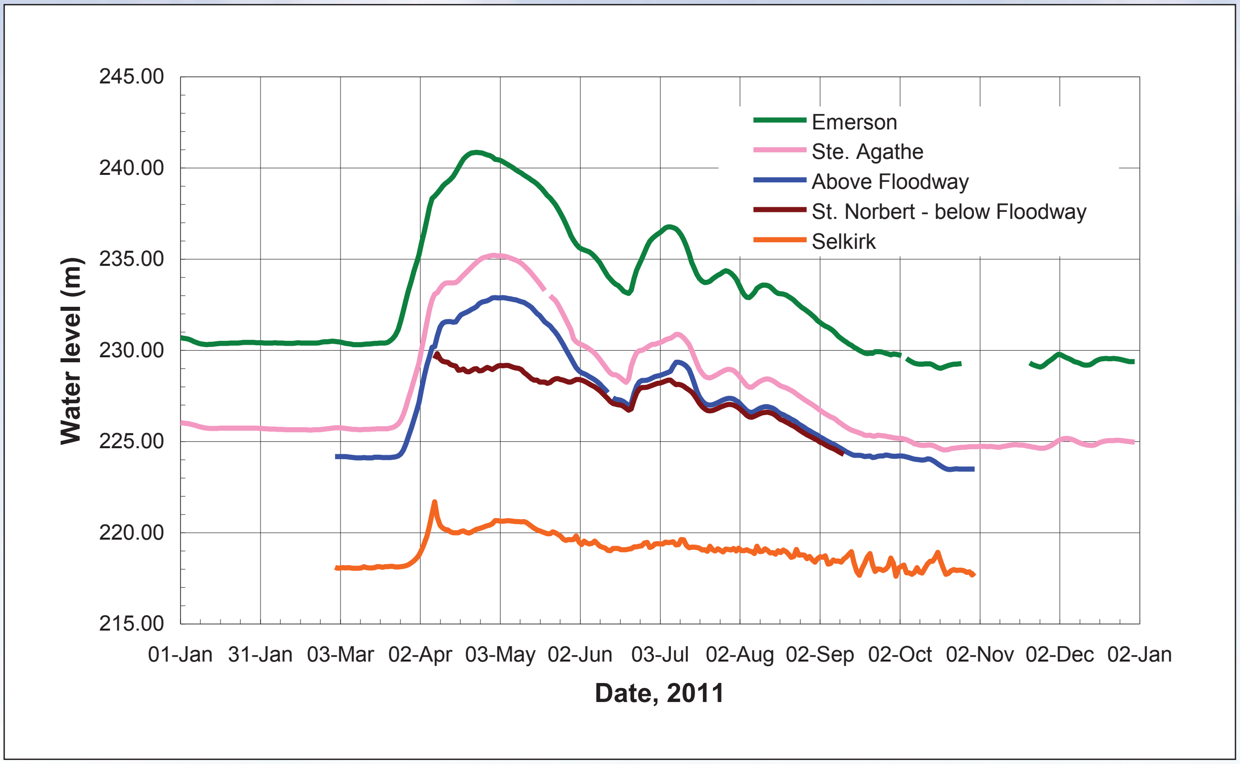


Figure 64: Water levels at salient location on the Red River, 2011.



C. March 2011 Spring Flood Outlook for Manitoba

Manitoba MediaBulletin

March 25, 2011

MARCH - 2011 SPRING FLOOD OUTLOOK FOR MANITOBA

Summary

- Manitoba Water Stewardship's final spring flood outlook shows that the spring flood potential in 2011 remains high for much of Manitoba including the Red, Souris, Pembina, Assiniboine, Winnipeg, Saskatchewan and Fisher rivers as well as the Interlake region.
- The flood potential is high in these areas due to above-normal winter precipitation, high river flows, very-high soil-moisture conditions at freeze-up, above-normal snow water content in the snowpack and an expected wetter spring.
- Additional precipitation experienced in the southern areas of the Red River basin is expected to cause a slight increase in the river levels compared to predictions in the February flood outlook.
- With average weather conditions along other rivers and streams in Manitoba, flooding is still anticipated and, with unfavourable weather, significant flooding could occur.
- Average weather conditions along the Red River south of Winnipeg could result in a flood slightly higher than 2009 while unfavourable weather conditions could result in Red River water levels lower than 1997.
- Open water levels on the Red River north of Lockport could be slightly higher than 2009 for the normal weather scenario and 0.61 metres (two feet) higher than 2009 for unfavourable weather conditions.
- The spring flood potential is still dependent on weather conditions in the next few weeks until the spring melt begins. The amount of additional snow and rain, the timing and rate of the spring thaw and the timing of peak flows in the U.S., Manitoba and other provinces will have a significant effect on flood potential.
- Localized overland flooding is expected in most of central and southern Manitoba and could occur during the early part of the run-off period due to ice jams, snow blockages or frozen culverts in river channels, drains and ditches.

Climatic Conditions

- Precipitation during the autumn of 2010 was well-above normal in most of Manitoba, central and southern Saskatchewan, North Dakota and Minnesota.
- Cold temperatures since mid-November 2010 have resulted in deeply frozen soil conditions in most areas.

- more -

- Widespread and heavy snow occurred from late November through early February in Manitoba, central and southern Saskatchewan, North Dakota and Minnesota. Many areas generally experienced below-normal to normal snowfall in February, but the overall snow precipitation ranges from normal to above normal. Based on recent measurements, the ice thickness in the Assiniboine main stem ranges from 10 centimetres (four inches) to one m (3.3 ft.), while in the Red River the ice ranges from thin to 0.9 m (2.9 ft.).
- Significant meltwater is still trapped within the snowpack on fields, in depressions and ditches.
- Recent mild weather has slightly decreased the depth of the snowpack but the overall water content over the watersheds remains relatively unchanged. Most of the snow water is contained in the snowpack or near the surface layer and is expected to remain in place until the start of the spring thaw.
- Both the Assiniboine and Red River main stem channels have risen slightly, by less than three cm (1.2 in.), indicating minor flow from the recent snowmelt run-off.
- The onset of colder weather has reduced or completely stopped the spring melt.
- Currently, a moderate La Niña in the equatorial Pacific is expected to gradually weaken through the spring months and may bring below-normal temperatures and normal to above-normal snowfall in the Red River Basin.
- El Niño conditions may also occur, bringing normal spring rain. Alternatively, a cooler-than-average spring might result in a staggered, slowmelt.
- Temperatures are expected to remain below the freezing point in most areas of Manitoba, Saskatchewan and North Dakota until the end of March, followed by a very gradual rise in the early part of April.

Soil Conditions

- The soil moisture at freeze-up was well-above normal across most of central and southern Manitoba, central and southern Saskatchewan, North Dakota and Minnesota (Figure 1 and Figure 2).
- Soil-frost information is sparse, but the data available up to mid-March for southern Manitoba and North Dakota suggests the soil is frozen to a depth of 10 cm to one m (3.6 in. to 3.3 ft.). Wet and frozen soils do not allow meltwater to soak in and, as a result, increase spring run-off potential.

Snow Cover and Winter Precipitation

- A ground snow survey was conducted over the Red, Assiniboine and Souris rivers watersheds from March 4 to 9 (Figure 3 and Figure 4). The survey indicated that, snow-water content ranged from four to 15 cm (1.6 to 5.8 in.) or an average of 9.6 cm (three in.) over most of southern Manitoba. This is approximately five to 10 per cent above-normal snow-water content for the region.

Spring Run-off

- Based on soil moisture and snowpack conditions as of March 20, the 2011 spring run-off is expected to be average to above average over most of central and southern Manitoba (Figure 5).
- Well-above-average run-off potential is expected in the following locations:
  - along the Saskatchewan-Manitoba border between The Pas area and Roblin;
  - in the upper Assiniboine Watershed; and
  - the southwestern Manitoba-North Dakota border.
- The expected run-off is based on 2010 summer and fall soil moisture, snowpack conditions as of late March and average future weather conditions for precipitation.
- Spring run-off could change significantly if future precipitation and breakup conditions differ significantly from the average.

River Forecasts

- The spring flood outlook is classified into three future weather scenarios related to additional snow, melt rates and spring rain. These scenarios are based on available climate statistics for the past 30 to 40 years.
- The three future weather scenarios are referred to as favourable, average and unfavourable.
- There is a one-in-10 chance of the weather being favourable and there is a one-in-10 chance of it being unfavourable. The favourable and unfavourable scenarios assume that breakup will be slow and relatively fast, respectively. Average weather and breakup conditions are assumed for the average scenario.
- Forecasts do not include the effects of possible ice jams which are generally unpredictable. Localized and brief flooding can occur in locations where ice jams develop, even with below-average river flows.

Red River Main Stem

- The soil moisture index at 2010 freeze-up was the second highest recorded since 1948 and well above the level before the 1997 flood. However, it was slightly lower than the record high measured prior to the 2009 flood.
- Snow cover is generally above average, especially south of Grand Forks, but still less than in mid-March 1997.

- Favourable Weather
  - With little additional precipitation and a gradual snowmelt, a flood close to that of 1979 is expected. This would cause significant over-bank flows from St. Jean Baptiste to Morris, with bank-full conditions elsewhere (Figure 6).
- Average Weather
  - With average weather from now until April, flood levels are expected to exceed those of 2009 by 0.4 to 0.7 m (1.3 to 2.3 ft.).
  - Flood protection works will prevent flooding of communities and most homes in the Red River Valley. However, transportation may be significantly disrupted with the closure of PTH 75 near Morris and the closure of many smaller roads in flooded areas.
  - Under this scenario, operation of the Red River Floodway would keep levels in downtown Winnipeg in a range of 6.1 to 6.6 m (20 to 23 ft.), depending on the flows from the Assiniboine River. In 1997, water levels in the Red River at James Avenue reached 7.47 m (24.5 ft.).
- Unfavourable Weather
  - There is a one-in-10 chance of unfavourable weather. With unfavourable conditions, peak stages would be similar to or slightly lower than 1997 levels at most locations (Figure 7).
  - At most locations south of Winnipeg, Red River levels would not exceed those of 1997. As a result of flood protection measures, it is unlikely that homes would be flooded even under unfavourable weather conditions. However, transportation and access to properties in the flood plain would be reduced for up to three weeks. The crest in downtown Winnipeg would be slightly lower than 1997, with a maximum of about 7.47 m (24.1 ft.).
  - Peak stages from Selkirk to Breezy Point would depend on whether ice jams develop. Ice-cutting and breaking operations will reduce the chance of significant ice jams. Currently, ice buildup is slightly less than the winter average due to high river levels and substantial groundwater flows which typically add warmer water to the Red River. With unfavourable weather, significant ice jamming will be reduced by ice cutting and icebreaking.
  - Flooding of low-lying properties in the Breezy Point area is likely, even if no significant ice jams form. Elsewhere, flooding is not expected unless significant ice jams develop.

Red River Tributaries

- With favourable weather from now through to spring, flooding is expected to be fairly localized.
- If average weather conditions occur, significant over-bank flows could develop on portions of most streams and there would be overland flooding in low-lying areas.

- With unfavourable weather, extensive over-bank flows would occur on all streams, bringing them close to 1997 levels.

Pembina River

- With favourable weather conditions, there is the potential for flooding higher than 1969, but lower than 1974.
- With average weather conditions, peak water levels along the Pembina River and tributaries would be slightly higher than 1997.
- With unfavourable weather there is a one-in-10-chance that flooding could exceed that of 2009.

Roseau River

- With favourable weather conditions, minor flooding is expected.
- With average weather conditions, flooding would occur at close to 1986 levels.
- With unfavourable weather conditions, flooding would occur at close to 2009 levels.

Assiniboine River Main Stem

- Favourable Weather
  - With favourable weather conditions, there would be minor flooding along the Assiniboine River (Figure 8).
- Average Weather
  - With average weather conditions, there would be flooding along the Assiniboine River. The Shellmouth Reservoir is now at the target level following the drawdown of the reservoir. This is expected to minimize the risk of flooding while providing sufficient water supplies to meet downstream needs in 2011 and beyond.
  - Average weather conditions may also result in flooding from Millwood to Brandon, with levels generally below those of 1995, but higher than 1979.
- Unfavourable Weather
  - Unfavourable weather would result in flooding of valley lands from Shellmouth to Brandon with levels likely higher than those of 1976 and 1995 by about 0.2 to 0.8 m (0.5 to 2.7 ft.).
  - The Shellmouth Reservoir is being operated this winter to provide maximum storage space for spring flood control along the Assiniboine River. This will reduce spring peak stages along the river, especially for the portion between the dam and St. Lazare, where flooding will be avoided only if favourable weather conditions occur.
  - The Portage Diversion will be operated to prevent ice jams and flooding from Portage la Prairie to Winnipeg. Flooding may occur in this region with unfavourable weather conditions and, as a result, protective dikes along parts of the Assiniboine River are being strengthened.

Assiniboine River Tributaries

- With favourable weather, localized flooding is expected.
- With average weather conditions, flooding is likely.
- Unfavourable weather conditions would result in significant flooding on most tributaries leading to over-bank flows.

Souris River

- The flood potential is high for the Souris River due to high soil moisture and higher-than-normal snow cover in the North Dakota portion of the watershed. Significant flooding of agricultural lands adjacent to the river is likely (Figure 9).
- A favourable weather scenario would produce a flood similar to that of 1969.
- With average weather conditions, a flood slightly less than that of 1974 is likely. Low-lying portions on the south edge of Melita would require diking.
- Unfavourable weather conditions would result in water levels higher than those of 1974 but lower than the peak stages of the 1976 record flood. Low-lying homes near Souris would require diking in addition to the area next to PTH 3 at Melita.

Souris River Tributaries

- With average weather conditions, flooding is likely on Souris River tributaries.
- Under unfavourable weather conditions, Souris River tributaries would experience significant flooding.

Interlake Region

- Soil moisture is well-above normal and most small depressions are relatively full from heavy rains last summer and fall. Snow cover is currently average to above average.
- With favourable weather, flooding would be limited to low agricultural lands and streams would remain within their banks.
- With average weather conditions, flooding would occur and the Fisher River would see flood levels close to those of 1996 but lower than 2006. Overland flooding would also occur.
- With unfavourable weather, flooding similar to 1986 (but lower than 2009) could occur. There could also be difficulties due to a high water table, resulting in seepage into basements in rural areas.
- Record high levels are likely on the Shoal Lakes, even with average weather conditions.

Eastern Region

- Soil moisture is currently above average and snow cover overall is above average in the region.
- With favourable weather conditions, localized flooding could occur on the Brokenhead, Whitemouth, Whiteshell and Winnipeg rivers.
- If average weather conditions develop, flooding is likely to occur along streams and lake shores. The Winnipeg River could experience levels similar to those of 1994.
- Unfavourable weather conditions could result in flooding of agricultural lands close to previous record floods. In unfavourable weather conditions, water levels in the Winnipeg River would be similar to 2009 flood levels.

Westlake, Dauphin and The Pas Regions

- Soil moisture is above normal to well-above normal in most areas. Snow cover remains generally near normal to above normal.
- With average weather conditions, flooding is possible on the Whitemud, Turtle, Swan and Carrot rivers. With average conditions, the Saskatchewan River would be expected to see flood levels similar to the 1983 flood at The Pas.
- With unfavourable weather conditions, general flooding could occur. Brief localized flooding is also possible due to snow-blocked or ice-filled streams, drains or ditches. If unfavourable weather conditions develop, flood levels similar to 2005 are expected on the Saskatchewan River at The Pas.

Northern Manitoba

- Run-off in most of Manitoba’s far north (54 degrees north) is likely to be average. Run-off is expected to be more substantial in northeast Manitoba.

Flood Preparedness

- The $1.1 million ice jam mitigation program has been very successful.
  - So far 693 km (430.6 miles) of ice has been cut along the Red River and about 30.5 km (19 miles) has been broken and cut between Netley Creek to the Selkirk area. Cutting the ice weakens it and makes it easier to break up without jamming, and breaking the ice with the Amphibexes further reduces the chances of jamming.
  - Ice cutting crews were able to cut the ice on the Red River as planned and have been operating along the Whitemud River and the Icelandic River at Riverton. An Amphibex has been breaking ice at the Brokenhead River and the Portage Diversion. Work is also expected to proceed at Fisher River and the Assiniboine River near Glenboro.

- Over 230 pieces of equipment are working to reinforce and raise 70 km (43.5 miles) of earthen dikes along the Assiniboine River between Portage la Prairie and the Baie St. Paul Bridge, north of Elie. Work has progressed well and the dikes will be completed before the spring flood crest.
- Approximately five km (3.1 miles) of dikes have been raised in Brandon and super sandbags have been installed along First and 18th streets.
- Maintenance work along the Portage Diversion is continuing and currently heavy rock, also known as rip-rap, is being placed along the channel to protect against stream bed erosion during spring flows. Traffic going east bound to Portage la Prairie is being redirected for the next ten days to allow for safe movement of heavy equipment. Detours are signed and marked.
- The Manitoba government is continuing to assess short- and long-term solutions to control Shoal Lake flooding north of the City of Winnipeg.
- Steaming of provincial drains and culverts is expected to begin next week providing the weather is warm enough.
- The following equipment is currently in place in Manitoba:
  - three Amphibex icebreakers
  - seven ice-cutting machines
  - three Argo amphibious ATVs and six trailers
  - three million sandbags
  - six provincial sandbagging machines, operating in various locations around the province
  - 30,000 super sandbags
  - 43 km (26 miles) of rapid-deployment cage barriers
  - 24 additional heavy-duty steamers for a total of 61
  - 21 new mobile pumps, bringing the provincial total to 36
  - 72 km (44 miles) of water-filled barriers of which 30 km (18 miles) are in rapid-response trailers
- Three municipal flood seminars have been held and two seminars on the Disaster Financial Assistance program have also been held.
- Municipalities in partnership with the Manitoba government are finalizing flood response plans and undertaking preparation work as needed.
- Volunteers interested in helping municipalities with sandbagging efforts outside of the city of Winnipeg can link up with communities that need volunteers through the Volunteer Manitoba website at www.mbvolunteer.ca. The City of Winnipeg is co-ordinating its volunteers through its 311 call centre.
- The Canadian Red Cross is also recruiting volunteers at www.redcross.ca/manitoba to assist with their flood response and recovery operations.

Detailed forecast information related to this outlook is presented in Table 1 for major rivers and in Table 2 for small watersheds.

Information is also available at www.manitoba.ca and:
www.gov.mb.ca/waterstewardship/floodinfo/index.html .

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Manitoba Water Stewardship--- Hydrologic Forecast Centre

Table 1.

FORECAST SPRING PEAK STAGES FOR RED, ASSINIBOINE, SOURIS

All Water Levels in Feet Above Sea Level Unless Noted

March 24, 2011

	Predicted Spring Peak Stages **Weather Condition Favourable	Average	Unfavourable	Flood Stage (Rural)	Dyke Elevation (Towns)	Comparative Spring Peak Water Levels		
RED RIVER (Flood Control Works in Operation)						**1997**	**2006**	**2009**
Emerson	791.0	792.0	792.3	783.2	794.0	792.5	789.5	790.8
Letellier	785.4	786.0	786.5	780.1	790.6	787.7	783.8	785.2
St.Jean	782.5	783.3	784.1	771.6	788.0	784.3	781.0	782.9
Morris	781.4	782.3	783.2	769.4	787.4	783.3	779.3	781.9
Ste. Agathe	773.1	775.2	776.2	771.0	778.5	776.5	771.0	773.7
St. Adolphe	768.5	771.0	772.4	757.5	775.5	772.5	766.6	769.2
Above Floodway Inlet	766.6	769.0	770.1	760.0		771.5	763.4	766.8
Below Floodway Inlet	754.1	755.4	758.9	752.0		761.1	753.0	756.6
Winnipeg-James Ave.				745.6	754.1	752.1	748.0	750.1
" (Above Datum)	18.6	20.1 - 21.5	24.1	18.0	26.5	24.5	20.4	22.5
Selkirk (Town Bridge)				727.5		729.2	723.6	729.4
ASSINIBOINE RIVER (Flood Control Works in Operation)						**1976**	**1979**	**1995**
Shellmouth				1353.0		1356.1	1355.0	1360.8
Russell				1343.2		1342.5	1342.2	1352
Millwood				1321.6		1321.8	1321.6	1332.1
St. Lazare	1287.0	1288.3	1289.8	1283.7	1293.4	1287.1	1284.8	1288.8
Miniota	1243.2	1245.2	1246.8	1236.8		1245.2	1242.5	1245.0
Virden	1217.1	1217.9	1219.1	1213.5		1218.8	1216.5	1218.4
Griswold	1199.4	1200.5	1202.0	1196.4		1201.9	1199.1	1201.0
Brandon (Ist Street)	1175.1	1177.5	1180.0	1172.0		1179.5	1175	1178.8
Portage Inflow 1st Peak								
--2nd Peak-no ice-(cfs)	21,000	26,600	34,500					
Diversion 1st Peak (cfs)	18,000	23,000	25,000					
Portage la P.(Southport)	838.5	840.5	845.5	848.0		848		847.9
Baie St. Paul	789.0	792.5	797.0	796.0		801.2	794.7	795.9
Former P.R. 412				783.0				
PTH 1 east-(Lido Plage)				775.0				
Headingley		762.4	767.0	767.5		770.5	765.9	766.0
SOURIS RIVER						**1976**	**1995**	**1999**
Coulter	1419.2	1420.0	1421.4	1406.5				1417.6
Melita (PTH #3)	1410.1	1410.4	1410.9	1401.6		1411.8	1408.6	1409.6
Napinka	1403.0	1403.5	1404.1	1394.1			1400.8	1402.4
Hartney (u/s Dam)	1389.2	1390.0	1391.3	1379.0		1394.6	1385.8	1387.6
Souris (u/s Dam)	1355.8	1356.9	1358.8	1354.0		1364.3	1354.2	1353.8
Wawanesa	1155.1	1156.1	1157.8	1155.0		1163.2	1154	1152.0

Notes: Forecast includes possible effect of stationary ice, but effect of possible ice jams is not included.

** --Favourable-- refers to a combination of future weather conditions whose severity has been exceeded 90% of the time during the past 40 years---(lower decile condition)

--Average-- same as above except has been exceeded 50% of the time---(median condition)

--Unfavourable-- same as above except has been exceeded 10% of the time---(upper decile condition)

This represents a brief peak due to an ice jam or subsequent flow surge, usually less than six hours in duration.

DETAILED SPRING FLOOD OUTLOOK FOR SMALLER WATERSHEDS

****Predicted spring peaks based on Favourable, Average and Unfavourable Weather Conditions**

Mar. 24, 2011

Table 2

(All Flows in Cubic Feet per Second)

Stream Location	**Predicted Spring Peak Flow			Bankfull	Largest Peaks on Record^ (Year)					*Recent Spring Peaks*		
	Favourable	Average	Unfavourable	(no Ice)						2005	2006	2009
Red River Watershed:												
Aux Marais - Christie	610	700	870	500	920(2002)	980(1992)	1200(1996)	1300(1979)	2600(1974)	434	960	1,483
Boyne River - Stephenfield	2,660	3,020	3,690	2,500	2500(1969)	2500(1923)	3700(1970)	4200(1979)	4700(1974)	1,750	3,600	1,607
LaSalle River - Sanford	3,570	4,020	4,850	3,500	4000(1956)	4200(1979)	4300(1974)	4400(1997)	4400(1970)	2,941	3,955	4,026
Morris River - Rosenort	4,070	4,610	5,630	*5,000	4200(1987)	4400(1996)	4600(2004)	4700(1970)	5900(1974)	3,602	5,049	-
Buffalo Creek - Rosenfeld	3,540	4,130	5,180	3,000	4400(1996)	4900(1974)	5400(1971)	7000(1979)	7800(1997)	2,747	5,100	1,660
Deadhorse Creek - Rosenfeld	4,290	4,950	6,120	4,000	5000(1996)	6400(1997)	6400(1971)	9000(1974)	10200(1979)	2,062	4,000	2,769
Rat River - Otterburne	1,670	1,860	2,200	2,500	3400(1923)	4600(1927)	5000(2002)	5900(1950)	6100(1997)	1,547	2,133	2,288
Roseau River - Dominion City	2,980	3,500	4,420	*4,500	5000(1927)	5100(1974)	5400(1997)	6000(2002)	8100(1950)	2,860	3,500	4,697
Seine River - Prairie Grove	3,150	3,450	4,000	1,500	1200 (1969)	1900 (2004)	2000 (1979)	2100(1997)	2200(1974)	1,077	1,515	-
Seine River Diversion - PTH 59	5,700	6,330	7,500	4,000	3600 (2004)	3800(1996)	4200(1998)	4700(1967)	8100(1997)	4,237	5,932	3,743
Tourond Creek - Tourond	770	860	1,010	650	550(2004)	610(1979)	860(2002)	900(1997)	950(1974)	473	586	448
Seine River at St. Anne (u/s Div.)	1,430	1,590	1,870	2,000	1000(1966)	1000 (2001)	1100 (1979)	2100(1974)	3000(1997)	1,356	2,052	-
Cooks Creek u/s Diversion				1,200	270(2004)	470(1998)	500(2001)	700(1996)	1850(1997)	-	-	-
Assiniboine River Watershed:										**2005**	**2006**	**2009**
Birdtail Creek - Birtle	1,140	1,340	1,730	1,500	1500(1970)	1600(1976)	1700(2001)	1700(1979)	2400(1995)	1,462	862	-
Conjuring Creek - Russell	290	320	370	300	230(1992)	260(1979)	270(2003)	400(1995)	440(1974)	186	90	-
Gopher Creek - Virden	520	600	720	800	430(1996)	470(1974)	580(1995)	610(1969)	1600(1976)	671	55	844
Little Sask. River - Minnedosa	2,610	2,990	3,690	3,000	3100(1979)	3100(1970)	3200(1995)	3300(1947)	3600(1969)	3,100	1,500	-
Oak River - Rivers	1,120	1,250	1,710	1,400	670(1995)	680(1974)	830(1976)	1200(1979)	1200(1969)	1,006	252	-
Qu'Appelle River - St. Lazare	5,670	6,120	6,750	*5,000	3800(2001)	3900(1996)	4600(1995)	5900(1976)	8900(1955)	2,737	1,980	-
Shell River - Inglis	400	460	560	1,500	1580(1979)	2280(2006)	2295(1995)	2430(1976)	2670(1988)	572	2,278	773
Sturgeon Creek - Winnipeg	2,740	3,060	3,630	1,700	2100(1987)	2200(1997)	2200(1996)	2200(1979)	2900(1974)	2,020	2,412	2,440
Omands Creek - Metro Route90				500	260(1993)	330(1983)	490 (1962)	500 (1979)	600 (1997)			
Souris River Watershed:										**2005**	**2006**	**2009**
Antler River - Melita	2,700	2,990	3,300	1,500	2200(1996)	2600(1974)	2600(1948)	3700(1969)	4200(1976)	1,126	18	279
Elgin Creek - Souris	1,390	1,560	1,740	1,000	1000(1999)	1100(2001)	1400(1974)	1900(1976)	1900(1996)	1,744	918	302
Gainsborough Creek - Lyleton	590	700	820	1,000	1000(1999)	1100(1996)	1500(1969)	1600(1974)	3100(1976)	487	89	133
Medora Creek - Napinka	870	970	1,080	500	580(1969)	740(2001)	760(1999)	1000(1996)	1400(1976)	858	530	268
Pipestone Creek -PTH 83	1,680	1,920	2,180	2,000	2600(1974)	2600(1955)	3500(1996)	4000(1969)	5400(1976)	1,324	466	911
Waskada Creek - Cranmer	320	340	400	300	310(1975)	310(1985)	350(1979)	360(1996)	680(1976)	-	-	-

** Favourable and unfavourable weather refers to the lower decile and upper decile condition respectively for melt rate and precipitation.

* Flooding could occur with lesser flows at these stations due to possible backwater from nearby rivers.

