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FINAL REPORT

Human Health Risk Assessment RED RIVER Floodway Expansion Project

MANITOBA FLOODWAY AUTHORITY

PROJECT NO. 1025616

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REPORT TO	**Manitoba Floodway Authority** **200 – 155 Carleton Street** **Winnipeg, MB R3C 3H8**
FOR	**Final Report - Human Health Risk Assessment**
ON	**Red River Floodway Expansion Project**

July 31, 2008

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EXECUTIVE SUMMARY

Jacques Whitford was commissioned by the Manitoba Floodway Authority (MFA) to conduct a human health risk assessment (HHRA) resulting from potential changes in water quality due to the current expansion of the Red River Floodway. Public perception about the project has suggested that health risk may be increased as a result of increased chemical hazards originating in surface runoff from upstream areas that enter the channel during flood events or that the widening of the channel will bring the existing hazards closer to existing domestic wells adjacent to the alignment. Particular concerns have been raised during public consultation and permitting, suggesting that elevated levels of chemicals of concern in the Floodway waters may be able migrate into domestic supply wells adjacent to the Floodway and affect potable drinking well supplies. As part of its permit requirements, the MFA was required to conduct an independent HHRA to assess potential human health risks associated with the widening of the Floodway channel. As this HHRA progressed, consultation was used to confirm key public concerns were being adequately considered and addressed, within the context of the overall project scope. Consultation included two rounds of public meetings, one after the initial review of existing data (to verify conclusions of existing conditions and issues drawn by Jacques Whitford), and after the draft report was issued to confirm key concerns were addressed and the HHRA process was understood and generally accepted.

A detailed review of previous groundwater modeling and monitoring data was completed to determine if potential operable pathways between surface water and groundwater could occur during flood events. The study reviewed previous modeling efforts, and revisited the 2-D transient flow model in an attempt to use this tool to predict groundwater impacts during flood conditions. This effort was unsuccessful as the previous and re-visited models could not be calibrated. To complete the HHRA, the risk assessment adopted an exposure evaluation approach through a review of existing surface water and groundwater data to determine health risks. The following steps were followed:

- A database of all monitoring data for groundwater and surface water was assembled. This included surface water and groundwater data between the period 2005 to 2008 inclusive, for flood and non-flood periods.
- The database was sorted by surface water and groundwater.
- The groundwater data was separated between monitor wells and domestic (bedrock) water supply wells
- The overburden monitoring wells were further subdivided based on geological conditions (i.e. sand and gravel, or clay tills) .
- Certain data was excluded from analysis based on hydrogeologic factors (i.e. groundwater wells located in low permeable clay formations, typically found south of Highway 15). However, groundwater seeps (“blow-outs”) located between the TransCanada Highway and Highway 15 at the Deacon Reservoir, were considered.
- The remaining data (north of Highway 15) was carried forward for further analysis. Anomalous data (i.e. wells with water softeners) was removed from the data set. A limited amount of data (7 wells) was also excluded as their location relative to the floodway could not be determined. Ultimately, a total of 20 overburden monitor wells, and 29 bedrock monitor wells, and 286 domestic wells were used in the analysis.

- The final data set was then sorted by flood and non-flood events, although the effects of precipitation on local well water quality was not included. Flood event data included the time period from start of operation to one month after end of Floodway operation (to account for latent effects of surface water infiltration).
- For surface water, only data obtained between the inlet and outlet Floodway control structures were consider as source data; other data upstream and downstream (from the Red River) was excluded. The surface water data was used to identify potential indicator parameters (such as nitrate) that were unique and largely different in concentration to that seen in the groundwater. Using indicator parameters, trends were plotted to determine if the groundwater concentrations changes during flood events directly in the Floodway channel, and if so, how these varied with distance. When groundwater concentrations declined to those seen in non-flood periods, a zone of influence could be determined.
- Monitor well groundwater chemistry data from was sorted by lateral distance in 100 m increments from the Floodway centerline. Analysis of data was completed (median, mean) for select indicator parameters (such as TSS, major ions, conductance) and plotted for both flood and non-flood events to determine trends and distances extending laterally outward from the Floodway centerline.
- Health based parameters (i.e. human health hazards) considered in the analysis included nitrates and bacteria. Limited pesticide and other chemical data was also considered where available.
- The most sensitive receptors were identified as residents with domestic supply wells within the zone of influence, following the Floodway widening.
- The existing monitor well data was used to first determine the extent of the groundwater "zone of influence" associated with the flood operations. Subsequently, this zone of influence (approximately 300m from the Floodway centerline) was used to identify potential points of exposure (i.e. domestic wells located within in close proximity to the identified zone of influence). The potential risk based parameters that could have an effect on human health (e.g. nitrate, e-coli, fecal coliform) were then evaluated.
- From the analysis of the water quality data we found that domestic water supply wells within the identified zone of influence were evaluated for health-based parameters (nitrate and bacteria) and found to be consistently below water quality guidelines, and had concentrations consistent with domestic wells outside the zone of influence (background or naturally occurring values).

Based on the independent analysis and results provided in this study, Jacques Whitford provides the following conclusions:

- Through review and public consultation, issues of public concern with regards to the widening of the existing Floodway were identified and assessed.
- Modeling could not be used as a definitive tool to demonstrate potential exposure pathways to sensitive receptors (surface water to potable groundwater wells) as there is insufficient aquifer data to permit model calibration. As modeling was not conclusive, the potential of a pathway was assumed and required study.
- In the absence of modeling, a risk assessment using pathway analysis could not be completed, and an exposure assessment using existing groundwater and surface water data was conducted in support a qualitative human health risk assessment..
- There are confirmed differences in surface water quality in the Floodway between flood and non-flood events that represent potential hazards to residents along the floodway (i.e. elevated nitrate and bacteria).

- There are varying geological conditions along the Floodway alignment that can influence the pathway between surface water and groundwater. The least sensitive geological area generally lies south of Highway 15 in areas of low permeable clay till. The most sensitive geological formations are those which provide a direct interaction between surface floodwater and bedrock groundwater (areas between Birds Hill to outlet near Lockport). The area between Highway 15 and Birds Hill have geological formations which also make the area susceptible to interaction between surface water and the bedrock groundwater.
- Selected parameters that were found to be different in concentration when comparing flood and non-flood periods were used as indicators to determine the zone of influence in the overburden of the Floodway on groundwater. Using nitrate and conductance as indicator parameters, it was demonstrated that the lateral zone of influence in overburden monitor wells extends to approximately 300m from the Floodway centerline. This zone of influence is typically within the Floodway right-of-way where groundwater withdrawal restrictions are established.
- Using nitrate, sulphate and hardness as indicator parameters, there was no major change in the bedrock monitor well chemistry within the Floodway right-of-way when comparing flood and non-flood data, indicating recharge to the bedrock aquifer during flood events is limited. Trends were noted in bedrock wells as groundwater traveled across the Floodway in an upgradient to downgradient direction. Indicator parameters such as conductance and hardness tended to increase as expected. Nitrate also decreased moving in a downgradient direction as expected when moving from an agricultural area to a more urban setting.
- The data did not indicate an influence of the Floodway on the large scale groundwater production wells supplying water to the Community of Birds Hill in the Rural Municipality of East St. Paul. However, it is noted that MFA have included cut-off walls to be constructed adjacent to more sensitive areas (Outlet and East St. Paul) as a precautionary approach. Furthermore, the data did not demonstrate a clear connection between the groundwater in localized areas of identified seeps or blow-outs.
- Water quality in existing domestic water supply wells located within the zone of influence were evaluated against health benchmarks and background. Only one well in the Lockport area showed a nitrate exceedance of Guidelines for Canadian Drinking Water Quality (Health Canada, 1996). in multiple sample events (representing 5 of 1500 samples completed) which suggests a localized issue not associated with Floodway operations. In all other cases, wells were found to have chemistry below water quality guidelines and were consistent with those wells outside the zone of influence (i.e. background values).
- While bacteria were identified in several individual wells, none were found on subsequent sampling nor were they correlated well with lateral distance from or operational occurrences of the Floodway. This is suspected to be an artefact of common cross contamination during sampling. E-coli was found in only 11 of 1540 samples, which represents 9 of 286 wells; only two wells had two confirmed E-coli detections. Like bacteria, the data is random and is believed to be associated with well construction/quality issues and not associated with Floodway operations.
- Based on the results of the human health risk assessment, no unacceptable risk has been identified to domestic water supply wells within the identified Floodway zone of influence. In an expanded Floodway, where excavations are expected to extend up to 100 meters beyond the existing Floodway limits, the zone of influence can be expected to extend proportionally in a lateral direction. It should be noted that the existing Floodway right-of-way boundary extends between 300 and 600 m out from the alignment centerline and that Manitoba has controls over well construction within the right-of-way. In geologically sensitive areas where significant widening is to occur, existing domestic wells in the extended zone of influence may see some short-term changes in water quality during Floodway operations although increases above water guidelines are not expected to occur.

Based on the above, we recommend the following:

- In order to confirm the uncertainties of the risk assessment, a post-construction monitoring plan should be developed which includes selecting existing monitoring and domestic wells located within the zone of influence (of the widened Floodway). This should include existing wells where health based parameters (bacteria and nitrates) have been identified previously. Some well improvements may be required in some individual cases. In addition, sentinel wells should be installed in the Floodway Right-of-Way in areas with wells at higher risk.
- Monitoring should continue for a minimum of two years after construction, and include at least two flood events. Post-construction monitoring requirements should be reviewed after two Floodway operation events have occurred to determine future monitoring needs.
- Further investigation should be completed on individual wells which have historically exceeded health based criteria throughout the past monitoring periods.

The statements made in this Executive Summary text are subject to the limitations included in Section 7.0, and are to be read in conjunction with the remainder of this report.

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1.0 INTRODUCTION

1.1 General

Jacques Whitford Limited was commissioned by the Manitoba Floodway Authority (MFA) to conduct a human health risk assessment (HHRA) resulting from potential changes in water quality due to the current expansion of the Red River Floodway. Public perception about the project has suggested that health risk may be increased as a result of chemical hazards originating in surface runoff within the Floodway from upstream areas or that the widening of the channel will bring the hazards closer to domestic wells adjacent to the alignment. Particular concerns have been raised during public consultation and permitting process, suggesting that elevated concentration of chemicals of concern (COCs) in the Floodway waters may be able migrate into domestic supply wells adjacent to the Floodway and affect potable drinking well supplies, including through groundwater discharge sites (seeps or blow-outs) found in localized areas along the Floodway channel.

This project has been commissioned by the MFA in response to regulatory requirements established in Licence No. 2691 issued under the Manitoba Environment Act. The study has been designed to include public input including information and feedback sessions at the beginning of the study to understand the public concerns and describe the assessment process and at the end of the study to present results of the health risk assessment report.

The results of this assignment will be subject to review and comment by the Steering Committee as well as an external peer review team. The outcomes of this study will be used to develop or adjust risk management programs for groundwater protection, if deemed necessary.

1.2 Background

The Red River Floodway is a 48 km long flood water diversion channel, located east of the City of Winnipeg. Its inlet control structure is located at St. Norbert, at the south end of the City of Winnipeg, and its outlet control structure located at Lockport, north of the City of Winnipeg (MFA, 2007; refer to Figure 1 in Appendix A). The Floodway intersects the Rural Municipalities of Ritchot, Springfield, East St. Paul and St. Clements.

The existing Floodway is an excavated channel that was constructed as a Provincial Waterway on Crown Land between 1962 and 1968. In 1997 runoff created peak flows in the Floodway channel of 1,880 m^3/s (KGS, 2004m), which exceeded the channel's capacity and was the impetus for expansion of the Floodway, which began in 2005. The expansion is designed to increase the capacity of the Floodway from 1,700 m^3/s to 3,960 m^3/s. In doing so, the flood risk to the City of Winnipeg will be reduced to less than one fifth of the current exposure.

Concerns related to the protection of groundwater supplies resulted in the additional capacity being achieved through a channel widening, as opposed to a channel deepening design. Erosion control measures are also being proposed to ensure the deepening of the channel does not occur through further erosion (MFA, 2007).

Current public concerns relating to the expansion of the Floodway include impacts to domestic and municipal groundwater supply wells. Ongoing investigations completed by KGS Group have suggested that the current Floodway expansion project, which includes widening of the channel, poses little risk of impact to groundwater supplies. Work to date suggests that widening of the channel will result in negligible additional drawdown of the water table, with the most significant drawdown occurring within the Floodway channel right-of-way (KGS, 2004q). KGS had noted the potential pathway, and MFA have initiated a monitoring program to evaluate the situation.

1.3 Regulatory Framework

Provincial and federal regulatory approvals were needed before construction activities could begin. The Project is a development that required a License pursuant to t*he The Manitoba Environment Act*. As well as being cost shared with Canada, certain Project components require authorizations under the Federal *Navigable Waters Protection Act* or the *Fisheries Act*. These interactions with Federal jurisdiction require that the provisions of the *Canadian Environmental Assessment Act* (CEAA) must be met. Accordingly a cooperative environmental assessment was conducted pursuant to the *Canada-Manitoba Agreement on Environmental Assessment Cooperation*.

1.3.1 Canada-Manitoba Agreement on Environmental Assessment Cooperation.

A formal provincial and federal environmental review process was initiated on July 28, 2003, when MFA submitted an Environment Act Proposal Form for the Project to Manitoba Conservation. This cooperative assessment process resulted in, among other things, the review and finalization of joint environmental impact assessment guidelines which were issued on February 5, 2004.

The MFA undertook a public involvement program during the project environmental assessment phase. A concern that was raised by rural municipalities and members of the public related to the protection of groundwater. Much of the area surrounding the Floodway is dependent on groundwater to supply water for domestic uses and other purposes. The MFA made a number of changes to the Floodway design and undertook a number of studies to develop groundwater protection and effects mitigation plans which were presented in the environmental impact statement and supporting documents.

The environmental assessment was completed and an Environmental Impact Statement (EIS) was submitted on August 3, 2004, with additional information provided on November 1, 2004, December 23, 2005, and April 19, 2005. The EIS and additional submissions provided information on the existing groundwater conditions and quality and the expected impact of the Project on groundwater. A baseline groundwater quality report was filed in March 2006 (KGS, 2006).

A public hearing was held by the Manitoba Clean Environment Commission as a component of the environmental assessment and licensing process. At the public hearing, the Rural Municipalities of St. Clements, Springfield, and East St. Paul and the Coalition for Flood Protection North of the Floodway, along with others, raised concerns regarding groundwater issues. Concerns were raised regarding the potential for surface water to infiltrate into the groundwater and as a result there was the possibility of the development of a long-term plume of contaminated surface water some distance from the Floodway. The Clean Environment Commission in its report dated June 2005, made recommendation number 7.4 to the Minister that, as a condition of a license to expand and maintain the Floodway, a comprehensive health risk assessment be conducted.

1.3.2 Manitoba Environment Act

On July 8, 2005, the Minister for Manitoba Conservation (the Minister) issued Environment Act License No. 2691 pursuant to *The Environment Act* and Canada's Responsible Authorities made a decision pursuant to the *Canadian Environmental Assessment Act* to permit the Red River Floodway Expansion Project to proceed. Both the provincial license and federal screening report included conditions related to groundwater protection and public involvement. The MFA and Manitoba Water Stewardship are committed to complying with all of the federal and provincial environmental conditions as they proceed with construction and operating phases of the project.

1.4 Scope of Work

The Statement of Work for the present study was established in the Request for Proposals for Health Risk Assessment (FLD 309) issued by the Manitoba Floodway Authority on November 8, 2006 (MFA, 2006). The overall project scope originally included the elements outlined in Table 1.1 below as established in our proposal dated January 19, 2007 (JW, 2007a) and the Project Charter dated September 2007(JW, 2007b).

TABLE 1.1 Summary of Project Scope Elements

Task	Description of Task
1	Review existing reports, drawings, and other documents made available by Manitoba Floodway Authority. Determine what additional information, if any, would be necessary to do the work.
2	Develop an assessment approach based on hydrogeologic modeling, an acceptable health risk assessment model, and existing information. The study will include describing the problem formulation, identifying the hazards, exposure assessment, risk characterization, and uncertainty and variability considered in the risk assessment.
3	Participate in Round 1 of public information sessions to understand the public perception of the issue, explain the study, and receive feedback on the proposed assessment approach. This includes preparing a Public Consultation Plan.
4	Conduct a health risk assessment regarding the potential human health effects of infiltration of surface water into the groundwater along the Red River Floodway under inactive, active spring flood operation, active non-spring emergency operation and proposed future non-spring non-emergency operation.
5	Communicate with the project Steering Committee on a monthly basis to report progress.
6	Prepare and submit to the MFA, 15 printed copies, and three electronic copies (on compact disc) of the draft Comprehensive Health Risk Assessment report, including conclusions.
7	Participate in Round 2 of public information sessions to present and receive feedback on the draft assessment report.
8	Prepare and submit to the MFA, 15 printed copies, and three electronic copies (on compact disc) of the final Comprehensive Health Risk Assessment report, including conclusions.

A summary of the outcomes of items 1, 2 and 3 from Table 1.1 above was provided in an interim report dated November 13, 2007 (JW, 2007c) which included a review of historic data and relevant information, assessment of the cross-sectional numerical groundwater model configurations developed by KGS Group, and the results of the Round 1 Public Consultation. The outcomes and conclusions of these three work elements were synthesized to identify up to three potential points along the Floodway alignment for further cross-sectional numerical groundwater modeling in support of the HHRA.

2.0 CHARACTERIZATION OF THE STUDY AREA

2.1 Physical Setting

The study area (refer to Figure 1, Appendix A) is defined by the existing Floodway channel that is located on the east side of the City of Winnipeg. It is aligned in a general south-north direction with a length of approximately 48 km (29.5 miles) from its inlet south of St. Norbert, to its outlet north of Lockport.

2.1.1 Physiography

The Floodway is situated in the Red River drainage basin, which in turn is located in the Manitoba Lowlands physiographic region. This physiographic region is characterized by gentle topographic relief (Betcher, et al., 1995). The most significant relief in the area occurs in the vicinity of Birds Hill Provincial Park.

2.1.2 Climate

Based on the thirty-year climate normals (1971 – 2000) for the Winnipeg International Airport (Environment Canada, 2007), the following is a summary of climate information for the Winnipeg area:

- The daily average temperature is 2.6°C, and ranges from a high of 19.5°C (July) to a low of -17.8°C (January); and,
- Average annual precipitation is 515 mm, of which 415 mm (81%) was recorded as rainfall and 110 mm (19%) was recorded as snowfall (as water equivalent). Approximately 75% of the annual precipitation (and 90% of recorded annual rainfall) occurs through the period of May to October.

Mean annual potential evapotranspiration is anticipated to be approximately 500 mm for the Winnipeg area (Betcher et al., 1995, based on 1931 – 1960 climate data). The high potential evapotranspiration suggests that groundwater recharge via infiltration of precipitation has the potential to be close to nil in areas with low-permeability overburden materials (*i.e.* clay).

2.2 Geology

2.2.1 Overburden

Surficial geology of the study area is shown on Figure 2, Appendix A. Overburden in the study area consists primarily proglacial lacustrine clays and silts underlain by till. The clay can be divided into upper and lower units, the upper (brown) clay unit consisting of thin clay layers interbedded with silts and fine sand, and the lower, massive, (grey) clay unit (Render, 1970). Sand and gravel deposits also occur in the area, and are primarily associated with the Birds Hill glaciofluvial complex (Betcher et al., 1995; KGS, 2004n). The overburden thickness (or depth to bedrock) is greatest in the southern portion of the City of Winnipeg, and in the Birds Hill area, northeast of the City of Winnipeg (refer to Figure 3,

Appendix A).

The base of the low-flow Floodway channel is situated entirely in clay overburden from the inlet to a location just south of the Highway 15 crossing. The clay separating the base of the low-flow channel from the underlying till tends to become thinner from south to north, along the Floodway alignment. Between the Highway 15 crossing and the Dunning Road crossing, the base of the low-flow channel is situated in either clay or till. North of Dunning Road, the base of the low-flow channel is situated primarily in till except where it intersects the Birds Hill glaciofluvial complex near Oasis Road and Spring Hill. The foundation of the Floodway outlet structure is situated directly on carbonate bedrock (refer Drawing No. FE-PDEA-1-251H-005.c prepared by KGS Group, a copy of which is provided in Appendix B).