Note: Peak stage on any stream could be briefly higher than implied by the peak flow if channel becomes blocked by ice or debris.

^ Some of the values are summer peaks.

DETAILED SPRING FLOOD OUTLOOK FOR SMALLER WATERSHEDS

****Based on Favourable, Average and Unfavourable Weather Conditions**

Mar. 24, 2011

(All Flows in Cubic Feet per Second)

Table 2 continued

Stream Location	Predicted Spring Peak Flow			Bankfull	Largest Peaks on Record ^ (Year)					*Recent Spring Peaks*		
	Favourable	Average	Unfavourable	(no Ice)						2005	2006	2009
Pembina River Watershed:												
Pembina River - Rock Lake (feet)	1338.5	1339.2	1339.8	1337.0						1336.4	1338.2	1339.3
Pembina River - Windygates	10,200	14,500	20,000	7,000	6700(1998)	7300(1995)	8100(1969)	11200(1974)	13500(1997)	4,061	12,996	16,000
Badger Creek - Cartwright	3,960	4,400	5,060	2,500	3600(1997)	3700(1995)	5600(1979)	5600(1974)	7300(1969)	2,041	2,761	-
Cypress Creek - Clearwater	1,820	2,030	2,310	1,700	1900(1976	2000(1982)	2400(1974)	2600(1971)	2700(1997)	1,331	2,539	-
Interlake & Eastern:										**2005**	**2006**	**2009**
Brokenhead River - Beasusejour	2,160	2,390	2,700	4,000	2900(1960)	3000(2001)	3500(1950)	4100(1997)	5800(1974)	1,677	1,434	
East Fisher River - Hodgson	950	1,260	1,580	1,200	1200(1986)	1400(1963)	2200(1976)	2300(1974)	2500(1979)	-	-	-
Fisher River - Peguis Townsite	2,100	2,300	2,600	2,200	3000(1976)	3100(2001)	3100(1986)	3700(1974)	4200(1979)	2,514	2,600	3,000
Icelandic River - Riverton	3,680	4,080	4,960	5,500	3700(1960)	4300(1976)	4600(1986)	5500(1979)	7200(1974)	3,121	2,655	1,409
Whitemouth River - Whitemouth	3,120	3,380	3,900	5,000	6400(2002)	7000(1996)	7500(1950)	8400(1974)	10200(1997)	3,167	3,700	
Westlake-ThePas:										**2005**	**2006**	**2007**
Big Grass River - Glenella	780	960	1,560	2,000	2900(1969)	3200(2001)	3400(1979)	3700(1970)	3900(1976)	-	2,930	1,978
Carrot River - The Pas	8,625	10,500	12,750	*8,000	7800(1997)	8000(1972)	8500(1985)	8500(1979)	8700(1974)	4,500	7,300	7,310
Ochre River - Ochre River	630	700	860	3,000	2600(1969)	3000(1971)	3200(1953)	3800(1986)	7500(1975)	530	760	388
Pine Creek - Pine Cr.Station	720	840	1,020	800	1000(1969)	1100(1960)	1400(1970)	1500(1965)	1600(1979)	-	-	-
Red Deer Lake Inflow	10,140	12,480	14,820	10,000	13000(1957)	13800(1965)	15500(1972)	16800(1955)	16900(1954)	6,003	31,000	21,076
Swan River - d/s Swan River	4,070	5,000	6,290	7,000	7000(1979)	7200(1997)	7700(1974)	7700(1983)	8500(1995)	1,928	9,640	5,262
Turtle River - Laurier	1,870	2,040	2,380	3,500	3000(1971)	3100(1953)	3600(1974)	7100(1986)	8000(1975)	1,144	2,990	1,529
Valley River - Grandview	1,520	2,090	3,230	3,000	2000(1971)	2800(1983)	3000(1995)	3000(1979)	3100(1974)	-	-	-
Vermilion River - Dauphin	1,750	2,000	2,380	6,000	3600(1957)	5200(1956)	5400(1975)	5800(1979)	6000(1974)	593	600	1,006
West Squirrel Creek - Austin	240	270	330	400	260(1965)	260(1974)	290(1969)	340(1962)	550(1970)	-	-	-
Whitemud River - Keyes	2,480	2,890	3,440	3,500	4000(1969)	4600(1960)	4900(1974)	6400(1979)	7300(1970)	2,546	3,780	1,953
Whitemud River - Westbourne	3,300	3,800	4,500	6,000	5400(1996)	6300(1976)	6500(2001)	8600(1974)	10800(1979)	3,813	6,670	3,182
Wilson River - Ashville	3,750	4,130	4,630	5,000	3400(1999)	3400(1998)	4100(1995)	5400(1983)	5800(1979)	1,080	1,530	752
Woody River - Bowsman	7,980	8,740	10,260	6,000	4900(1974)	5400(1972)	6000(1983)	8100(1993)	9800(1988)	1,384	9,750	3,454
Saskatchewan R. at The Pas	39,700	55,700	74,100	70,000	85100(1974)	90700(1917)	99900(1915)	103100(1916)	105900(1948)	73,000	67,000	63,920

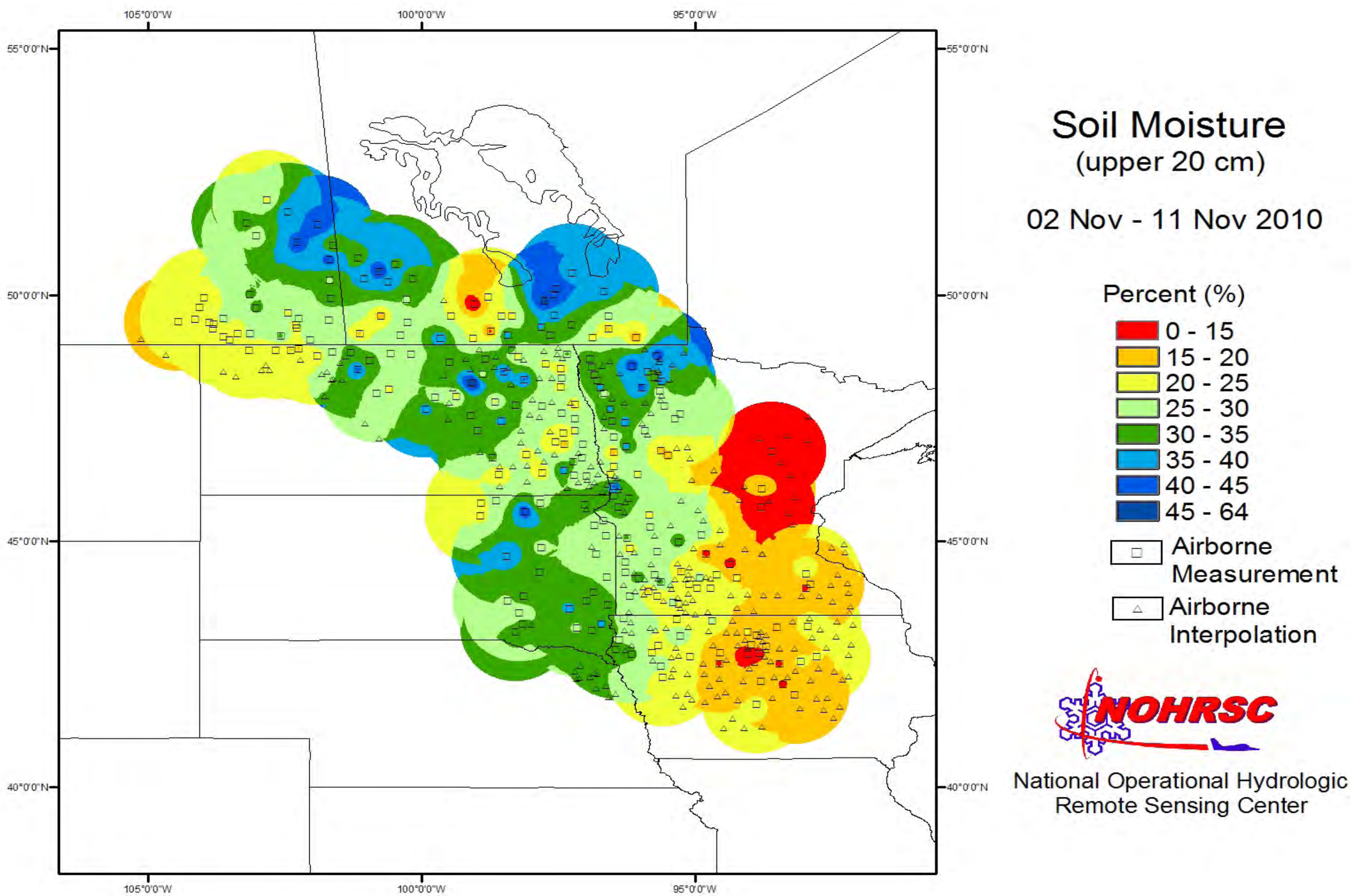
**Favourable, average and unfavourable weather refers to the lower decile, median and upper decile condition respectively for melt rate and additional precipitation.

(There is a 10 % chance that the peak could be at or lower than the 'Favourable' value and a 10% chance it could be at or greater than the 'Unfavourable' value)

* Flooding could occur with lesser flows at these stations due to possible backwater from nearby rivers.

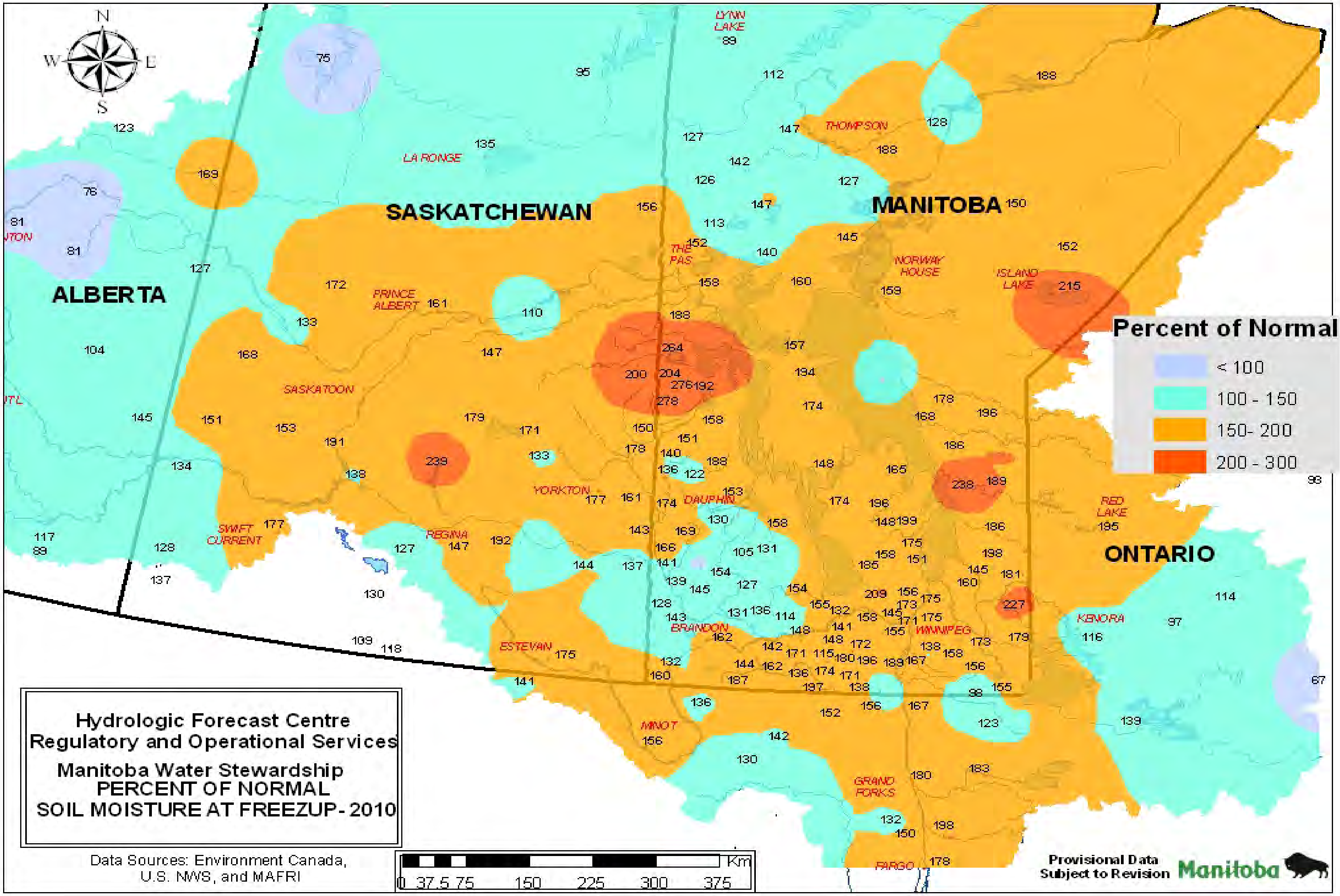
Note: Peak stage on any stream could be briefly higher than implied by the peak flow if ice or debris blockages develop.

Figure 1

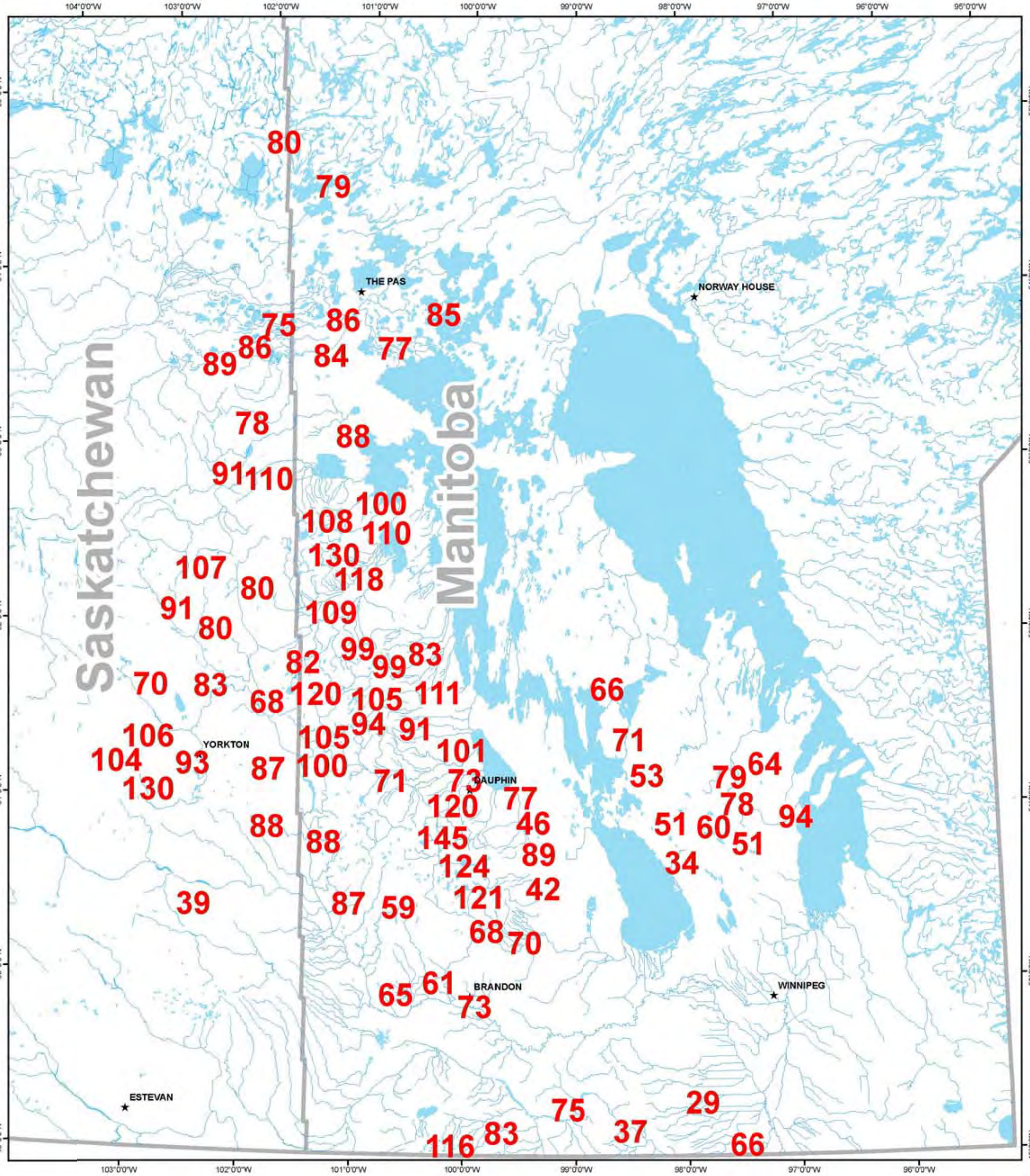


105°0'0"W
100°0'0"W
95°0'0"W
55°0'0"N
50°0'0"N
45°0'0"N
40°0'0"N
Soil Moisture
(upper 20 cm)
02 Nov - 11 Nov 2010
Percent (%)
0 - 15
15 - 20
20 - 25
25 - 30
30 - 35
35 - 40
40 - 45
45 - 64
Airborne Measurement
Airborne Interpolation
NOHRSC
National Operational Hydrologic Remote Sensing Center

Figure 2


SASKATCHEWAN
MANITOBA
ALBERTA
ONTARIO
Percent of Normal
< 100
100 - 150
150- 200
200 - 300
Hydrologic Forecast Centre
Regulatory and Operational Services
Manitoba Water Stewardship
PERCENT OF NORMAL
SOIL MOISTURE AT FREEZUP- 2010
Data Sources: Environment Canada,
U.S. NWS, and MAFRI
Provisional Data
Subject to Revision
Manitoba

SNOW SURVEY MAP

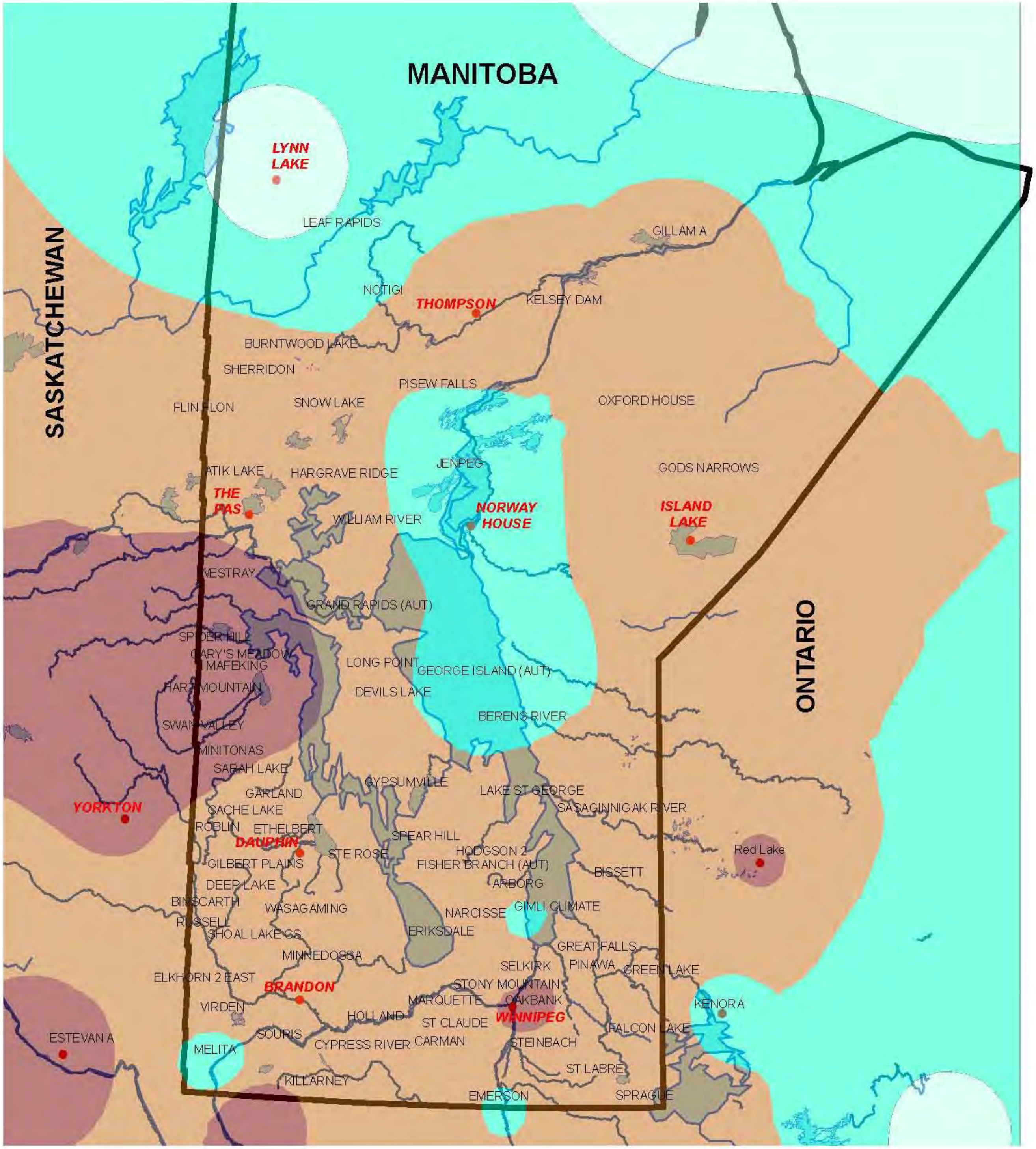


WATER CONTENT (mm)
MARCH 4-9, 2011

Manitoba and Eastern Saskatchewan

0 45 90 180 km

Manitoba
Flood Forecasting Branch
Regulatory and Operational Services
Manitoba Water Stewardship



Hydrologic Forecast Centre
Regulatory and Operational Services

Manitoba Water Stewardship

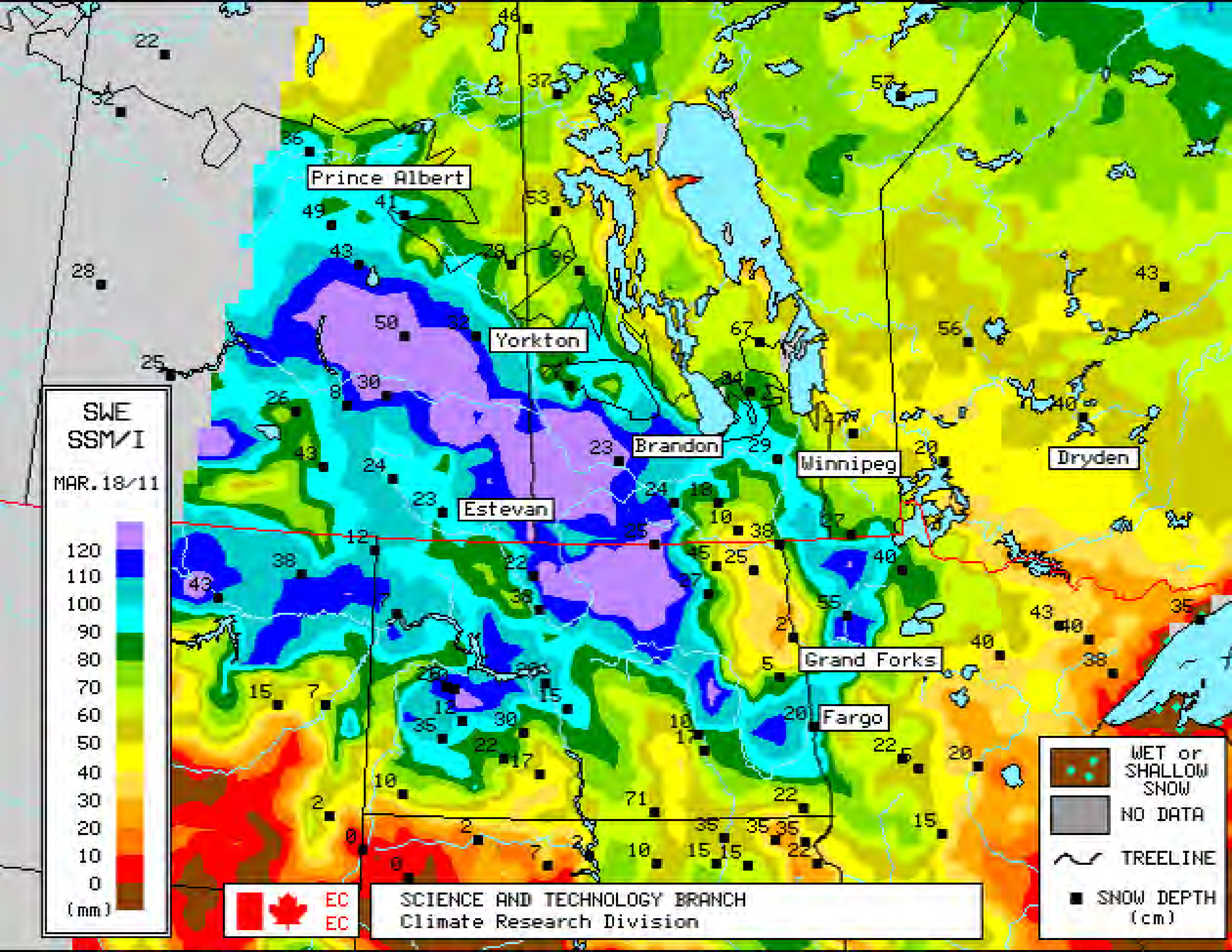
Data Sources: Environment Canada, U.S. NWS, MAFRI, Weatherbug, Manitoba Fire Program

SPRING 2011 RUNOFF POTENTIAL

- 50% - 80%: Below Normal
- 80% - 120%: Near Normal
- 120% - 150%: Above Normal
- 150% - 250%: Well Above Normal

Provisional Data Subject to Revision

Manitoba
Water Stewardship


SWE
SSM/I
MAR.18/11
120
110
100
90
80
70
60
50
40
30
20
10
0
(mm)
Prince Albert
Yorkton
Brandon
Winnipeg
Dryden
Estevan
Grand Forks
Fargo
WET or SHALLOW SNOW
NO DATA
TREELINE
SNOW DEPTH (cm)
EC
EC
SCIENCE AND TECHNOLOGY BRANCH
Climate Research Division

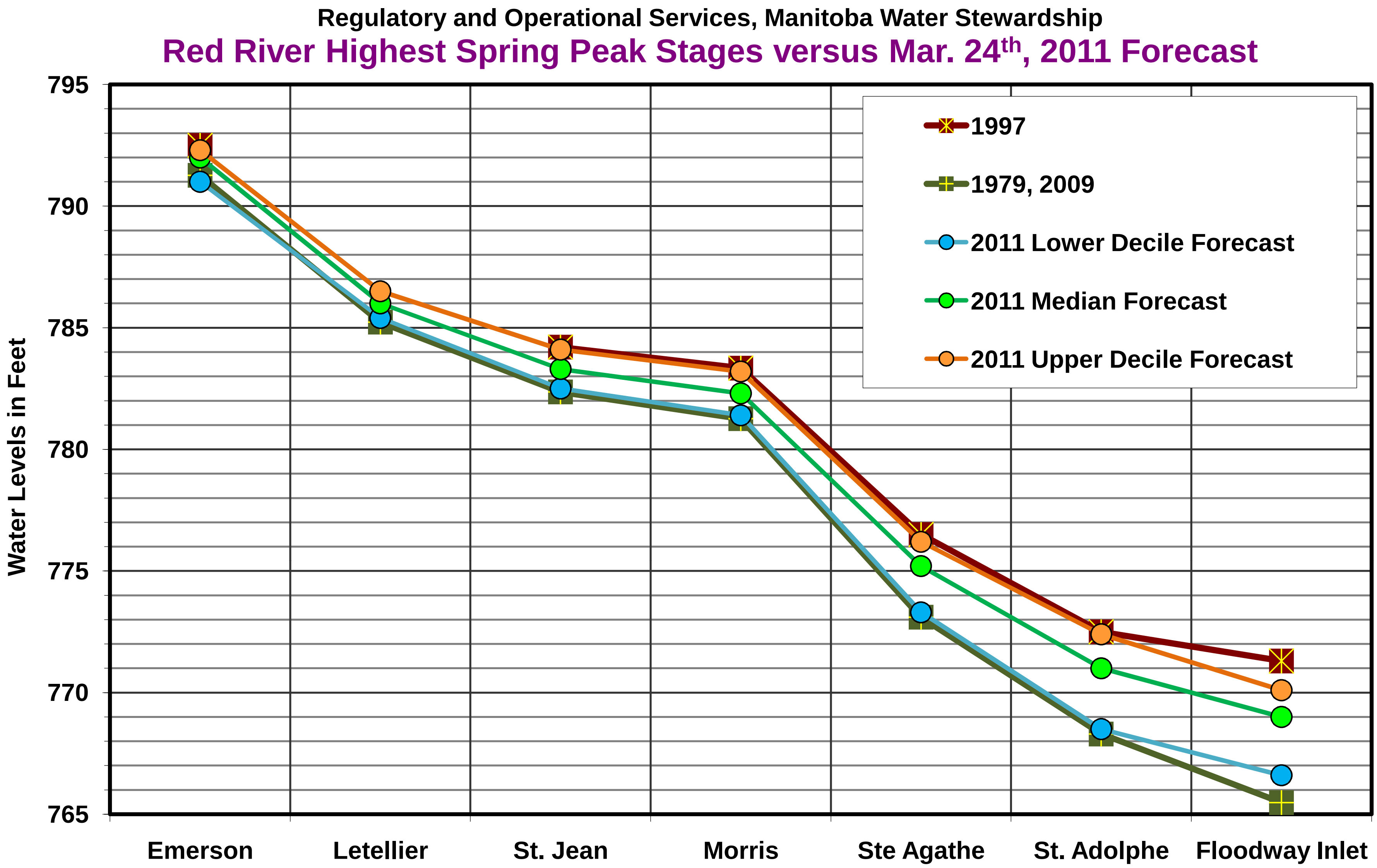
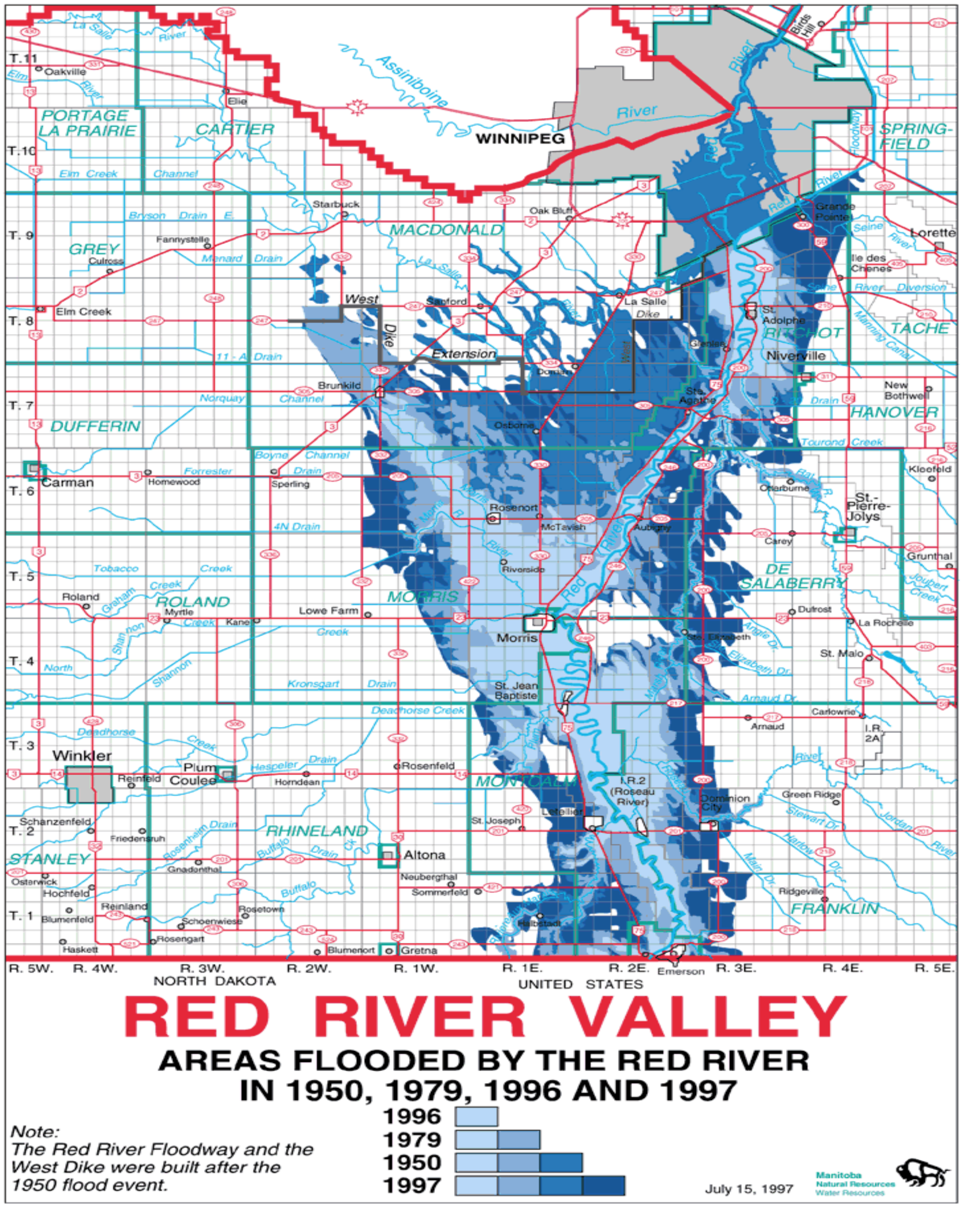

Regulatory and Operational Services, Manitoba Water Stewardship
Red River Highest Spring Peak Stages versus Mar. 24th, 2011 Forecast
Water Levels in Feet
795
790
785
780
775
770
765
Emerson
Letellier
St. Jean
Morris
Ste Agathe
St. Adolphe
Floodway Inlet
1997
1979, 2009
2011 Lower Decile Forecast
2011 Median Forecast
2011 Upper Decile Forecast

Figure 7

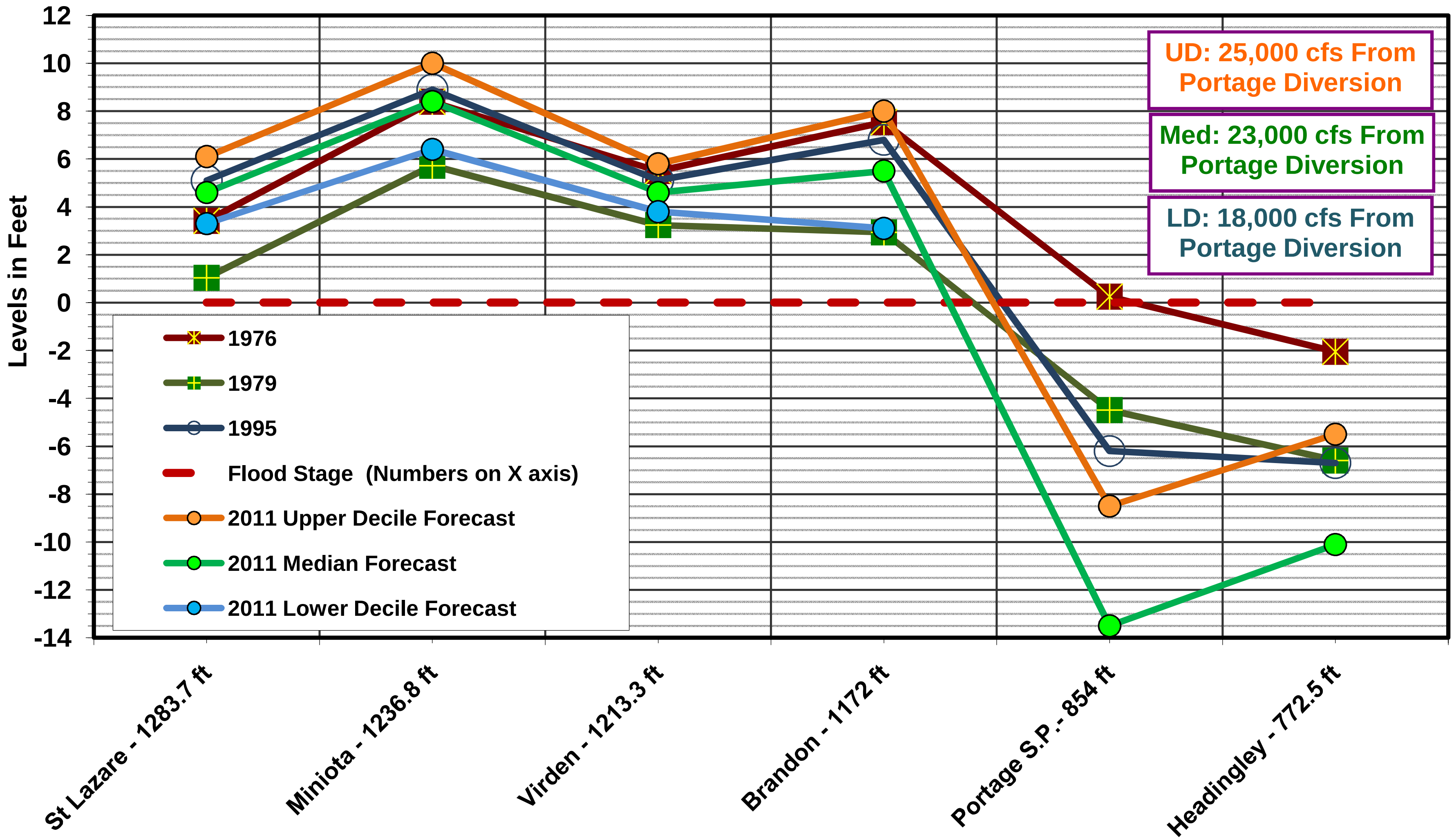


RED RIVER VALLEY
AREAS FLOODED BY THE RED RIVER
IN 1950, 1979, 1996 AND 1997
1996
1979
1950
1997
Note:
The Red River Floodway and the
West Dike were built after the
1950 flood event.
July 15, 1997
Manitoba
Natural Resources
Water Resources
WINNIPEG
NORTH DAKOTA
UNITED STATES

Regulatory and Operational Services, Manitoba Water Stewardship

Assiniboine River --- Spring Peak Stages Relative to Flood Stages

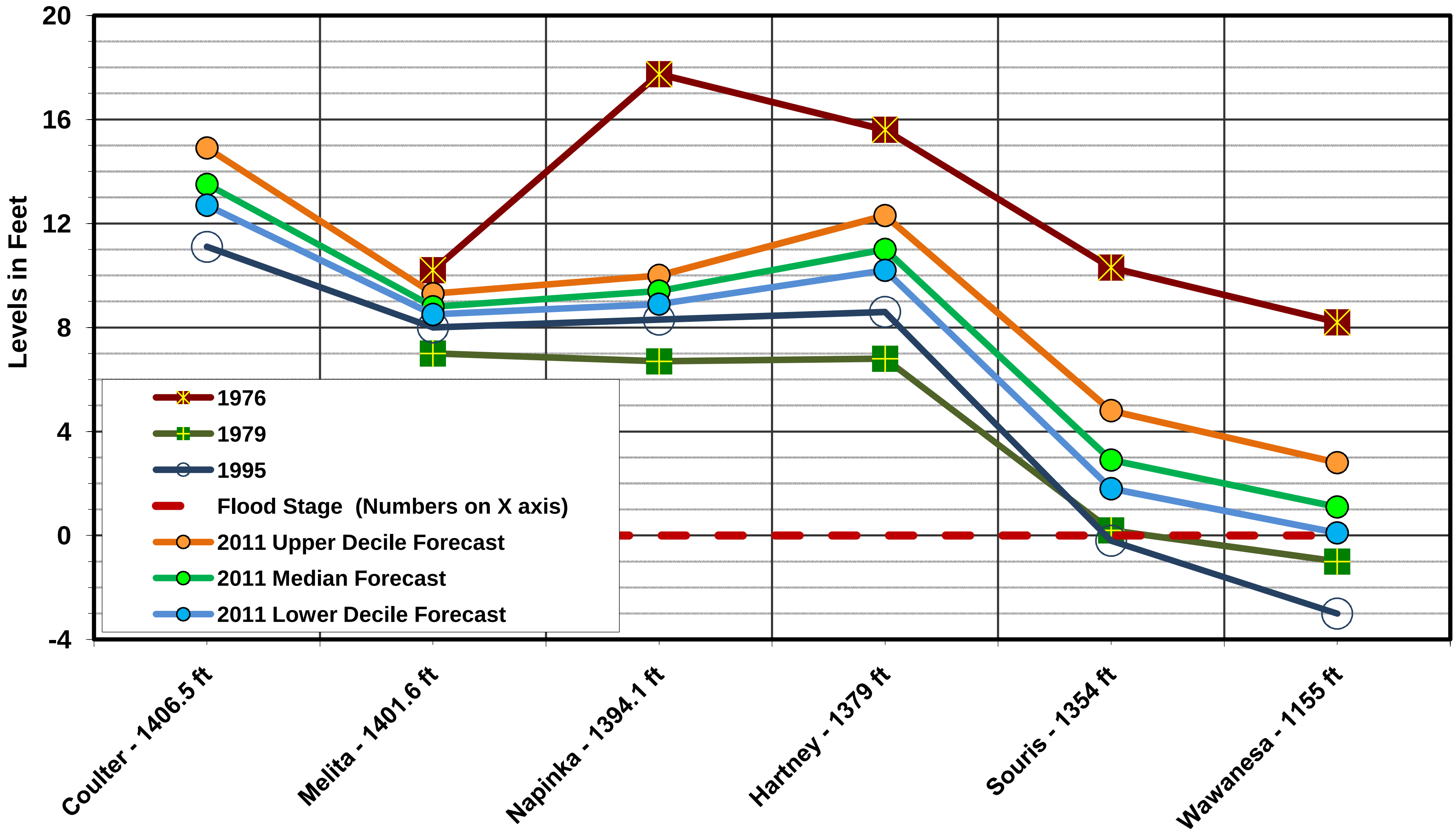
Past Floods versus Mar. 24th, 2011 Forecast



Regulatory and Operational Services, Manitoba Water Stewardship

Souris River --- Spring Peak Stages Relative to Flood Stages

Past Floods versus Mar. 24th, 2011 Forecast



D. Typical Flood Sheets for the Operational Forecasts

Regulatory and Operational Services, Manitoba Water Stewardship

Daily Water Levels and Forecasts

Apr 15 2011

The Pas and Swan River Region

http://www.gov.mb.ca/waterstewardship/

LOCATION	Conditions this morning - 9.00 a.m. measurements		Change from **Apr 14**	Total Rise	Forecasted Peak		Existing Channel Capacity		Previous Peak Stages and Flows			
	FLOW (cfs)	STAGE (feet)		(feet)	STAGE (ft)	DATE	Flood Stage (ft)	Dike Elev. (ft)	FLOW (cfs)	STAGE (ft)	FLOW (cfs)	STAGE (ft)
The Pas Area												
Saskatchewan River at the Pas	33,200	851.01	+0.36	+1.10	852-856	May 1-5	855		103,100 (1916)	860	105,900 (1948)	861
Carrot River near Turnberry	470	861.67	+0.35	+0.47		April 23-26	875		8,500 (1985)	875	8,700 (1974)	876
Swan River Area												
Overflowing River at Overflowing River	1,950	837.94	+0.22	+0.60		April 23-26						
Birch River near Birch River	35	971.64	+0.71	+0.38		April 23-26						
Woody River Near Bowsman	2,600	984.33	+3.45	-0.13	992-994	April 23-26	989		8,100 (1993)	991	9,800 (1988)	993
Swan River near Minitonas	4,950	910.74	-1.08	-0.92	911-912	April 23-26	913		7,700 (1983)	914	8,500 (1995)	915
North Duck River at Cowan	180	1170.35	+0.37	-0.47		April 23-26						
Garland River near Duck River	2,600	918.04	+0.05	+3.06	918.09	Peaked April 15						

Note: Forecast is based on average-unfavourable weather conditions, and will be updated with weather forecasts accordingly.

Sheet printed at 2:58 pm

Manitoba Water Stewardship

Regulatory and Operational Services, Manitoba Water Stewardship

Daily Water Levels and Forecasts

May 05, 2011

MANITOBA LAKES

http://www.gov.mb.ca/waterstewardship/

LOCATION	LEVEL[3] (feet)	Change from Last Reading	Last Reading	Date of Last Reading	Forecasted Peaks[1]		Flood Level[2]	Desirable Range (feet)	ice conditions		forecasted wind conditions for May 5		Risk of shore-line ice pile-up
					Favourable weather conditions (feet)	Unfavourable weather conditions (feet)			ice cover (%)	date of satellite imagery	max. wind speed (km/hr)[4]	wind dir.	
Dauphin Lake	857.60[1]	0.29	857.31[1]	May 04	858.2	859.0	858	853-854.8	90	May 4	15	→	low
Lake Winnipeg at Gimli	715.55[1]	0.03	715.52[1]	May 04	715.6	716.1		711-715	70	May 4	30	↑	medium
Lake Manitoba	814.08[1]	0.09	813.99[1]	May 04	814.2	814.5[5]	814	810.9-812.9	70	May 3	light	–	low
Lake Winnipegosis	834.26[1]	0.22	834.04[1]	May 04	834.3	834.6			100	May 3	light	–	low
Lake St. Martin	803.41[1]	0.01	803.40[1]	May 04	804.2	804.6[6]	805-806	798-802	85	May 2	15	→	low
Oak Lake	1411.71	0.07	1411.64	May 03	1412.25	1412.25	1411.4	1409-1410.5	*no ice cover*				
Pelican Lake	**1353.55**	0.09	1353.46	May 03	*peaked May 1 (1353.57 ft)*		1354	1350-1351.5	*no ice cover*				
Rock Lake	1336.60	-0.03	1336.63	May 04	*peaked Apr 13 (1339.6 ft)*			1328-1330	*no ice cover*				
Nutimik Lake	904.18	0.11	904.07	May 04					*no ice cover*				
Red Deer Lake	**863.82**	0.09	863.73	May 03	863.9	864.7	865.5		*no ice cover*				
North Shoal Lake	**860.41**	0.05	860.36	May 02	860.60	861.00			50	May 3	20	→	low
East Shoal Lake	**860.83**	0.08	860.75	May 02	860.60	861.10			50	May 3	20	→	low
West Shoal Lake	**860.72**	0.03	860.69	May 02	860.60	861.10			50	May 3	20	→	low

General Information: Forecasted peaks are a range, with the lower value based on average conditions and the upper value based on unfavourable conditions, and will be updated with weather conditions accordingly.

Notes:
[1]wind-effect eliminated levels

[2]flood management level or lowest dike height

[3]readings in **bold** from May 4

[4]daily maximum values based on 10 minute averages

[5]preliminary & under review; expected crest date is June 4

[6]preliminary & under review; expected crest date is July 1

Manitoba

Regulatory and Operational Services, Manitoba Water Stewardship

Daily Water Levels and Forecasts

July 10, 2011 — Assiniboine River — http://www.gov.mb.ca/waterstewardship/

LOCATION	Conditions this morning		Change from July 9 (ft)	Total Rise (ft)	Forecasted June Peak			Existing Channel Capacity		Previous Peak Stages and Flows 1995		1976	
	FLOW (cfs)	STAGE (feet)			STAGE (ft)	DATE	DIKE LEVEL (ft)	FLOW (cfs)	STAGE (ft)	FLOW (cfs)	STAGE (ft)	FLOW (cfs)	STAGE (ft)
Kamsack	2,190	20.42	-0.19		**29.04	Apr 21				18,000	1430.00	9,700	1428.15
Shell nr. Inglis	230	1438.63	-0.06							2,100	5.42	1,090	4.47
Shellmouth Reservoir :													
-Inflow	2,450				**20,000 cfs	Apr 21				25,000		11,000	
-Level		1408.27	-0.13		**1414.44	May 07		FSL = 1408.5 ft			1415.00		1409.38
-Conduit Flow	3,690									6,000			
-Spillway Flow	0									11,800		2,500	
-Total Outflow	3,690				**12,040 cfs	May 07				11,800			
Shellmouth Bridge								1,600	1353.00		1360.75		
Russell- old Hwy 4	4,000	1345.45	+0.42		**1349.5	Jun 04		3,000	1343.20	12,700	1352.00	2,900	1342.51
Millwood- PR579								1,700	1323.00		1332.05	3,000	1321.84
Qu'Appelle-Welby	3,990	16.17	-0.11		**18.57	May 11				4,600	16.30		
St. Lazare							1295.36	5,000	1283.70	14,500	1288.80	8,100	1287.12
Miniota	7,700	1241.18	-0.10		**1243.52	Jul. 1		5,250	1236.80	16,600	1245.00	16,000	1245.19
Virden								5,400	1213.30	18,000	1218.40	20,000	1218.80
Griswold					**1201.14	Jul. 3		5,900	1196.40	18,500	1201.00	22,000	1201.85
Brandon---Grand Valley	11,600	1186.33	-0.20		**1188.03	Jul. 4		5,800	1182.60				
Brandon---1st Street		1174.15	-0.44		**1175.63	Jul. 4		8,200	1172.00	20,000	1178.80	21,700	1179.54
Holland	39,200	977.07	-0.37					26,000	974.20	25,000	973.60	51,500	981.49
Portage-u/s Div.	41,460				Cresting			45,000		25,100	866.20	49,000	868.45
Portage Diversion	23,480							25,000		13,500		26,000	
Portage-Southport	17,980								854.00	12,000	847.90	23,600	854.25
Baie St. Paul		799.85	-0.02					18,000	800.20	12,000	795.85	22,000	801.22
PTH 1 east (Lido Plage)									775.00				781.00
Headingley	18,200	769.29	-0.02					30,000	772.50	12,000	766.00	21,700	770.45

General Information: -Forecasted peaks are a range, with the lower value based on average conditions and the upper value based on unfavourable conditions. Forecasts will be updated accordingly to weather conditions.

Notes:

**Crested at the indicated level/flow.

Note: Most recent peak is provided

Manitoba Water Stewardship

Regulatory and Operational Services, Manitoba Water Stewardship

Daily Water Levels

Spring 2011

Assiniboine River Tributaries

http://www.gov.mb.ca/waterstewardship/

(Levels in Feet)

Hydrometric Station Name	10-May	11-May	12-May	13-May	14-May	15-May	16-May	17-May	18-May	19-May	20-May
Qu'appelle River Near Welby	17.98										
Cutarm Creek Near Spy Hill	10.53										
Birdtail Creek Near Birtle	1595.94										
Conjuring Creek Near Russell	1815.37										
Smith Creek Near Marchwell	11.26										
Scissor Creek Near Mcauley	4.09										
Silver Creek Near Binscarth	8.10										
Little Saskatchewan River Near Minnedosa	1720.18										
Arrow River Near Arrow River	3.74										
Gopher Creek Near Virden	4.82										
Oak River Near Rivers	5.55										
Souris River At Wawanesa	1156.23										

* Crest

Manitoba

Regulatory and Operational Services, Manitoba Water Stewardship

Daily Water Levels and Forecasts

July 1, 2011

Souris River

http://www.gov.mb.ca/waterstewardship/

LOCATION	Conditions this morning		Change from June. 30	Total Rise (feet)	Forecasted Peak		Existing Channel Capacity		Previous Peak Stages and Flows 1976		1996	
	FLOW (cfs)	STAGE (feet)			STAGE (ft)	DATE	Dike Level (ft)	STAGE (ft)	FLOW (cfs)	STAGE (ft)	FLOW (cfs)	STAGE (ft)
Rafferty Reservoir		83.93	-0.60									
Alameda Reservoir		85.81	-0.13									
Sherwood	11,900	1628.48	-0.28		***1631.66	Jun. 24			13,700	25.15	2,500	1623.03
Lake Darling		1600.30							8,500	1601.29		
Minot 4NW	18,400	1568.63	-0.25		***1570.06	Jun. 25			9,300	1567.02	2,000	1558.95
Verendrye	19,700	1483.13	-0.08		***1483.40	Jun. 26					3,500	1478.27
Towner												
Bantry	21,800	1443.89	-0.23		***1444.45	Jun. 28			9,300	1442.07	3,600	1440.66
Westhope	*24,500	1424.81	+0.76		1425.45-1425.95	Jul. 3 - 5			12,400	1421.58	5,100	1418.13
Coulter												
Melita - PTH #3	23,200	1412.82	+0.76		1413.75-1414.5	Jul. 4 - 7	1,414	1401.60	21,300	1411.75	5,600	1408.70
Napinka u/s Dam					1408-1408.5	Jul. 5 - 8		1394.10	22,200		6,000	1401.00
Hartney u/s Dam					1397.0-1398.0	Jul. 5 - 8		1379.00	23,500	1394.55	6,000	1386.00
Souris u/s Dam	19,800	1360.72	+0.18		1368.0-1368.5	Jul. 5 - 9		1354.00	24,800	1364.30	6,800	1352.40
Wawanesa	20,350	1158.43	-0.01		1164.5-1165.5	Jul. 7 - 11		1155.00	26,200	1163.19	8,500	1153.00

General Information: -Forecasted peaks are a range, with the lower value based on average conditions and the upper value based on unfavourable conditions. Forecasts will be updated accordingly to weather conditions.

* Estimated

*** Crested at indicated level

Manitoba

Regulatory and Operational Services, Manitoba Water Stewardship

Daily Water Levels and Forecasts

April 15, 2011

Red River

http://www.gov.mb.ca/waterstewardship/

LOCATION	Conditions this morning measurements		Change from	Total Rise	Forecasted Peak		Existing Channel Capacity		Previous Peak Stages and Flows			
							Flood Stage (ft)	Dike Elev. (ft)	1997		2009	
	FLOW (cfs)	STAGE (feet)	Apr. 14	(feet)	STAGE (ft)	DATE			FLOW (cfs)	STAGE (ft)	FLOW (cfs)	STAGE (ft)
Breezy Point		717.12	-0.18	+3.08	719.8-722.1		718.00	No Dike		720.30		721.90
Selkirk (PTH #4)		720.60	-0.20		725.9-726.8		724.50	No Dike		726.20		726.60
Selkirk (Dock)	75,000	#722.01	-0.27	+6.60	728.8-729.7		727.50		152,500	728.50	113,000	729.40
Lockport (d/s Dam)					735.9-738.2		735.00	No Dike				737.90
Lockport (u/s Dam)					735.9-738.2		735.00	No Dike		738.90		738.50
Winnipeg-James	54,160	18.97	-0.23	+7.95	20.1-22.8	Apr30-May04	18.00	26.50	80,000	24.50	72,000	22.50
Below Floodway	41,830	753.08	-0.26		754.6-756.5	Apr30-May04	752.00	No Dike	72,900	761.10	55,800	756.60
Above Fldwy Natural		759.97	-0.12		766.4-767.8				138,000	770.10		767.00
Above Fldwy Actual	61,300	759.70	-0.10	+24.39	766-767.4	Apr30-May04	760.00	773.50	138,000	771.50	98,000	766.80
St. Adolphe	59,000	762.56	-0.26		769.6-771.1	Apr29-May03	757.50	775.50		772.50	98,000	769.20
Ste. Agathe	56,800	766.56	-0.03	+26.32	773.5-774.9	Apr28-May02	771.80	778.50		776.50	90,760	773.70
Morris (PTH 23)	49,600	773.54	+0.05		781.5-782.6	Apr26-30	769.40	787.40		783.30		781.90
St. Jean	**50,000	777.07	+0.18		782.8-783.5	Apr25-29	771.60	788.00		784.30		782.90
Letellier		781.41	+0.20		785.6-786	Apr25-28	780.10	790.60		787.70		785.20
Emerson	49,000	785.53	+0.52	+29.37	791-791.5	Apr25-28	783.20	795.60	145,000	792.50	86,000	790.80
Drayton	64,577	41.83	+0.77		96500 cfs	Apr 19-21	32.00		125,000	45.50	85,700	43.60
Grand Forks	82,515	49.31	-0.18	***	84800 cfs	14-Apr	28.00		120,000	54.00	80,000	49.50
Halstad	59,676	39.93	-0.18		68500 cfs	Apr. 12***	26.00		70,000	40.70	67,500	40.50
Fargo	20,156	36.03	-0.73		25600 cfs	Apr. 9***	18.00		28,000	39.80	29,100	40.80
Wahpeton	7,379	13.71	-0.18				10.00			19.10		

General Information: -Forecasted peaks are a range, with the lower value based on average conditions and the upper value based on unfavourable conditions, and will be updated with weather conditions accordingly.