2.2.2 Bedrock

The upper bedrock unit underlying the study area is comprised primarily of limestone/dolostone (carbonate rock), which sub-crops beneath the study area and dips to the west-southwest (Render, 1970, Betcher et al, 1995). Figure 4, Appendix A shows the bedrock surface underlying the study area.

2.3 Hydrogeology

2.3.1 Upper Carbonate Aquifer (UCA)

The carbonate bedrock forms a regional aquifer in the area, and is used as a major source of domestic, agricultural and industrial water supply. The occurrence and movement of groundwater within the UCA occurs primarily through fracture networks, some of which have been expanded by dissolution of the rock. Betcher et al. (1995) indicates that the upper few meters of carbonate rock typically has the highest production due to the presence of significant fractures within this zone. Render (1970) reports that the UCA occurs in the upper 15 m to 30 m of the carbonate bedrock, where the rock is more highly fractured; however, he goes on to note that the greatest yields and flows are associated with the upper 7.5 m due to larger fracture openings. It is anticipated that the thickness of the UCA is highly variable throughout the region.

The estimated direction of groundwater flow in the UCA (after Betcher et al., 1995, and Grasby and Betcher, 2002) is shown in Figure 5, Appendix A. In general, the anticipated direction of groundwater flow in the on the east side of the Red River, is to the west, towards the Red River.

Throughout much of the study area, the UCA is considered to be confined, particularly where it is overlain by thick clay over till. Semi-confined and unconfined conditions exist where the clay is absent and/or the water table is present in overlying till and/or sand and gravel overburden.

KGS (2004n) indicates that recharge to the UCA is through the sands and gravels of the Birds Hill complex, and through more permeable surficial tills lying on the eastern and edge of the region (KGS, 2004n). KGS (2004n) suggest recharge rates, due to the infiltration of precipitation, ranging from 0 mm/year (in the lower permeability clays) to 105 mm/year (in the highly permeable core of the Birds Hill sand and gravel complex). In addition, it should be noted that the eastern edge of the carbonate rock sub-crops beneath the Sandilands glaciofluvial complex located approximately 70 kilometres east of the Floodway, which is an additional, and significant, source of recharge to the UCA (Grasby and Betcher, 2002).

2.3.2 Birds Hill Aquifer

The Birds Hill aquifer, comprised of sand and gravel, is a localized source of domestic and agricultural water supply for the area, with a large number of private potable wells (refer to Figure 2, Appendix A). The municipal supply wells for the community of East St. Paul also draw a certain amount of water from the Birds Hill aquifer. The Birds Hill glaciofluvial complex is comprised of sands and gravels ranging from 15 m to 30 m thick (KGS, 2004n). A thin, discontinuous till unit separates the Birds Hill sand and gravel from the underlying UCA in some areas. Water table mounding within the Birds Hill complex suggest that it is a source of recharge to the underlying UCA (KGS, 2004n).

The Birds Hill aquifer is reportedly unconfined towards the centre of the complex, where the sand and gravel is exposed at surface. The primary source of recharge to the Birds Hill aquifer is from infiltration of precipitation, particularly where sand and gravel are exposed at surface.

2.4 Chemical Hydrogeology

2.4.1 Groundwater Chemistry

Render (1970) indicates that groundwater quality in the UCA is typically hard and sulphate-rich, with total dissolved solids (TDS) ranging from 300 mg/L to 1,500 mg/L. Betcher et al. (1995) characterizes fresh-water of the UCA as a calcium-magnesium-bicarbonate type water with significant concentrations of sulphate and sodium, and notes TDS ranging from 400 mg/L to 800 mg/L. Higher TDS, sulphate and sodium concentrations are anticipated in groundwater of the UCA, to the east and northeast of Winnipeg, as a result of local recharge from infiltrating precipitation which moves through the overlying clay and/or tills (Betcher et al., 1995). Within the overlying till unit, KGS (2004n) indicates that groundwater chemistry, determined through analytical testing, is similar to that of the UCA with the exception of higher calcium, magnesium and sulphate concentrations. Domestic supplies of groundwater extracted from the UCA are often softened prior to use.

2.4.2 Surface Water Chemistry

The following discussion of surface water chemistry is based solely on a review of the 2006 Construction Surface Water Monitoring reports completed by KGS Group (KGS, 2007b), which was provide by the MFA.

During the 2006 construction surface water monitoring program, sampling was completed at a number of locations along the Floodway alignment. The program included 12 monthly events, and 13 event-based events. The monitoring program suggests that during low-flow conditions, surface water chemistry in the low-flow channel closely resembles that of groundwater. During high-flow conditions, dilution occurs and water quality generally shows decreases in specific chemical species concentrations that are associated with groundwater (*e.g.*, hardness). Monitoring of water discharging into the Floodway from drains and outfalls, suggests that these drains and outfalls are a source of bacteria and nutrients to Floodway waters.

2.5 Large Scale Groundwater Withdrawals

Based on a review of KGS (2004m), in addition to numerous private domestic wells located in the vicinity of the Floodway, several municipal supply well fields are located in the area (refer to Figure 2, Appendix A). These include the following:

- Four production wells operated by the Rural Municipality of East St. Paul's supplying water to residents of Birds Hill from the Birds Hill aquifer;
- Two production wells operated by the Rural Municipality of Springfield, supplying water to residents of Oakbank from the Moosenose aquifer, an extension of the Birds Hill complex; and
- Two production wells operated by the Rural Municipality of Tache, supply water to residents of Lorette from the UCA.

The Regional Municipality of East St. Paul well field is the nearest municipal groundwater-derived supply to the Floodway, and perceived as being the most at risk to impacts resulting from the operation of the Floodway. The well field for Springfield and Tache and located some distance upgradient from the study area.

2.6 Public Consultation

Two Public Consultation sessions were undertaken to gain an understanding of the relevant public concerns, describe the health risk assessment process, and obtain feedback on the results of the HHRA work. The consultation process focused on specific municipalities located along the Floodway alignment, identified by the MFA, including the Rural Municipalities (RMs) of Springfield, East St. Paul and St. Clements. One community in each RM (Dugald, Birds Hill and Lockport, respectively) was selected for the public consultation sessions, and participation was solicited through advertising in several local newspapers. Consultation was conducted in two rounds, with the first round being designed to obtain feedback on specific areas or issues of concern around the Floodway widening. The second session was conducted in the same communities and presented the methods and findings of the HHRA work.

<u>Round 1 Consultation</u>

At the outset of the review process, Jacques Whitford identified general target areas which were susceptible to increased risk including the following:

- Chemically sensitive settings – areas with poor water quality, where slight changes in water quality due to expanded Floodway impacts, may pose a potential health risk to receptors.
- Physically sensitive settings – areas where travel times between source and potential receptors would be a minimum. Physically sensitive settings would include the following sub-categories:
    - geological sensitivity
    - thin till over the UCA – north of Highway 15
    - direct connection to the UCA – Floodway outlet at Lockport
    - sand and gravel aquifer – Birds Hill and surrounding area
    - potential fracturing of thin overburden materials
    - blow-outs and groundwater seeps, where a direct connection to the UCA may be present – primarily north of Highway 15 crossing to just north of CPR Keewatin crossing
    - zones of high groundwater demand

- public water supply withdrawals – Spring Hill (RM of East St. Paul municipal well field)
- clustered domestic water supply withdrawals – RM of East St. Paul, and Birds Hill area

- "Other" sensitive settings – areas that may not fall into the above categories, but public concern requires an assessment. In this case, the Lockport area was a primary focus public concern.

Based on Jacques Whitford's review and input from the first round of consultation sessions, no chemically sensitive areas were identified. However, several areas of concern were identified that fall in both the physically sensitive and "other" sensitive setting categories. In order to address public concern associated with these areas, Jacques Whitford recommended specific groundwater modeling be completed for these areas to support the HHRA (JW, 2007c).

The following key points were noted after the first round of public consultation.

- Impact of groundwater seeps (blow-outs).
- Use of groundwater models to predict impacts.
- Potential impacts to the Lockport area.
- Lack of public accessibility to historic water quality data.

The first three bullets noted above were carried forward as issues to address in the HHRA. Data available from groundwater seeps was reviewed as part of the work as was available data for the Lockport area. The concerns respecting the use of numeric models were also considered during the detailed numeric modeling component of work, specifically relating to use of high quality assurance/quality control measures when conducting the modelling work. The fourth bullet was subsequently addressed by MFA through its publically accessible web site where information was posted.

<u>Round 2 Consultations</u>

A second round of public consultation was conducted between July 22 to July 24, 2008 at the same locations as Round 1 consultation. Information respecting the outcomes of the risk assessment were presented, which included the methods for data analysis and issues that were encountered when the numeric modelling was attempted. A summary of the public presentations, including attendees for each, is included in Appendix E. Attendance was generally low, with the largest turnout occurring in Lockport (7 people). In general, concerns that were raised during the second round were associated with Floodway widening and how HHRA focused on the zone of influence. The public were supportive of the recommendations to have long-term monitoring implemented after the widening was complete. Concerns raised during the first round of consultation respecting use of models were also addressed and discussed, particularly since the final HHRA did not ultimately use numeric modeling to assess the influence of potential contaminants migrating through groundwater pathway during operation.

3.0 DECISION MAKING FRAMEWORK FOR IDENTIFYING, ASSESSING AND MANAGING HEALTH RISKS

3.1 General Approach

The following describes the component tasks established in the Health Canada Decision Making Framework (Health Canada, 2000):

- *Identify the Issue and Its Context* - Clearly define and describe the issue and its context. This is key to focusing risk assessment efforts, identifying risk management goals, selecting efficient and effective strategies, and appropriately allocating resources.

- *Assess Risks and Benefits* - Assess risks using biological, chemical, and physical data from scientific studies; integrate information related to risk factors (e.g. social, cultural, ethical considerations, economic status), and risk perceptions, where this information is demonstrated to have an impact on the level of risk. Assess benefits in a similar manner.
- *Identify and Analyze Options* -. Consider a range of risk management options whenever possible. Take into account a variety of considerations when analyzing options, including the perspectives of interested and affected parties.

- *Select a Strategy* - Maintaining and improving health is the primary objective. This must take precedence over all other considerations.
- *Implement the Strategy* - Strive to implement risk management strategies in an effective, expeditious, and flexible manner, and with the support of interested and affected parties.
- *Monitor and Evaluate Results* - Monitor and evaluate the risk management strategy to determine whether it has been effective. Revisit previous steps of the decision-making process as needed if the strategy is found to be ineffective, or if significant new information becomes available.

This study focuses on Tasks 1, 2 and 3 above. The remaining Tasks will be completed by the MFA in consultation with the public health authorities.

3.1.1 Task 1 - Identify the Issue and Its Context

The issue to be examined within this human health risk assessment is the potential for an unacceptable health based adverse impact on water quality within domestic wells which could be affected by the operation of an expanded Floodway.

A decision has been made to expand the existing Floodway to accommodate potential peak flows resulting from future flood events. The expansion is intended to prevent large scale regional flood damage to the City of Winnipeg and surrounding area. Flood damage includes threats and damage to human health and safety, property and the environment. The expansion is designed to accommodate and control the effects of this potential large scale flooding which is anticipated due to future climate change and the increased likelihood of severe flooding (observed most recently in 1997).

This work follows on significant ongoing work including detailed monitoring of over 300 wells, many of which were carried forward in this study. The approval issued by Manitoba Conservation for the implementation of the project included both construction monitoring and ongoing groundwater monitoring. Annual monitoring reports have been provided since construction of the expanded

Floodway began in 2005. The analysis includes current and historical data. These reports are intended to provide monitoring and interpretation of changes in water quality data observed during the construction phase. The intention of this Human Health Risk Assessment is to interpret the data in the context of risks to human health only.

3.1.2 Task 2 - Assess Risks and Benefits

As discussed in Section 1.4 above, the implementation of the Project is designed to maximize the safety of the residents of the City of Winnipeg and surrounding area from future Floodway flooding, and minimize property and environmental damage from flood events. The MFA undertook an extensive public involvement program during the environmental assessment phase of the Project.

Based on public concerns for the potential impacts on groundwater, the MFA made a number of changes to the Floodway design and undertook a number of studies to develop groundwater protection and effects mitigation plans which were presented in the environmental impact statement and supporting documents.

The report of the Clean Environment Commission dated June 2005, made recommendation Number 7.4 to the Minister that, as a condition of a license to expand and maintain the Floodway, a comprehensive health risk assessment be conducted.

In keeping with the Health Canada Decision-Making Framework for Identifying, Assessing, and Managing Health Risks (Health Canada, 2001), this risk assessment has adopted the four basic components in the assessment of risk, which include the following:

- Identify Hazards.
- Characterize Hazards.
- Assess Exposures.
- Characterize Risks.

Each of these key components are described in detail in Section 4 of this report,

3.1.3 Task 3 Identify and Analyze Options

Based on the outcomes of the Risk Characterization, options can be prepared for mitigating actual risks. Risk mitigation options may be of many forms ranging from implementing engineered controls, to institutional controls (such as establishment of protective buffer zones).

3.1.4 Task 4 and 5 – Select and Implement a strategy

Based on the outcomes of the risk assessment and final risk characterization, a strategy can be developed. Prior to implementing the strategy, consultation with stakeholders (such as been done in this work) is appropriate to make sure the approach is acceptable and correct. This HHRA makes recommendation for further action for implementation by the MFA and local health authorities.

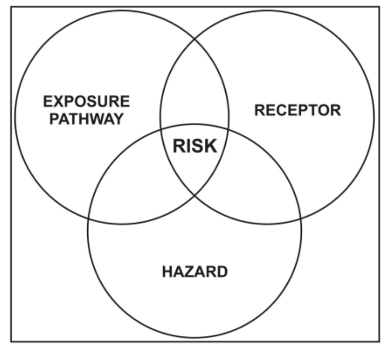
3.1.5 Task 6 - Monitor Results

Once the risk mitigation strategy is put in place, long term monitoring of performance is often required to verify assumptions of the risk assessment were correct, and that the outcomes meet with stakeholder expectations and requirements. This HHRA provides recommendations for required monitoring and evaluation of results.

4.0 HUMAN HEALTH RISK ASSESSMENT

4.1 General Approach

The following sections describe the components of this human health risk assessment (HHRA):

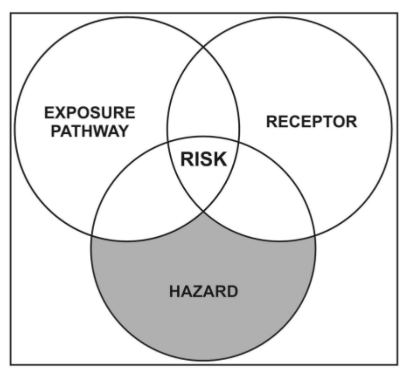


- *Hazards Assessment* - environmental hazards that may pose a health risk (e.g. chemicals). This includes the health based parameters in the Floodway waters that could come into contact with domestic wells.
- *Receptor Identification* - Identification of the human receptors that may be exposed to the above hazard(s).
- *Exposure Assessment* - Qualitative or quantitative evaluation of the likelihood or degree to which the receptors will be exposed to the hazard.
- *Risk Characterisation* - Qualitative or quantitative assessment of the actual health risk of each hazard to each receptor, based on the degree of exposure.
- *Confidence Assessment* - A qualitative or quantitative assessment of the uncertainty associated with the risk estimation.

The main concern with respect to human health risk to domestic groundwater users from the operation of the Floodway is the potential for impacted floodwater to move vertically and horizontally out of the Floodway under flood conditions, and to reach adjacent water supply wells.

4.2 Hazard Assessment

Hazard identification was begun by evaluation of existing surface water chemistry obtained during Floodway operational periods and comparing these to the health based guidelines as found in the Guidelines For Canadian Drinking Water Quality (Health Canada, 1996 revised 2008). Health based indicators include nitrate and pathogens such as bacteria and viruses; and man-made chemical contaminants including agri-chemicals (*i.e.,* fertilizers and pesticides) and petroleum products. Other parameters were also assessed (such as turbidity) as they can provide insight into pathways which may be present during Floodway operational periods.



Jacques Whitford has reviewed the historical data provided for review by the MFA. Potential groundwater quality change resulting from the Floodway expansion project include physical changes such as colour, turbidity taste and odour; chemical changes such as increase in hardness, TDS, SO_4, Fe and Mn.

Several hundred domestic wells were originally inventoried and/or sampled in the broad sampling program conducted by KGS Group; this groundwater database has been reduced to include 286 domestic wells and 51 monitoring wells. Between 2005 and present, monitoring has been generally performed four times per year, typically before, during and after the spring flood event, and during a summer flood event or late summer period. Table HM38-1 (KGS 2008) and Table HM38-2 (KGS, 2008); have been included in Appendix C, and summarize the monitoring parameters currently used for the Floodway monitoring program.

Parameters analyzed for the domestic wells include: field parameters (temperature, pH, conductance, water level); major ions (Na, K, Ca, Mg, SO_4, Cl, HCO_3, F), physical parameters (turbidity, hardness, alkalinity, conductivity, pH, carbonate, hydroxide), nutrients TDS, (NO_3+NO_2-N), metals (total Fe and Mn; dissolved Cu, Zn), and pathogens (total and fecal coliform bacteria).

Parameters analyzed for monitoring wells include those outlined above, except for pathogens, along with a dissolved metals scan. One round of pesticides, and pentachlorophenol is completed for 9 monitoring wells and 10 domestic wells.

Surface water is analyzed for general chemistry, total suspended solids (TSS), ortho-phosphorous (O-PO_4), total phosphorus, dissolved organic carbon (DOC), total organic carbon (TOC), and total Kjeldahl nitrogen (TKN).

Annual groundwater monitoring and sampling conducted by KGS Group in 2005 (baseline), 2006, and 2007 has identified NO_3+NO_2-N and bacteria as the key health-based indicator parameters potentially affecting water supply wells adjacent to the Floodway.

4.2.1 Surface Water Chemistry Characterization

Available water quality monitoring data for the Floodway under flood and non-flood conditions is presented in Table HM38-F-1-1, Appendix B. Figure MN4-1, Appendix C shows the locations of the various Floodway surface water monitoring points. Samples were collected from the Red River, upstream of the Floodway Inlet (sampling locations S-01, S-02 and S-03); Red River downstream of the Floodway Outlet (sampling locations S-30, S-31, S-32 and S-33); Red River upstream of the Floodway Outlet (sampling location S-34); Floodway channel downstream of the Floodway Inlet (sampling location S-04); Floodway channel at weir locations within the alignment (sampling locations S-13, S-14, S-21, S-23, S-25, S-28); and, Floodway at eleven locations where drains outfalls enter the channel (sampling locations S-05, S-06, S-07, S-08, S-09, S-10, S-11, S-12, S-22, S-26 and S-27).

Table D-1 in Appendix D, summarizes the average and median concentrations for surface water in the Floodway and the Red River during flood events and during non-flood events. Most Floodway surface water samples are representative of the conditions during flooding operations (Table D-1, Appendix D). During flood condition, the Floodway water is characterized as a turbid (mean turbidity 89 NTU), hard (mean hardness 188 mg/L), naturally alkaline (mean alkalinity 164 mg/L, mean pH 8.0), calcium bicarbonate water type of moderate total dissolved solids (TDS) (mean 263 mg/L), and moderate total suspended solids (TSS) (mean 101 mg/L). The floodwater has a moderate dissolved organic carbon concentration (mean DOC 13.8 mg/L), a low nutrient concentration (mean nitrate 1.42 mg/L, mean ammonia 0.17 mg/L, mean TKN 2.1 mg/L, mean O-PO_4 0.34 mg/L), and a detectable coliform bacteria concentration (mean total coliform 642/100 ml; mean Fecal coliform 99/100 ml). Iron (mean 0.56 mg/L, attributed to turbidity) exceeds the Freshwater Aquatic Life (FAL) guideline of 0.30 mg/L.

The main health-based issues with respect to the influence of the Floodway on groundwater include total and fecal coliform bacteria, and to a lesser extent, nutrients such as nitrate.