Notes: *Measured yesterday

** Estimated

***crested at 49.87 ft at 86,500 cfs

Yesterday's value in error

sheet printed at 3:07 pm

Manitoba Water Stewardship

E. Hydrologic Impacts of Prairie Wetland Drainage

Current Knowledge and Research of the Hydrologic Impacts of Prairie Wetland Drainage
Prepared for the
2011 Manitoba Flood Review Task Force
By R.W. Harrison P.Eng,
December 20, 2012

Introduction

Following the 2011 historic flooding through southern Manitoba questions were raised regarding the value of wetlands for flood reduction. Some believe that undrained wetlands have a moderating influence on the flood volume and peaks as they act as storage reservoirs, slowing storm runoff, and decreasing the runoff volume and peak. The draining of such wetlands increases flooding. While others argue wetlands and their drainage have minor impacts on flooding during extreme events as occurred in 2011 as they are near filled or full and have little storage available for flood reduction.

Prairie potholes theoretically provide depression storage for runoff, but the amount of available storage will depend on the antecedent conditions. If the wetlands are full, or partially full, available storage is reduced. Complicating the wetland hydrology is the presence of man-made drainage, such as drain tiles and enhanced surface drainage by ditch systems. Prairie potholes, which are shallow wetlands formed through glacial action, lose water through evapo-transpiration and infiltration. In a wet period, the level of water in such wetlands may rise and thus their effectiveness in flood control will be reduced or minimal.

The lack of understanding and the propagation of misinformation have confused the public about the role of wetlands on flooding. The impact of prairie wetland drainage has been a long standing issue having been raised as early as the 1980s in the Upper Assiniboine River Basin. This document attempts to provide a summary of the current knowledge and the research being undertaken to understand the hydrologic impacts of wetland drainage.

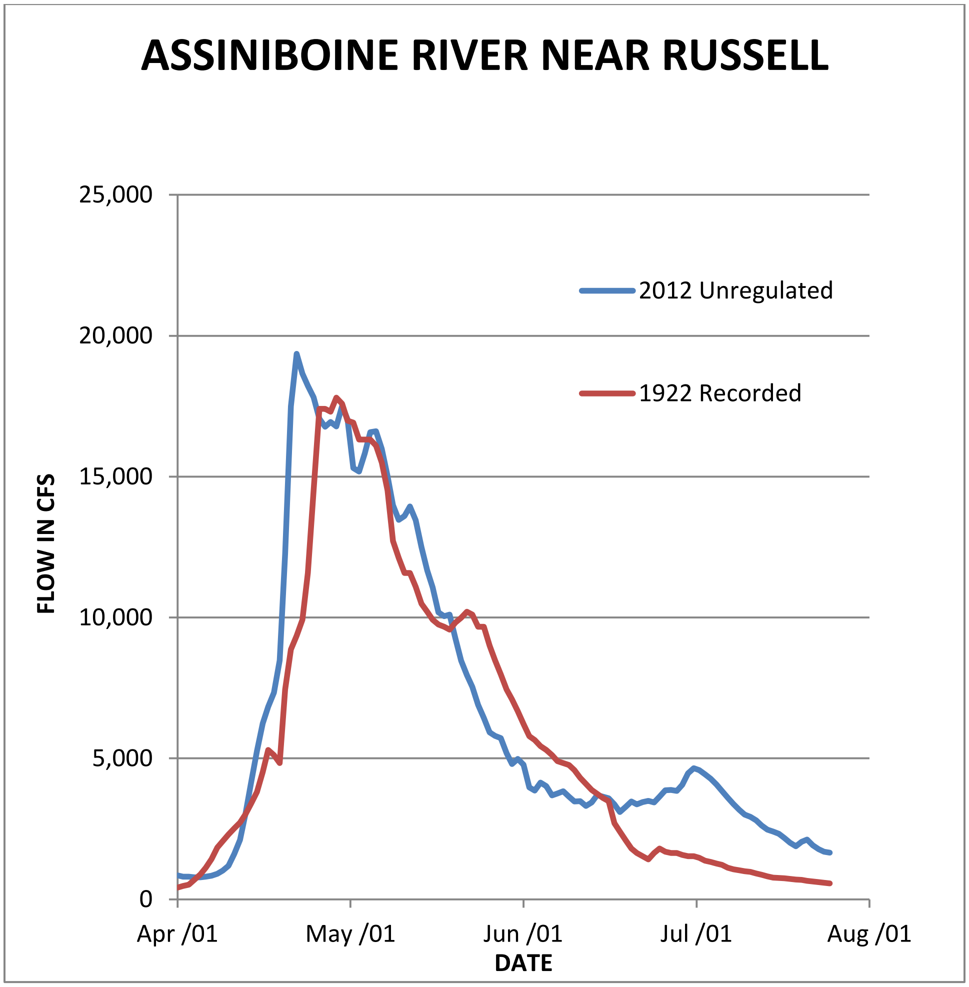
Historic Floods

There were major floods on the Assiniboine River prior to wetland drainage in the basin. The flood of 1882 resulted in reported overflows to Lake Manitoba. On the upper portion of the Assiniboine River a major flood was recorded in 1922 on the Assiniboine River near Russell. To compare the 2011 and 1922 floods, unregulated flows (without the effects of Shellmouth Dam) for the Assiniboine River near Russell were computed for 2011[1]. The 2011 unregulated and 1922 recorded flows for the Assiniboine River near Russell are shown on Figure 1. As indicated on Figure 1, the 2011 runoff volume was approximately 15% greater than that recorded in 1922. The 2011 unregulated peak discharge was about 8% greater than the 1922 peak discharge. The time to peak of the 2011 unregulated flow as shown on Figure 1 is much shorter and steeper. The change in the shape of the raising limb of the 2011 hydrograph is what is expected because of land use changes in the upper Assiniboine River Basin since the 1920s. In the basin a lot of land has been converted from woodland to agricultural crop land along with the drainage of

[1] Computed by Manitoba Infrastructure and Transportation Flood Forecast Centre

wetlands. Both land use changes may result in a more rapid runoff response. Also, the higher baseflow during the summer of 2011 may be attributable to wetland drainage. The occurrence of the 1882 and 1922 floods prior to wetland drainage demonstrates that climatic processes dominate the generation of major floods.

Figure 1: Comparison of the 1922 and 2011Unregulated Flood Hydrographs



Upper Assiniboine Basin Study

In October 1996, the governments of Saskatchewan, Manitoba and Canada agreed to examine at length the issue of wetland drainage because of concerns about the alleged contribution of agricultural drainage to the 1995 flood. The 1995 flood was estimated as a one hundred year event. Of particular interest was the drainage of wetlands associated with agricultural development and practises in the Basin.

It was found that the high flows in 1995 can be attributed to a combination of meteorological events. Runoff from high precipitation in the fall of 1994 had nearly filled many of the natural wetlands and soil moisture levels were high, reducing the natural storage available for spring snowmelt runoff. There was an above-normal snowpack followed by a mid-April rainstorm, which contributed additional runoff water and caused rapid melting of the snowpack. This rapid melt across much of the Basin resulted in an unusual hydrologic condition — the nearly coincident peak flows on the Assiniboine and Whitesand rivers at Kamsack, as well as on smaller local tributaries between Kamsack and Shellmouth Dam. To compound the situation locally, high levels in the receiving streams reduced or prevented flow from many drainage ditches. It was felt that "drainage works in the Basin did not contribute significantly to the observed 1995 flood peaks and volumes. These can be attributed to natural conditions".

The SLURP hydrologic model was successful applied in modelling flows for larger watersheds of the upper Assiniboine River Basin with 1995 to 1997 land cover. However, it is not possible to determine the effect on Basin hydrology of changes to land use using the SLURP model. If was felt that while the modelling was not successful in determining the effect of land cover change on Basin runoff, it did not preclude the eventual success of such an initiative with a complete land cover model of both the predevelopment condition as well as the current land cover. It was recommended that research and development of practical watershed modelling tools which can be used by provincial regulatory agencies to assess the impact of drainage projects on watershed hydrology should be continued.

The principal study conclusions relevant to the hydrologic impacts of agricultural wetland drainage were:

- *Climatic processes dominate the generation of major flood events;*
- *The greatest relative impact of drainage of wetlands is during moderate runoff events, with the effect diminishing for increasingly larger flood events;*
- *Drainage of wetlands has little effect on major flood events;*
- *Effects of land cover changes and wetland drainage in the Basin could not be quantified, but a trend of increasing runoff volume was detected;*
- *Increased runoff volumes into lakes gives rise to management issues and reduces operational flexibility of reservoirs; and*
- *Continued need to develop a comprehensive runoff simulation models for prairie conditions as found in the Upper Assiniboine River Basin.*

University of Saskatchewan Prairie Hydrological Model Study

In 2010, the University of Saskatchewan developed a Prairie Hydrological Model (PHM). The study objectives were to develop and test a hydrological model suitable for wetland dominated Prairie basins and to use the model to estimate the sensitivity of streamflow to changes in drainage and land use. Because of the broad interested in the issue of wetland drainage the work was jointly funded by Prairie Habitat Joint Venture Policy Committee, Agriculture and Agri-Food Canada, Prairie Provinces Water Board, Saskatchewan Watershed Authority, Manitoba Water Stewardship and Ducks Unlimited Canada.

The Prairie Hydrological Model incorporated all major prairie hydrological cycle components such as wetland storage and runoff generation mechanisms in order to be capable of addressing the influences of changing land use, wetland drainage and climate variability. A key component of the model was wetland modules that permitted open water evaporation and fill and spill from wetlands. In the model, hydrological processes were simulated on landscape units called hydrological response units (HRU). HRUs are landscape units, within which processes and states are represented by single sets of parameters. HRUs can be finely scaled (hillslope segment), or coarsely scaled (sub-basin). HRUs in the prairies typically correspond to agricultural fields (stubble or fallow fields), natural cover (grassland or forest woodland), and bodies of water (lake or pond).

The model was used to analyze the impacts of wetland drainage and restoration as well as changes in surrounding upland land use on the downstream hydrology on Smith Creek (~445 km^2), a Saskatchewan tributary of the Assiniboine River immediately downstream of Shellmouth Dam. Smith Creek is a highly drained watershed. The two spring runoff events of 2008 and 2009 were simulated. 2008 had a good streamflow prediction whereas 2009 had a poor streamflow prediction illustrating the model still need further refinements.

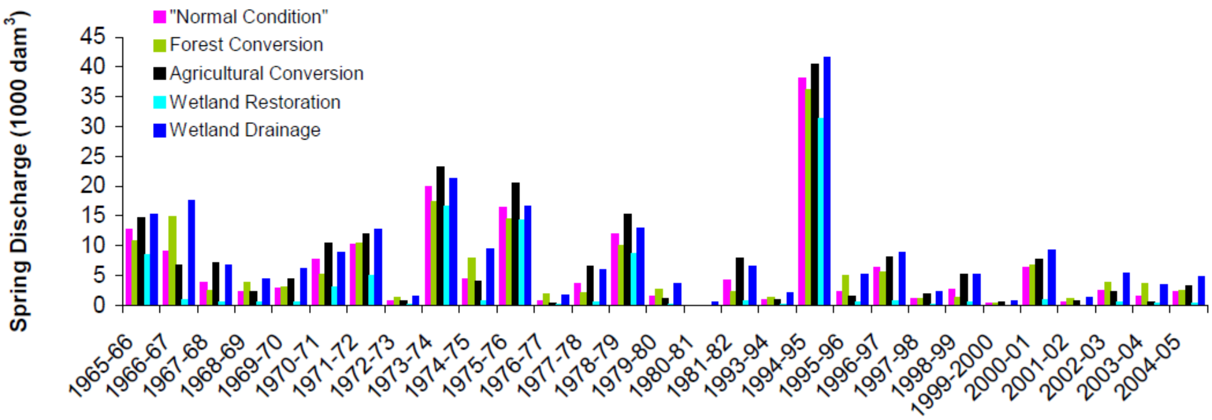
Using the Prairie Hydrological Model a series of scenarios of changing land use and wetland drainage was modelled for 2008 and 2009. These were average to below average runoff years. These simulations indicated that:

- spring runoff volumes decreased by 79% with complete restoration of wetlands; and
- conversely, spring runoff volumes increased by 117% with complete wetland drainage.

Additional sensitivity analysis of scenarios on basin streamflow using historical (29-year periods: 1965-82 and 1993-2005) data showed that:

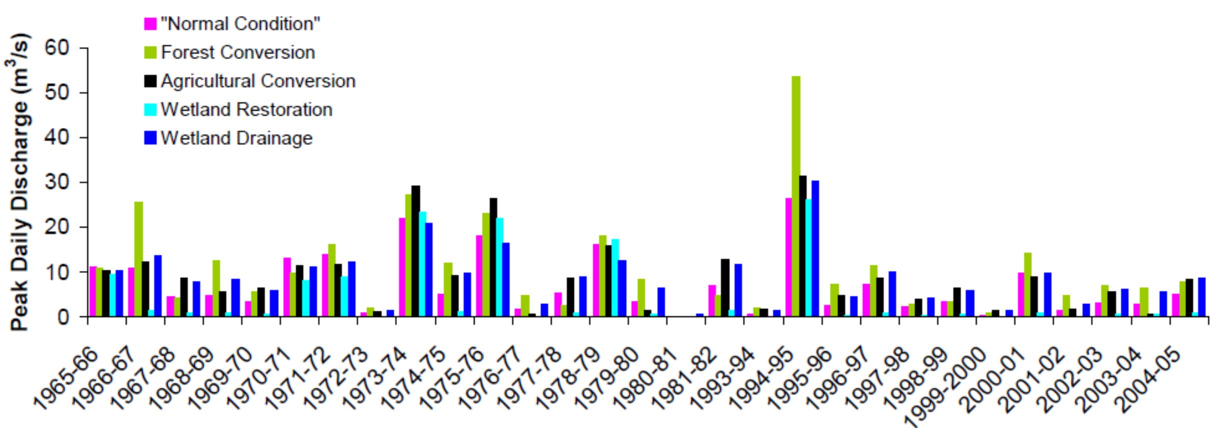
- The simulated long-term impact of land use and wetland drainage on spring runoff volumes is shown in Figure 2. The effects on spring runoff volumes were highly variable from year to year. The basin spring runoff volume appeared to be most sensitive to changes in wetland storage. Restoration of wetlands led to a 45% decrease in the spring discharge volume and a 36% increase with complete drainage of wetlands. As shown on Figure 2, under the wetland drainage scenario the 1995 spring runoff volume was increased by about 5%.

Figure 2: Simulated Smith Creek Spring Runoff Volumes



- The simulated long-term impact of land use and wetland drainage on spring peak flows is shown on Figure 3. The peak daily discharge tends to be increased with wetland drainage scenarios and decreased for the wetland restoration scenario. Wetland restoration results in reduced peak spring discharge due to increased wetland capacity for storing runoff and subsequent decreasing the seasonal discharge. However, it noted in the study that the complex response of peak discharge to drainage and restoration requires that substantial caution be exercised in interpreting the results.

Figure 3: Simulated Smith Creek Peak Daily Spring Discharge



The study recommended that to model a prairie basin with substantial wetland drainage developments the model needs to consider the temporary storage effects of drained wetlands which dampen flood and attenuate flows. The model currently assumes that drained wetlands have the same runoff characteristics as the surrounding landscape. It is anticipated that including more wetland classes in the model would improve the prediction for the cumulative volume of basin discharge and for hydrograph recession curves. These improvements would dampen the effect of wetland drainage in peak flows shown on Figure 3.

University of Saskatchewan - Improvements and Testing the Prairie Hydrological Model

Work is currently underway, funded by Ducks Unlimited Canada, to develop a new wetland module for the Prairie Hydrologic Model that incorporates the dynamics of drained wetland complexes and permits explicit calculation of the contributing area. Hydrometric and meteorological monitoring of Smith Creek was planned for 2011 and 2012. The modified Prairie Hydrological Model will be evaluated on the Smith Creek watershed through hydrological simulation and quantitative analysis of streamflow and used in sensitivity analysis of the effect of changing land cover and wetland storage/drainage on wetland extent and streamflow on Smith Creek.

Fisher River Study

In a 2009 study, AECOM examined the causes of flooding and estimate the contribution to flooding from historic land use changes and extension of the drainage network since the mid-1960s in the Fisher River Watershed which is located in the Interlake Region of Manitoba. The river has a drainage area of approximately 2,200 km^2 and flows northward and eventually drains into Lake Winnipeg at Fisher Bay. The First Nations belief that drainage improvements and land clearing in the upstream Rural Municipality of Fisher had contributed to their flooding problems.

The MIKE11 hydrodynamic modelling software was used to model the Fisher River watershed with its complex system of main channel, branches and tributaries. Estimation of inflow hydrographs at 148 locations for the MIKE11 hydraulic model was achieved through application of the hydrologic model HEC-HMS.

The study concluded that land use changes and drainage improvements have little impact on peak water levels or the flood duration for extreme flood events at downstream locations in First Nation Communities. The impact of drainage is much more pronounced in the upper and middle reaches of the Fisher River. This was because of timing of upland drainage reaching the downstream locations which was after the downstream runoff and the attenuation of the flood peak because of the throttling effect of existing culverts and floodplain storage.

The study illustrates that the location of wetlands within a watershed affects their ability to control floods. The hydraulic capacity of the downstream receiving water courses and waterway crossings also needs to be considered.

Broughten Creek

In 2008, Ducks Unlimited applied the U.S. Department of Agriculture Soil and Water Assessment Tool (SWAT) to examine the hydrologic and environmental effects of wetland loss in the Broughton's Creek watershed. The watershed located in the Rural Municipality of Blanshard (north of Brandon, MB) has a drainage area of about 97 square miles. Between 1968 and 2005, the project confirmed that 5,921 wetland basins, or 70 per cent of the total number of wetlands in the Broughton's Creek watershed, have been degraded or totally lost due to drainage activity.

The wetlands were incorporated into SWAT using the "hydrologic equivalent wetland" (HEW) concept on the sub-basin basis. HEW is described by five parameters, namely the fraction of the sub basin area that drains into the HEW, the surface area at normal water level, the volume of water stored in the HEW when it is filled to its normal water level, the surface area at maximum water level, and the volume of water stored in the HEW when it is filled to its maximum water level. The daily streamflow for Oak River at Shoal Lake (05MG008) were transferred using an empirical equation to approximate the streamflow at the outlet of the Broughton's Creek watershed, where observed data are unavailable for the verification of the model. In two of the five verification years the SWAT model predication was questionable.

The modelling indicated the cumulative effects of wetland drainage since 1968 have increased annual total flows by 62 per cent and peak flows by 37 per cent. This modelling applied to moderate to low runoff years. The strength of SWAT is the combination of upland and channel processes are incorporated into one simulation package, however, the processes in SWAT are a simplification of reality and subject to the need for improvement.

Summary:

The impacts of draining prairie wetlands are variable from year to year and are dependent on the hydrological conditions. To understand the impacts of wetland drainage, it is necessary to understand the hydrological processes and the hydraulic characteristics of both the natural and manmade drainage systems and the receiving streams. Models must incorporate both these components and be able to capture the location and spatial distribution of intact and drained wetlands within a watershed.

The University of Saskatchewan, Centre for Hydrology has significantly advanced hydrologic modelling of prairie watersheds with intact and drained wetlands with the development of their Prairie Hydrologic Model. But, more work is needed to better include the hydraulics of prairie wetlands and the downstream watercourses.

The modelling of wetlands is data intensive and requires a Digital Elevation Model that is adequate to capture the shallow depressions of wetlands and the hydraulic characteristics of the wetlands and receiving streams. This is why hydrologic modelling to assess wetland drainage has been only applied to Smith and Broughten creeks which are smaller watersheds. There is need for a research watershed where streamflow from separate drained and intact wetlands sub-watersheds are monitored along with wetland water levels and hydro- meteorological conditions in the watershed. Such a watershed would provide invaluable data to calibrate and verify prairie hydrologic models against that are being used to understand the hydrologic impacts of wetland drainage

From the findings of the hydrologic modelling of Smith and Broughten creeks, small watersheds, it appears that the local impact of wetland drainage is to increase peak flows and runoff volumes. These findings appear applicable to the low to moderate flood events modelled. However, caution should be taken in transferring these findings to large basins as the location of wetlands within a basin affects their ability to control floods. For instance, if the wetlands are all located in the upper portion of the watershed and drain only a small percentage of the total contributing area, they may have little impact on downstream flood peak and only contribute to the runoff volume on the recession of the flood.

Major floods are normally generated in response to abnormally wet conditions. Under these conditions natural wetland are near filled or full. In 2010, southern Manitoba experienced well above normal summer and fall precipitation that filled many natural wetlands and saturated the moisture significantly reducing the natural storage available for the 2011 spring snowmelt and rainfall runoff. The occurrence of the 1882 and 1922 floods prior to wetland drainage demonstrates that climatic processes dominate the generation of major floods.

Conceptually, natural wetlands should have their least impact during these wetter conditions as they have little remaining flood control storage and will readily spill similar to drained wetlands so that under the undrained state, a larger portion of the watershed would contribute to runoff during large flood events. Drainage would not add as much volume to the natural runoff during these large events as during smaller events. Also, during major floods, the backwater from the main river channels may prevent drainage ditches from contributing to the peak flows and floodplain storage dampen peak flows, so that wetland drainage will eventually increase the runoff volume, but not necessarily the peak flows.

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F. HATCH Report

Manitoba Infrastructure
and Transportation
Winnipeg, Canada

FINAL

2011 Flood Review Task Force Report - Environmental Effects

For

Assiniboine River 2011 Flood Review

H342696-0000-07-124-0001
Rev. 0
February 2013

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Manitoba Infrastructure and Transportation
Assiniboine River 2011 Flood Review

2011 Flood Review Task Force Report - Environmental Effects

25-Feb-13						
	0	Final	J. Donetz	A. Lupu	W.Gendzelevich	
Date	Rev.	Status	Prepared By	Checked By	Approved By	Approved By
HATCH						Client

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Executive Summary

Flooding in 2011 along the Assiniboine River watershed was unprecedented in both scope and extent. In response to this, the Manitoba Government formed the Manitoba 2011 Flood Review Task Force (the Task Force) to examine various aspects of the 2011 flood. Hatch was contacted to provide such technical expertise to examine the following:

"The environmental, social, water quality and human health impacts related to flooding of environmentally sensitive developments such as sewage lagoons, landfill sites and gasoline, oil and farm chemical sites."

This review was conducted at a high level to summarize what happened during the 2011 flood from an environmental perspective. If possible, an attempt would be made to review various outcomes from the flooding.

The scope of the issues was identified as the environmental, social, water quality, and human health impacts from flooding of environmentally sensitive areas. These include sewage lagoons, landfill sites, and storage areas for hazardous materials such as gasoline, oil and farm chemicals. Further, a review was undertaken on riparian zones where flood effects to these areas led to accelerated erosion that could lead to further environmental impacts.

Study Approach

The scope of the project was extensive and the ability to cover the entire area was limited by both time and cost. As this was to be a high level review, an approach had to be developed to provide a reasonable assessment of the environmental impacts related to the flooding of sensitive areas while remaining within timeline and budget.

At the outset of the project, discussions were held between representatives of the Task Force, Manitoba Infrastructure and Transportation and the Hatch Team. The purpose of the discussions was to determine communication protocols, identification of key persons who would contribute information to the study, a review of the project scope of work, report reviews, and Project schedules. This laid the groundwork for the study approach.

Information Gathering

The assessment of the effects that resulted from flooding of environmentally sensitive areas was accomplished by review of background information regarding the 2011 flood including:

- literature for the 2011 flood,
- past reports of Manitoba floods, and
- interviews of key personnel from MIT.

The most important source of information was the collection of data from the public/stakeholders. A list of key questions to identify the observed 2011 flood impacts and locations was developed and presented to the public. One (1) of the key goals of the study was to be able to select representative environmentally sensitive sites impacted by the flood.

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Identification of Study Sites and Site Visits

The original work plan had been to select study sites related to potentially environmentally sensitive conditions, such as sewage lagoons, hazardous materials (agricultural chemical and petroleum product) storage areas and landfill sites. However, it became apparent early in the study that the priorities of the stakeholders were somewhat different, and the observations of the 2011 flood effects included a modified approach.

Lagoons

The inclusion of lagoons was seen by many respondents, and confirmed by later field visits, to be one (1) of the major issues. This was because of their proximity to surface water bodies throughout Manitoba. Almost 70% of respondents to the surveys indicated that they had witnessed flooding issues with lagoons. Further discussion was focused around the Glenboro lagoon, although many other lagoons were visited and identified.

Hazardous Material Storage Sites

Commercial hazardous materials sites were not mentioned at all during the study. This was because existing regulations and business practices effectively protected these types of sites, and made them resistant to flood events. Hazardous materials issues were focused on domestic quantities that were stored throughout the flooded area. Paints, solvents, gasoline, chemicals and other items were frequently noted as having entered the environment during the 2011 flood. To capture this issue, further discussion regarding the situation at Delta Beach is included in the report.

Landfill Sites

Flood issues with landfill sites were only reported on one (1) occasion, at Strathclair, Manitoba. However, a subsequent field visit could not determine the extent of the concern. Most active landfill sites that were visited were deliberately set away from surface water bodies to comply with regulatory approvals. It is probable that there were abandoned landfill sites that were impacted by the flood, but locating and evaluating these was not possible during this study.

Domestic Water Supplies and Wastewater Handling Facilities

A common issue was the overall flooding effects of domestic water systems, including wells and septic fields/holding tanks. This was a common issue throughout the extent of the 2011 flood. Groundwater sources became susceptible to contamination by sewage from nearby tanks, flooded lagoons and privies. Likewise hazardous materials such as agricultural pesticides were able to enter the groundwater supply through flooded wells. The area of Twin Beaches was selected for further discussion, due to the widespread impacts reported and observed.

Riparian Zones and Erosion

The loss of riparian zones led to severe erosion and downstream impacts of natural and infrastructure systems. This was not something originally anticipated to be studied. However, this issue had the potential to be one (1) of the longest term impacts, and one of the most severe impacts to the natural environment. Riparian zones are environmentally sensitive areas, and serve to protect water quality. As a result, the area around Lake St. Martin and Grahamdale was selected for further discussion.

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Environmental Impacts

The potential for impacts from the flooding of environmentally sensitive areas as previously noted is high.

Impacts from Flooding of Wastewater Lagoons

The effects of flooded lagoons tended to be of a local impact during the flood and of short duration, although potential for medium to long term impacts existed. This is particularly true when considering the ongoing impacts to water quality being observed in settling basins such as Lake Winnipeg. However, for the most part, the large volume of water served to dilute the concentrations of the raw sewage. Impacts to groundwater and potentially human health from the 2011 flood remain unknown.