Bacteria

Based on the 2006 construction monitoring (KGS, March 2007), bacteria appears to be related to outfall drains discharging into the Floodway. There are strong seasonal trends, with the lowest (0-10 count) occurring in winter and peak runoff (April), the drains with the highest bacteria counts appear to be Springfield (S-22) and Skholny (S-26) in summer to fall, and the Floodway Station with the highest bacteria counts is Keewatin Weir (S-21). The annual median concentrations suggest Red River and outfall drains into Floodway are the main sources of E-coli bacteria.

4.3 Receptor Identification

The people who may be most affected by exposure to the identified hazards were determined based on the existing and potential future groundwater use as a potable water source. Receptors for the current study are limited to human receptors who obtain drinking water from domestic supply wells within an area of influence adjacent to the existing Floodway alignment.

4.4 Exposure Pathway Assessment

The likelihood that the identified receptors may be exposed to the identified hazards through the various exposure routes is evaluated qualitatively. The significance of exposure includes consideration of the duration and frequency of exposure to each hazard, the relative concentrations to which the receptor is likely to be exposed and the chemical/physical properties of the hazard. Those hazard-receptor-exposure combinations considered to have the highest likelihood to contribute a health risk are carried forward for further analysis.

The exposure pathway assessment evaluates the likelihood that potential hazards may come into contact with potential receptors. The exposure analysis considers the properties of individual hazards that control chemical mobility and the various pathways through which the hazard could come into contact with the receptor.

4.4.1 Exposure Scenarios Considered

Since its completion, the existing Floodway has operated 29 times over the period of 1969 to 2007. The average operational period during this time has been 25.4 days, with a low range of 5 days in 1983 and 53 days in 1996. Peak flows during Floodway operation have ranged from low of 17.8 m^3/s in the spring of 1982, during 8 days of operation, to 1,880 m^3/s in the spring of 1997, during 45 days of operation. Table D-4, Appendix D, provides an annual record of Floodway operation over this period.

Observed base flow in the low-flow channel, at the Floodway outlet, has been measured to range from 0.08 m^3/s to 0.12 m^3/s (1,000 Igpm to 1,500 Igpm; KGS, 2005) during February and March of 2005. During low-flow conditions, the potential for impacts to infiltrate into the UCA from the Floodway channel is considered unlikely due to the high aquifer head conditions adjacent to the Floodway alignment.

During high-flow, flood conditions, the vertical gradients may be reversed, and a groundwater recharge condition, rather than a groundwater discharge condition, may develop along the channel as the elevation of the water surface within the channel progresses above that of the groundwater table. Should the Floodway channel act as a source of recharge to the underlying UCA, there is potential for impacts to enter groundwater, particularly north of Highway 15, where the Floodway channel base is founded in thin clay and/or till, directly in carbonate bedrock, or where there is a direct connection to the underlying carbonate bedrock (*e.g.* at the location of groundwater seeps and/or blow-outs; KGS, 2004q). Typically, the Floodway is operational for a period of 4 to 6 weeks annually. Should the duration of operation increase (*e.g.* to facilitate lower water levels on the Red River for recreational purposes), and higher-flows be maintained for longer periods, there is an increased potential for surface water to enter the UCA.

For this study, the exposure scenario considered reflects the Floodway operation condition and the potential for the Floodway surface water to recharge local groundwater. This focus is in support of "Task 4" Of the Health Canada Decision Making Process (Section 3.1 above), requiring that "Maintaining and improving health is the primary objective.".

4.4.2 Potential Transport Mechanisms and Exposure Routes

The receptor wells evaluated in this exposure assessment are located east and west of the Floodway and north of Highway No. 15. This area is characterized as either highly permeable sand and gravel of the Birds Hill Aquifer, locally underlain by variable thicknesses of clay and glacial till (decreasing in thickness in a northerly direction); or variable thicknesses of sandy silt to silty sand glacial till overlying fractured bedrock north of Birds Hill to the Floodway outfall. These areas have been identified by KGS as being at greater risk to potential hydraulic interaction between the operational Floodway and the bedrock aquifer (host of the majority of domestic wells) or the sand and gravel (host aquifer for several major municipal screened water supply wells).

The bedrock domestic water supply wells situated south of the TransCanada Highway are considered to be effectively isolated from the effects of the Floodway during operational periods by thick deposits of low permeability clay materials that would effectively limit the movement of deleterious dissolved or suspended constituents in flood water between the operational Floodway and receptor wells. Between the TransCanada Highway and Highway 15, there is a significant clay deposit at surface although groundwater seeps have been confirmed immediately adjacent the Deacon Reservoir. These seep zones may represent localized pathways between the Floodway channel and groundwater.

4.4.3 Numerical Modeling Study

Health Canada recognizes that exposure pathways can be evaluated using numeric models to assist in developing potential outcome predictions as well as qualitative evaluation of existing data (Health Canada, 1996). The original project scope of work called for an evaluation of pathway operability based on 2D modeling of groundwater flow and transport under the transient conditions of the Floodway under various operating conditions. The purpose of modeling was to evaluate potential pathways between surface water and groundwater during the Floodway operational period. Using calibrated models, predictions can be made about the potential groundwater-surface water interactions to a certain degree of accuracy. However, modeling is only one of many tools available to evaluate potential pathways and interactions. For this study, 2D modeling trials were completed on Visual MODFLOW Pro (version 4.2).

Based on the results of preliminary review of the original KGS work and the results of the first round of public consultation, Jacques Whitford completed a review and (where possible) reassessment of two, cross-sectional groundwater flow models completed by KGS Group in 2004. The results were intended to provide tools to evaluate potential risks to groundwater supplies in sensitive settings along the Floodway alignment through an evaluation of pathway operability. (Refer to Figure 6, Appendix A)

Following a detailed review of the Oasis Road steady-state cross-sectional model, Jacques Whitford was not able to move forward with the modeling effort using the two-dimensional model framework created by KGS Group. The primary issue identified in moving forward with the Oasis Road cross-sectional modeling effort was the inability to incorporate the East St. Paul pumping wells into a two-dimensional model framework.

Furthermore, Jacques Whitford was also unable to calibrate the CPR Keewatin steady-state cross-sectional model, and as a result, was not able to move forward with the modeling effort. Best-fit modeling results yielded a normal root mean square (NRMS) error of 17 % (exceeding the pre-defined target of NRMS error < 10%). The results of a sensitivity analysis conducted on the best-fit model results suggest that a better fit cannot be achieved within the limits of the current conceptual model and the available hydrogeological information. A detailed summary of the Jacques Whitford modeling effort and resulting outcomes is presented in a separate document issued to the Manitoba Floodway Authority under separate cover. (JW, 2008 (c)).

Consequently, the full scope of the modelling exercise could not be completed to confirm a pathway in support of the HHRA as proposed. Based on this outcome, a potential pathway was assumed to exist and the HHRA has been completed using the results and analysis of actual testing data collected from numerous monitoring wells and domestic wells within the study area. Details of the Risk Characterization are provided in Section 4.5.

4.4.4 Conceptual Site Model of Exposure

A comprehensive groundwater monitoring program has been carried out by KGS using both location-specific installed monitoring wells within 500 m of the centerline of the Floodway, and existing domestic wells located between 250 m and 4 kilometres of the centerline. Refer to Drawing MH38-1, HM38-5 (2 Drawings) in Appendix C for monitoring locations.

Based on the preliminary review of previous monitoring results, direct hydraulic interaction between the Floodway and domestic wells appears to be minimal, with a few exceptions at domestic wells immediately adjacent to the Floodway in the more permeable zones (KGS, 2007).

The potential for human exposure is greatest from domestic supply wells in areas of blow-outs (such as were reported at bridge structures in the south end), and in areas of seeps (such as the sand and gravel areas of Birds Hill Aquifer). Furthermore, because of the net upward vertical hydraulic gradient into the Floodway from the underlying bedrock aquifer, potential movement of surface water from the channel to the groundwater can only occur during flood events, when the head in the Floodway greatly exceeds that of the surrounding receptor wells. Studies to date have indicated an upward head in the order of 6 m into the base of the Floodway; resulting in the estimated 1,500 to 3,000 igpm base flow in the low flow channel. Under flood conditions, the head in the Floodway can temporarily become reversed, due to 15 m of water, resulting in about 9 m or more head force to drive surface water into the underlying aquifer over periods of a few weeks. Most of these events occur in the spring (April to May), and summer (July to August) periods (refer to Table D-4 in Appendix D).

Data from the monitoring wells alone was used for the purpose of defining a potential hazard exposure that was associated with Floodway operation. The monitoring wells provide more certainty with respect measuring changes due to their strategic placement along the length of the Floodway, and the standards for construction and installation which provide less variability than domestic wells. Based on the results of the data, a zone of influence was identified.

Statements of risk are based on an evaluation of health based parameters, identified in domestic supply wells within the area of influence.

4.4.5 Previous Monitoring

The groundwater monitoring to date (KGS, 2007; KGS, 2006; KGS, 2004m) has demonstrated negligible water quality change or fluctuation that could be attributed to the Floodway operation, at the locations tested. Most variations in water level, specific conductance, nitrogen and bacteria concentrations in the domestic wells and monitoring wells have been attributed to natural seasonal events (*e.g*. rainfall events), or high densities of wells in more developed areas. However, a few wells in very close proximity to the Floodway, and completed in areas where a direct hydraulic connection between the Floodway and the UCA exists, do exhibit transient changes in water quality, as well as water level changes. These studies also demonstrate that water levels and water chemistry quickly return to normal conditions immediately following the passage of a flood event. In addition, monitoring of 4 out of 15 identified groundwater seeps, discharging to the Floodway channel, display water quality characteristics which are typical of groundwater. The results of monitoring quality after flood events suggest that groundwater discharge conditions from these seeps are re-established within days (or sooner) of the Floodway draining (KGS, 2007).

The groundwater chemistry shows negligible impact from bacteria at distances greater than 200 m from the Floodway centerline. It is strongly suspected that the random coliform counts reported in the database are related to well construction, and local land uses near wells. Coliform bacteria levels in domestic wells are generally low and do not correlate with flood events but rather appear to be related to periods of heavy rainfall (KGS, May 2007). Nitrate is generally within 10 mg/L guideline with no correlation to Floodway operation (except in a few individual wells).

The most common measured effect to water conditions under flood conditions is an increase in water levels (pressure effect), and decreases in dissolved ions, hardness, electrical conductance, etc.

4.4.6 Qualitative Assessment of Existing Data

A qualitative hazard assessment was prepared using existing groundwater and surface water data. This approach was considered appropriate as there are four years of data available extending between 2005 to 2008 inclusive for a variety of wells along the alignment as well as corresponding surface water data (from within the Floodway) during operational periods. As noted in Section 4.5 (Uncertainty Assessment), the data does not include extreme events such as the flood of 1997 and

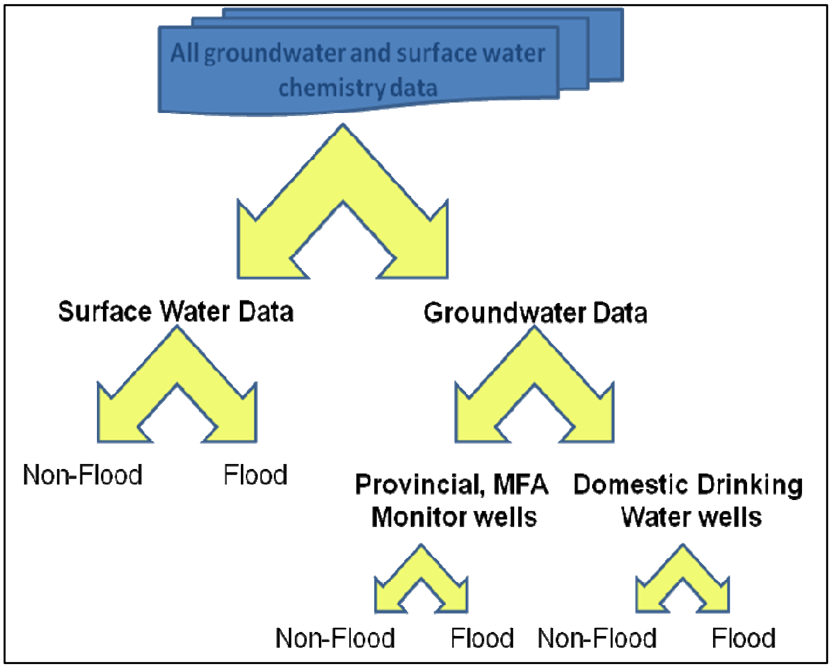


FIGURE 4-1 Data Preparation

recommendations for managing this uncertainty are provided. Using existing data, the potential for groundwater to be influenced by surface water during flood events was determined by comparing changes in historic data from monitor wells and domestic wells along the Floodway alignment. If groundwater quality was being influenced by the current Floodway configuration, resulting in a hazard exposure, the effects should be seen in the data when comparing changes in groundwater and surface water chemistry during flood and non-flood periods. If effects were noted under current conditions, then these effects would be expected to also occur in a widened Floodway profile.

In general, the assessment of the surface water-groundwater pathway for this qualitative risk assessment was completed based on physical indicators rather than hypothetical modelling, in the following manner:

- The existing groundwater data for wells within 1000 m of the Floodway alignment was assembled in a database. All data for wells associated with the clay till (i.e. areas south of the TransCanada Highway) was removed from analysis as this formation under the Floodway has a very low permeability which significantly limits surface infiltration.

- As noted in Figure 4.1, the groundwater data was then divided up by well type (three broad types including MFA and provincial *monitor wells in till overburden*, *monitor wells in bedrock*, and residential *domestic water supply wells*). This data was further subdivided by geological units, consisting of till overburden, sand and gravel overburden, and bedrock. In addition, the data was also prepared to allow analysis of sensitive settings (i.e. Birds Hill and Lockport, as well as seep areas) to evaluate specific trends in those areas. For this analysis, it was assumed all domestic wells were completed in bedrock. Finally, all groundwater data (monitor wells and domestic wells) was sorted by flood and non-flood events. A “flood event” was defined as the period the Floodway operated plus 30 days after the event finished; the 30 day post flood information was included to capture potential floodwater that infiltrated into groundwater (lag time).

- Similarly, surface water data was compiled into a database and then sorted into flood and non-flood events.

- Once the above-noted groundwater datasets were established, the wells were then grouped as a function of distance from the Floodway centerline in 100 m intervals. This grouping was prepared to identify trends that may indicate a “zone of influence” the surface water may have on groundwater chemistry adjacent to the Floodway alignment (see Figure 4.2).

- To determine if there was a “zone of influence” in the overburden, each of the datasets for till and for sand and gravel wells were studied. A potential zone of influence was determined by selecting an indicator parameter, such as nitrate, that was relatively high in surface floodwater but relatively low in background groundwater concentrations. If an influence was present, it should be seen as a gradient which is highest near the Floodway centerline, and declining with distance from centerline.

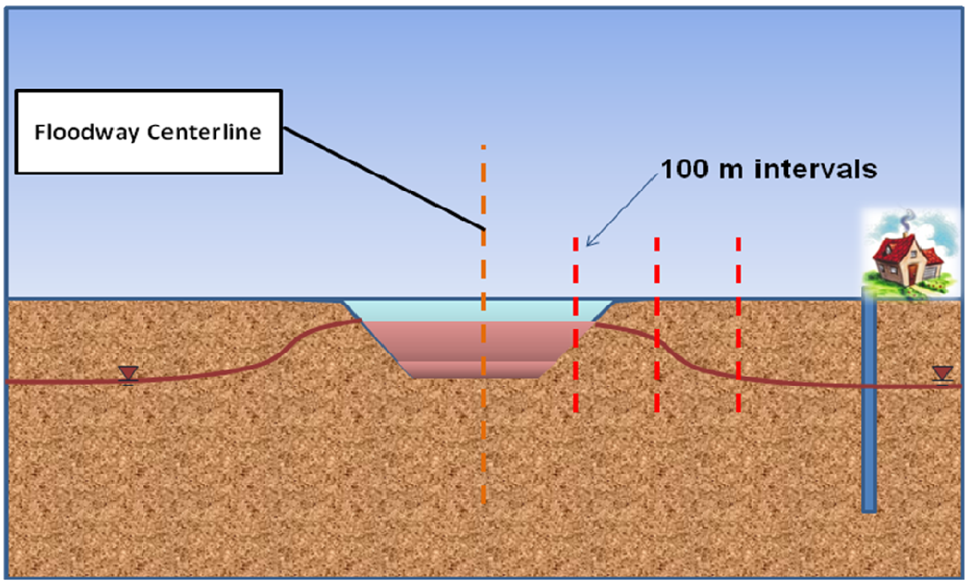


FIGURE 4-2 Grouping Datasets from Floodway Centerline

- Similarly, the bedrock monitor well data was grouped in 100 m offset intervals from the Floodway centerline and concentrations of select indicator parameter concentrations were compared for flood and non-flood events. If the bedrock was being significantly influenced, it was expected that there would be large changes in bedrock groundwater chemistry (comparing flood and non-flood events) near the floodway centerline, and decline with distance.

- Finally, groundwater data for domestic wells, which were generally beyond the Floodway right of way (500 m from centerline on average), was assessed for flood and non-flood events to determine if groundwater chemistry changes could be seen beyond the zone of influence (for either till or bedrock). This considered general flood and non-flood event trends, and also looked for specific wells where health-based criteria (nitrate and bacteria) was exceeded over multiple periods and was coincident with flood events.

- Having determined a zone of influence for overburden and bedrock wells, the potential effect on domestic wells (found further out from the Floodway centerline) was assessed. The Floodway is planned to be widened an additional 60 meters (on average) on either side of the existing centerline. The effects of this increase were added to the estimated zone of influence to determine if domestic wells could be affected after widening was complete. A risk statement was then prepared based on the observed zone of influence and Floodway widening.

4.4.7 Data Analysis Methodology

Jacques Whitford carried out a review of the groundwater and surface water monitoring data compiled by KGS between 2003 and 2007 to provide an independent evaluation of KGS conclusions, and also to assess the potential risks to well receptors located along the east and west side of the Floodway.

To date, there has been considerable evaluation of individual perimeter monitoring wells and domestic wells at varying distances from the Floodway. Several of these appear to indicate some kind of effect from Floodway operation, but are generally located very close (within 100 m) to the Floodway. Other wells exhibit fluctuations that may or may not be related to seasonal recharge activity, and are difficult to separate from the Floodway events.

This assessment began by looking at the data overall by grouping all 2500 or so chemical analysis for over 300 individual monitoring points based on location and distance for the Floodway centerline. A database was set up that organized all available data collected from bedrock and overburden wells with respect to location, either east or up-gradient of the Floodway, or west, or down-gradient of the Floodway. The data was further subdivided into monitoring wells (MFA and Provincial), and domestic wells. A summary of the data evaluation is as follows:

Parameters selected for assessment:

- Major ions (Na, K, Ca, Mg, SO_4, Cl, HCO_3)
- Nutrients (NO_3+NO_2-N)
- Metals (Fe, Mn)
- Physical parameters (turbidity, TDS, conductivity, pH, hardness)
- Microbiological (total & fecal coliform bacteria)

All wells:

- Grouped by 100 m increments, east and west of Floodway
- Calculated average and median values

Wells within 1000 m of Floodway (both east and west):

- Bedrock wells
- Sand and gravel wells
- Till wells
- East side (upgradient) and west side (downgradient)

Wells in Sensitive Settings:

- Lockport,
- Birds Hill
- Areas of known Seeps

A characterization of the source water quality was based on the several years of flood and non-flood monitoring data at surface water sampling stations located in Red River upstream of the Floodway and stations within the Floodway. Comment is provided previously on the effects on surface water quality resulting from outfalls into the Floodway.

For groundwater, emphasis was placed on the more permeable portions of the Floodway from Highway No. 15, through the Birds Hill aquifer, north through thin glacial till to the Floodway outfall. These areas have been identified in previous assessments as potential release pathways from the operational Floodway. Groundwater seeps, or potential former "blow-outs" identified between the TransCanada Highway and Highway 15 crossings are also considered in this assessment.

Assessment of potential exposures (connections between Floodway water and surrounding wells) began by first focusing on the groundwater monitoring wells (both overburden and bedrock monitoring wells), as these are in closest proximity to the Floodway alignment and have been constructed specifically for groundwater chemistry and hydraulic head monitoring at critical locations along the Floodway. It was assumed that all monitoring wells were properly constructed in a manner that provides samples which are most representative of potential groundwater quality changes.

A characterization of the overburden aquifer water quality during flood and non-flood events was undertaken, and trends of median water quality values were evaluated at 100 m offset intervals both east (upgradient) and west (downgradient) of the Floodway. The objective was to identity the zone of influence of water quality changes during a flood event as a function of distance from the Floodway centerline.

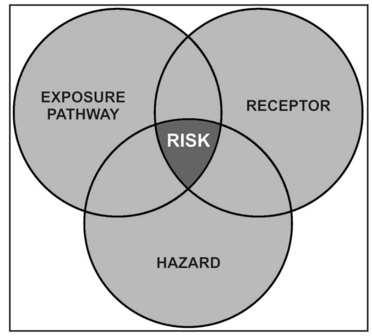
A similar characterization was made for the bedrock monitoring wells, using the specific monitoring well data. These wells were chosen next as infiltration water would eventually enter the bedrock after passing through the overburden material. In addition, a general assessment of domestic well chemistry was done within 1000 m of the Floodway. Domestic well data for wells located at distances greater than 1000 m from the Floodway centreline was determined to be free of influence of the Floodway operation during flood conditions and was used as the basis local background groundwater quality conditions. In total, 286 domestic wells, 29 bedrock monitor wells, and 20 overburden monitor wells were included in the data analysis.

The use of 100m offset intervals was used to normalize the wide range of concentrations observed, and to reduce bias from elevated outlier concentrations where numbers of wells or sample sets within a specific unit, 100 m zone or water source were limited. In addition, a percent difference calculation was done for key indicator parameters to determine the degree of change between the flood events and non-flood event data sets. To address specific public concerns, the data set was also assessed by specifically looking at sensitive areas (e.g. Birds Hill) to determine if these exhibited large differences as compared to the calculated medians of the whole data set.

The distance to wells used in this data assessment is measured from the Floodway centerline. Since the existing Floodway is approximately 250 m wide, this implies that wells within 100 m to 200 m of the centerline are likely constructed within the Floodway itself (*e.g.,* along major bridges), and wells within about 300 m are immediately adjacent to the Floodway soil piles. It is noted that the nearest domestic water supply wells are at least 250 m from the existing Floodway centre line. Therefore wells would be closest to the edges of the Floodway (*i.e.,* potentially on or immediately adjacent to the soil piles).

Several plots of chemistry variation with distance from the Floodway centerline are included. Tables summarizing the major ion chemistry and median values for each well grouping are included in Tables D-1 to D-3, in Appendix D.

4.5 Risk Characterization



The following section provides the Risk Characterization for the Floodway. The risk assessment is based on a qualitative assessment hazards (such as nitrates), versus a predictive pathway assessment using numeric modeling. The historic trends of various groundwater parameters are used as the basis to illustrate potential pathways adjacent to, and beneath the Floodway alignment. Based on the review of data, the degree of risk is defined by one of four criteria, which are as follows:

1. A "high risk" would be stated if receptor well water quality evidence showed health parameters were exceeding in the drinking water guidelines during Floodway operation.
2. "Some risk" would be stated if receptor well water quality evidence showed change during Floodway operation (i.e. there is a confirmed pathway and changes have reached the domestic wells);
3. "Potential risk" would be stated if water quality data showed evidence of change during Floodway operation, but the change had not reached receptors (domestic wells); or
4. "No risk" would be stated if no evidence of water quality change is found at the point of exposure (domestic wells), and thus no pathway exists.

4.5.1 Surface Water Quality

As a necessary first step in evaluating potential surface water influence in the underlying Floodway aquifer during operational periods, it was necessary to differentiate surface water chemistry between operational (flood) and non-operational (non-flood) events. The available surface water chemistry data, between 2005 to 2008 inclusive, was assembled to assess median concentrations of various indicator parameters in flood and non-flood events. For flood event data, select parameters were identified that were much higher than those found in groundwater. These parameters were used to evaluate whether or not surface water infiltration effects were being seen in groundwater during flood events, and if occurring, they were used to determine how far out from the centerline the influence extended. The "zone of influence" was determined by plotting 100 m off-set intervals for an indicator parameter (e.g. nitrate) and determining where the concentrations were equal to or less than groundwater background (i.e. non-flood) conditions.

Table D-1, Appendix D summarizes the range, mean and medium of the Floodway and Red River (upstream) waters for flood and non-flood dates. The Red River water is characterized as a hard to very hard, calcium bicarbonate water of moderate TDS and turbidity.

4.5.1.1 Flood vs. Non –Flood Events

A comparison of the flood vs. non-flood data (between 2005 and 2008) for the eight Floodway sampling stations S-13, S-14, S-21, S23, S-25, S-28 indicates that the flood waters are typically lower in major ions, TDS, TSS, hardness, pH, conductivity, and total coliform bacteria. Flood waters also have higher turbidity, potassium, sulfate, nitrate, ammonia, phosphorus, iron, and manganese concentrations as compared to non-flood events.

A comparison of the flood and non-flood data with the Red River water quality (Table D-1, Appendix D) for the same periods indicates that the flood data more closely reflects the Red River upstream waters than the non-flood waters, as would be expected (*e.g.,* generally less than 10% difference in parameter concentrations). The flood periods are dominated by Red River drainage from the south. During the non-flood events, the Floodway water quality is dominated by groundwater base flow into the low-flow channel, and rainfall drainage and discharge from outfalls from surrounding areas.

With the exception of total and fecal coliform bacteria, the Floodway waters during non-flood periods is of better overall quality than the Red River water, with lower concentrations of major ions, nutrients, TSS and TDS. The higher mean and median bacteria are likely related to the many outfalls into the Floodway along its 48 km length. A cursory comparison of outfall chemistry data to the overall Floodway chemistry indicates higher bacteria from outfalls as compared to the Red River or the Floodway surface water quality.

4.5.2 Overburden Monitoring Wells

In assessing influence of Floodway surface water on the underlying groundwater, it was necessary to next assess the potential migration into overburden soil (this is the first geological unit surface water must pass to reach the bedrock aquifer where domestic supply wells are completed). For this study, the overburden data was divided into two geological groups which included till, and sand and gravel. As noted above, changes in various indicator parameters were assessed by grouping overburden wells into 100m increments away from the Floodway centerline, and plotting select parameters on graphs to determine if there were large changes in groundwater chemistry when comparing flood and non-flood periods. If changes were seen during flood periods, the “zone of influence” could be determined by noting the distance required to see the concentration return to background (i.e. non-flood) levels.

A total of 20 overburden monitoring wells with 100 chemical analysis events are identified in the KGS database. Overburden monitoring wells are placed in high risk areas along the Bird’s Hill aquifer, and North of Highway No. 15. Most wells are completed in either sand and gravel (7 wells) or glacial till (10 wells; with one well completed into the till-bedrock interface/rubble zone (Springfield/CPR Keewatin monitoring well W03-11018), and two wells completed into sandy silt or silty sand till (Oasis Road K04-12104 and K06-8721). A summary of number of wells as a function of distance from the Floodway centerline is presented in Figure 6.1

4.5.2.1 Groundwater Quality – Overburden Monitoring Wells

The data show a strong differentiation between the bedrock chemistry and the glacial till, and the sand and gravel. Select summary statistics (means and medians) are provided in Table D-2, Appendix D. The general groundwater quality in overburden wells is described as follows:

- Using all available data, the sand and gravel groundwater characteristic of Birds Hill aquifer (at the 7 locations sampled) is described as a slightly hard (median hardness 249 mg/L, mean hardness

347 mg/L, range 203 mg/L to 1150 mg/L), calcium bicarbonate groundwater of low TDS (median 276 mg/L, mean 404 mg/L, range 206 mg/L to 2100 mg/L). All parameters except turbidity, and (concentrations greater than 200 mg/L in the 7 wells), and occasional iron and manganese (1 each of limited sampling data) and TDS (in 2 of the 7 wells) fall within guidelines for Canadian Drinking Water Quality. The exceedance of turbidity can be attributed to sampling bias (*e.g.,* effects of bailing). With the exception of hardness and turbidity, most exceedences were not persistent.

- The glacial till groundwater chemistry characteristic of the area north of the Highway 15 crossing (at the 10 locations sampled) is described as a very hard (median hardness 703 mg/L, mean hardness 982 mg/L, range 161 mg/L to 3180 mg/L), calcium bicarbonate groundwater with high sulfate concentration (median 132 mg/L, mean 548 mg/L), of high TDS (median 829 mg/L, mean 1387 mg/L, range 180 mg/L to 7370 mg/L). All analyzed parameters except occasional sodium (in 2 of the 10 wells), chloride (in 3 of the 10 wells), sulfate (in 5 of the 10 wells), turbidity (in all 10 wells), hardness (in all 10 wells), iron and manganese (in 5 each of the 10 wells), TDS (in 8 of the 10 wells) and nitrate (in 1 of the 12 wells), fall within guidelines for Canadian Drinking Water Quality.
- The silty sand groundwater chemistry is approximately intermediate to the sand and gravel and the glacial till groundwater chemistry. Based on 4 samples collected from 2 locations, this water is described as a hard (median 418 mg/L, mean 411 mg/L), magnesium-bicarbonate groundwater of moderate TDS (median 539 mg/L, mean 505 mg/L). Parameters that may exceed drinking water guidelines include turbidity, sulfate (in 1 of the 2 wells), hardness, manganese and TDS (in 1 of the 2 wells).
- When comparing the overall median values for more sensitive areas near Lockport, Birds Hill, CPR Keewatin, and the Highway 15 area, there do not appear to be large differences in localized indicator parameter values (flood and non-flood events) to those of the overall dataset for the study (Table 4.2a, Appendix D).

4.5.2.2 Spatial and Temporal Trends

The flood event data were assessed on a 100 m horizontal offset distance interval from the Floodway. Figure 6.2 of Appendix A shows trends over distance are present for the median values of nitrate+nitrite, sulphate and hardness in the till groundwater as well as the sand and gravel groundwater during flood operation periods. It is noted that for both sulphate and hardness in the median Floodway surface water concentrations (flood-event operation) are much lower than those seen in till groundwater, suggesting there are other factors influencing the local groundwater and not the Floodway itself. Sulphate and hardness concentrations in the sand and gravel aquifer remains relatively unchanged with distance from the Floodway centerline; it is noted that the median Floodway surface water hardness (during flood events) is less than concentrations in the groundwater. This data suggests that the Floodway has limited effect/influence on the sand and gravel, and till groundwater during operational periods.

Median value nitrate+nitrite plots (Figure 6.2, Appendix A) show a distinctly declining trend for both the Sand and Gravel, and Till groundwater. In both Till and Sand and Gravel, the nitrate+nitrite concentrations in Floodway surface water (Flood-event operation) are above those seen in groundwater which is what should be expected. The nitrate+nitrate trends suggest that if there were a surface water influence to the Till and Sand and Gravel groundwater (during flood operation), it's influence is limited to within 300 m of the Floodway centerline where concentrations approach non-flood median values. For the purposes of this study, the more conservative results from the nitrate+nitrite data are carried forward suggesting there is some limited influence of surface water to groundwater during Floodway operations, but this influence is limited to within 300 m of the Floodway centerline.

4.5.2.3 Flood vs. Non –Flood Events

A comparison of the flood vs. non-flood data for each of the four overburden units (Table D-2) indicates a moderate probability for hydraulic and geochemical interaction between the Floodway and the adjacent sand and gravel, glacial till or shallow bedrock aquifers under flood conditions. The only health-based guideline is for nitrate+nitrite-N, which exhibited very small increases in concentration, consistent with the low nitrate concentration in both the aquifers (median 0.12 mg/L and 0.04 mg/L for sand and till respectively) and the much higher nitrate in the flood waters (median 1.44 mg/L). Major ion concentrations generally decrease by 5 to 10% compared to non-flood events. Specific comments related to the main overburden units are as follows:

- Based on 11 flood and 33 non-flood samples for the sand and gravel, during flood events there was an increase in turbidity (7.4 % increase in the median), nitrate (40% increase in the median) and a small general decrease in major ions, hardness, EC, TDS, compared to non-flood events. The median data exhibits a more consistent percent difference between flood and non-flood waters, than the average data (higher numbers due to sample variation). This assessment would suggest a potential hydraulic connection between the sand and gravel aquifer in the vicinity of these wells, and the Floodway waters, as noted Section 4.10.1.2 above.
- Based on 23 flood and 25 non-flood samples for the till, during flood event there was a 32% to 170% increase in turbidity, an approximate 25% to 50% increase in conductance and TDS, major ions, EC, hardness and negligible change in pH. Nitrate (96% increase in the median) appears to be a useful health-based indicator of the interaction of surface water from the Floodway and groundwater in the glacial till aquifer. This would suggest a potential hydraulic connection between the Floodway and the glacial till in the vicinity of these wells. There is a distinct increase in hardness, alkalinity, TDS and major ions, despite lower concentrations of these parameters in the flood water during operation. This suggests that the increases are not associated with the Floodway operation, but rather may be due to other influences such as road salt application.

The above comments assume there were no concurrent major rain events that could also strongly affect mean and median groundwater chemistry (*e.g.,* seasonal variations due to recharge). Results are presented in Table D-2 in Appendix D.

4.5.3 Bedrock Monitoring Wells

There are 29 bedrock monitor wells installed in close proximity to the Floodway alignment. These wells are used only for assessing bedrock groundwater quality (i.e. not potable supply wells). The same approach for assessing potential influence of Floodway surface water on overburden groundwater (4.5.2 above) was applied to assessing bedrock groundwater. If there was a large difference in bedrock groundwater chemistry when comparing flood and non-flood events, it would be noted; if large differences were noted, a zone of influence for the bedrock aquifer could be calculated, as described in 4.5.2 above.

A total of 29 bedrock monitoring wells with 274 chemical analysis samples are identified in the KGS database. The bedrock monitoring wells are located in high risk areas along the Bird's Hill Aquifer, and North of Highway No. 15, with emphasis on major highway bridge crossings having dewatering issues. Fifteen wells are located on the west (downgradient) side at distances of 65 m to 514 m from the centerline, and 14 wells are located on the east (upgradient) side at distances of 35 m (likely in Floodway) to 355 m from the center line (refer to Figure 6.3 Appendix A). The wells are completed in fractured limestone and shale bedrock at CN Redditt (4 wells), Hay Road (3 wells), Dunning Road (4 wells), PTH59N (2 wells), Springhill (2 wells), Kildare Road (2 wells), Highway 15 (1 well), CPR Keewatin (3 wells), Ludwig Road (1 well), Lockport (1 well) Oasis Road (3 wells) and the Floodway Outlet structure (3 wells). Refer to Drawing No. HM38-5 (2 Drawings), Appendix B for monitor well locations.

The bedrock aquifer chemistry and hydraulic responses to flood events are assessed using the 29 Floodway and provincial monitoring wells completed into the bedrock aquifer, and 286 domestic water supply wells located within a distance of 1000 m from the Floodway centerline. The monitoring wells which are closer to the Floodway, are considered to be the better source of information for an assessment of likely hydraulic and hydrochemical interactions between the Floodway and the bedrock. The domestic wells are used to confirm the monitor well observations, and for an assessment of bacteria mobility and persistence (note that monitor wells are not suitable for bacteria monitoring; this is best done with operational wells that limit inter-sampling biological growth in the well bore).

4.5.3.1 Groundwater Quality – Bedrock Monitoring Wells

The distribution of bedrock monitor wells grouped by 100 m horizontal offsets from the Floodway centerline, is presented in Figure 6.3 (Appendix A). The bedrock chemistry data show a strong differentiation between the bedrock chemistry and the overburden aquifer units (Section 4.5.2). There is also a wide range in hardness and TDS along the northern portion of the Floodway. In general, the bedrock groundwater chemistry, based on the specific locations sampled (Table D-3) is described as a hard (median 430 mg/L, mean 470 mg/L, range 59 mg/L to 1510 mg/L), calcium-magnesium-bicarbonate groundwater of high TDS (median 554 mg/L, mean 659 mg/L, range 120 mg/L to 2480 mg/L). Wells with low measured TDS in groundwater (less than 400 mg/L) tend to be located in the vicinity of Spring Hill, Oasis Road, Ludwig Road, the Outlet Structure, CPR Keewatin, and the PTH59 Bridge, and are likely being recharged from the overlying Birds Hill aquifer. Wells with measured TDS in groundwater greater than 1000 mg/L TDS tend to be located at Dunning Road, north of Highway 15, CN Redditt, Hay Road, and Lockport. The wide range in dissolved solids is suspected to be related to well depth, location along the flow field, and the source of recharge.

All parameters fall within Guidelines for Canadian Drinking Water Quality except hardness and turbidity (most wells), TDS (in 19 of the 29 wells), sulfate (in 6 of the 29 wells), and occasional iron and manganese (in 3 and 4 of the 29 wells, respectively), sodium and chloride (in 3 and 2 of the 29 wells, respectively). With the exception of elevated hardness and TDS which are natural to the bedrock aquifer, and turbidity which can be attributed to sampling bias (*e.g.,* bailing), most exceedences were not persistent. Bacteria are not analyzed due to natural borehole bacteria re-growth in non-pumped monitor wells.

4.5.3.2 Spatial and Temporal Trends

The flood and non-flood event data were assessed on 100 m distance intervals from the Floodway. Review of the data generally indicates lower parameter concentrations on the east (upgradient) side than on the west (downgradient) side, which correlates to the east to west direction of groundwater flow, and the presence of a major overlying freshwater aquifer (Birds Hill aquifer) on the east (upgradient) side of the Floodway, which provides recharge to the bedrock aquifer. No obvious trends are observed in the non-flood data. This is consistent with the hypothesis that groundwater is discharging into the Floodway most of the year during non-flood events.

The Floodway operational data indicate a general increase in bicarbonate, EC, and TDS with distance from the Floodway, consistent with recharge of lower conductivity flood waters into the shallow bedrock near the Floodway. The recharge is more apparent on the east side, likely adjacent to the Birds Hill aquifer. Some parameters such as potassium and sodium decline slightly with distance from the Floodway. The trends in the bedrock data are much less defined than for the sand and gravel and till overburden units.

4.5.3.3 Flood vs. Non-Flood Events

A comparison of the flood vs. non-flood data for the bedrock monitor wells indicates a low probability for hydraulic and geochemical interaction between the Floodway and the underlying bedrock in comparison to the overburden units under flood conditions. Only nitrate+nitrite exhibited very small concentration increases, consistent with the low nitrate concentration in the bedrock (median 0.02 mg/L, mean 0.24 mg/L), and the higher concentrations in the flood waters (median 1.44 mg/L, mean 1.42 mg/L).

Based on 114 flood and 160 non-flood groundwater samples for the bedrock monitoring wells (Table D-3), during flood events, there was an increase in turbidity (73% median, 62% mean, nitrate (11 % median, 45% mean) and chloride (4.9 % median, 33.7% mean), and a small general decrease (0% to 10% in both means and medians) of major ions, metals, hardness, EC, and TDS as compared to non-flood events. The median data exhibits a more consistent percent difference between flood and non-flood waters than the average data (much higher numbers due to sample variation). This assessment would suggest a minor potential hydraulic connection between the Floodway and the bedrock aquifer in the vicinity of these wells as illustrated for nitrate and conductance in (Figure 6-4, Appendix A) for flood and non-flood events.

When comparing the overall median values for more sensitive areas near Lockport, Birds Hill, CPR Keewatin, and the Highway 15 area, there do not appear to be significant differences in localized indicator parameter values (flood and non-flood events) to those of the overall dataset for the study (Table 4.2b, Appendix D).

Jacques Whitford also reviewed the results of the 2005 sampling program for surface water discharging from local seeps along the Floodway channel (KGS, 2005b). The samples here were collected shortly after Floodway operation in May 2005. The data was reviewed for evidence of a surface water influence through the groundwater seeps (also referred to as “blow-outs”) following a flood event. Any such response would be identified by a clear difference, specifically a decrease in select water quality indicator parameters measured in the seep as compared to nearby groundwater.