Impacts from Flooding of Hazardous Materials Storage Sites

The impacts from hazardous products that entered the environment during the 2011 flood had the potential for long term effects. This is for a number of reasons including the integrity of storage containers, and the overall volumes of substances that were released during the flood. The threat of release may persist for some time and the effects to natural systems and human health are unknown.

Impacts from Flooding of Domestic Water Supplies and Wastewater Facilities

Destruction of domestic water systems including flooding of wells and individual wastewater collection systems will impact the surface water in local areas for a short duration of time. However, the long term effects to groundwater supplies are unknown. This may present potential long term impacts to human health. Impacts may also be felt if regulatory authorities mitigate risks by excluding further development in potential flood zones, such as future recreational opportunities.

Impacts from Flooding of Riparian Zones and Erosion

The loss of the riparian areas leading to severe erosion will produce the most complex impacts over time. While the zones themselves may recover in the medium term, the long term implications to natural ecosystems are unknown. Over this medium term, it is expected that aquatic life will potentially be significantly impacted, although the extent of the impacts is unknown.

Recommendations:

In assessing the 2011 flood effects there were many instances where either the scope or significance of impacts were unknown. It is therefore recommended that consideration be given to the following actions to locate and identify impacts that may result from the 2011 flood.

1. Groundwater Quality – Ensuring the integrity of the groundwater supply is critical. This can be done by instituting an annual water quality program, and begin investigations into the various pathways to groundwater contamination that may arise during a flood. Mitigation measures for flood prone areas should be investigated and implemented. This would include an examination of individual wastewater containment systems, and available options.

2. Surface water quality – A basin wide water quality monitoring program could help identify any future impacts. Investigate options for the storage of domestic quantities of hazardous materials in flood zones and implement an educational program. Implement a removal program for containers that have entered surface water bodies as a result of the 2011 flood.

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3. Fish and Wildlife – The impacts to the fish and wildlife from the flood are not known. It is therefore recommended that a structured monitoring program for fish and wildlife, including habitat and physical environment, be instituted.

4. Establish Public Consultation Protocols for Environmental Issues – One (1) of the keys to environmental protection during flood events is the establishment of procedures and protocols that can be implemented prior to, during and following a flood event. This could include public education seminars, news releases and open house events.

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1. Introduction

Flooding in 2011 along the Assiniboine River watershed was unprecedented in both scope and extent. In response to this, the Manitoba Government, through MIT, formed the Manitoba 2011 Flood Review Task Force (the Task Force) to examine various aspects of the 2011 flood. The mandate of the Task Force was to examine the conditions and results of the 2011 flood in order to learn from the actions taken before, during and after the event. The Task Force was authorized to engage experts where required to provide technical advice.

Hatch was contacted to provide such technical expertise to examine the following:

"The environmental, social, water quality and human health impacts related to flooding of environmentally sensitive developments such as sewage lagoons, landfill sites and gasoline, oil and farm chemical sites."

This review was conducted at a high level to summarize what happened during the 2011 flood from an environmental perspective. If possible, an attempt would be made to review the outcomes from the flooding.

1.1 Scope

The geographical extents of the study were defined by the areas impacted along the Assiniboine River, Portage Diversion Channel, Shellmouth Reservoir (Lake of the Prairies), Souris River, Fairford River and Lake Manitoba (Figure 1). The total extent of the 2011 flood investigations essentially covered much of the Lake Winnipeg watershed, although more emphasis has been placed on the Assiniboine River watershed. The geographical scope of the 2011 flood was the largest in Manitoba's history, as stated by the Manitoba Government (2011).

The temporal scope of the environmental component was focused on the period of the 2011 flood, particularly those months of high water. However, in order to evaluate the effects, the study also had to take into account post-flood issues, including the summer period of 2012.

The scope of the issues was determined to be the environmental, social, water quality, and human health impacts related to the flooding of environmentally sensitive areas such as sewage lagoons, landfill sites, and storage areas for hazardous materials such as gasoline, oil and farm chemicals. Not included in the scope of the review were overall environmental impacts not related to the flooding of sensitive areas, such as the impacts of high water on natural biological systems including aquatic, vegetative or terrestrial ecological systems. The exception to this was a review of riparian zones where flood effects to these areas led to accelerated erosion that could lead to further environmental impacts.

In order to fulfill the mandate of the study, Hatch incorporated the required elements into a work plan, as outline in the following approach.

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1.2 Study Approach

The geographical scope of the project was extensive and the ability to cover the entire area was limited by both time and cost. As this was to be a high level review, an approach had to be developed to provide a reasonable assessment of environmental impacts on sensitive areas while remaining within timeline and budget.

At the outset of the project, discussions were held between representatives of the Task Force, MIT and the Hatch Team. The purpose of the discussions was to determine communication protocols, identification of key persons who would contribute information to the study, a review of the project scope of work, report reviews, and project schedules. This laid the groundwork for the study approach.

1.2.1 Information Gathering

The first agreed-to task was to collect background information regarding the 2011 flood and to research select literature pertaining to the effects of flooding. Sources included:

- government reports, scientific databases, water quality records, and any other available data sources that were directly applicable to the flood;
- information that discussed environmental issues of past Manitoba floods, in particular the 1997 Red River Flood;
- geospatial information for mapping purposes; and
- interviews of key personnel from MIT, municipalities and the general public who had information or observations with regards to the 2011 flood.

In order to maximize the collection of data from the public stakeholders, a list of key questions to identify the observed 2011 flood impacts and locations was developed (Appendix A). This list of questions was presented to the public in three specific ways:

1. Posted to the Task Force website;
2. Distributed at all 11 public open house events (Brandon, Souris, The Pas, Russell, Dauphin, St. Laurent, Fairford, Ashern, Portage la Prairie, Langruth and Winnipeg); and
3. Directly to stakeholders who participated in site visits, special events, and by request.

It was felt that the responses to these questions would provide the best identification of actual flood events related to sensitive environmental areas. This was important to select representative environmentally sensitive sites for the different types of impacts that had resulted from the flood. Once the project was underway, it became apparent that the information being received was not necessarily defined as clearly as anticipated. In some instances, information was specific enough to choose a particular site. This was certainly the case with wastewater treatment lagoons, where over 12 sites were identified as having been impacted by flood waters.

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However, other environmentally sensitive situations that were identified at the start of the study proved to be less practical to investigate. This was the case with hazardous material sites. Large, easy to identify locations such as warehouses or storage yards had been either relocated prior to flood events, or flood proofed to withstand flood levels. This did not mean that hazardous materials such as petroleum products or agricultural chemicals could be discounted from further study. Indeed, feedback from stakeholders identified domestic quantities had been inundated in numerous locations. This made selection of a particular site difficult, and instead a broader area had to be selected.

1.2.2 Identification of Study Sites and Site Visits

The original work plan had been to select study sites by:

- reviewing the answers to the questionnaires regarding effects;
- prioritizing a list of potential sites from "most impacted" to "least impacted";
- consultation with the key personnel circulating a list of potential sites; and
- selecting the sites that receive agreement for further review.

Each selected site was to be visited with the following objectives in mind:

- List all nearby environmentally sensitive areas.
- Examine the site and surrounding area for signs of obvious impacts such as:
  - discolouration/staining of surface soils;
  - distressed vegetation;
  - closed sites;
  - warning signs; and
  - recent flood protection measures.
- Compile a record of surrounding land use.
- Use site visit to also talk to key personnel regarding issues, and where possible invite them to attend the site visit.
- As the study progressed and information was received, it became apparent that this would be impractical to implement. This was due to:
- Prioritization of the sites to be visited was impossible, as equal weighting was given to all incidents reported on survey sheets.
- In some instances, the identification of a specific site was not possible, and instead an area had to be selected.
- Some environmentally sensitive sites, particularly solid waste sites, received very little comment from the public. However, individual instances were commonly noted.

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It was therefore decided to visit a number of sites that were both reported by the public or government agencies, and select a representative sample following the site visit. The following sites were visited:

Lagoons

- Glenboro
- Melita
- Strathclair
- Manipogo
- Spruce Woods
- Sandy Bay First Nation

Waste Disposal Sites

- Portage la Prairie (combined RM and City)
- RM of Woodlands
- RM of Cartier
- Town of Melita located 3 km S.E. of town limits
- Sandy Bay

Potential Hazardous Waste Sites

- Melita – Petro Canada Bulk Fuel Site Government Road allowance at Highway 3
- Souris – Shell Canada Bulk Fuel Site (Glenwood)
- Souris – Redfern Farm Supplies Ltd.
- Portage la Prairie – Munroe Farm Supplies
- Hartney – Redfern Farm Services
- St. Laurent – Esso Gas Station
- Long Plain Reserve – Arrowhead Crossing Gas Bar
- Wawanesa – Home and Agro Centre
- Souris – Esso Station
- Hartney – Coop Cardlock
- Melita – Esso Station
- Fairford – Pinaymootang Gas Bar

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- Twin Beaches Community
- St. Laurent Community

The above sites were visited during a 3 day evaluation July 14, 15 and 21. It should be noted that sites were selected to see if observable flood effects were present. Their selection did not necessarily mean that any effects had taken place, and in many cases none had occurred. During the site visits, other instances of flood damage that were relative to the environmental review were observed, and these are discussed later in this report.

Following the completion of the site visits, examples of impacts that had occurred from the flooding of environmentally sensitive areas were chosen. These were presented at a meeting of the Task Force on October 17, and after some discussion a list of four (4) examples for further discussion were chosen. These were:

Sewage Lagoons

The Glenboro Lagoon was selected for further discussion. This lagoon was completely inundated by the 2011 flood.

Private Property Domestic Hazardous Waste

The Delta Beach area of Lake Manitoba was severely impacted by the flood. Many buildings containing domestic quantities of hazardous waste were washed away.

Domestic Water Supplies/Waste Disposal Facilities

This was an easy selection due to significant reports of holding tanks, septic tanks and even privies that have been overtopped or displaced by the flood. The Twin Beaches area is being concentrated on for the report, although St. Laurent and Lake Manitoba First Nation will also be discussed.

Vegetation and Riparian Zones

This was not something originally anticipated. However, it is readily observable anywhere within the 2011 flood footprint. Riparian zones are environmentally sensitive areas, and serve to protect water quality. The area around Lake St. Martin and Grahamdale will be discussed.

It should be noted that the selection of a particular area for further study does not indicate that only those impacts occurred at that location. For example, almost every type of flood related environmentally sensitive area impact could be found at the Twin Beaches area. Areas were selected to illustrate the particular effect noted.

2. Study Results

The following discussion is organized to present study results as they relate to the selection of projects for further study. Each will include background discussions and study results.

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2.1 Glenboro Lagoon

2.1.1 Background

From the survey questions, 30% of respondents indicated that flooding of lagoons had been observed at various locations. This was not overly surprising, as Manitoba municipalities rely on construction of multi-celled lagoons for the treatment of domestic waste. This is accomplished by sizing the lagoon capacity to hold sufficient volumes over a winter or summer period in a primary cell, transferring to a secondary clarifying cell. Effluent is then released to surface water streams, once testing has determined that biological pathogens, such as *E. coli* have been reduced to acceptable levels. Such systems by necessity are located near surface water bodies, usually streams and rivers. This means, that in the case of flood events, the lagoons are vulnerable, either by overtopping or backing up the drainage channels into the lagoon. This was certainly the case with the Melita lagoons, which are located in the flood plain of the Souris River, and which were overtopped in 2011. Closer to Glenboro were the Spruce Woods Park lagoons. These were not overtopped by the Assiniboine River in 2011. However, because the cells are located adjacent to the Assiniboine River, high flows caused severe erosion along the banks, and threatened the integrity of the lagoon. This has led to the need for relocating the lagoons to higher ground. Figure 2 shows the number of wastewater lagoons registered in the study area, and their proximity to surface water bodies.

With both the Melita and Spruce Woods lagoons, potential environmental risks may result from introduction of untreated sewage in the form of pathogens and coliforms. Impacts from such events can be high on a localized basis. However, high flows within surface water systems are part of functioning lagoon systems. High flows dilute any impacts to water quality to the point where changes are undetectable. This would be especially true during a large flood event. As well, pathogens such as *E. coli* are still exposed to UV light from the sun, and as such reduced in reproductive capability. So while near site conditions may be affected, the overall impact is greatly reduced over time and distance. The exception to this is that nutrients such as phosphates and nitrates, which are common components of waste water, can accumulate in downstream locations. This is certainly the case in Manitoba, and is of particular concern in Lake Winnipeg. Under normal operations, the treatment process from lagoons can decrease these values before release to the environment.

The fact that lagoons drain into rivers means that even during flood events, most of the volume of even an overtopped lagoon will be carried downstream. Further vulnerable systems such as groundwater are not as exposed to the full impacts of lagoon flooding.

The Glenboro Lagoon operates differently from traditional lagoon systems. The current lagoon was constructed in 1956 and rebuilt in 1982. Basically, the lagoon holds effluent until it is treated by UV radiation from the sun in order to remove pathogens. Rather than discharging the treated effluent to a nearby stream, the effluent is then infiltrated into the ground through a sand layer. In 2006, the bio-solids within the lagoon had accumulated since there had been no cleaning of the cell since 1982. The Department of Conservation

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issued a license for Glenboro to dredge the bottom of the lagoon, and spread the solids over nearby farmland in 2006. A review of potential impacts took place at the time, and the province noted that the levels of nutrient being applied were quite low. Conservation also noted that there was little danger of contaminating surface water sources due to the distance from any nearby streams or lakes. Strict application guidelines and timings were issued for the spreading.

During an event like the 2011 flood, the Glenboro lagoon waste water would essentially mix with the flood waters before any treatment from sunlight occurred. Unlike the Melita lagoon where high flows would dilute the wastewater and carry it far downstream, receding flood waters would present less of an opportunity for dispersion and mixing. This may provide an opportunity for nutrients to settle out in higher concentrations near the lagoon. More importantly, ground water access via uncapped or overtopped wells could occur, and introduce pathogens into the aquifer. Once in the aquifer, it is possible for organisms, particularly *E. coli* to reproduce rapidly, which could cause human health issues.

2.1.2 Site Visit

The location of the Glenboro Lagoon is shown in Figure 1. The site is located adjacent to the town of Glenboro on the west side, with access off a side road from PTH 2. At the time of the visit, no signage or restrictions to the property were observed.

The surrounding area was dominated by wetlands to the north and west. Spruce Woods Provincial Park was at least 10 km to the north of the site. The Cypress River was located east of the site, while the Assiniboine River was approximately 10 km north.

The lagoon was surrounded by a low dike which appeared to be at least partially new construction. Evidence on fence lines, shelter belt trees and posts in the area still clearly showed the high water mark from more than a year before.

Roadside ditches along the access road carried surface flows to the north, where large ditches along PTH 2 carried waters east and west. There were a number of groundwater wells in the area. Most rural residences had shallow sand point wells, which were vulnerable to surface seepage.

A wide variety of wildlife, including deer, waterfowl, small mammals and neotropical birds were observed in a 1 km radius of the site.

2.2 Delta Beaches

2.2.1 Background

The Delta Beaches area (Figure 1) is located on the south end of Lake Manitoba, and is home to a number of cottages, farm residences, and commercial enterprises. The Delta Waterfowl Wetlands Research station is located here as well. Delta Marsh is a well known ecological preserve, and is world famous for its research and educational pursuits. The Portage Diversion empties into Lake Manitoba to the west of the Beaches area.

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Examination of the Delta Beaches area was done in response to feedback from a number of received comments regarding hazardous materials. Originally, sites that were known depots for bulk storage of fuels, agricultural chemicals or other hazardous waste were targeted as part of the study. However, it soon became apparent that these facilities shared common traits such as:

- storage facilities were not likely located in areas prone to flooding;
- due to the lead time of the flood, any vulnerable storage locations were either emptied, or protected; and
- most facilities were located in towns where protections efforts included these types of facilities.

During the course of the study, no major point source of hazardous waste, other than lagoons was found. Partially, this was due to efforts from Manitoba Conservation. They circulated a “Fighting the Flood Fact Sheet” in January 2011 that included the following:

- anhydrous ammonia nurse wagons and delivery units must be moved out of the flood-prone area;
- pesticide warehouses must be emptied if there is a risk of flood waters reaching them; and
- fertilizer storage buildings must be emptied of packaged and bulk materials if there is a risk of flood waters reaching them.

Similarly the fact sheet contained advice for domestic residences, such as;

- small, portable, hazardous materials containers and packages (paint, cleaners, lube oil, water treatment chemicals, solvents, fuels, pesticides, agricultural chemicals, fertilizers, etc.) should be moved to higher ground and secured so they will not float away. Remember that many household products are a hazard to the public and the environment if they are released into the environment. Lids, caps, bungs and spouts, must be tightened so containers will not leak. Do not leave them in sheds or out buildings because high water can wash them out and downstream. It is advisable to move them out of the flood-prone area.

Commercial bulk storage facilities were located strategically so as not to be vulnerable to flooding, and had the equipment and staff to secure products. In spite of the fact that the Delta Beach community was located on the shore of Lake Manitoba, few residences secured domestic supplies of hazardous goods. This was probably in response to an overall belief that flood levels would not affect the area to any great extent.

The rapidity of the flood levels that occurred as a combination of high water levels and 2 m waves at Delta Beach caused overland flooding to the structures and property. Many cottages and homes were destroyed, along with numerous outbuildings, machine sheds, garages and storage compounds. There are an overwhelming number of stories regarding lost sheds that contained fuel, fertilizer, paint, herbicides, pesticides and other items, such as fishing nets. As one (1) respondent to the questionnaires stated:

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"This is not about large chemical sites. It is about the contents of private structures that were washed into Lake Manitoba and Delta Marsh."

This shifted the focus of the study from large commercial sites, which were largely found to have suffered few impacts from the flood, to domestic quantities that were stored in the hundreds of sheds that were destroyed by the flood. Cumulatively, the impact from the flooding of these facilities could be significant.

2.2.2 Site Visit

The area was accessed via PR 240, which exhibited signs of repair from the 2011 flood. The site visit was composed of three (3) components, including a tour along passable access roads, a lake front canoe trip of the south Delta Beach shoreline, and Delta Marsh along the northwest end.

It was immediately apparent that the level of damage was severe. Even though the flood had occurred more than 1 year previously, there were many buildings and structures that were still severely damaged, many likely beyond repair. Evidence of the high water was everywhere. Debris could still be found along the access roads and even in treed areas leading up to Delta Beach.

The shoreline tour revealed a number of debris items including dislodged trees, building materials, domestic waste and various containers. A destroyed fishing net was found entangled in the rocks near the mouth of the Portage Diversion. Severe erosion was evident along the entire length of the shoreline. The Delta Waterfowl Research Station appeared to be highly affected, with outbuildings and even the main structure exhibiting severe flood effects.

The canoe trip of the Delta Marsh revealed a large quantity of debris that could only have come from the flooding event. Items such as gas containers, paint cans, and sealed drums were observed along the shoreline and in the water. It was difficult to get an estimate of the volume of debris due to time constraints, but it ranged from sparse to dense depending on location. It should be noted that the observation area concentrated in the marsh cell nearest the outlet to Lake Manitoba, and where the Delta Waterfowl Research Station was located.

2.3 Twin Lakes Beach

2.3.1 Background

Twin Lakes Beach is located along the southeast shore of Lake Manitoba. Lake Frances is located slightly further to the east, and is separated from Lake Manitoba by a strip of land approximately 250 m wide that was formed between the two (2) water bodies as a result of deposition. This strip is where many early cottage properties were located. Twin Beaches has over 300 properties, but less than 50 permanent residents. Population numbers are over 1,000 during the summer months.

Water supply to the residents is generally by sand point well. These wells are easy and convenient to install. However, they may be more susceptible to contamination from surface sources than deeper wells.

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The presence of sand point wells for domestic water supply has also led to the installation of holding tanks for wastewater disposal. This is in large part to help avoid the potential for groundwater contamination by wastewater, which may be more likely with septic fields. Tanks are pumped regularly and disposed of in a nearby wastewater lagoon.

Respondents to the questionnaire focused on a number of issues, but a large percentage indicated issues with wells. This was because of the unique circumstances that engulfed Twin Beaches. The loosely consolidated fill around many of the holding tanks was easily eroded by the flood waters. This led to them floating up in the rising flood waters and often emptying their contents. Those tanks that were installed in more secure locations often had their contents displaced by the rising flood waters, letting the sewage escape to the environment. Several holding tanks could be seen floating in Lake Manitoba during the flood.

Most of the well heads in the area were overtopped. This provided an easy pathway into the groundwater supply for any contaminants. The situation was exacerbated by the length of time the flood waters remained. It was more than 4 months before the water receded, leaving time for many adverse effects to develop. Several respondents noted that they had positive tests for *E. coli* from their water tests, making the water unsuitable for domestic purposes.

The impact to the drinking water supply from the flood overtopping wells was widespread. One respondent from Lake Manitoba First Nation noted that for some time following the flood the water was unsuitable for drinking.

2.3.2 Site Visit

The site visit to Twin Beaches revealed an area that still exhibits many of the effects of the 2011 floods. The area visited is shown in Figure 1. Many buildings were completely destroyed, and on closer inspection some were clearly displaced from their original location. This would serve to severe any connection between domestic plumbing and holding tanks, which may exacerbate contamination from leakage.

During the brief visit, at least 12 holding tanks were seen to be lying on the surface where they had presumably been deposited after floating up during the high water period. Two (2) fibreglass holding tanks were damaged beyond repair, and any contents had obviously long leached out.

No tanks were observed in the lakes, although one (1) resident encountered during the visit indicated that he had seen one (1) in Lake Francis.

Several exposed well heads were observed. Most of these were secured against infiltration by either temporary or permanent plugs (sand filled), although it was not know if this was entirely due to the flood event. Although water levels had receded at the time of the site visit, it was easy to envisage how vulnerable several of the wells would have been to flood waters.

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2.4 Vegetation and Riparian Zones

2.4.1 Background

This was not something originally anticipated. However, it is readily observable anywhere within the 2011 flood footprint. Grahamdale expressed their concerns as follows:

"The 2011 Flood caused significant damage to Riparian Zones along the Lake Manitoba and Lake St. Martin shorelines. The extreme water levels and high winds that occurred during the flood also resulted in unusually high rates of erosion along the shoreline."

This was easily observable on field visits made during the course of the study. Although the problem was widespread, it was decided to concentrate on the Fairford River and Lake St. Martin Areas.

The effects of the flood on these areas were a result of different processes than experienced in other locations. All of the excess water from the Lake Manitoba area had to drain through these areas. This prolonged the effects of the flood, and led to more severe problems related to erosion and vegetation loss than were apparent elsewhere.

The most critical effect of vegetation loss is to the Riparian zone. Riparian areas are generally referred to as the transition zones along the banks of streams, rivers and lakes. These zones, sometimes called shorelands, are capable of holding saturation within the soil, resulting in the presence of lush vegetation. This vegetation in turn protects water quality by buffering run off to the water body. The vegetation also provides excellent habitat for a variety of wildlife and shore birds. Shore land vegetation also provides habitat and food sources for fish. Most importantly, the riparian zone allows rivers and streams to maintain a healthy channel profile, necessary to control water temperature, erosion, and depth. Riparian zones can be highly altered by extreme floods or elevated flows. Riparian zone sensitivity is related to the type of eco-region and the proclivity to flood events. The Prairie eco-region is among the most impacted by flood events. Most of the study area is located within this eco-region (Figure 3).

2.4.2 Site Visit

The site visit to Fairford was made in response to a written request from the RM of Grahamdale to include vegetation and riparian zones in the review. The Fairford River has long been subjected to extreme erosion events, and in some cases it was difficult to attribute effects to the 2011 flood.

However, there were high numbers of floating woody debris (trees and branches) that accumulated at bridges crossing the Fairford River. These trees were indicative of recent shoreline erosion. The fact that mature trees were falling into the stream indicated that the erosion had been relatively recent, particularly if trees had established over a long period of time. This observation was similar to several other areas impacted by the 2011 flood, where log jams actually were occurring as a result of the erosion due to high flows.

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The loss of the riparian zone in many areas was accompanied by severe erosion. In locations where trees had died and fallen from flood effects, it was easy to observe how much soil the root systems could carry into the waterway.

Lake St. Martin appeared to have lost much of the riparian lake shore zone. It was not possible to distinguish how long this effect had persisted.

3. Environmental Impacts

This section of the report is to discuss in broad terms the impacts that could be present as a result of the flood effects on environmentally sensitive locations. The following key points need to be considered:

This is not an evaluation of the entire environmental effects of the 2011 flood, only on aspects related to the four (4) selected projects.

Research was limited to available literature and feedback from people who filled out the questionnaires.

While site visits were conducted, it should be noted that no field studies were done. Also a number of sites were visited in a very short time frame.

No implications for mitigation activities were considered, as the event has already occurred.

The potential for impacts from the flooding of environmentally sensitive areas is high. In doing a high level review of the impacts, the following criteria were used:

Scope

- Local – effects would likely be observed within the immediate vicinity.
- Wide – effects were widespread.

Duration

- Short – probable effects would not be evident following 30 days of the event.
- Medium – probable effects would not be evident 1 year following the event.
- Long – probable effects would persist into the foreseeable future.

Significant

- No – potential impact not expected to be severe.
- Yes – potential impact expected to be severe.
- Unknown – effects of potential impact are unknown.

The following tables present the results.

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Project 1: Glenbrook Lagoon

Event	Source of Impact	Type of Effect	Scope	Duration	Significant
Overtopping of Lagoon	Untreated sewage into environment.	Flora and Fauna – contaminants into local system may affect local wildlife.	Local	Short	No
		Groundwater – potential for sewage to enter groundwater supply.	Local	Medium	Unknown
		Agriculture – Crops contaminants could impact local crop growth.	Local	Short	No
		Agriculture – Livestock dugouts for cattle watering could become contaminated.	Local	Short	No
		Human Health – pathogens in environment may cause human health concerns.	Local	Short	Unknown
		Recreational Activities – contaminants may restrict use of waterways/beaches.	Local	Short	No

Project 2: Delta Beach – Hazardous Contaminants

Event	Source of Impact.	Type of Effect	Scope	Duration	Significant
Destruction of storage sheds from flood waters.	Hazardous Products found in sheds enter the environment.	Flora and Fauna – hazardous waste products into local system may affect aquatic eco-systems.	Wide	Long – many containers may deteriorate over time.	Unknown
		Groundwater – potential for hazardous material to enter groundwater supply.	Local	Medium – depends on level of contamination.	Unknown
		Agriculture – crops contaminants could impact local crop growth.	Local	Short	No
		Agriculture – livestock dugouts for cattle watering could become contaminated.	Local	Short	No
		Human Health – pathogens in environment may cause human health concerns.	Local	Medium	Unknown
		Recreational Activities – contaminants may restrict use of waterways/beaches.	Local	Short	No

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Project 3: Twin Beaches Water Supply

Event	Source of Impact	Type of Effect	Scope	Duration	Significant
Overtopping of wells and destruction of sewage holding tanks.	Flooding of wells gives pathway to groundwater. Untreated sewage into environment.	Flora and Fauna – contaminants into local system may affect local wildlife.	Local	Short	No
		Groundwater- potential for sewage to enter groundwater supply. Potential for contaminants in groundwater.	Local	Medium	Unknown
		Agriculture – Crops contaminants could impact local crop growth.	Local	Short	No
		Agriculture – livestock dugouts for cattle watering could become contaminated	Local	Short	No
		Human Health – pathogens in environment may cause human health concerns.	Local	Medium	Unknown
		Recreational Activities – contaminants may restrict use of waterways/beaches. Cottage development may be restricted due to lack of water supply.	Local	Long	Unknown

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Project 4: Lake St. Martin - Loss of Riparian Areas

Event	Source of Impact	Type of Effect	Scope	Duration	Significant
High Outflows	Bank Erosion leading to sedimentation and nutrient loading.	Flora and Fauna – contaminants into local system may affect local wildlife. Spawning fish may have eggs covered. Loss of stream integrity/higher temperatures.	Wide	Medium	Yes
		Groundwater – high waters may change ground water tables.	Local	Medium	Unknown
		Agriculture – access to fields restricted by erosion.	Local	Short	No
		Agriculture – livestock may be unable to access water supplies.	Local	Short	No
		Human Health – N/A.	Local	Short	Unknown
		Recreational Activities – erosion may restrict boat access.	Local	Medium	No

4. Recommendations

It is certain that the flooding of environmentally sensitive zones during the 2011 flood event in Manitoba led to a number of environmental impacts. As previously stated, it is not the intent of this study to evaluate the entire environmental impact related to the flood, but only to categorize the types of impacts that may have occurred. This has been done by selecting representative projects that reflect the input of the general public.