For comparison, the groundwater seep data from 2005 was compared to average groundwater values for select indicator parameters including hardness, sulphate, and nitrate+nitrite (refer to Table 4-1, Appendix D). The data generally indicates that for most of the seeps, there is little difference when compared to groundwater data from adjacent wells. However, groundwater seep location SPR-9 (Springfield Road) did show anomalous results, with groundwater discharge from the seep having lower concentrations of indicator parameters as compared to groundwater, possibly indicating a localized influence. In contrast, groundwater seep SPR-5 (Branch I Aqueduct crossing) showed increases concentrations of indicator parameters in the groundwater discharged, suggesting there is a local geologic anomaly in this area. Based on this review, there is little evidence to demonstrate an interaction between the groundwater seeps and groundwater during Floodway operation.

4.5.4 Domestic Water Supply Wells

After assessing potential pathway connections on groundwater in the till and bedrock immediately adjacent to the Floodway (4.5.2 and 4.5.3 above), the groundwater chemistry for nearby domestic supply wells (which are completed in bedrock) was assessed to determine if there were large measurable differences when comparing flood and non-flood periods. As there were no apparent influences to the bedrock under, and immediately adjacent to the Floodway (see 4.5.3 above), large changes in bedrock groundwater chemistry in domestic supply wells should not be present, unless they were within the Floodway zone of influence.

The domestic wells which were monitored and sampled are distributed along the length of the Floodway, at distances of 310 m to over two kilometres west (downgradient), and 255 m to over 4 km east (upgradient) of the centerline. A total of 286 domestic water supply wells with 1560 chemical analysis samples are identified within 1000 m of the Floodway centerline in the KGS database. Using the wells within 1000 m distance of the Floodway centreline, 179 wells are located on the west (downgradient) side and 107 wells are located on the east (upgradient) side. All domestic wells are assumed to be completed in fractured carbonate bedrock aquifer. A distribution of domestic supply wells within 1000 m of the Floodway centerline is presented in Figure 6-5 (Appendix A).

4.5.4.1 Groundwater Quality – Domestic Water Supply Wells

The bedrock groundwater chemistry from the domestic wells within 1000 m of the Floodway is similar to that of the bedrock monitoring wells. In general, groundwater collected from the domestic wells was found to be harder and higher in TDS than that collected from the overburden units. The average bedrock groundwater chemistry, based on data obtained from the domestic wells, can be described as a hard (median 417 mg/L, mean 473 mg/L, range 21 mg/L to -1350 mg/L), and alkaline (median alkalinity 286 mg/L, mean alkalinity 402 mg/L, mean and median pH 7.92), calcium-magnesium-bicarbonate groundwater of high TDS (median 558 mg/L, mean 625 mg/L, range 94 mg/L to 2710 mg/L). The wide range in dissolved solids is suspected to be related to well depth, location along the flow field, and the source of recharge.

All parameters measured in groundwater collected from the domestic wells, except occasional turbidity (23% of samples), sulfate (in 13 of the 286 wells), iron and manganese (in 28% and 4% of the 1560 samples), fluoride (in 1 of the 286 wells), nitrate (in 3 of the 286 wells), sodium (in 5 of the 286 wells), sulfate (in 13 of the 286 wells), chloride (in 11 of the 286 wells), and commonly elevated hardness (in 99% wells, hardness was found to be greater than 200 mg/L), and TDS (in 57.3 % of the 1560 samples) fall within guidelines for Canadian Drinking water Quality. With the exception of hardness and TDS, which are naturally elevated to the bedrock aquifer, and occasional turbidity (likely related to poor well construction), most exceedences were isolated to a few specific wells.

Total coliform bacteria were detected at least once in 86 wells (12%), and fecal coliform were noted at 9 wells (0.9-%). The bacteria occurrences were highly random, and generally were not persistent amongst wells. Only 9 of 286 wells exhibited more than 4 bacteria occurrences over the monitoring period. Based on the distribution of the wells and the random occurrences, there is no clear correlation between bacteria in water supply wells and Floodway operation. The wells with the most occurrences occur 400 m to 500 m from the Floodway.

4.5.4.2 Spatial and Temporal Trends

The flood and non-flood event data were assessed on a 100 m distance intervals from the Floodway centreline. Since no apparent differences were noted between the overall average bedrock monitor well data and domestic well data, and there was no apparent difference between the flood and non-flood data (Section 4.5.3), the key indicator parameters were plotted for all of the domestic well data together to determine if there is any regional influence from the Floodway.

The selected parameter charts shown on Figure 6-6 (Appendix A) show very minor trends in data between the closest domestic wells (255 to the east,, and 310 m to the west) and 1000 m from the Floodway. In comparison with the bedrock monitor wells (Figure 6-4), no obvious trends are observed in the domestics well data.

4.5.4.3 Flood vs. Non-Flood Responses

A comparison of the flood vs. non-flood data for the domestic bedrock wells indicates almost no groundwater geochemistry difference between the flood event data and the non-flood data.

Based on 503 flood event samples from 155 domestic bedrock wells, and 1049 non-flood samples from 286 domestic bedrock wells, the following points are noted.

- During flood event, there were slightly higher major ion, TDS, EC and hardness concentrations as compared to the non-flood stage (Table D-3, Appendix D). It should be expected, during flood events, that there would be a general decline in most monitoring parameters, and a slight increase in nitrate; this observation suggests there are no effects from the Floodway operation on the domestic water supply wells.
- The domestic wells for which data has been provided are all located more than 255 m east and 310 m west of the Floodway centerline (Figure 6-5). These wells are assumed to be completed in bedrock, and as noted previously do not appear to be affected by Floodway operation.
- In summary, a comparison of median data within 1000 m from the Floodway centerline indicates a general increase in hardness, TDS, major ions from east to west in the direction of groundwater flow as would be expected. A small decrease in average parameter concentration occurs at monitor wells within about 300 m of the Floodway, with lower concentration occurring on the east side than the west side. No trends with respect to coliform bacteria are indicated.

Based on the results of the qualitative risk assessment, no health risk was determined to be present based on the definitions of risk described at the start of this Section. Specifically, no trends were seen to indicate exceedences of health based parameters in domestic wells during Floodway operational periods. Some water quality changes for non-health based parameters were noted in overburden wells which suggest a connection to the till, and sand and gravel aquifer over a “zone of influence”. Although this overburden zone of influence (approximately 300m from Floodway centerline) is present in areas north of Hwy 15, there are no corresponding water quality changes in bedrock wells during Floodway operational periods.

4.6 Confidence Assessment

Risk estimates normally include an element of uncertainty, and generally these uncertainties are addressed by incorporating overly conservative assumptions in the analysis. As a result, risk assessments tend to overstate the actual risk. Although many factors are considered in preparation of a risk analysis, analysis results are generally only sensitive to some of these factors. The uncertainty analysis is included to demonstrate that assumptions used are conservative, or that the analysis result is not sensitive to this assumption.

A risk assessment containing a high degree of confidence will be based on:

- conditions where the problem is defined with a high level of certainty based on data and physical observations;
- an acceptable and reasonable level of conservatism in assumptions which will ensure that risks are overstated; or
- an appreciation of the bounds and limitations of the final solution.

The exposure assessment performed as part of this study was based on:

- available data to describe existing surface soil conditions metal distributions;
- sound conservative assumptions for certain parameters, as required; and
- well-understood and generally accepted methods for risk prediction.

The risk assessment has been preformed to assess current trends of potential hazards as a function of distance under the current floodway profile. The risk assessment assumes that similar influences will result in a widened Floodway profile. However, this assumption must be confirmed through long-term monitoring, as noted in the Section 6.0 below.

TABLE 4-1 Evaluation of Assumptions in the Risk Analysis

Risk Analysis Study Factor/Assumption	Justification	Analysis Likely to Over/Under Estimate Risk ?	Acceptable Assumption?
Geological Factors			
Some high risk areas of the floodway have impacted surface water in direct contact with bedrock.	Data from these areas has been included in the analysis. Human health guidelines are exceeded in one location only. Cut-off walls have been installed in areas of highest risk.	Neutral	Yes
Data from overburden monitoring wells used to identify zones of influence.	Overburden wells in sand and gravel/till are expected to be more sensitive to potential influence from floodway operations. Bedrock wells will generally show slower and suppressed response to floodwater. Conservative assumption.	Over Estimate	Yes
Fractures /conduit flow has been suggested in preview studies which may represent risk to the underlying aquifer.	This has been considered and results have not confirmed this effect	Neutral	Yes
Hazard Identification			
Some domestic water supply data has been excluded due to the presence of water softeners.	Some domestic water supply wells results show supply systems have been installed with water softeners. Water softeners artificially reduce some indicator parameters. Including this data would lower median results and not accurately reflect the general nature of the aquifer. This occurred in the case of approximately 50 wells.	Over-estimate	Yes
Some domestic water supply data has been excluded as the well locations could not be confirmed.	In cases where data was lacking to confirm the well location, the data was excluded. This occurred in the case of 7 wells.	Neutral	Yes

TABLE 4-1 Evaluation of Assumptions in the Risk Analysis

Risk Analysis Study Factor/Assumption	Justification	Analysis Likely to Over/Under Estimate Risk ?	Acceptable Assumption?
Groundwater/Surface water data is representative of different flood events and influences	Data was included for a four year period. Extreme (1 in 100 year) event data is not available. Data set used in study is considered typical of more common flood events	Neutral	Yes
Not all well were tested for health based parameters.	Monitoring wells were not typically tested for bacteria		
Pathway Analysis			
There is uncertainty to potential future risk because of variability of the channel width respect to the extension of the zone of influence from a widened floodway.	Analysis shows the zone of influence extends to approximately 300 m from the floodway centreline. The floodway expansion will result in an average width increase of 100 m from centerline which extends zone of influence proportionally. An extension of the zone of influence by 100 m still places the zone within the extended floodway right of way which has development restrictions for the placement of additional wells.	Neutral	Yes
It has been assumed that all domestic water supply wells are bedrock wells.	This is a reasonable assumption based on well construction standards.	Neutral	Yes

5.0 CONCLUSIONS

Based on the independent analysis and results provided in this study, Jacques Whitford provides the following conclusions:

- Through review and public consultation, issues of public concern with regards to the widening of the existing Floodway were indentified and assessed.
- Modeling could not be used as a definitive tool to determine potential exposure pathways to sensitive receptors (surface water to potable groundwater wells) as there is insufficient aquifer data to permit model calibration. In the absence of modeling, the use of existing groundwater and surface water data sets were suitable to complete the human health risk assessment. As modeling was not conclusive, the potential of a pathway was assumed and required study
- There are confirmed differences in surface water quality in the Floodway between flood and non-flood events that represent potential hazards to residents along the floodway (i.e. elevated nitrate and bacteria).
- There are varying geological conditions along the Floodway alignment that can influence the pathway between surface water and groundwater. The least sensitive geological area generally lies south of Highway 15 in areas of low permeable clay. The most sensitive geological formations are those which provide a direct interaction between surface floodwater and bedrock groundwater (areas between Birds Hill to Lockport). The area between Highway 15 and Birds Hill have geological formations which also make the area susceptible to interaction between surface water and the bedrock groundwater.
- Selected parameters that were found to differ significantly between flood and non-flood periods were used as indicators to determine the zone of influence between the Floodway and the groundwater. Using nitrate and conductance as indicator parameters, it was demonstrated that the

lateral zone of influence in overburden monitor wells extends 200 to 300m from the Floodway centerline. This zone of influence is typically within the Floodway right-of-way where groundwater withdrawal restrictions are established.

- Using nitrate and conductance as indicator parameters, there was no major change in the bedrock monitor wells within the Floodway right-of-way when comparing flood and non-flood data, indicating recharge to the bedrock aquifer during flood events is limited. Trends were noted in bedrock wells as groundwater traveled across the Floodway in an upgradient to downgradient direction. Indicator parameters such as conductance and hardness tended to increase as expected. Nitrate also decreased moving in a downgradient direction as expected when moving from an agricultural area to a more urban setting.
- The data did not illustrate the influence between large scale groundwater production wells and the Floodway. However, it is noted that MFA have included cut-off walls to be constructed adjacent to these more sensitive areas (Outlet and East St. Paul) as a precautionary approach. Furthermore, the data did not demonstrate a clear connection between the groundwater in localized areas of identified seeps ("blow-outs").
- Water quality in existing domestic water supply wells located within the zone of influence was evaluated against health benchmarks and background. Only one well in the Lockport area showed a nitrate excedence in multiple sample events (representing 5 of 1500 samples completed) which suggests a localized issue not associated with Floodway operations. In all other cases, wells were found to have chemistry below water quality guidelines and were consistent with those wells outside the zone of influence (i.e. background values).
- While bacteria were identified in several individual wells, none were found to be present subsequent sampling nor were they correlated well with lateral distance from the Floodway. This is suspected to be an artefact of cross contamination during sampling. E-coli was found in only 11 of 1540 samples, which represents 9 of 286 wells; only two wells had two confirmed E-coli detections. The E-Coli data is random and is believed to be associated with well construction/quality issues and not associated with Floodway operations.
- Based on the results of the human health risk assessment, no unacceptable risk has been identified to domestic water supply wells within the identified Floodway zone of influence. In an expanded Floodway, where excavations are expected to extend up to 100 meters beyond the existing Floodway limits, the zone of influence can be expected to extend proportionally in a lateral direction. It should be noted that the existing Floodway right-of-way boundary typically extends 500 m out from the alignment centerline which has controls over well construction. In geologically sensitive areas where significant widening is to occur, existing domestic wells in the extended zone of influence may see some short-term changes in water quality during Floodway operations although increases above water guidelines are not expected to occur.

6.0 RECOMMENDATIONS

Based on the above, we recommend the following:

- In order to confirm the uncertainties of the risk assessment, a post-construction monitoring plan should be developed which includes selecting existing monitoring and domestic wells located within the zone of influence (of the widened Floodway). This should include existing wells were health based parameters (bacteria and nitrates) have been identified previously. Some well improvements may be required in some individual cases. In addition, sentinel wells should be installed in the Floodway Right-of-Way in areas with wells at higher risk.

- Monitoring should continue for a minimum of two years after construction, and include at least two flood events. Post-construction monitoring requirements should be reviewed after two Floodway operation events have occurred to determine future monitoring needs. Wells which have shown to repeatedly exceeded health-based criteria during the monitoring program should be investigated further to determine potential cause.

7.0 CLOSURE

This report has been prepared for the sole benefit of the Manitoba Floodway Authority. The report may not be used by any other person or entity without the express written consent of Jacques Whitford Limited and the Manitoba Floodway Authority.

Any uses that a third party makes of this report, or any reliance on decisions made based on it, are the responsibility of such third parties. Jacques Whitford Limited accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made, or actions taken, based on this report.

The information and conclusions contained in this report are based upon work undertaken by trained professional and technical staff in accordance with generally accepted engineering and scientific practices current at the time the work was performed. Conclusions and recommendations presented in this report should not be construed as legal advice.

The conclusions presented in this report represent the best technical judgement of Jacques Whitford Limited based on the data obtained for the work, in the form of documentation provided by the Manitoba Floodway Authority. If any conditions become apparent that differ significantly from our understanding of conditions as presented in this report, we request that we be notified immediately to reassess the conclusions provided herein.

This report was prepared by David MacFarlane, MA.Sc., P.Geo and John Henderson, P.Eng.

P:\enveng\102xxxx\1025616 Manitoba Floodway Modeling\Risk Assessment\Final Document\Final Report.docx

8.0 REFERENCES

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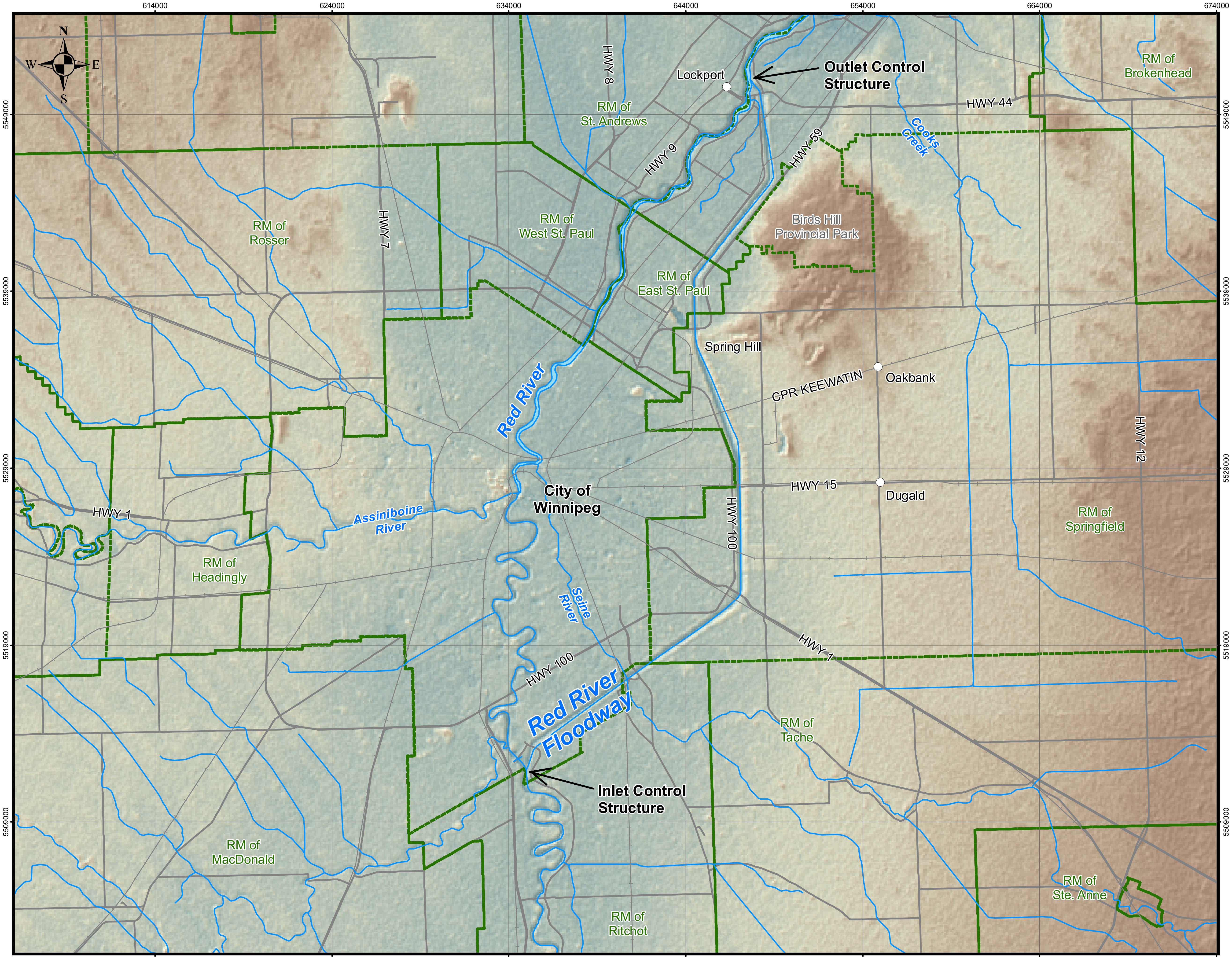
APPENDIX A

Figures



Manitoba Floodway Authority

Figure 1

Project Location

Red River Floodway Expansion Project

Map Features

- Places
- Rail Line
- Watercourse
- Regional Municipality
- Provincial Road
- Waterbody

Elevation Model (m)

High : 276

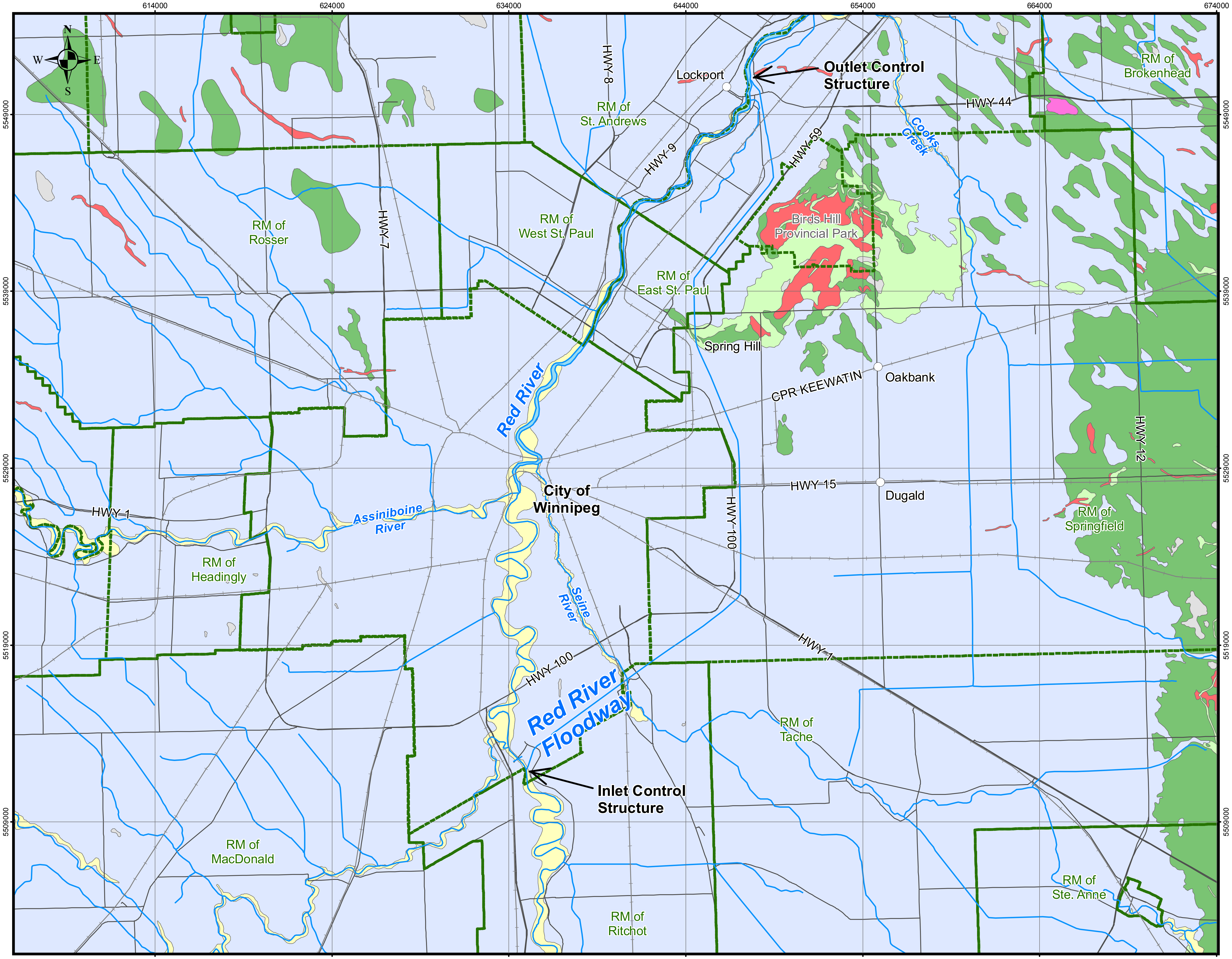
Low : 216

0 2 4 8 12

Kilometres

Map Parameters
Projection: UTM, NAD83, Zone 14N
Scale 1:200,000
Date: November 2, 2007
Project No.: 1025616.