In assessing the 2011 flood effects related to environmentally sensitive areas, there were many instances where either the scope or significance of impacts were unknown. These instances provide an opportunity to improve the understanding and future prevention of flood effects by undertaking further review and study. The following recommendations are therefore made with respect to instances where the significance or scope of the impact is either unknown, or where impacts are expected to be significant.

4.1 Monitoring for Groundwater Quality

Issues related to water quality result from contamination of the groundwater by floodwaters entering aquifers through pathways that are not normally available, such as uncapped wells or breaches in surface integrity. The following recommendations are made:

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- In areas where groundwater has been compromised by flood waters, institute an annual water quality program.
- Investigate the potential for raising well heads above flood level by:
  - establishing flood levels;
  - investigating technologies to extract water; and
  - making information available to avoid contamination in future floods.
- Investigate pathways and situations where groundwater may be contaminated, such as by sewage;
  - Investigate potential to avoid lagoon flooding by designing flood protection measures, such as flood proof berms; and
  - Establish criteria to protect holding tanks and make them flood resistant.
- Work with local property owners, First Nations and local governments to establish the scope of effects, and distribute information for avoiding future instances.
- Establish emergency procedures for instances of predicted flood.

4.2 Monitoring for Surface Water Quality

Issues related to water quality result from contamination of the surface water by floodwaters carrying hazardous or toxic substances into water ways. The following recommendations are made:

- In areas where surface water has been compromised by flood waters, institute an annual water quality program to establish basic water chemistry, metals, pesticides and hydrocarbons. This would be in addition to annual monitoring for recreational parameters.
- Investigate the potential for reducing potential contamination by:
  - establishing storage requirements for toxic substances in domestic quantities;
  - implementing a public education program to discuss making flood prone areas safe from potential hazardous material; and
  - making information available to avoid contamination in future floods.
- Inventory and remove any containers that may contain toxic material from existing waterways by:
  - establishing public relation programs that ensures that safety is foremost,
  - discouraging the public from handling floating containers etc.,
  - establishing "hot line" or email to receive reports of potential contaminated debris for removal by trained personnel, and

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- establishing criteria to continue a structured monitoring program for identification of high risk areas, such as Delta Beach, Twin Beaches, Assiniboine River and others.

4.3 Monitoring of Fish and Wildlife

The impacts to the fish and wildlife from the flood are not known. It is therefore recommended that a structured monitoring program for fish and wildlife, including habitat and physical environment, be instituted for the following:

- Impacted fish bearing waterways, specifically lower Assiniboine River, Lake Manitoba, Fairford River and Lake St. Martin should be monitored for:
  - Fish species composition.
  - Fish condition and health.
  - Fish growth rates and age composition for target species such as walleye, northern pike and perch.
  - Analyze data annually and note trends, such as year class gaps, increases in fish mortality, lowering or raising of growth rates.
  - Fish fecundity monitoring for reproductive capability.
- Review fish critical life cycle requirements (such as spawning and nursery) and identify the areas before and after the flood. Assess any changes and quantify if possible.
- Develop mitigation strategies for any losses of critical life cycle habitat.
- Establish a riparian health program along affected waterways that:
  - establishes the areas where riparian zones have been impacted,
  - implement a long term Riparian restoration strategy,
  - identify a prioritized restoration list, and
  - engage stakeholder groups in restoration and protection activities.
- Investigate erosion and sediment loading effects as a result of flooding.
  - Establish sediment regime as a result of pre and post flooding.
  - Review and establish new bed load conditions in major rivers and streams.
  - Implement an annual deposition/sedimentation investigation at junctions of major river mouths, flood by pass channels and major lakes.
- Establish aquatic mammal monitoring program along flood affected water courses for:
  - animal health and condition,
  - toxin accumulation in tissue, and

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  - mortality causes.

- Review critical life cycle requirements (such as breeding and nursery) and identify the areas before and after the flood. Assess any changes in flood affected areas and quantify if possible.
- Develop mitigation strategies to remediate impacted areas.

4.4 Establish Public Consultation Protocols for Environmental Issues

One (1) of the keys to environmental protection during flood events is the establishment of procedures and protocols that can be implemented. This requires buy in from the public. It is therefore recommended that:

- Flood protection information to be issued regarding environmental hazards that can be reduced or avoided;
- Conduct open house events and workshops in flood affected areas to discuss future mitigation options;
- Establish clear instructions and fact sheets regarding the types of effects to be reported and how to ensure safety is maintained;
- Establish call centre or contact protocol to deal with reports of flood effects that may compromise environmental and/or human health; and
- Work with stakeholders, such as commercial fishermen, First Nations subsistence fishers, hunters, rod and gun clubs etc to provide samples and to help with monitoring.

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Figures

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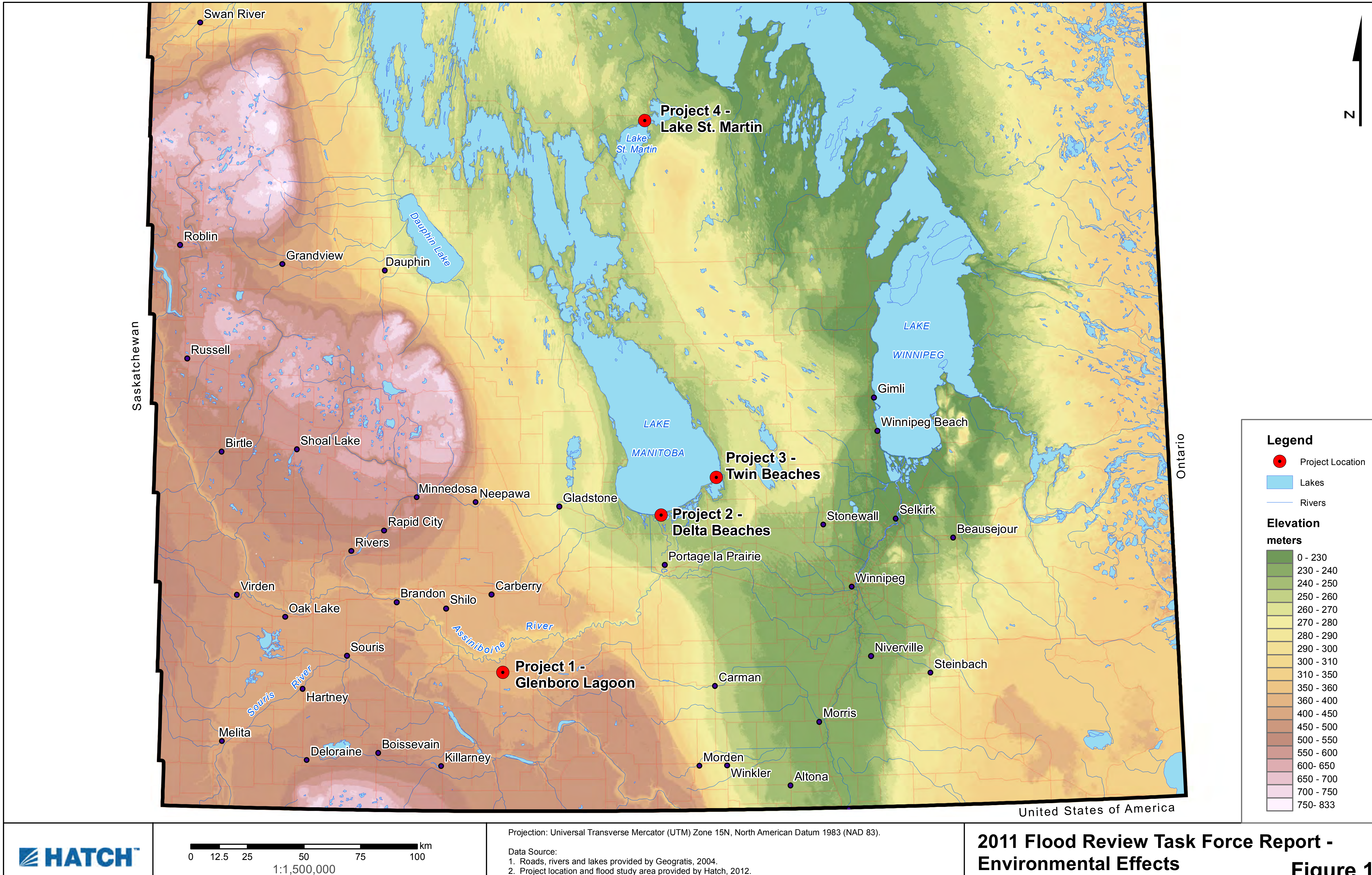

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Projection: Universal Transverse Mercator (UTM) Zone 15N, North American Datum 1983 (NAD 83).

Data Source:
1. Roads, rivers and lakes provided by Geogratis, 2004.
2. Project location and flood study area provided by Hatch, 2012.
3. SRTM data provided by USGS with acquisition date of 2004.

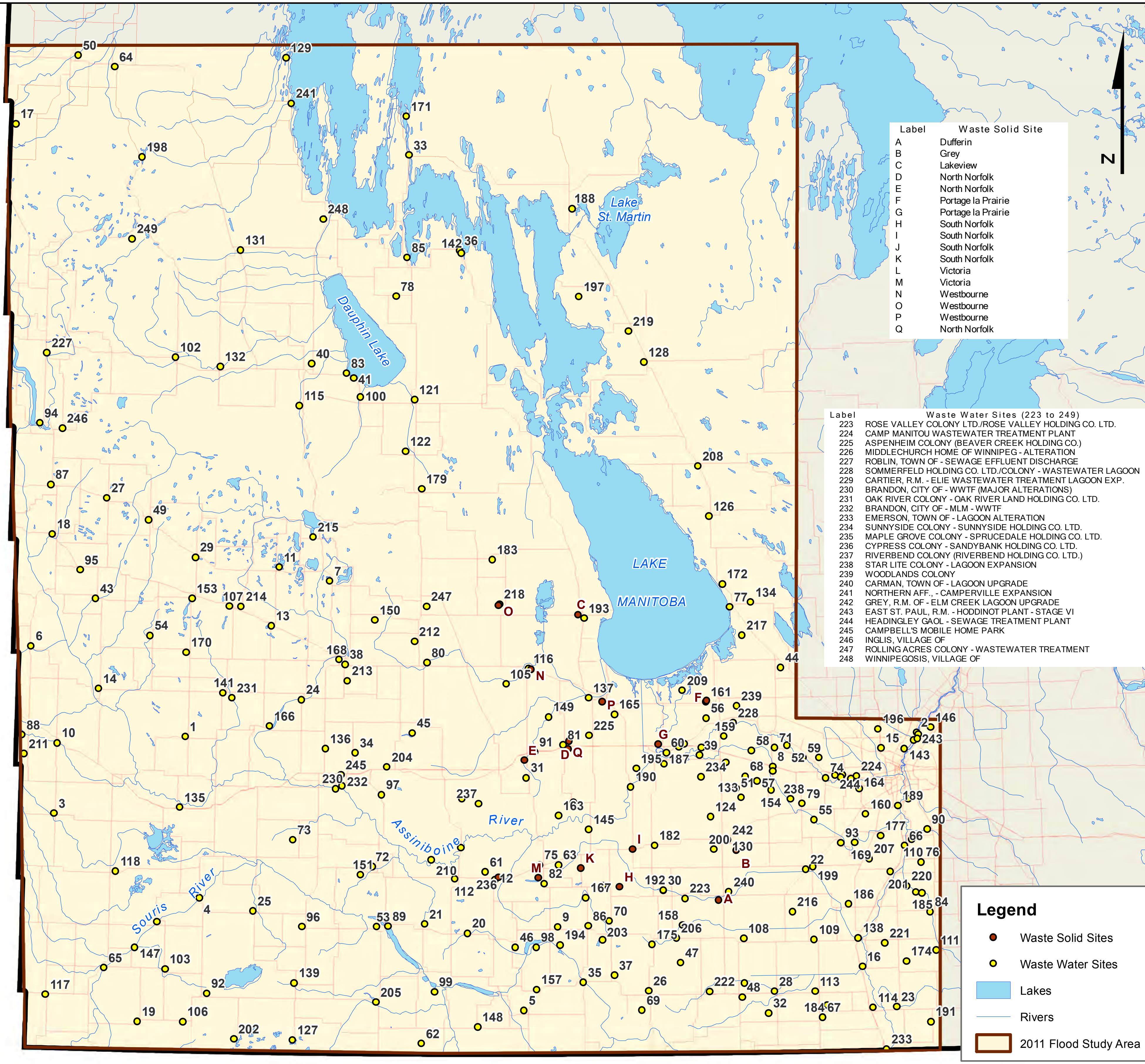
2011 Flood Review Task Force Report - Environmental Effects

Figure 1

Date Created: February 25, 2013

H342696-0000-07-124-0001, Rev 0

Label	Waste Water Site (1 to 112)
1	KENTON, VILLAGE OF
2	WPG., CITY OF(RIVERCREST)
3	ENBRIDGE PIPELINES INC. (CROMER)
4	HARTNEY, TOWN OF
5	CRYSTAL CITY, VILLAGE OF
6	MCAULEY, VILLAGE OF
7	ERICKSON, VILLAGE OF
8	CARTWRIGHT, VILLAGE OF
9	LORNE, R.M. OF - SWAN LAKE, VILLAGE OF
10	ELKHORN, VILLAGE OF
11	SANDY LAKE, VILLAGE OF
12	CYPRESS RIVER, VILLAGE OF
13	NEWDALE, VILLAGE OF
14	MINIOTA, VILLAGE OF(R.M. OF MINIOTA)
15	ENBRIDGE PIPELINES INC. (GRETNA)
16	ST. JEAN BAPTISTE, VILLAGE OF
17	BENITO, VILLAGE OF
18	BINSCARTH, VILLAGE OF
19	WASKADA, VILLAGE OF
20	ARGYLE, RM (Baldur Lagoon)
21	BELMONT, VILLAGE OF
22	BOWSMAN, VILLAGE OF
23	DOMINION CITY, VILLAGE OF
24	RAPID CITY, TOWN OF
25	ELGIN, VILLAGE OF
26	DARLINGFORD, VILLAGE OF
27	ANGUSVILLE (R.M. OF SILVER CREEK)
28	PLUM COULEE, VILLAGE OF (DIR. ORDER 3.044) MAY 20/98
29	OAKBURN, VILLAGE OF
30	PARKS - STEPHENFIELD PARK
31	HIDDEN VALLEY COLONY
32	BLUMENGART COLONY
33	FRONTIER SCHOOL DIV.(WATERHEN)
34	HILLSIDE COLONY
35	LA RIVIERE,VILLAGE OF (R.M. OF PEMBINA)
36	FRONTIER SCHOOL DIV.(CRANE RIVER)
37	MANITOU, VILLAGE OF
38	IMPERIAL OIL LIMITED - MINNEDOSA
39	ELM RIVER COLONY
40	DAUPHIN, TOWN OF
41	PARKS(RAINBOW BEACH)
42	CARTIER, R.M. - ELIE WASTEWATER TREATMENT LAGOON
43	BIRTLE, TOWN OF
44	SALVATION ARMY(R.M. OF WOODLANDS)
45	SPRUCEWOOD COLONY
46	MARIAPOLIS, VILLAGE OF(MAN. WATER SERVICES)
47	MIAMI HUTTERITE COLONY - SEWAGE DISPOSAL
48	WINKLER, TOWN OF
49	ROSSBURN, VILLAGE OF
50	SWAN RIVER, TOWN OF
51	GRAND COLONY - SEWAGE DISPOSAL
52	IBERVILLE COLONY - SEWAGE DISPOSAL
53	WELLWOOD COLONY
54	DECKER COLONY
55	HOMEWOOD COLONY(STARBUCK) - LAGOON
56	SOMEFELD COLONY(HIGH BLUFF) - SEWAGE SYSTEM
57	WALDHIEM COLONY(ELIE) - LAGOON
58	HURON COLONY(ELIE) - SEWAGE LAGOON
59	BARICKMAN COLONY - LAGOON
60	PORTAGE LA PRAIRIE, CITY OF - AER. SEWAGE LAG.
61	CYPRESS HUTTERITE COLONY
62	WILLOW CREEK COLONY
63	OAKRIDGE COLONY(HOLLAND) - SEWAGE DISPOSAL
64	MINITONAS, VILLAGE OF
65	MELITA, TOWN OF
66	UNIVERSITY OF MANITOBA - GLENLEA RESEARCH STN.
67	ALTONA, TOWN OF
68	BON HOMME COLONY(ELIE) - LAGOON
69	PEMBINA COLONY(DARLINGFORD - LAGOON
70	EVERGREEN COLONY(SOMERSET) - LAGOON
71	ROSEDALE COLONY(ELIE) - LAGOON
72	WAWANESA, VILLAGE OF - S.T.P.
73	NEWDALE COLONY(SOURIS) - LAGOON
74	CAMP ASSINIBOIA(R.M. OF CARTIER-HEADINGLY)
75	HOLLAND, VILLAGE OF
76	NIVERVILLE, VILLAGE OF
77	MAN. HOUSING & REN. CORP.(ST. LAURENT)-LAGOON
78	DUCK MTN. SCH. DIV.(RORKETON)-LAG.
79	STARBUCK, VILLAGE OF(MAN. WATER SERVICES)
80	NEEPAWA, TOWN OF
81	MACGREGOR, VILLAGE OF
82	TRAPPIST FATHERS(ST. NORBERT)
83	DAUPHIN COUNTRY CLUB LTD. - LAGOON
84	ST. PIERRE, VILLAGE OF
85	PARKS(MANIPOGO)
86	SOMERSET, VILLAGE OF - SEWAGE LAGOON
87	RUSSELL, TOWN OF - LAGOON
88	PLAINVIEW COLONY
89	NINETTE, VILLAGE OF(MAN. WATER SERVICES)
90	ILE DES CHENES, VILLAGE OF - M.W.S.B.
91	AUSTIN, VILLAGE OF(MAN. WATER SERVICES)
92	DELORAINE, TOWN OF(MAN. WATER SERVICES)
93	SANFORD, VILLAGE OF
94	PARKS(ASSESSIPPI)
95	FOXWARREN, VILLAGE OF
96	WHITEWATER, R.M. OF (MINTO)
97	SHILO INN
98	WINDY BAY COLONY
99	HOLMFIELD COLONY
100	OCHRE RIVER, VILLAGEOF (R.M. OF OCHRE RIVER)
101	WINNIPEGOSIS, VILLAGE OF
102	GRANDVIEW, TOWN OF(SE1/4-25-25-24W)
103	BRENDA, R.M. OF (MEDORA) NW32-3-24W
104	PARKS(SPRUCE WOODS PR. PK.) - SEWAGE LAGOON
105	RIVERDALE COLONY (ORDER #903 RESCINDED)
106	BRENDA, R.M. OF (GOODLANDS) NW1/4 2-2-24W
107	STRATHCLAIR, R.M. OF (SW 35-16-22) SEW. LAGOON
108	ROLAND, R.M. OF (NW114-2-5-4W)
109	LOWE FARM, VILLAGE OF - LAGOON
110	ST. ADOLPHE, VILLAGE OF - STBL. POND
111	ST. MALO, VILLAGE OF - WASTE STBL. POND



Label	Waste Solid Site
A	Dufferin
B	Grey
C	Lakeview
D	North Norfolk
E	North Norfolk
F	Portage la Prairie
G	Portage la Prairie
H	South Norfolk
I	South Norfolk
J	South Norfolk
K	South Norfolk
L	Victoria
M	Victoria
N	Westbourne
O	Westbourne
P	Westbourne
Q	North Norfolk

Label	Waste Water Sites (223 to 249)
223	ROSE VALLEY COLONY LTD./ROSE VALLEY HOLDING CO. LTD.
224	CAMP MANITOU WASTEWATER TREATMENT PLANT
225	ASPENHEIM COLONY (BEAVER CREEK HOLDING CO.)
226	MIDDLECHURCH HOME OF WINNIPEG - ALTERATION
227	ROBLIN, TOWN OF - SEWAGE EFFLUENT DISCHARGE
228	SOMMERFELD HOLDING CO. LTD./COLONY - WASTEWATER LAGOON
229	CARTIER, R.M. - ELIE WASTEWATER TREATMENT LAGOON EXP.
230	BRANDON, CITY OF - WWTF (MAJOR ALTERATIONS)
231	OAK RIVER COLONY - OAK RIVER LAND HOLDING CO. LTD.
232	BRANDON, CITY OF - MLM - WWTF
233	EMERSON, TOWN OF - LAGOON ALTERATION
234	SUNNYSIDE COLONY - SUNNYSIDE HOLDING CO. LTD.
235	MAPLE GROVE COLONY - SPRUCEDALE HOLDING CO. LTD.
236	CYPRESS COLONY - SANDYBANK HOLDING CO. LTD.
237	RIVERBEND COLONY (RIVERBEND HOLDING CO. LTD.)
238	STAR LITE COLONY - LAGOON EXPANSION
239	WOODLANDS COLONY
240	CARMAN, TOWN OF - LAGOON UPGRADE
241	NORTHERN AFF., - CAMPERVILLE EXPANSION
242	GREY, R.M. OF - ELM CREEK LAGOON UPGRADE
243	EAST ST. PAUL, R.M. - HODDINOT PLANT - STAGE VI
244	HEADINGLEY GAOL - SEWAGE TREATMENT PLANT
245	CAMPBELL'S MOBILE HOME PARK
246	INGLIS, VILLAGE OF
247	ROLLING ACRES COLONY - WASTEWATER TREATMENT
248	WINNIPEGOSIS, VILLAGE OF

Label	Waste Water Sites (112 to 222)
112	GLENBORO, VILLAGE OF - SEWAGE LAGOON
113	ROSENFELD, VILLAGE OF - SEWAGE LAGOON
114	MONTCALM, R.M. OF - LETELLIER SANITATION COOP
115	UKRAINIAN FOLK ARTS CENTRE + MUSEUM INC.
116	GLADSTONE, TOWN OF (SE1/4 29-14-11W)
117	PIERSON, VILLAGE OF - SEWAGE LAGOON EXPANSION
118	PIPESTONE, R.M. OF
119	WINKLER, TOWN OF (SW1/4 23-3-4W) LAGOON
120	WPG. BIBLE COLLEGE - STABILIZATION POND EXP.
121	STE. ROSE DU LAC, VILLAGE OF (EXPANSION)
122	LAURIER, VILLAGE OF (NW 18-22-15W)
123	BOWES TRAILER PARK
124	SUNNYSIDE COLONY WASTEWATER STABILIZATION POND
125	NOTRE DAME DE LOURDES (SE 2-7-9W) LAGOON
126	LUNDAR, VILLAGE OF (LAGOON EXPANSION)
127	PARKS(ADAM LAKE)
128	SIGLUNES, R.M. OF(VILLAGE OF ASHERN)
129	NORTHERN AF., DUCK BAY, COMMUNITY OF
130	GREY, R.M. OF - ELM CREEK SEWAGE LAGOON
131	ETHELBERT, VILLAGE OF
132	GILBERT PLAINS, VILLAGE OF - EXPANSION
133	GRAND COLONY FARMS LTD.
134	INTERLAKE COLONY FARMS LTD.
135	OAK LAKE, TOWN OF
136	ROLLING RIVER SCH. DIV. (R.M. OF ELTON)
137	WESTROC COLONY FARMS LTD. - BLOOMFIELD COLONY
138	MORRIS, TOWN OF (GOLF COURSE)
139	BOISSEVAIN, TOWN OF
140	PARKS(NORQUAY BEACH) - S.T.P.
141	OAK RIVER, VILLAGE OF
142	NORTHERN AF., CRANE RIVER
143	WPG., CITY OF(NORTH END POLLUTION CONTROL)
144	OAKVILLE, VILLAGE OF(MAN. WATER SERVICES) EXP.
145	SHADY LANE FARMS (BARICKMAN COLONY)
146	PINE RIDGE VILLAGE TRAILER PARK
147	BRENDA, R.M. OF - NAPINKA
148	ROBLIN, R.M. OF - MATHER
149	BONNE HOMME COLONY FARMS/KATRIME FARM SITE
150	UPLAND COLONY FARMS - R.M. OF MINTO
151	SPRING VALLEY COLONY FARMS
152	BREEZY BEND GOLF & COUNTRY CLUB
153	SHOAL LAKE, VILLAGE OF - EXPANSION
154	JAMES VALLEY COLONY - SE1/4 14-10-3W (LAGOON)
155	BIG SKY TRAVEL STOPS INC.
156	SHELL CANADA PRODUCTS LTD. - SHELL PRAIRIE INN
157	PILOT MOUND, VILLAGE OF - VAR. TO LIC. #875
158	ROSEBANK COLONY - WASTEWATER TREATMENT LAGOON
159	MILLTOWN COLONY - NORQUAY HOLDING CO. LTD.
160	OAK BLUFF - WASTEWATER TREATMENT LAGOON
161	PORTAGE LA PRAIRIE, R. M. OF - LIQUID WASTE
162	WPG., CITY OF(SOUTH END POLLUTION CONTROL)
163	CIRCLE SQUARE RANCH - WASTEWATER ALTERATION
164	WPG., CITY OF(WEST END POLLUTION CONTROL)
165	AIRPORT COLONY FARMS LTD.
166	NAT. RES., DEPT. OF (RIVERS CAMPGROUND) LAGOON
167	OAKRIDGE COLONY FARMS (KAMSLEY SITE)
168	MINNEDOSA, TOWN OF (OLD FILE NO. 3203.00)
169	VERMILLION COLONY FARM LTD.
170	HAMIOTA, VILLAGE OF (ALTERATION)
171	NORTHERN AF., DEPT OF - MALLARD COMMUNITY
172	ST. LAURENT, R.M. - WASTEWATER LAGOON
173	ST. FRANCOIS XAVIER, R.M. OF - ST. FRANCOIS
174	BLUE CLAY FARMS LTD. (BLUMENHOF HOLDING CO.)
175	MIAMI HOLDING CO. - DEERWOOD FARMS
176	SIMONSON RESIDENCE TREATMENT PLANT
177	LA SALLE, VILLAGE OF (EXPANSION)
178	CARBERRY, TOWN OF - LAGOON EXPANSION
179	MCCREARY, VILLAGE OF
180	RHINELAND, R.M./ALTONA (LIQUID WASTE H/PONDS)
181	RIVERGATE PROPERTIES INC.- S.T.P.
182	ST. CLAUDE, VILLAGE OF
183	GRASS RIVER COLONY - (ALTERATION)
184	ALTONA, TOWN OF - WASTEWATER LAGOON EXPANSION
185	DE SALABERRY, R.M. OF - OTTERBURNE
186	MORRIS, R.M. OF (ROSENORT LAGOON) EXPANSION
187	SOUTHPORT AEROSPACE CENTRE
188	PINEIMUTA PLACE LAGOON
189	HELLMUTH RESIDENCE TREATMENT PLANT
190	NEW ROSEDALE COLONY
191	MAXWELL HUTTERIAN - RIDGEVILLE COLONY
192	PARKS - STEPHENFIELD PARK
193	LAKEVIEW, R.M. OF - LANGRUTH LAGOON
194	VALLEY VIEW COLONY
195	GOOD HOPE HOLDING CO. LTD.
196	LAWRENCE AUCTION GROUP INC./WPG. AUTO AUCTION
197	GRAHAMDALE, L.G.D. OF - WASTEWATER
198	NAT. RES., DEPT. OF - WELLMAN LAKE (2-33-25)
199	MACDONALD, R.M. OF - (NW 1/4 20-7-1)
200	CLEARVIEW COLONY - EDEN HOLDING CO. LTD.
201	RITCHOT, R.M. - STE. AGATHE/RESCIND 191P - 97
202	WINCHESTER, R.M. OF - LAKE METIGOSHE
203	LORNE, R.M. OF - ST. LEON WASTEWATER LAGOON
204	MINTO HOLDING CO. LTD. - FAIRWAY COLONY
205	KILLARNEY, TOWN OF - WASTEWATER LAGOON
206	THOMPSON, R.M. OF - VILLAGE OF MIAMI
207	MACDONALD, R.M. OF - DOMAIN
208	ERIKSDALE, R.M. OF - LAGOON EXPANSION
209	WOODLANDS COLONY FARMS LTD.-WOODLANDS COLONY
210	MILLSHOF COLONY - MIBIDA INC.
211	PLAINVIEW HOLDING CO. LTD.-Boundary Lane Col.
212	SPRING HILL HOLDING CO. LTD.
213	ODANAH FARMS COLONY - 3124835 MANITOBA LTD.
214	HIGHLANDER AQUA-FARMS - STRATHCLAIR
215	PARK, L.G.D. OF - ONANOLE
216	SILVER WINDS HOLDING CO. LTD. (COLONY)
217	ST. ANDREWS, R.M. OF - WASTEWATER TREATMENT LAGOON
218	WESTBOURNE, R.M. OF - PLUMAS LAGOON ALTERATION
219	GRAHAMDALE, L.G.D. OF - MOOSEHORN
220	CRYSTAL SPRING COLONY FARMS LTD.
221	OAK BLUFF HOLDING CO. LTD./WASTEWATER TREATMENT LAGOON
222	MORDEN, TOWN OF - ALTERATION

HATCH™

km
0 15 30 60 90 120
1:1,550,000

Projection: Universal Transverse Mercator (UTM) Zone 15N, North American Datum 1983 (NAD 83).