Jacques Whitford



Manitoba Floodway Authority

Figure 2

Surficial Geology

Red River Floodway Expansion Project

Map Features

- Rail Line
- Watercourse
- Regional Municipality
- Provincial Road
- Waterbody

Surficial Geology

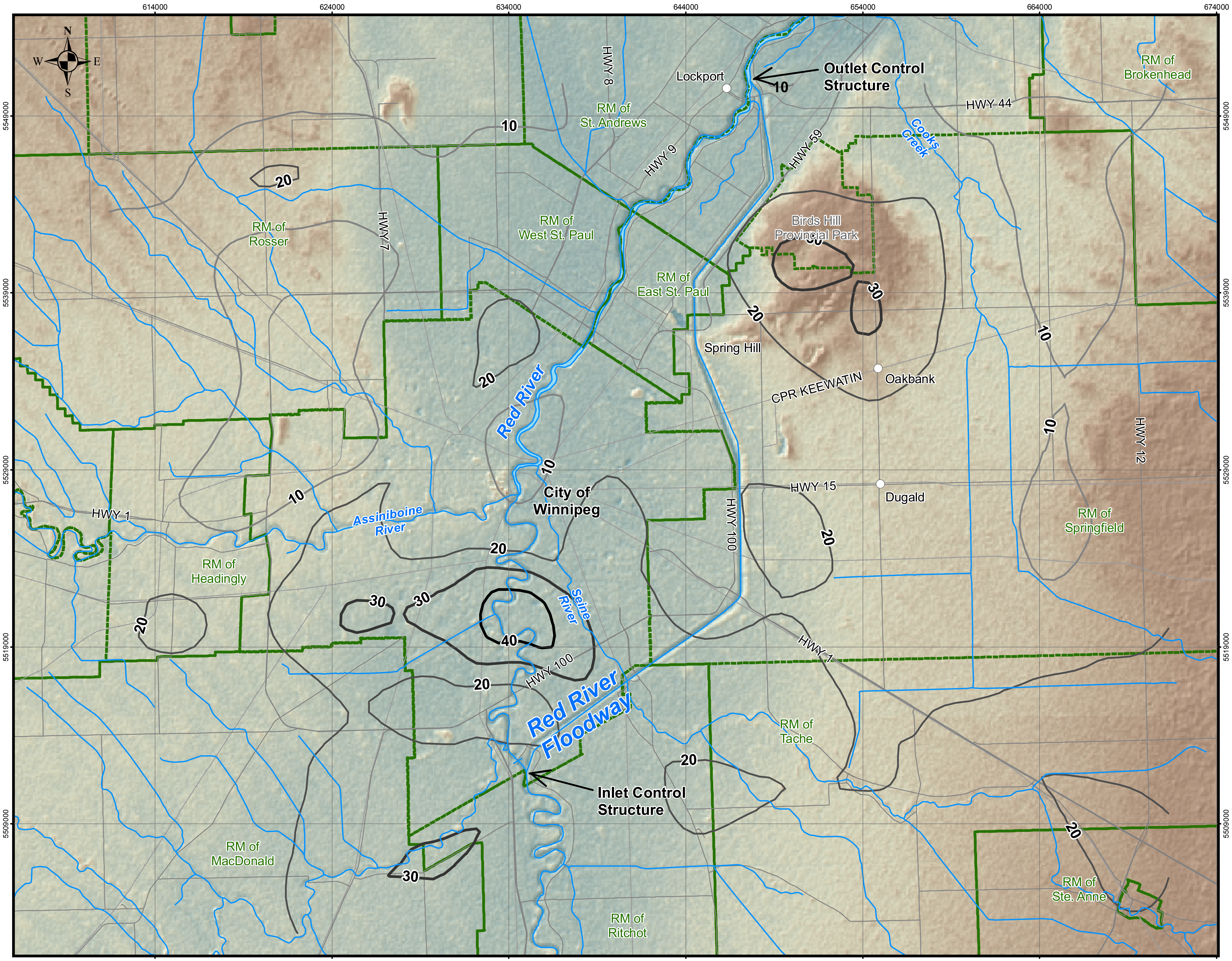
- Alluvial sediments: sand and gravel, sand, silt, clay, organic detritus
- Marginal glaciolacustrine sediments: sand and gravel
- Offshore glaciolacustrine sediments: clay, silt, minor sand
- Organic deposits: peat, muck
- Proximal glaciofluvial sediments: sand and gravel
- Paleozoic terrane; carbonate-dominated rocks
- silt diamicton; calcareous, largely composed of Paleozoic rocks

0 2 4 8 12

Kilometres

Map Parameters
Projection: UTM, NAD83, Zone 14N
Scale 1:200,000
Date: November 2, 2007
Project No.: 1025616.

Jacques Whitford



Manitoba Floodway Authority

Figure 3

Depth to Bedrock Contours

Red River Floodway Expansion Project

Map Features

Watercourse

Depth to Bedrock (m)

10
20
30
40

Provincial Road

Regional Municipality

Waterbody

Elevation Model (m)

High : 276

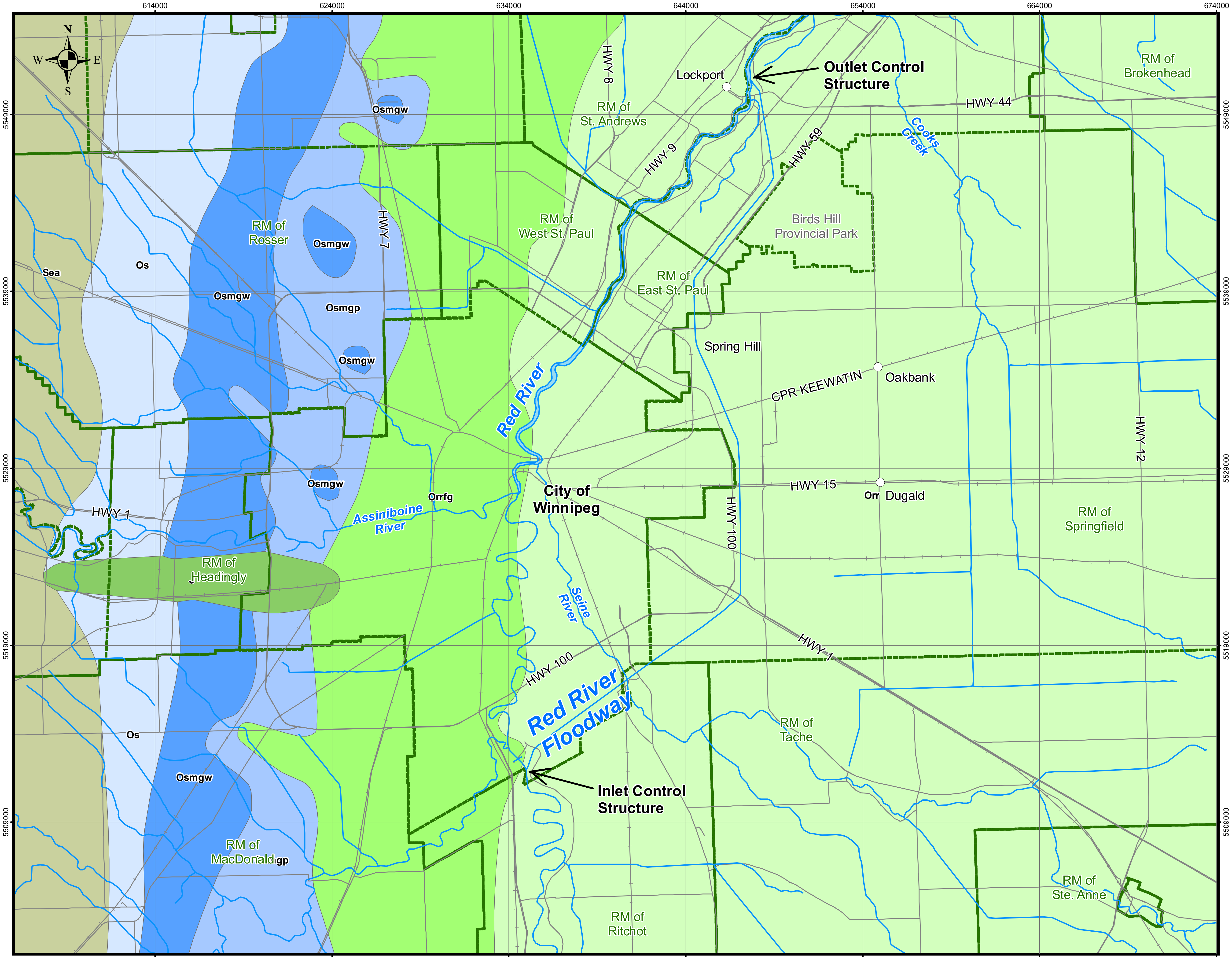
Low : 216

0 2 4 8 12

Kilometres

Map Parameters
Projection: UTM, NAD83, Zone 14N
Scale 1:200,000
Date: November 2, 2007
Project No.: 1025616.

Jacques Whitford



Manitoba Floodway Authority

Figure 4

Bedrock Geology

Red River Floodway Expansion Project

Map Features

- Watercourse
- Provincial Road
- Rail Line
- Regional Municipality
- Waterbody

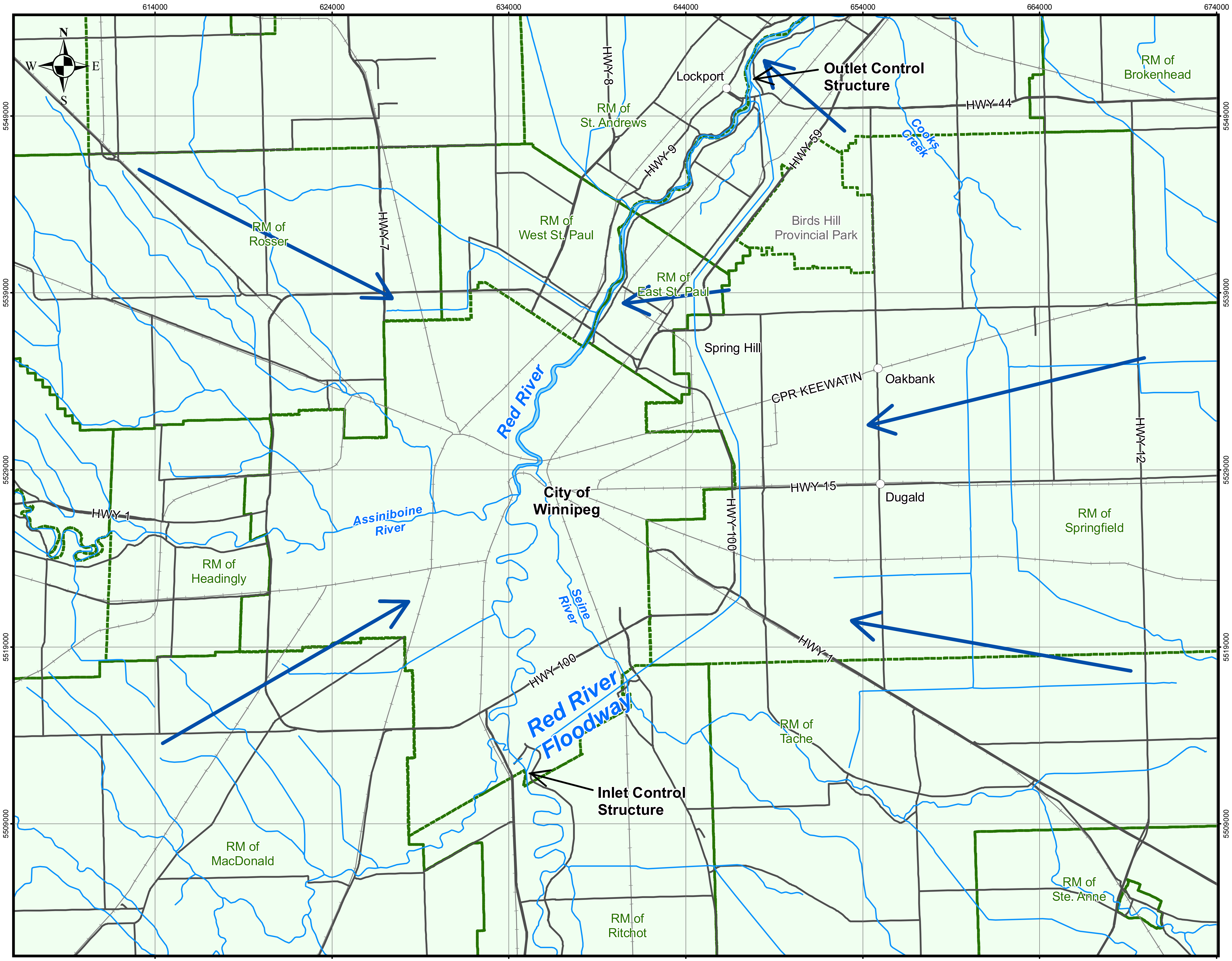
Bedrock Geology

- J - Amaranth, Reston, Melita Formations; Sandstone and shale
- Orr - Red River Formation; Limestone and dolomite
- Orrfg - Red River Formation; Massive dolomite
- Os - Stonewall Formation; Dolomite
- Osmgp - Stony Mountain Formation; Calcareous shale
- Osmgw - Stony Mountain Formation; Nodular dolomite
- Sea - East Arm Formation; Dolomite

0 2 4 8 12
Kilometres

Map Parameters
Projection: UTM, NAD83, Zone 14N
Scale 1:200,000
Date: November 2, 2007
Project No.: 1025616.

Jacques Whitford



Manitoba Floodway Authority

Figure 5

Estimated Regional Groundwater Flow

Red River Floodway Expansion Project

Map Features

- Watercourse
- Provincial Road
- Rail Line
- Regional Municipality
- Waterbody
- Estimated Regional Groundwater Flow Direction

0 2 4 8 12

Kilometres

Map Parameters
Projection: UTM, NAD83, Zone 14N
Scale 1:200,000
Date: November 2, 2007
Project No.: 1025616.

Jacques Whitford

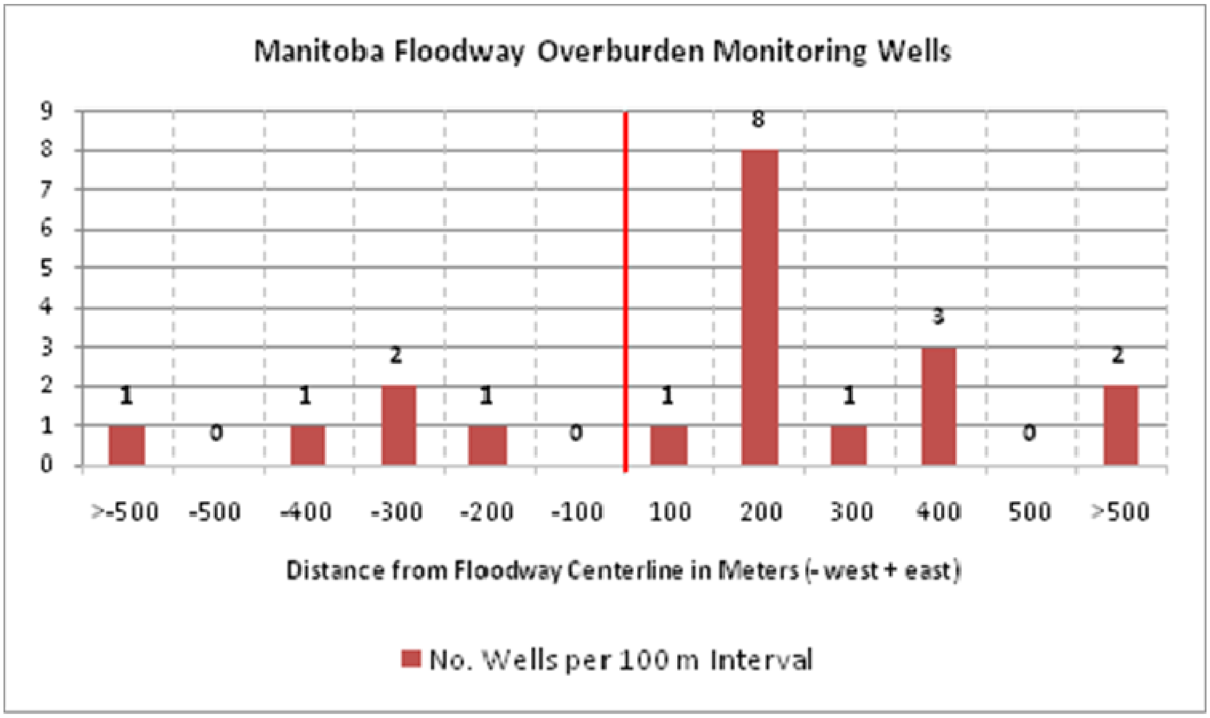


FIGURE 6-1 Distribution of Overburden Monitor Wells From Floodway Centerline (m)

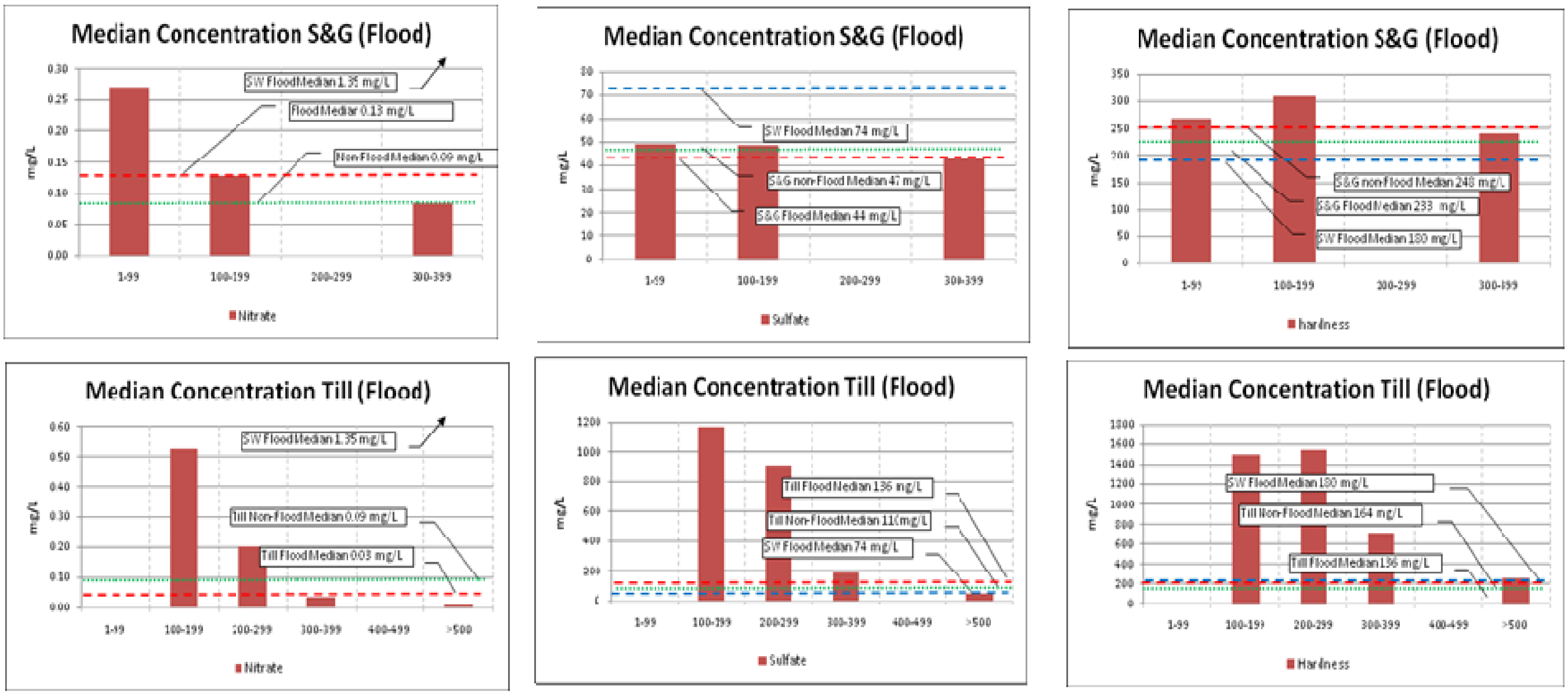


FIGURE 6-2 Comparison of Nitrate+Nitrite, Sulfate and Hardness, Overburden Wells, Flood and Non-Flood Events

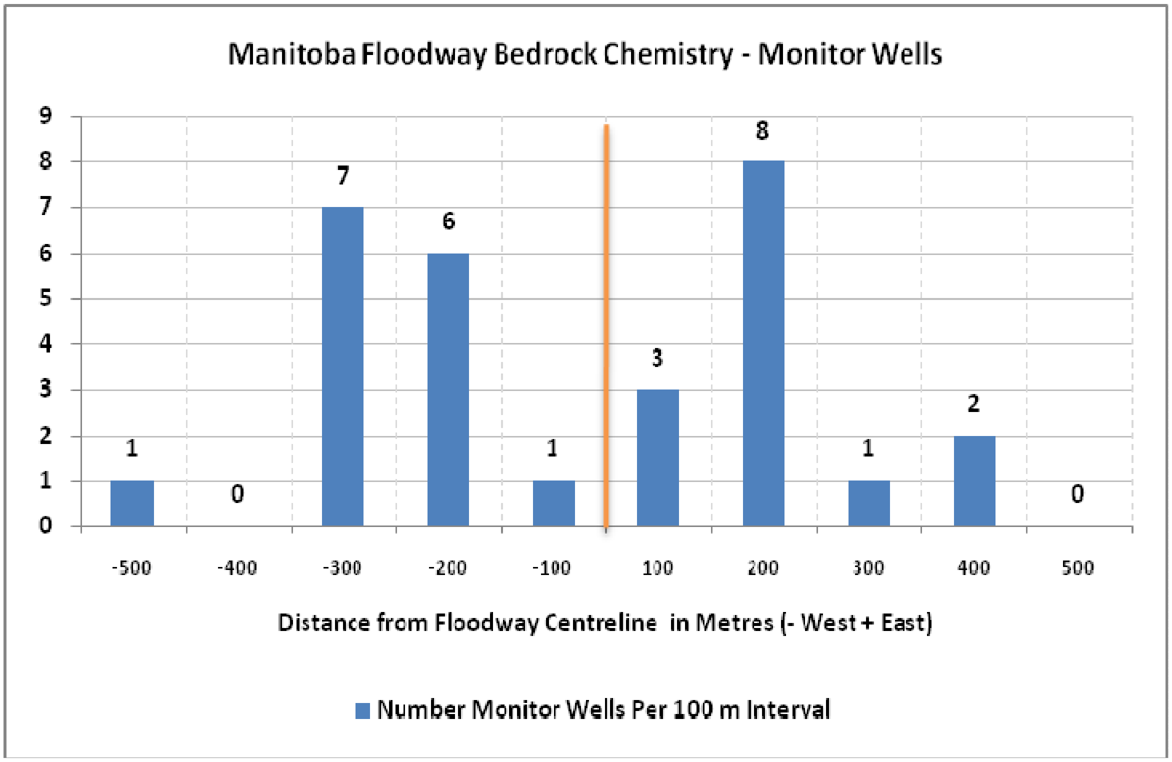
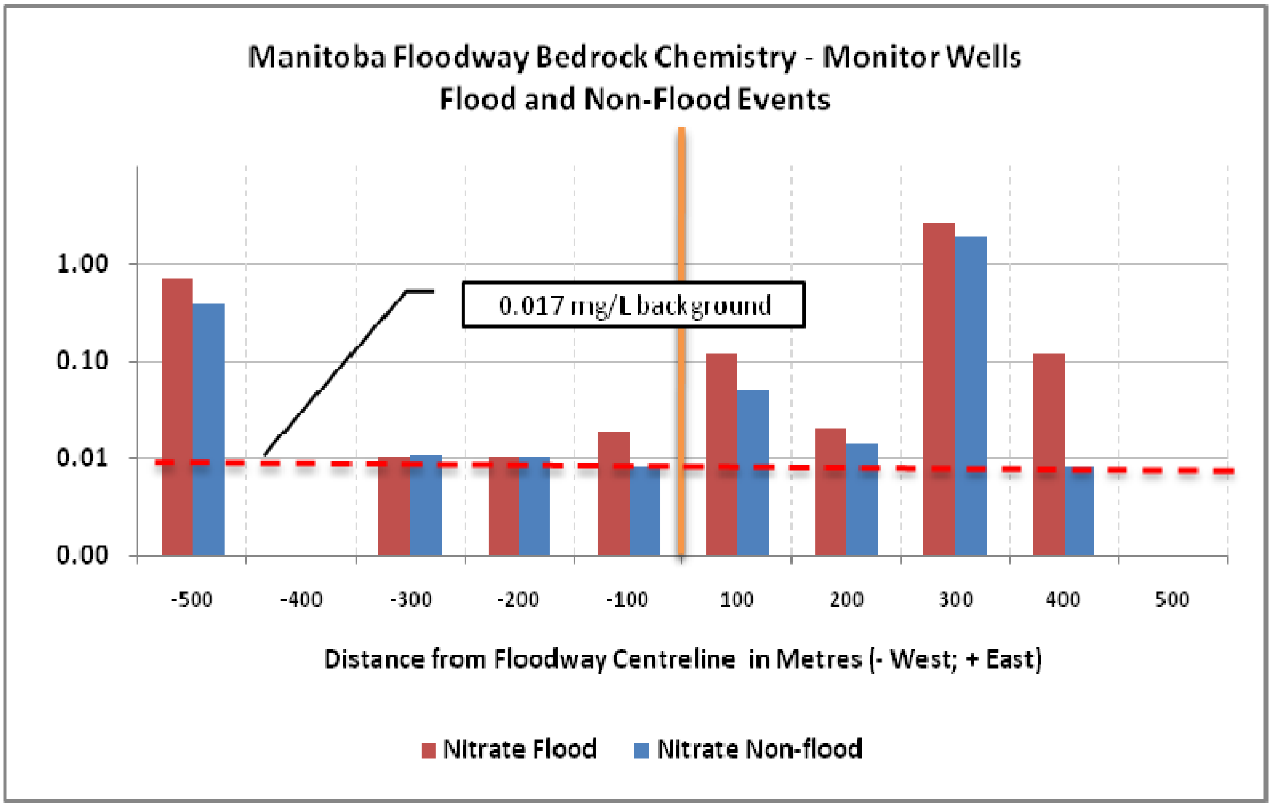


FIGURE 6-3 Bedrock Monitor Well Distribution from Floodway Centerline



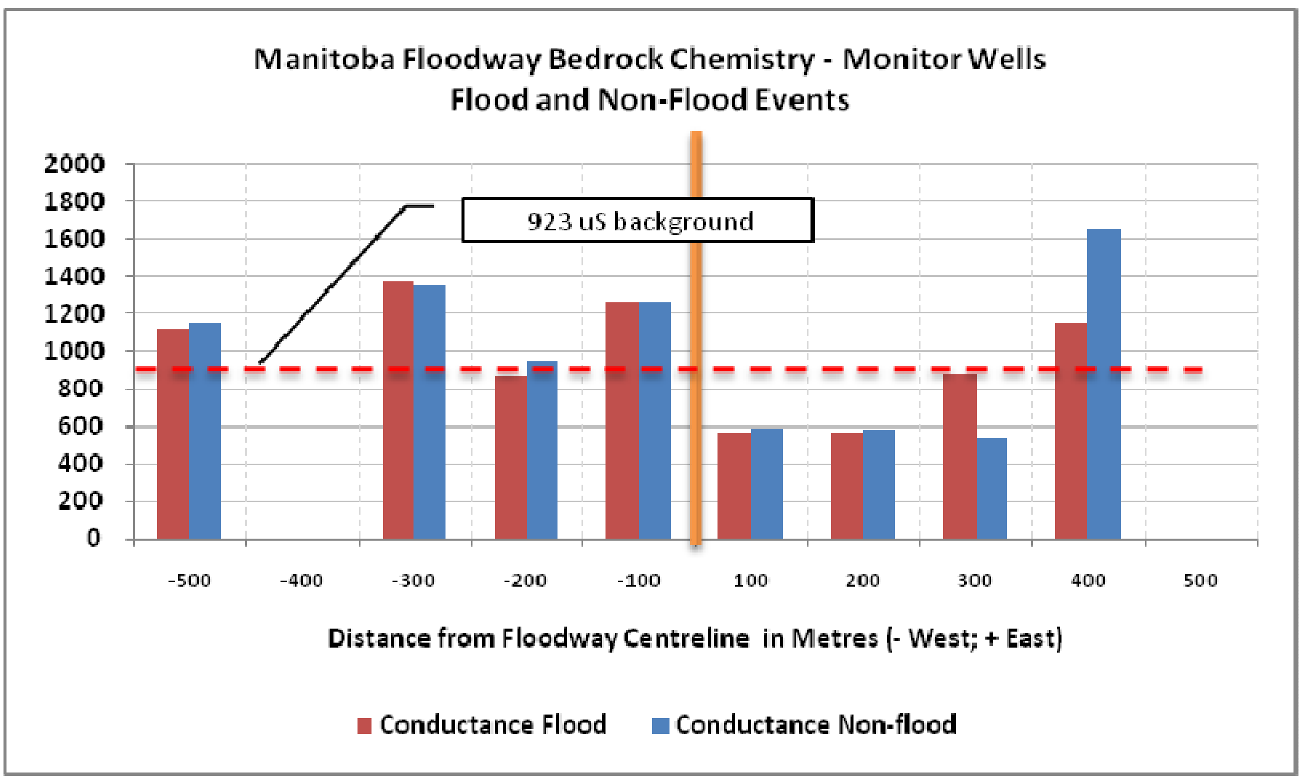


FIGURE 6-4 Comparison of Bedrock Groundwater Nitrate and Conductance Chemistry over Distance from Floodway Centerline during Non-Flood and Flood Events.

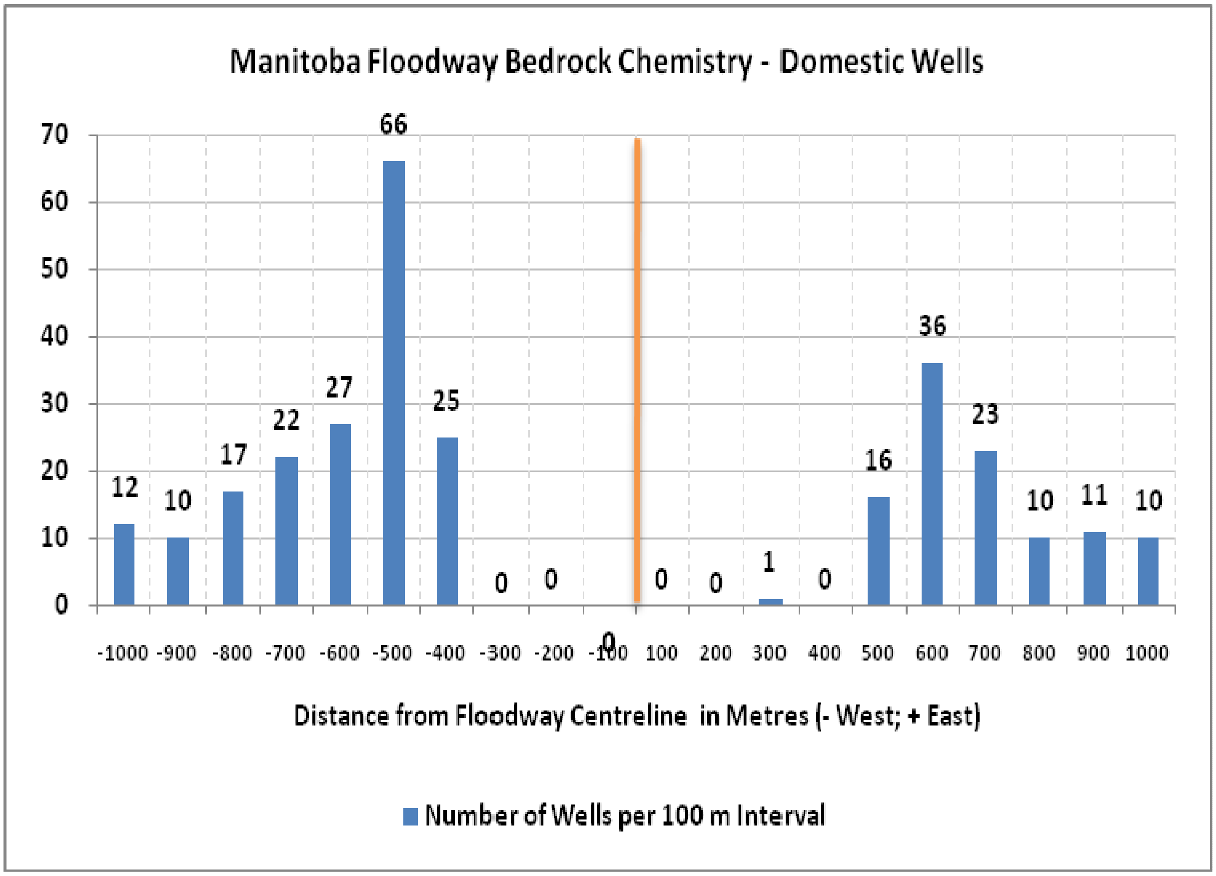


FIGURE 6-5 Distribution of Domestic Wells and Bedrock Monitor Wells From Floodway Centerline

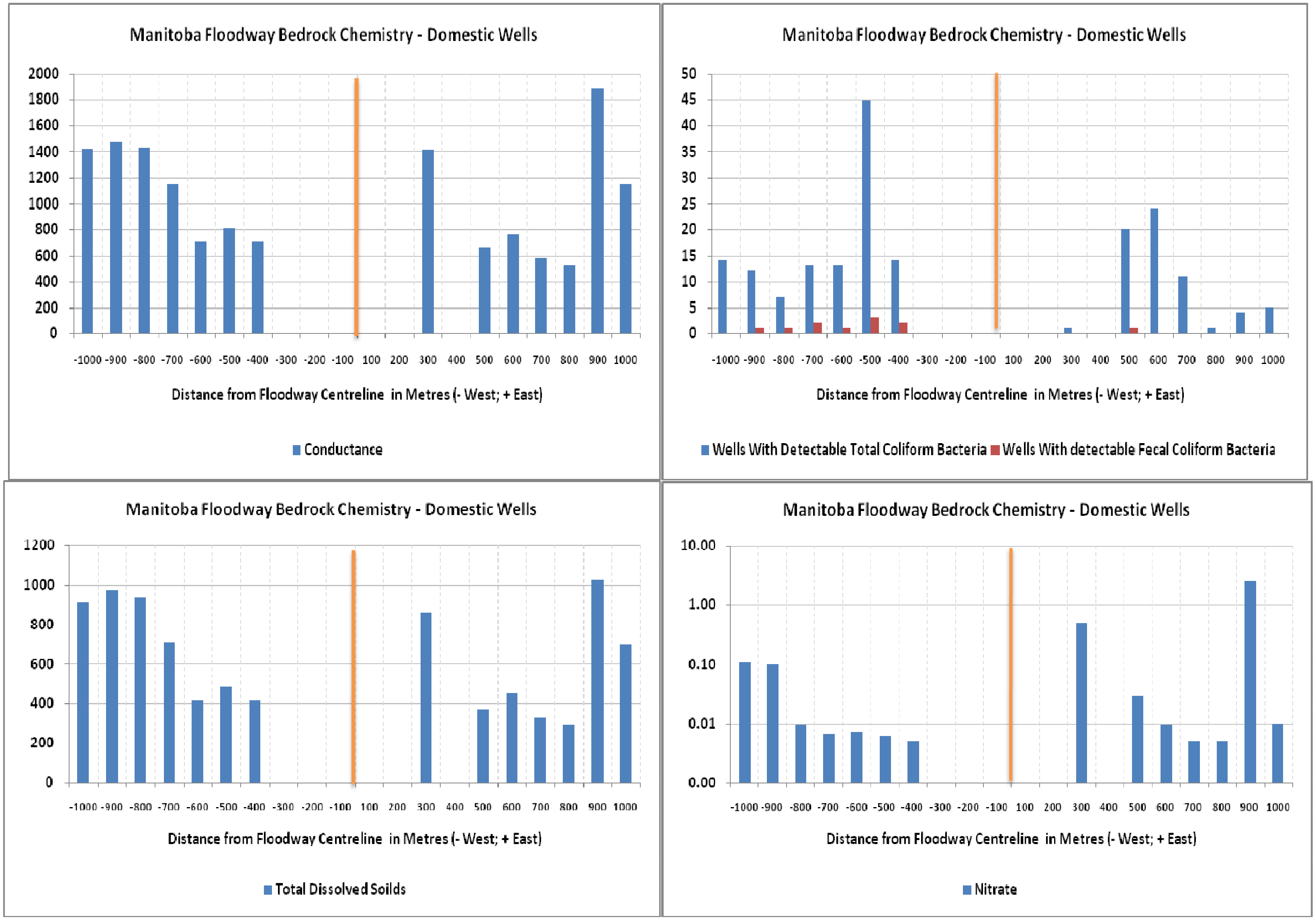
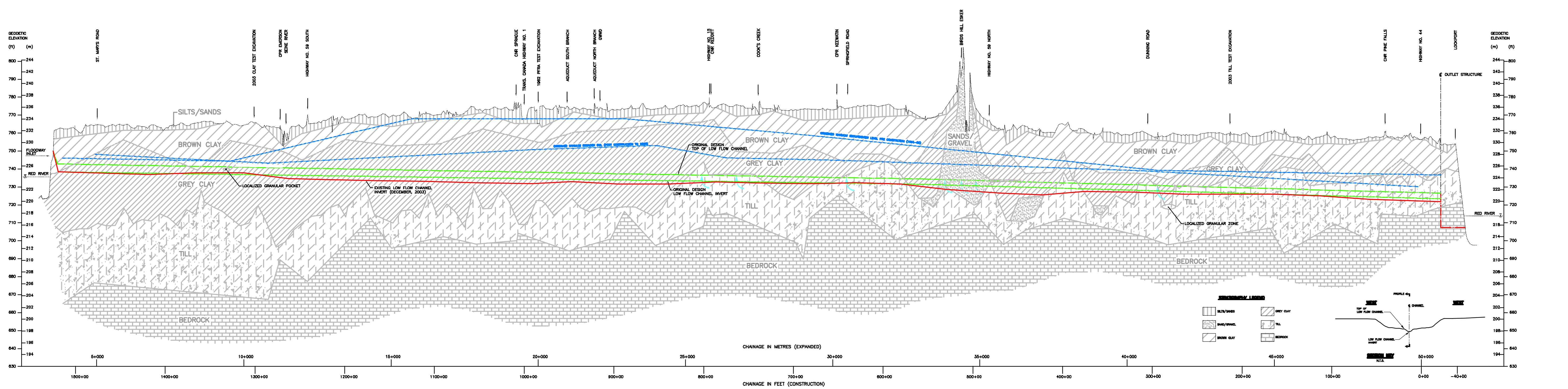