Data Source:
1. Roads, rivers and lakes provided by Geogratis, 2004.
2. Solid Waste and Water Waste sites provided by MLI, 2012.
3. 2011 Flood study area boundary provided by Hatch, 2012.

2011 Flood Review Task Force Report - Environmental Effects

Figure 2

Date Created: February 25, 2013

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0 12.5 25 50 75 100 km

1:1,500,000

Projection: Universal Transverse Mercator (UTM) Zone 15N, North American Datum 1983 (NAD 83).

Data Source:
1. Roads, rivers and lakes provided by Geogratis, 2004.
2. Ecozones provided by MLI, 2012.
3. Project locations and study area boundary provided by Hatch, 2012.

2011 Flood Review Task Force Report - Environmental Effects

Figure 3

Date Created: February 25, 2013

H342696-0000-07-124-0001, Rev 0

Appendix A

Literature and References

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Appendix B

Survey Questionnaire

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SURVEY QUESTIONS-ENVIRONMENTAL AND WATER QUALITY

1.1) Name (Optional)

2. 2) Please check all that apply: Please select the option(s) that best describes the role in which you were impacted by the flood. You may select more than one option.

Home Owner
Cottage Owner
Farmer/Rancher
Business Owner
First Nations Member
First Nations Leader
Municipal Elected Official
Municipal Employee
Provincial Elected Official
Provincial Employee
Federal Elected Official
Federal Employee
Flood Fighter - Employed
Flood Fighter - Volunteer
Non-directly Impacted Citizen

3. 3) Are you aware of any sites where water supply and/or wells were impacted during the 2011 flood?

Yes
No
Not Sure

If yes, please identify the location of the site and briefly describe the effects of flooding. If you are aware of multiple sites, please choose one you feel is particularly significant or most typical of the flooding.

4. 3a) For the site you just described, on a scale of 1 to 5 please rate the effects of the flooding.

1 Minimal effect 2 3 4 5 –Extreme effect

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5. 3b) Are you aware of any flood mitigation measures put in place for the site described, before, during or after the 2011 flood?
Yes
No
Not Sure

If yes, please describe.

6. 3c) On a scale of 1 to 5, please rate the effectiveness of flood mitigation measures used for the site described.
Before
During
After

1 Not Effective 2 3 4 5 –Very Effective

7. 4) Are you aware of any environmentally sensitive sites such as sewage lagoons, landfill sites and/or gas, oil or farm chemical storage sites that were impacted by the 2011 flood?
Yes
No
Not Sure

If yes, please identify the location of the site and briefly describe the effects of flooding. If you are aware of
multiple sites, please choose one you feel is particularly significant or most typical of the flooding.

8. 4a) For the site you just described, on a scale of 1 to 5 please rate the effects of the flooding.

1 Minimal effect 2 3 4 5 –Extreme effect

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9. 4b) Are you aware of any flood mitigation measures put in place for the site described, before, during or after the 2011 flood?

Yes
No
Not Sure

10. 4c) On a scale of 1 to 5, please rate the effectiveness of flood mitigation measures used for the site described.

Before
During
After

1 Not Effective 2 3 4 5 –Very Effective

11. 5) We are interested in contacting some individuals with follow up questions on this topic. May we contact you?

Yes
No

If yes, how may we contact you (please provide a phone number or email address)?

12. 6) Please share any additional comments you may have here.

13. Email address:

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Appendix C

Survey Results
(Note: From Manitoba 2011 Flood Review Task Force TOR #6)

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Summary of Sites, Impacts and Mitigation Measures Described

Task Force Survey Report – TOR #6:

Environmental and Water Quality Impacts of the 2011 Manitoba Flood

The focus of this survey was on environmental and water quality impacts related to the 2011 flood. In particular, information was sought on locations where water quality and wells were impacted, as well as areas where environmentally sensitive developments such as landfills, sewage lagoons and gas, oil and farm chemical storage sites may have been impacted.

The survey was available on the Task Force website from June 12 to October 17, 2012. In total, 47 people started the survey, with 30 of those people, or 64 percent, completing it. In this report on the survey results, the responses are displayed visually, followed by summaries of the individual sites, impacts and mitigation measures as described by respondents. Note that many respondents did not answer all questions on the survey, or provided incomplete information. Please note that personal contact information and individuals names have been removed.

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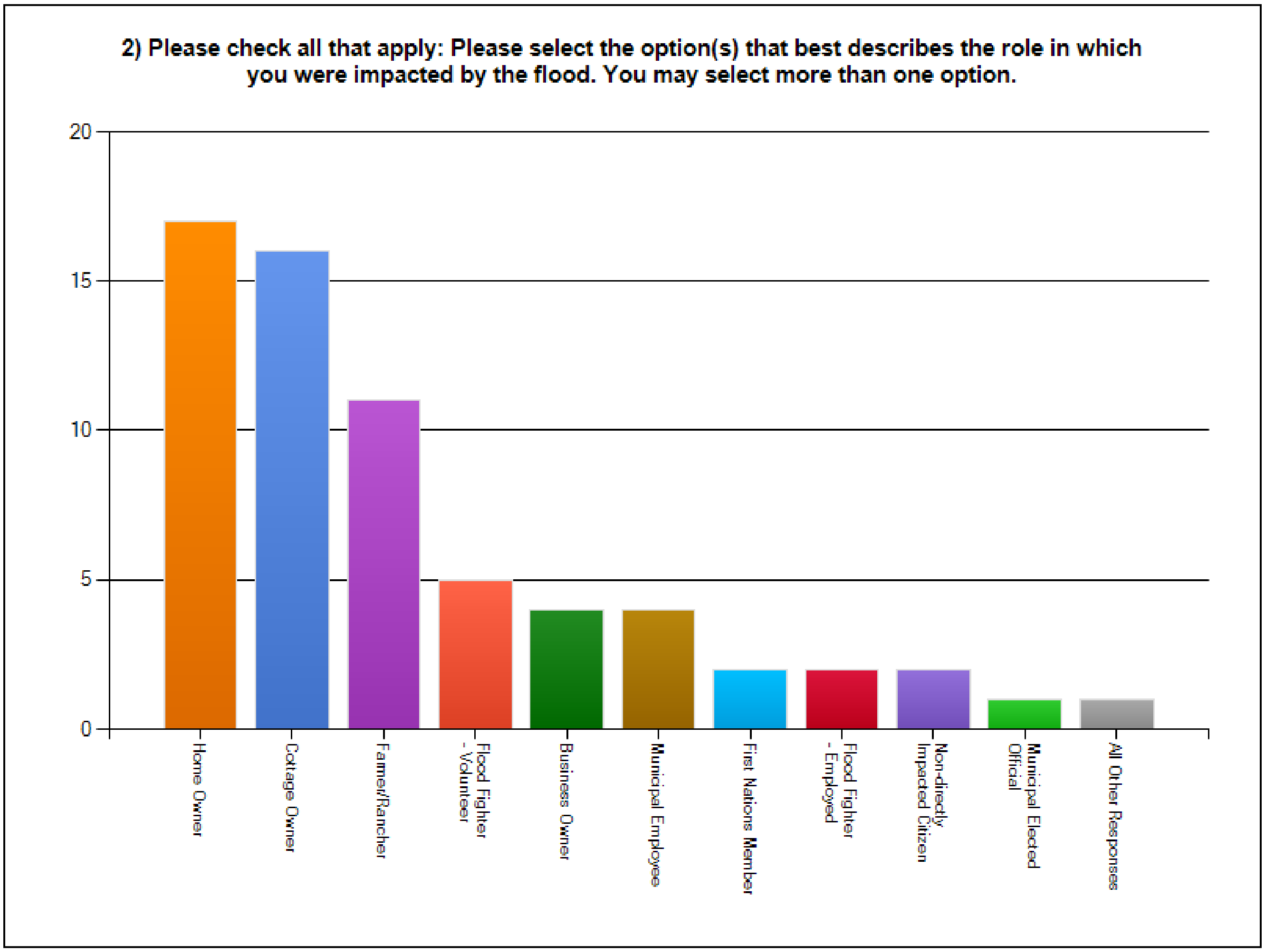
Visual Analysis of Results



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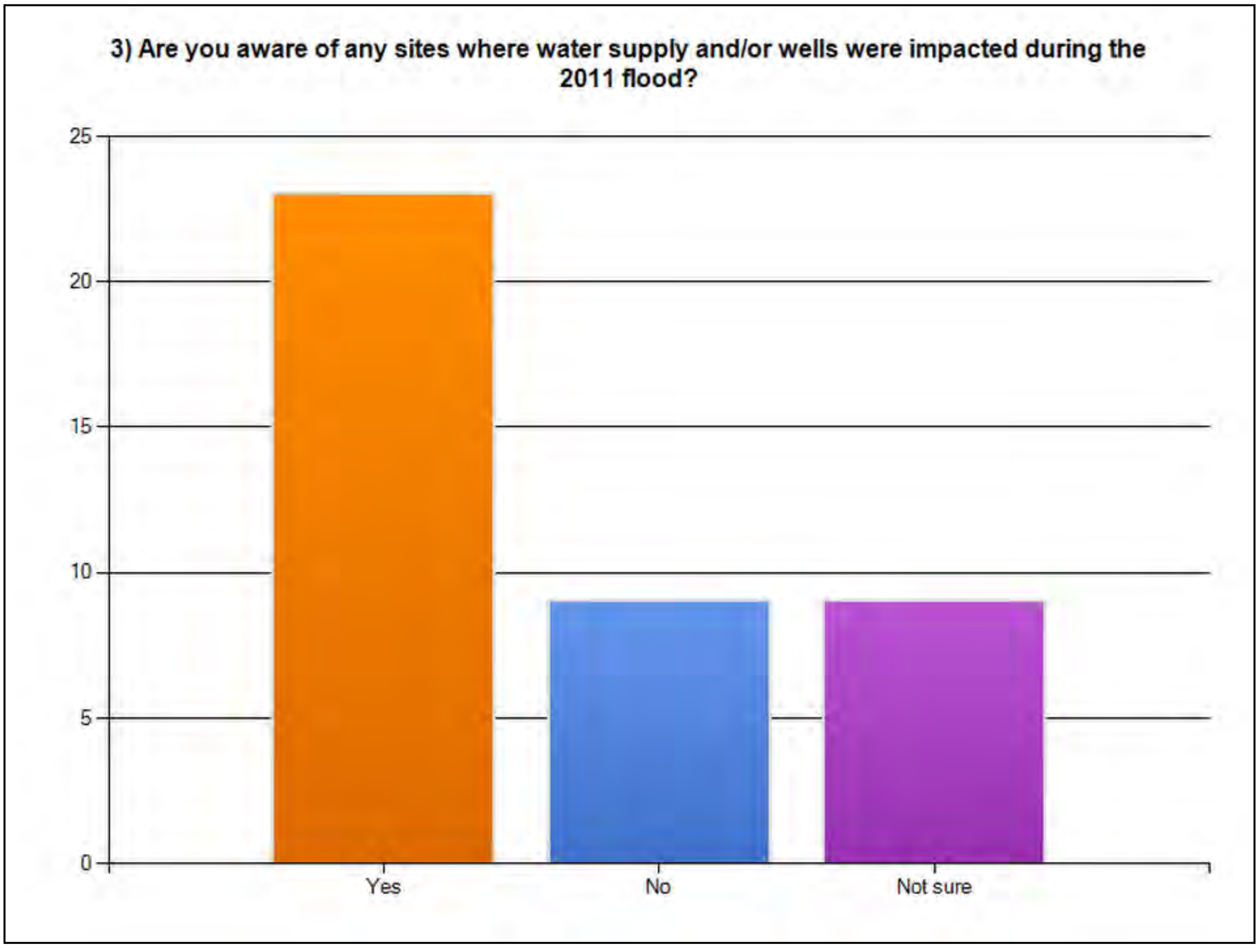

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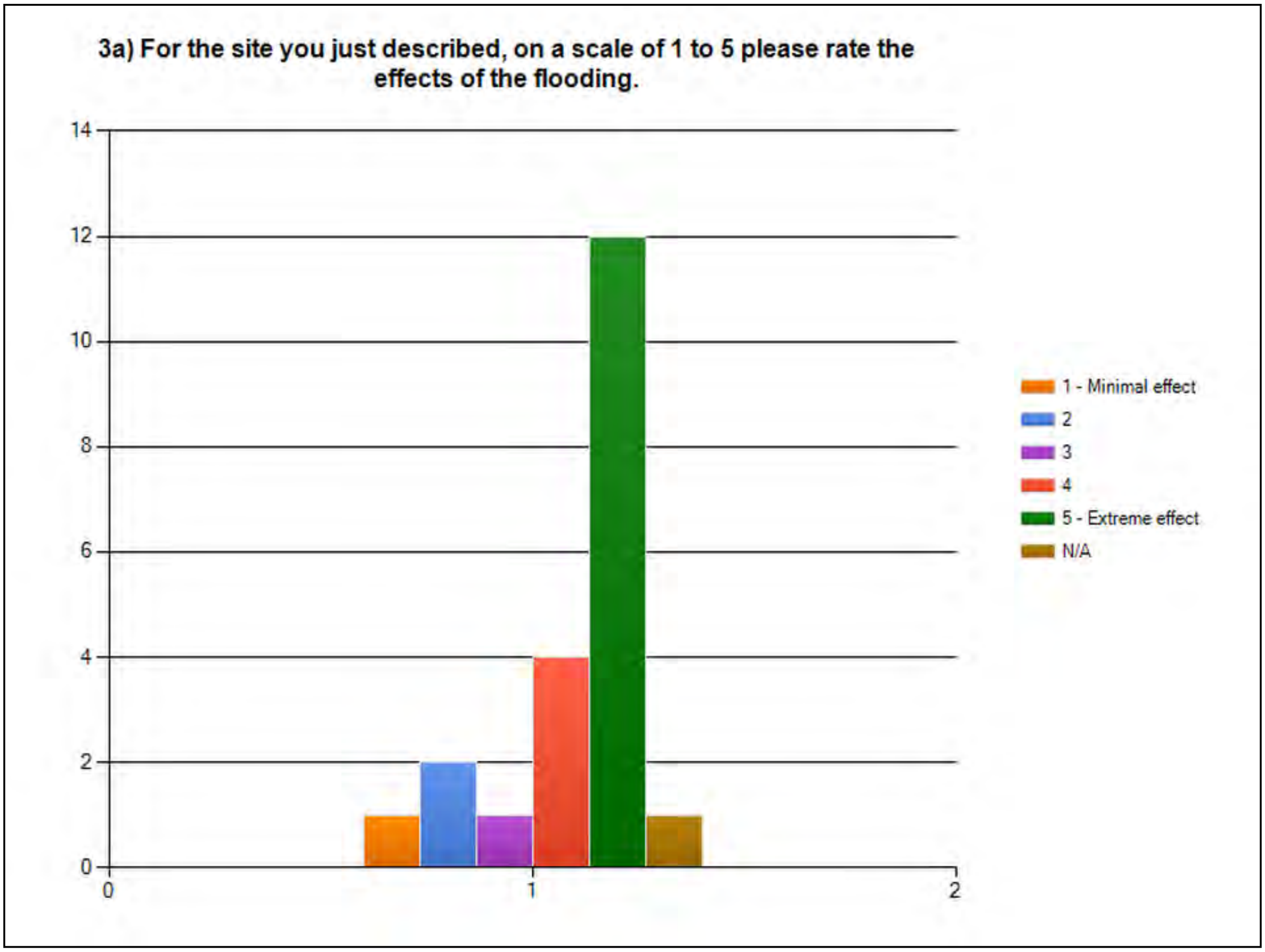

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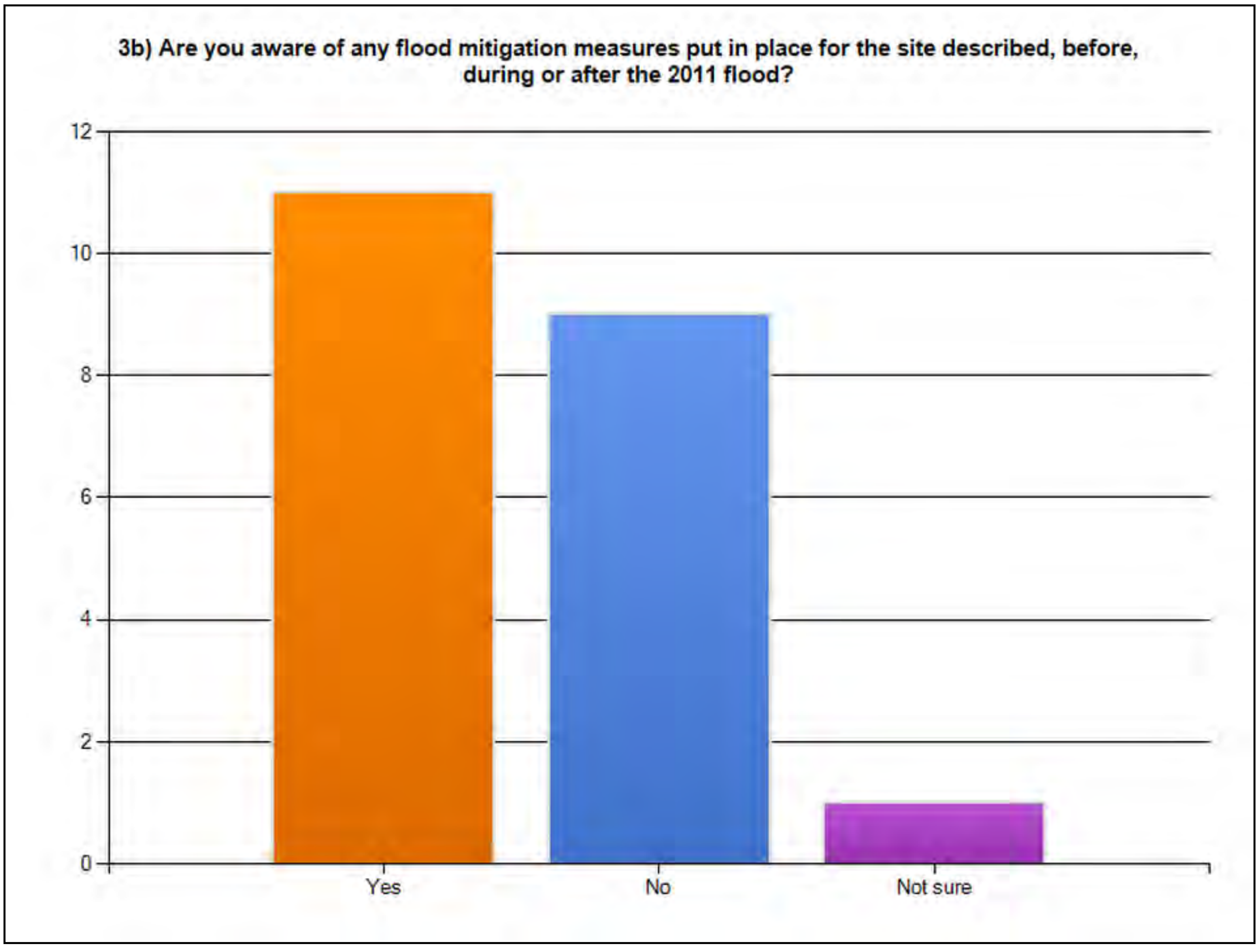

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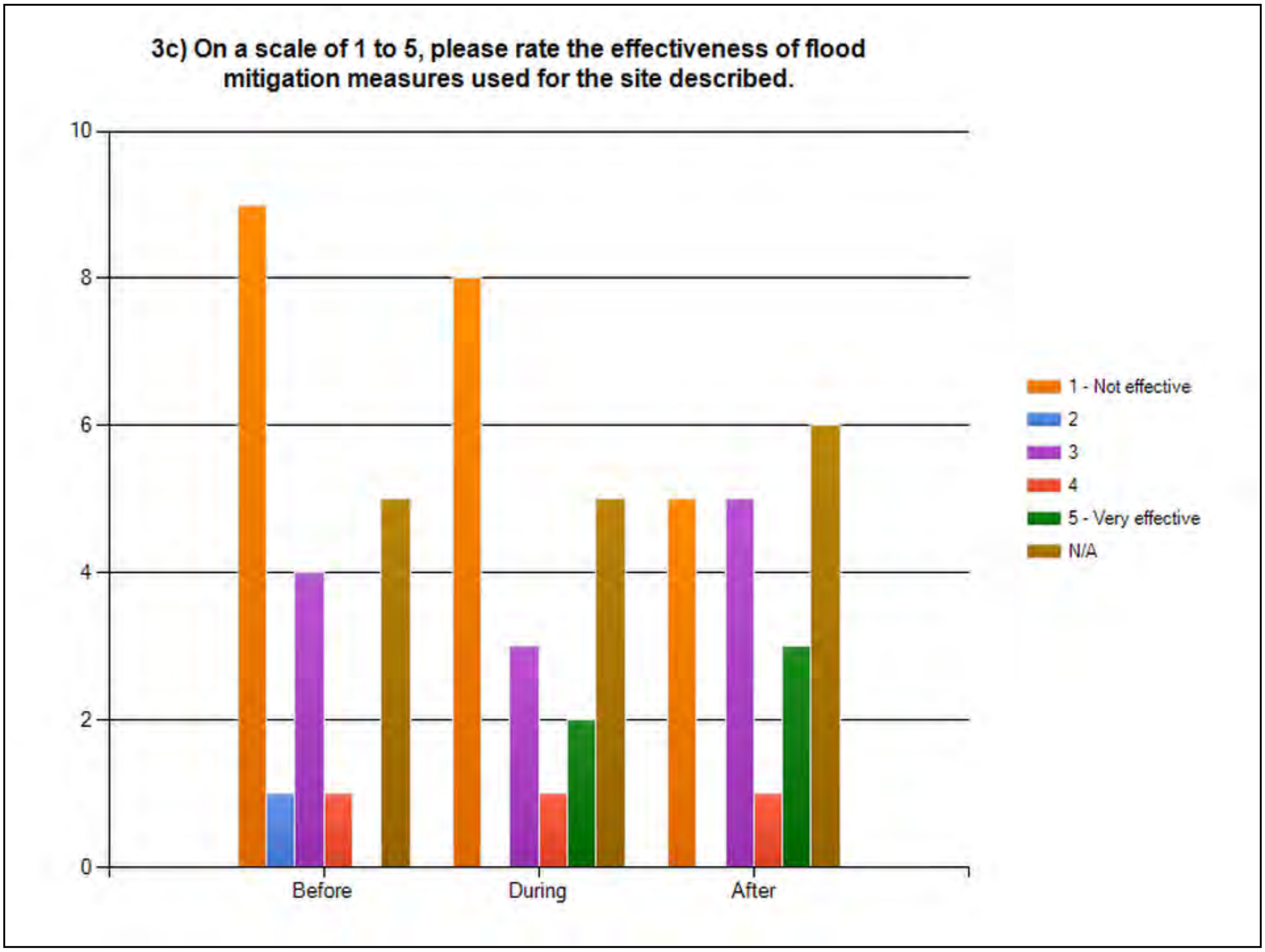

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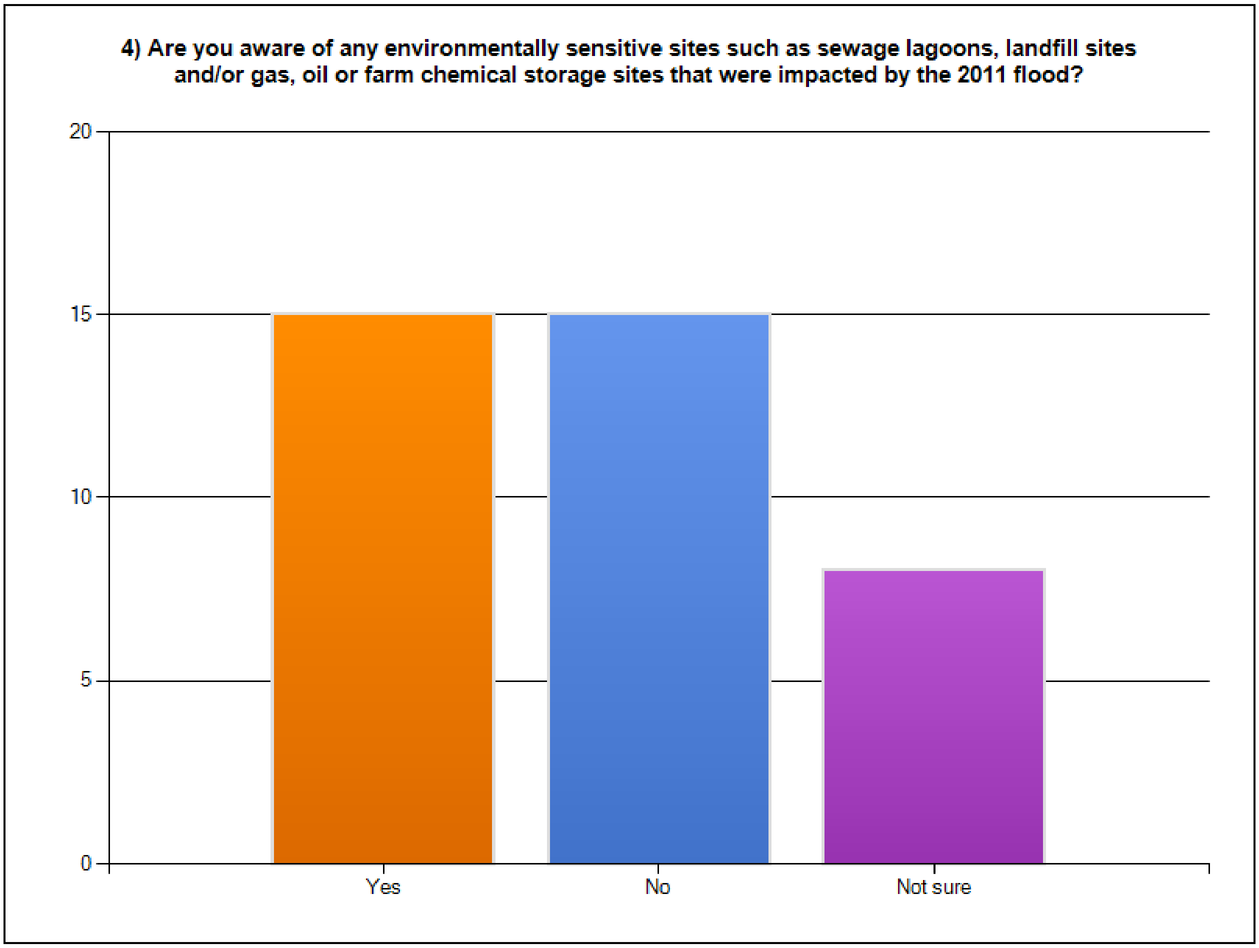

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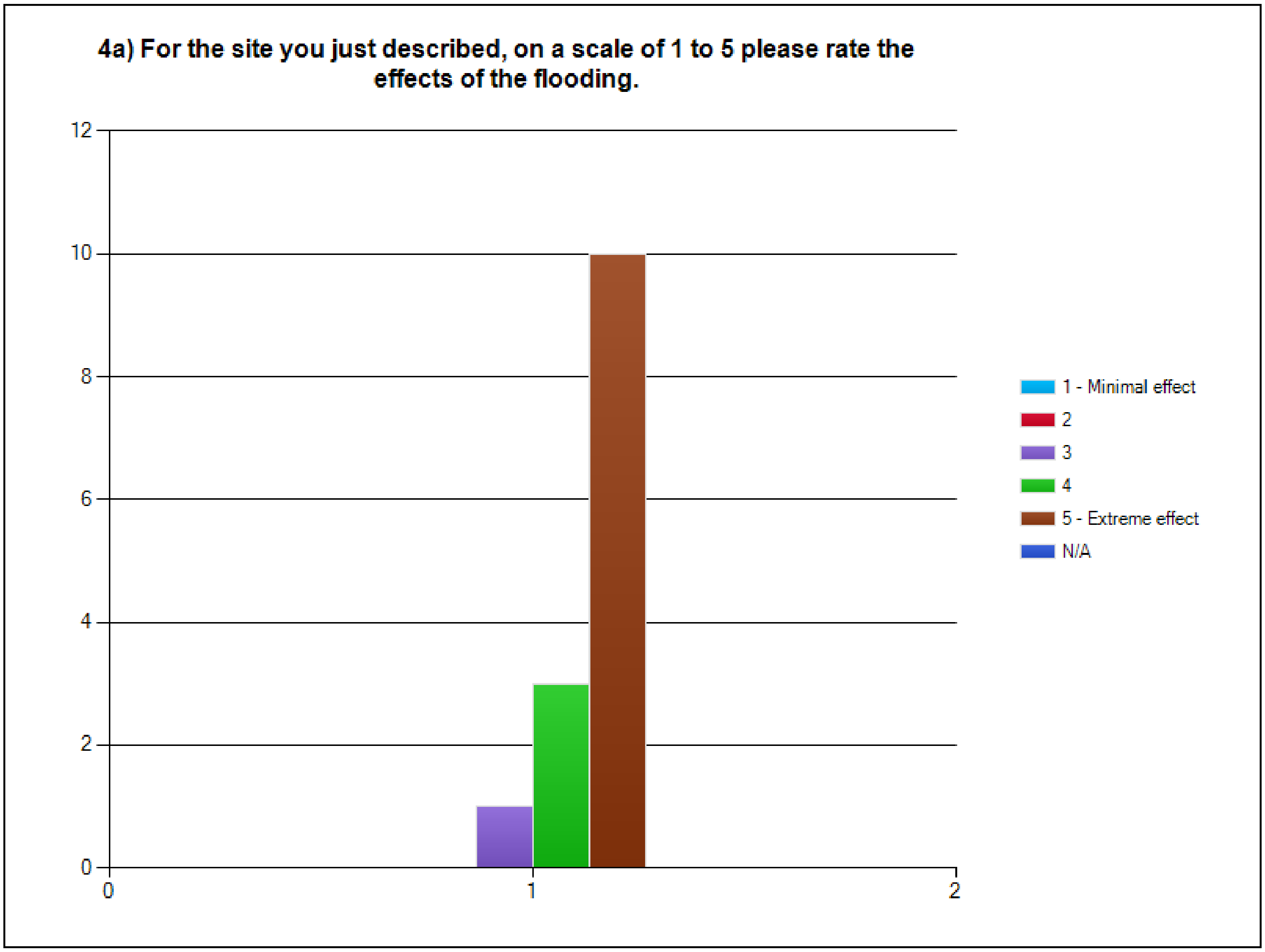

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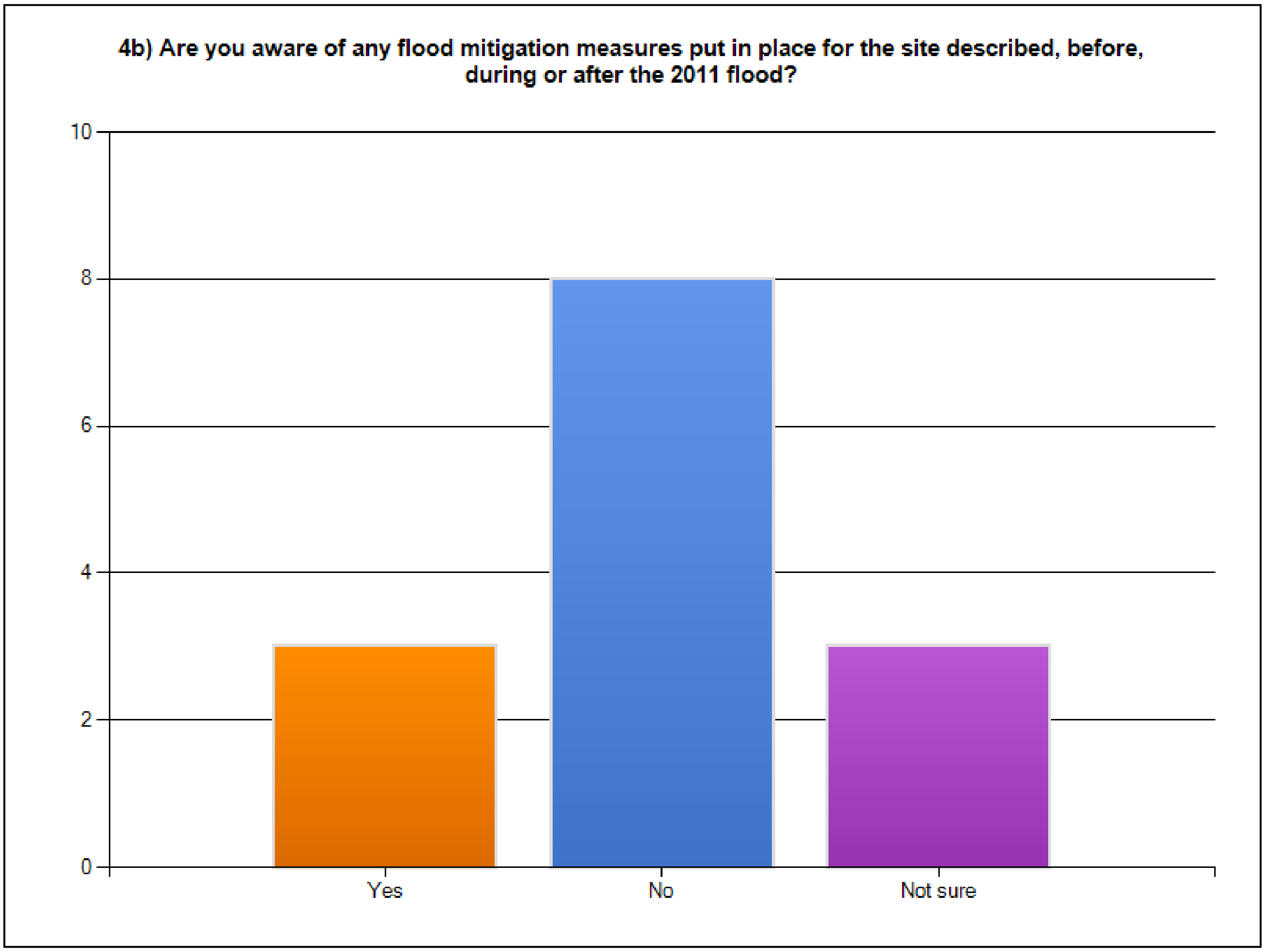

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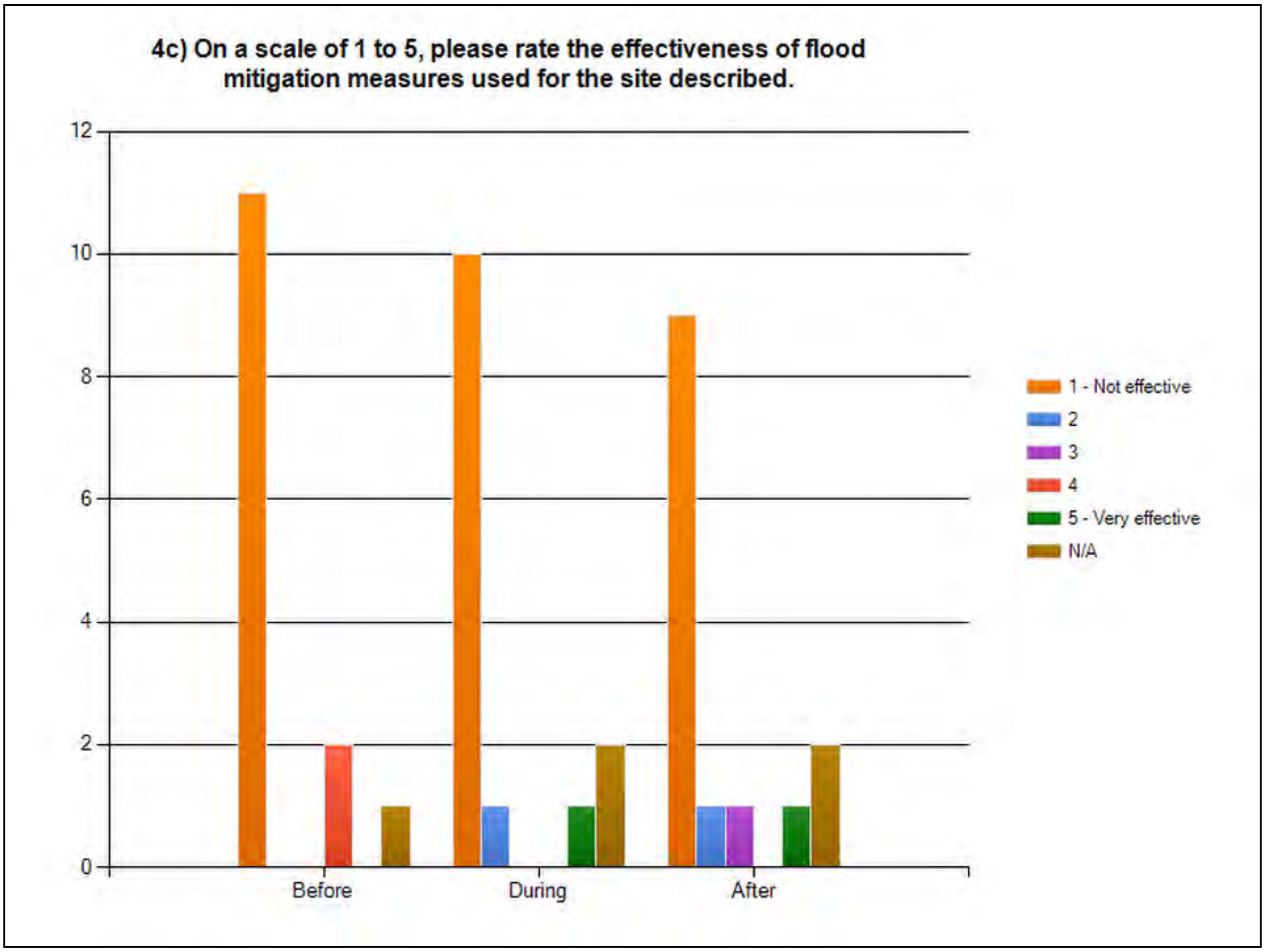

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Respondent Comments

1. Respondent: First Nations Member and Provincial Employee

This respondent described issues with drinking water on **Lake Manitoba First Nation** during and after the flood:

“During the flood and after, members of Lake Manitoba First Nation couldn't drink or use the water. Band members had to get water from the store and the amount of water that was given to each household was put at a limit. The water that flooded the community was dirty, filthy and there was plenty of garbage that came with it. My daughter has eczema and she had frequent flare ups from the change of water. The community no longer has a beach and the people couldn't fish. My family had an independent well nearby our home and that water was pulled out and topped off with sand without permission and is still stuffed with sand.”

The effects of flooding at this site were rated 4 out of 5 (with 5 equaling an extreme effect).
Flood mitigation measures put in place for this site were described as follows:

“The community was diked off as well as nearby our home. The water that was trapped inside the dike by the home was pumped out to the other side of the dike. However, the well was capped off with sand without permission and is still filled with sand. As a result, we can no longer use the well.”

The effectiveness of these mitigation measures were rated a 3 on a scale of 1 to 5.

Additional comments:

“Manitoba First Nation communities were deeply impacted by the flood of 2011, but it saddens me that the only thing that people heard of were the cottage owners. When I spoke of the flood to people I knew who were non Aboriginal and who didn't know much about Aboriginal communities, the first question I got many many times was "are you a cottage owner?" Aboriginal people were disregarded in the flood when the government [chose] to flood Lake Manitoba and even after lands, beaches, homes, cemeteries, homes, and roads were washed away by the flood of 2011. You should re-do your survey questions that will actually address the concerns related to Aboriginal people and the flood of 2011... or wait, you probably don't even know what to ask, because [you’re] another citizen of the government who don't really care about the effects that the flood has had on Aboriginal people and their communities.

2. Respondent: Cottage Owner and Volunteer Flood Fighter

Contact at:

This respondent did not identify any specific sites but noted:

“Many people had their holding tanks overflow and I know we lost 2 oil drums (either in the lake or marsh).”

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3. Respondent: Home Owner and Volunteer Flood Fighter
This respondent noted issues with water supply at **Lake Frances**:

"Many holding tanks were seen in the lake."

The effects of flooding on this site were described as extreme (5 out of 5).

4. Respondent: Municipal Employee, RM of Strathclair
This respondent indicated that the **sewage lagoon and landfill site at the Village of Strathclair** were impacted by the flood.

5. Respondent: Cottage Owner
Contact at:

This respondent indicated that there were issues at **Laurentia Beach**:

"Some septic tanks were completely destroyed."

The effects of flooding on this site were described as extreme (5 out of 5).

6. Respondent: Cottage Owner
Contact: phone:

This respondent indicated there many issues on public and private properties at **Sandpiper Beach in the RM of St. Laurent**:

"Septic tanks, fields, gas, oil, paint, herbicides, pesticides, etc. all swept from homes, garages, properties, etc during the initial storm. Then that water was left to stand for over 5 months on our properties."

The effects of flooding on this site were described as extreme (5 out of 5).

Flood mitigation measures put in place for this site included:

a). "An ill thought out geo-tubes design along Sandpiper Beach (it was not done properly or effectively in my opinion)".

b). "A raised dike through the RM. I understand why it was put in place, however, I am caught between the lake and the dike, with nowhere for the water to go. Are these measures permanent? Yes and No, depending who you ask. RM/ MASC/ MWS/ DFA all have different answers."

These mitigation measures were described as being not effective (1 out of 5).

Additional comments:

"Ensure the opening lines of your final report resemble this statement: The 2011 flooding around Lake Manitoba was caused by the NDP Selinger government's poor decisions."

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7. Respondent: Home Owner and Municipal Elected Official

This respondent indicated that sites were impacted at the **Maple Grove Hutterite colony near Lauder, MB**.

However, flooding was described as having a minimal effect (1 out of 5) on this site.

The respondent also indicated that the "**Melita, MB sewage treatment lagoon** was overrun by the flooding Souris River."

Effects of flooding on this site were described as extreme (5 out of 5).

8. Respondent: Cottage Owner

This respondent indicated there were wells impacted at **Twin Lakes Beach in the RMs of Woodlands and St. Laurent**:

"Wells submerged all of last summer. Holding Tanks popped out of ground others filled with flood waters displacing sewage."

Effects of flooding on this site were described as extreme (5 out of 5).

Mitigation measures described for this site included "sand bagging, gabion cages, rock works, Government built Demonstration Sea Wall."

These mitigation measures were rated 3 out of 5 for effectiveness before the flood, but only 1 out 5 for effectiveness during and after the flood.

Additional comments:

"The impact on the environment was huge. Natural vegetation is dead. The contaminants of gasoline, hydraulic fluid, paint, etc that were stored in sheds and garages are now in the ground."

9. Respondent: Home Owner

Contact:

This respondent also noted problems with wells at **Twin Lakes Beach**:

"I lived at XXXXX and the well head was destroyed on [May] 31st. I am sure a lot of the wells on the strip suffered the same damage."

Effects of flooding on this site were described as extreme (5 out of 5).

Flood mitigation measures described for the site included:

"A geo tube was put up in front of my home before it was destroyed by the mould as a result of the flood."

The effectiveness of this mitigation measure after the flood was rated as 3 out of 5.

10. Respondent: Home Owner

Contact:

This respondent noted impacts at **MacKenzie Bays on Twin Lakes Beach:**

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“Flood waters were high enough to engulf holding tanks along with wells in the area. This obviously has the potential to contaminate the wells.”

Effects of flooding on this site were rated 4 out of 5 (with 5 = extreme).

Mitigation measures described for this site included:

“Sandbagging was done around well sites but flood levels rose too high and, with evacuation orders, no remedial work could be done.”

These mitigation measures were rated 3 out of 5 for effectiveness before the flood, but only 1 out 5 for effectiveness during and after the flood.

The respondent also noted concern with unknown materials washed into Lake Manitoba.

The main flood mitigation measure put in place for this issue was sandbagging, which was described as being “completely ineffective against waves.”

This was rated as not effective (1 out of 5) before, during and after the flood.

11. Respondent: Home Owner
Contact:

This respondent described issues with wells in her area which was not specified but is presumed to be **Glenboro**:

“Every home in our area relies on a sandpoint well in our homes and anyone that experienced basement flooding, due to the high water table, had flood water in the hole surrounding their sandpoint well.”

Effects of flooding on this site were described as extreme (5 out of 5).

Flood mitigation measures were not specified but were described as having been put in place for some residents but not all. They were rated as not effective (1 out of 5) before, during and after the flood.

This respondent also noted that the **Glenboro lagoon** was impacted. The effects of flooding on this site were described as extreme (5 out of 5).

Additional comments:

“The 30 or so of us having to go to appeal are very disappointed in how this situation of sandpoint wells has been address by EMO and how we have been made to feel like ‘stupid rural hicks’.”

12. Respondent: Home Owner, Farmer/Rancher and Business Owner
Contact:

This respondent indicated that the sewage facility on the edge of **Manipogo Provincial Park** was flooded.

“I am not sure what action was taken. In my opinion that site should not be located where it is anyway and poses a severe threat if this high water is going to last.”

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Effects of flooding on this site were described as extreme (5 out of 5).

Additional comments:

"In general, as a home owner nearby, we have had many inspectors coming around and advising regarding damage to structures. We have also had a plethora of government agents coming around putting stakes into our driveway, by roadways, etc. indicating elevation levels. This is okay but more importantly, someone coming by to take water samples and test water on a regular basis would be more beneficial."

13. Respondent: Cottage Owner
Contact:

This respondent indicated there were unspecified impacts at "**Twin Beaches and the marsh, on the Woodlands side**."

Effects of flooding on this site were described as extreme (5 out of 5).

Mitigation measures put in place for this site included:

"22 trailer loads of rock and boulders were put down over the winter [to] re-enforce property frontage and shore line."

These measures were rated 4 out of 5 for effectiveness before the flood (5 = very effective), 1 out of 5 during the flood, and 3 out of 5 after the flood.

The respondent also noted that "many cabins, boat-houses and garages and all their contents on the Woodlands side of Twin Beaches were swept into the lake and marsh."

These flooding effects were also described as extreme (5 out of 5).

Additional comments:

"My lake front property is contaminated and worthless!"

14. Respondent: Cottage Owner
Contact:

This respondent indicated there were unspecified impacts at **Laurentia Beach**.

The effects of flooding on this site were rated 4 out of 5 (5 = extreme effect).

15. Respondent: Cottage Owner and Volunteer Flood Fighter
Contact:

This respondent indicated their well was impacted but the location was not specified:

"Well needs to be pumped out and shocked but nothing has been done to date as we are waiting for an engineer's report (we received one report then someone in their wisdom decided we didn't need a 4 ft

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cement foundation and could use a post and pad method for a cabin at half the cost of the foundation so now we are waiting for the revised engineers report) so we can get estimates from contractors to fix the property, send the estimate to the government and wait for the results, then contact the company that gives us the cheapest bid. Very frustrating dealing with engineers and contractors when we have had absolutely no experience dealing with this type of situation and we are supposed to know the laws and rules in the event of an accident of a worker on the job, etc. Whoever decided that the owner would be responsible for each and every worker involved must have had his head in the sand protecting themselves."

16. Respondent: Non-directly Impacted Citizen

This respondent indicated there were numerous impacted sites along the **Assiniboine River**.

The effects of flooding on this site were rated 4 out of 5 (5 = extreme effect).

Additional comments:

"Flooding also caused many other environmental issues not picked up by this survey. Examples include significant erosion, sedimentation, nutrient and contaminant mobilization and transport downstream."

17. Respondent: Farmer/Rancher

Contact:

This respondent indicated there were wells impacted in the **RM of Russell**:

"RM of Russell along banks of the river severely eroded away, wells flooded in homes."

Effects of flooding on this site were described as extreme (5 out of 5).

18. Respondent: First Nations Member and Employed Flood Fighter

Contact:

This respondent indicated there were impacts to the **sewage lagoon and septic tanks in Sandy Bay First Nation**:

"The sewage lagoon on our First Nation and most of the residents have septic holding tanks that overflowed onto land, cellars, basements and crawl spaces."

Effects of flooding on this site were described as extreme (5 out of 5).

19. Respondent: Cottage Owner

This respondent indicated impacts to **Leost Drive North and South**:

"The back fields along Leost Drive North and South are filled with debris left from the flood event."

Effects of flooding on this site were described as extreme (5 out of 5).

The respondent was not aware of any flood mitigation measures put in place for this site:

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"I do not believe the fields and marshes along St. Laurent Road were protected prior to the flood. The dike which was built to protect the school, church, cemetery etc. ensures the water and debris are contained in this area."

20. Respondent: Home Owner, Farmer/Rancher, Business Owner and Volunteer Flood Fighter
Contact:

This respondent noted the location of a specific site which was impacted: "**se18 29 11w**".

Effects of flooding on this site were rated 2 out of 5 (1 = minimal effect).

Additional comments:

"Septic fields, septic tanks, outhouses, and pump out tanks were flooded all around the lake. Fuel drums, oil jugs and pails have washed up on shore in various areas. There were places where water was 3 feet deep in machine sheds, with all the hazardous materials [they] contain. Tractors and equipment stood flooded over [their] crankcase[s] in some areas."

21. Respondent: Cottage Owner
Contact:

This respondent did not specify their location but it is presumed to be **Twin Beaches**:

"The [government] deliberately destroyed our well (the construction crew that tore down our building), the flood did not."

Effects of flooding on this site were described as extreme (5 out of 5).

Additional comments:

"We were told that the fire commissioner was going to remove hazardous material-propane tanks, gas tanks from properties....never happened at Twin Beaches."

22. Respondent: Cottage Owner
This respondent noted impacts but did not specify the location.

Mitigation measures were described as:

"Sandbagging along the lakeshore. However, it had little effect (I don't think sand bags are particularly effective against waves...). The well was flooded (entire system completely covered) and water remains non-potable, despite repeated treatments."

These mitigation measures were described as not effective (1 out of 5).

Additional comments:

"The death of hundreds of carp at Twin Lakes Beach is a concern. I read the report produced, and it is scant on detail. The research into the event does not appear to be particularly thorough. So much stuff was washed into Lake Francis and the surrounding marsh in 2011 that provincial scientists should at least

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consider the possibility that this event could be having an effect on the ecosystem. It appeared that they seemed eager to explain it away (i.e., the fish were in reproductive mode, they needed more oxygen and died was the rationale given for the deaths...). Please look into possible chemicals, metals or other contaminants that could have led to this event. The report did not indicate any such research had been done. Also, remediation of wells contaminated by the floods should not be at the expense of home and cottage owners, given that the Portage Diversion accounted for at least 3 ft of the flooding. Wells remain contaminated and communication about health risks [is] almost non-existent."

23. Respondent: Home Owner
Contact:

This respondent noted impacts to **Twin Beaches**.

Effects of flooding on this site were described as extreme (5 out of 5).

Flood mitigation measures put in place for this site included a ring dike.

This was rated 3 out of 5 for effectiveness before the flood, and 5 out of 5 (5 = very effective) during and after the flood.

The respondent also noted impacts to **Delta Marsh**:

"I have aerial photos and videos of what is in Delta Marsh. Quite [possibly] one of the worst environmental disaster[s] in the province of Manitoba. I know there was a very good reason why the Province did not allow any of their assessors [to] touch the water. In [an] area with stagnate water, there were no insects to speak of [mosquitoes]. An area teaming with bird life...it was totally void...the only thing creature that survived were frogs. Fish were dying due to the "lack of oxygen". I guess so. How can they survive breathing Freon, Propane, Gasoline, Diesel Fuel and [whatever] is in TV Tubes? The extent is unbelievable."

Effects of flooding on this site were described as extreme (5 out of 5).

Additional comments:

"So far it is a major concern that is ignored. Attempting to stop water quality measurements will not make the problem go away."

24. Respondent: Municipal Employee and Employed Flood Fighter
Contact:

This respondent noted there were impacts in the **RM of St Laurent**.

Effects of flooding on this site were described as extreme (5 out of 5).

The respondent indicated that no flood mitigation measures were put in place at this site before the flood, but dikes were built afterward.

These dikes were rated as being very effective during and after the flood.

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The respondent noted impacts to the **sewage lagoon for the RM's government housing**:

"RM of St Laurent sewage lagoon for the Govt Housing. Also there were several private septic tanks popping out the ground, outhouses floating, gas and propane tanks floating by."

Effects of flooding on this site were described as extreme (5 out of 5).

25. Respondent: Cottage Owner
Contact:

The respondent indicated there were impacts to a deep well at **Lots 318 and 319 in Twin Lakes Beach**.

Effects of flooding on this site were described as extreme (5 out of 5).

Flood mitigation measures for this site included:

"The municipality bulldozed our cabin and cleaned up our lot including a shallow well that after the flood was several feet out in the lake - there is still glass in the sand however."

These mitigation measures were rated as not effective (1 out of 5) before and during the flood, but 4 out of 5 afterward.

The respondent noted other issues at the same location as above:

"319 Twin Lakes Beach and our immediate neighbours - our septic tanks were swept away as were our outhouses. Storage buildings were destroyed which contained various household chemicals. The contents of our cabins were swept away including hot water tanks. Our refrigerator was supposedly taken to the land dump."

Effects of flooding on this site were described as extreme (5 out of 5).

26. Respondent: Farmer/Rancher and Volunteer Flood Fighter
This respondent indicated their well near **Langruth** was impacted:

"Our well [at] our farm near Langruth ran for months due to the high water table around Lake Manitoba."

Effects of flooding on this site were rated 3 out of 5 (5 = extreme).

Additional comments:

"I feel I did not have significant environmental and water quality impacts."

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