FIGURE 6-6 Distribution of Domestic Well Chemistry with Distance from the Floodway Centerline

APPENDIX B

Referenced Tables



LEGEND

- GROUND SURFACE (AS PER NOTE 1)
- EXISTING 2003 LOW FLOW CHANNEL INVERT
- OBSERVED MAXIMUM GROUNDWATER LEVEL EXCLUDING YEARS OF FLOODWAY OPERATION (FOR INTERVAL BETWEEN POST CONSTRUCTION AND 2003).
- OBSERVED MAXIMUM GROUNDWATER LEVEL PRE CONSTRUCTION (1964–65)
- ORIGINAL DESIGN TOP OF LOW FLOW CHANNEL
- ORIGINAL DESIGN LOW FLOW CHANNEL INVERT
- APPROXIMATE AREAS WHERE GROUNDWATER DISCHARGE (100 GPM OR GREATER) WAS NOTED DURING FLOODWAY CONSTRUCTION (RENDER,1970)

NOTES:

1. DATA USED TO COMPILE SECTION INCLUDES:
   - HOBSON (1964) HAMMER SEISMIC SURVEY
   - GWDRILL DATABASE
   - MANITOBA WATER RESOURCES WELL DATABASE
   - MANITOBA DEPARTMENT OF AGRICULTURE AND CONSERVATION WATER CONTROL AND CONSERVATION BRANCH DRAWING FILE NUMBERS 11-5-1067,11-5-1137,11-5-1516,11-5-1267.
   - ACRES MANITOBA LTD. (2003)
   - KGS GROUP INC. (2003)
   - UMA ENGINEERING LTD. (2003)
   - WARDROP ENGINEERING INC. (2003)
2. BOREHOLES USED TO PRODUCE SECTION ARE LOCATED WITHIN 100m OF FLOODWAY CENTERLINE.
3. PROFILE OF LOW FLOW CHANNEL INVERT BASED ON KGS GROUP SURVEY USING GPS SYSTEM IN DECEMBER 2003 AND LABELLED AS "EXISTING".

NO.	DATE	REVISIONS	BY	CKD.	APP.
00	29/07/04	ISSUED FINAL WITH PRE-DESIGN REPORT	PD	JS	RWC

CONSULTANT: KGS GROUP — CONSULTING ENGINEERS & PROJECT MANAGERS
WINNIPEG (204) 896-1209
THUNDER BAY (807) 345-2233

CONSULTANT DWG NO.: 03-0311-01-H05.dwg

C of A: APEGM Certificate of Authorization

DESIGNED BY: JM/NP | DRAWN BY: PD | SCALE: AS NOTED
CHECKED BY: MRJ | APPROVED BY: RWC | DATE: APRIL 2004

OWNER: Manitoba Floodway Expansion Authority

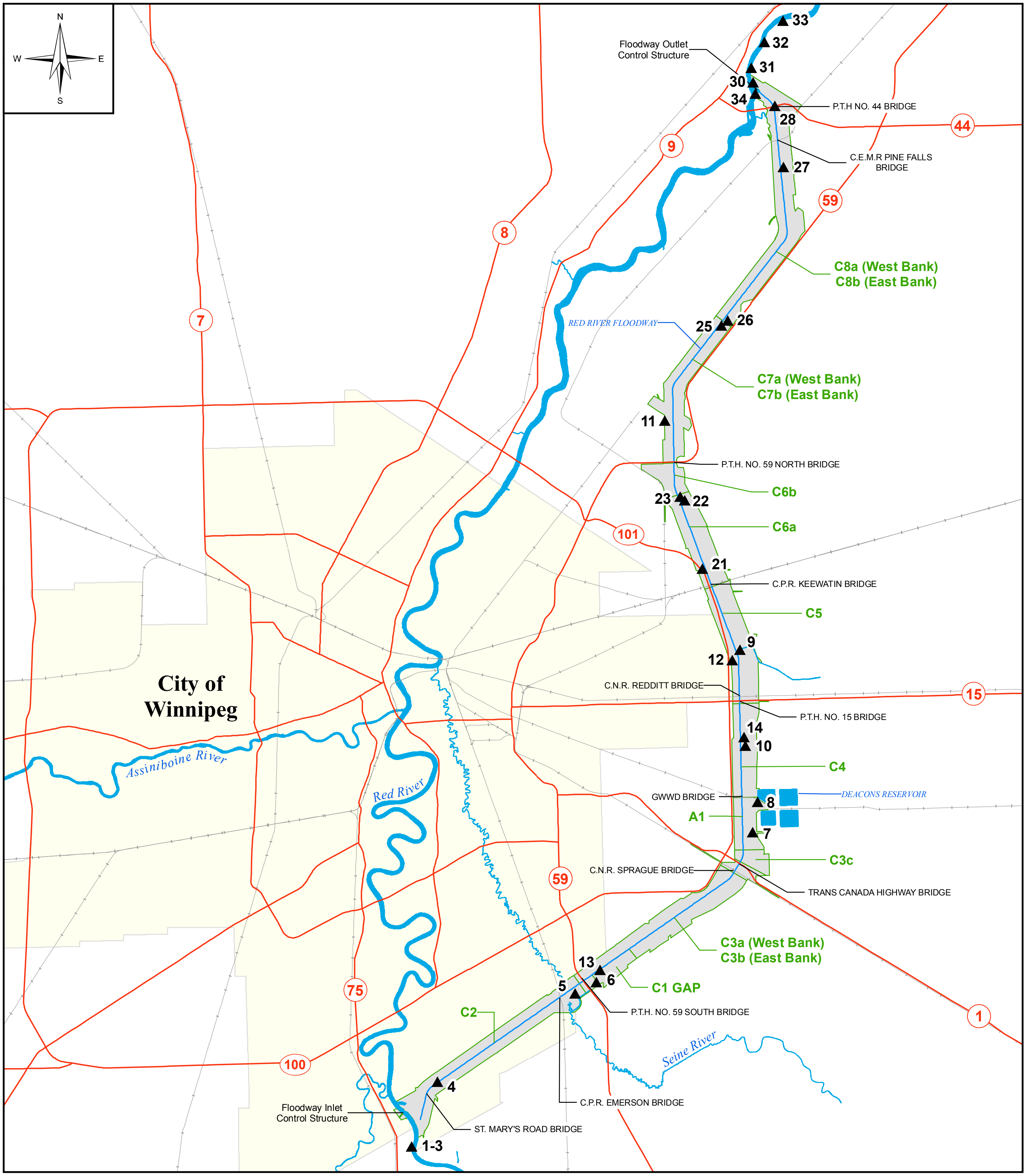
PROJECT: RED RIVER FLOODWAY EXPANSION

PHASE: PDEA-1 – GROUNDWATER INVESTIGATIONS – PRE-DESIGN

TITLE: STRATIGRAPHIC PROFILE ALONG FLOODWAY

MFEA approvals:
VP, HYDRAULIC ENGINEERING
VP, TRANSPORTATION ENGINEERING

OWNER DWG NO.: FE-PDEA-1-251H-005.c | SHT. 001 | REV. 00



▲ 10 Surface Water Sampling Locations

C2 Contract Reference Locations

1:200,000

0 1 2 4 6 8 10

Kilometres

MEMO REFERENCE 05-1100-01.9905210-NM4

KGS GROUP

MANITOBA FLOODWAY AUTHORITY

RED RIVER FLOODWAY EXPANSION

2006 CONSTRUCTION SURFACE WATER MONITORING

FLOODWAY CHANNEL SAMPLE LOCATIONS

APRIL 2006	FIGURE NM4-1	REV A

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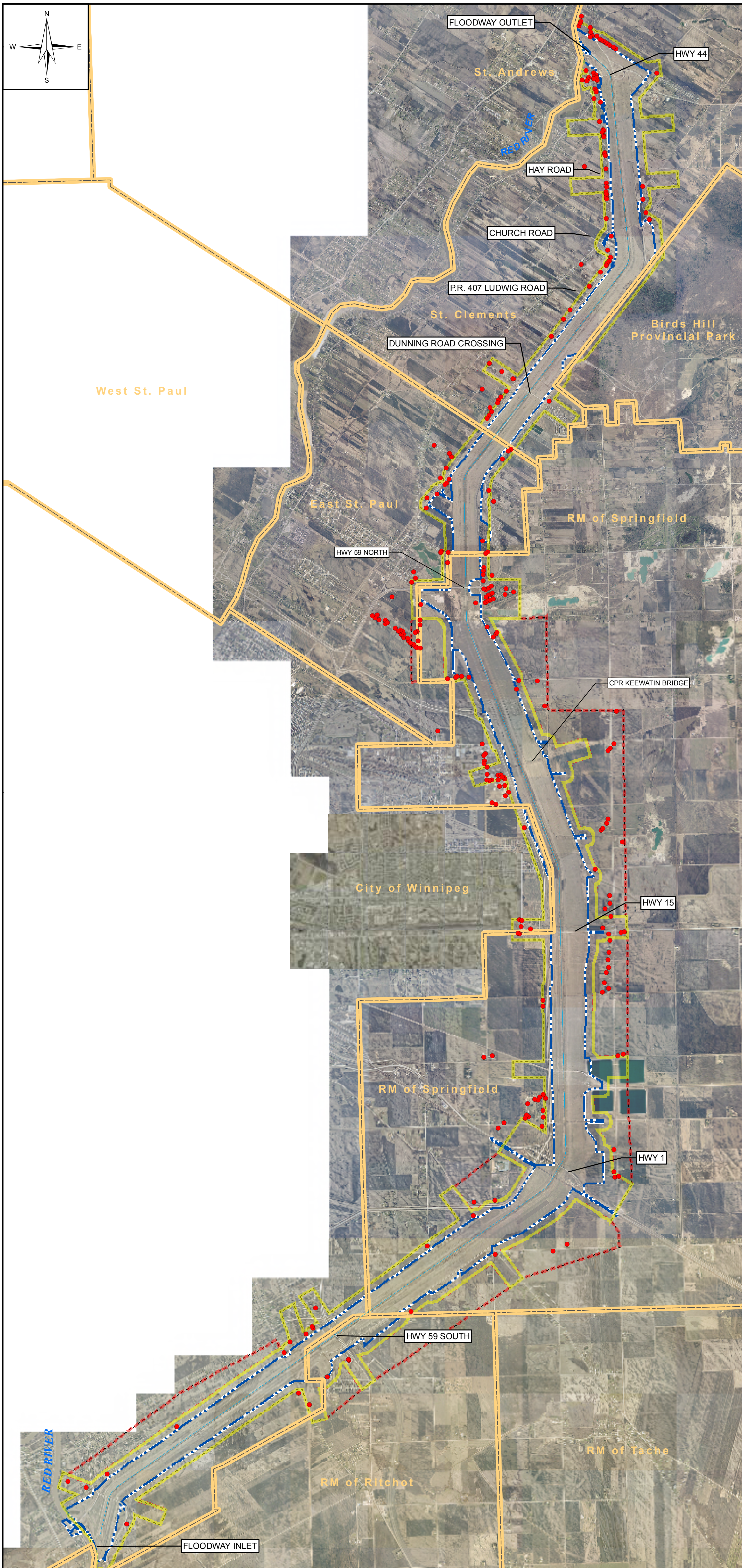
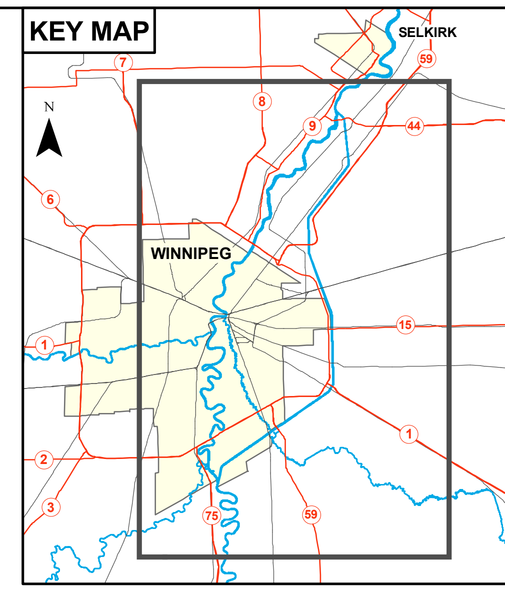


KEY MAP



- Floodway Right of Way Limits
- Domestic Well Monitoring Area Within
  - 200m of Floodway Right of Way
  - 1km of Bridge Crossings
  - 1km of Detailed Sections
- Additional Monitoring Area Boundary
- Domestic Wells Sampled 2007
- RM of Springfield
- RM Boundary

1:100,000

0 1 2 3 4 5

Kilometres

All units are metric and in metres unless otherwise specified.
Universal Transverse Mercator Projection, NAD 1983, Zone 14
Elevations are in metres above sea level (MSL)

MEMO REFERENCE ....05-1100-01.9905228-HM38........

KGS GROUP

MANITOBA FLOODWAY AUTHORITY

RED RIVER FLOODWAY EXPANSION

2007 GROUNDWATER MONITORING ACTIVITY REPORT

DOMESTIC WELL MONITORING LOCATIONS 2007

MARCH 2008	HM38-1	REV: A

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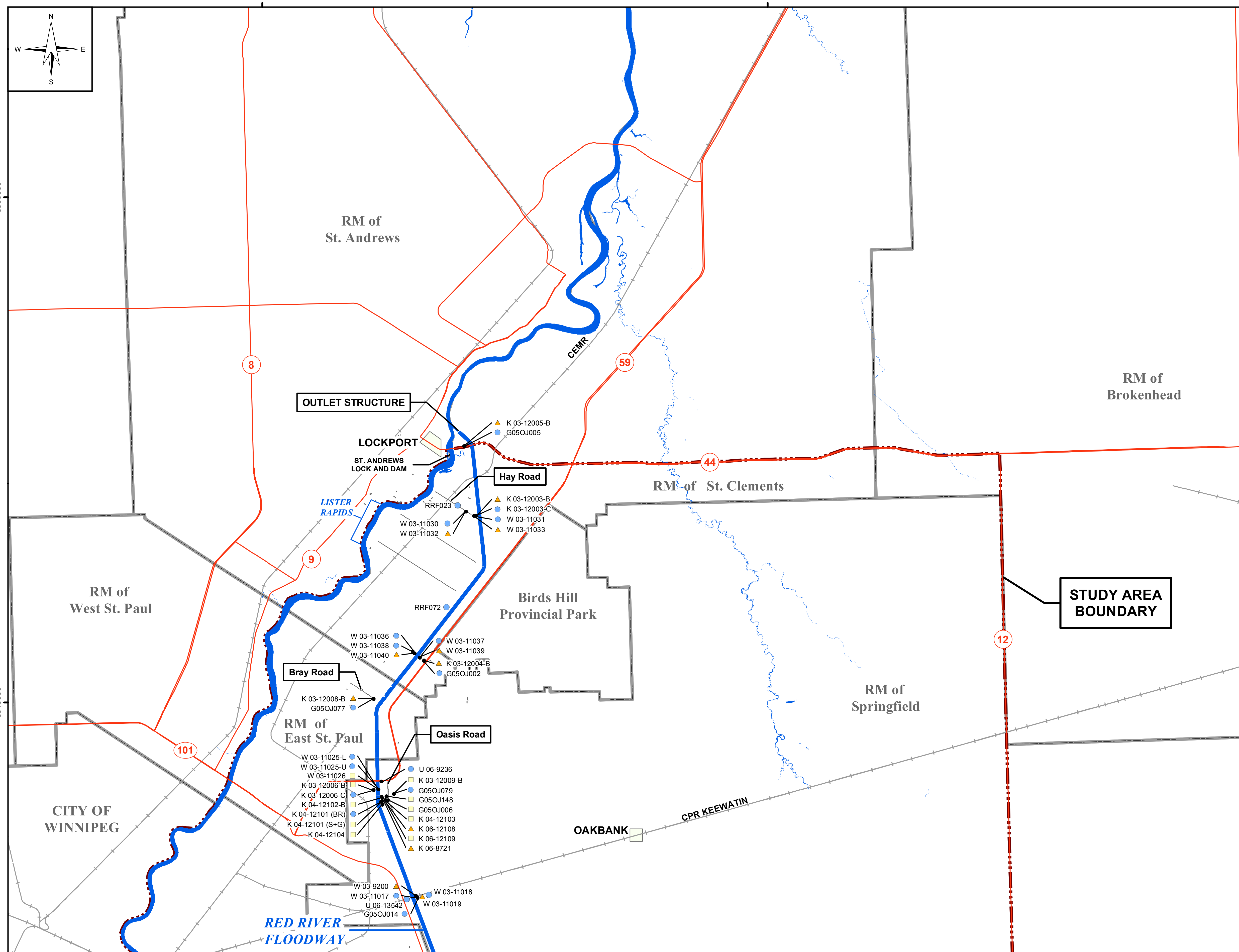
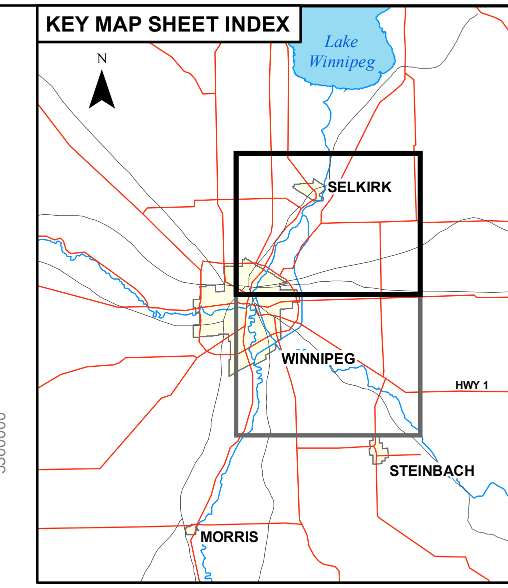


KEY MAP SHEET INDEX



Monitoring Wells

- Bedrock Well
- Till Well
- Sand and Gravel Well

Topographic Features

- Primary Highways
- Railway
- Major Rivers
- RM Boundaries
- Study Area Boundary

1:150,000

0 1 2 4 6 8

Kilometres

All units are metric and in metres unless otherwise specified.
Universal Transverse Mercator Projection, NAD 1983, Zone 14
Elevations are in metres above sea level (MSL)

MEMO REFERENCE 05-1100-01.9905228-HM38

KGS GROUP

MANITOBA FLOODWAY AUTHORITY

RED RIVER FLOODWAY EXPANSION

2007 GROUNDWATER MONITORING ACTIVITY REPORT

MONITORING PROGRAM
MONITORING WELL LOCATIONS
(NORTH SHEET)

MARCH 2008	HM38-5	REV: A

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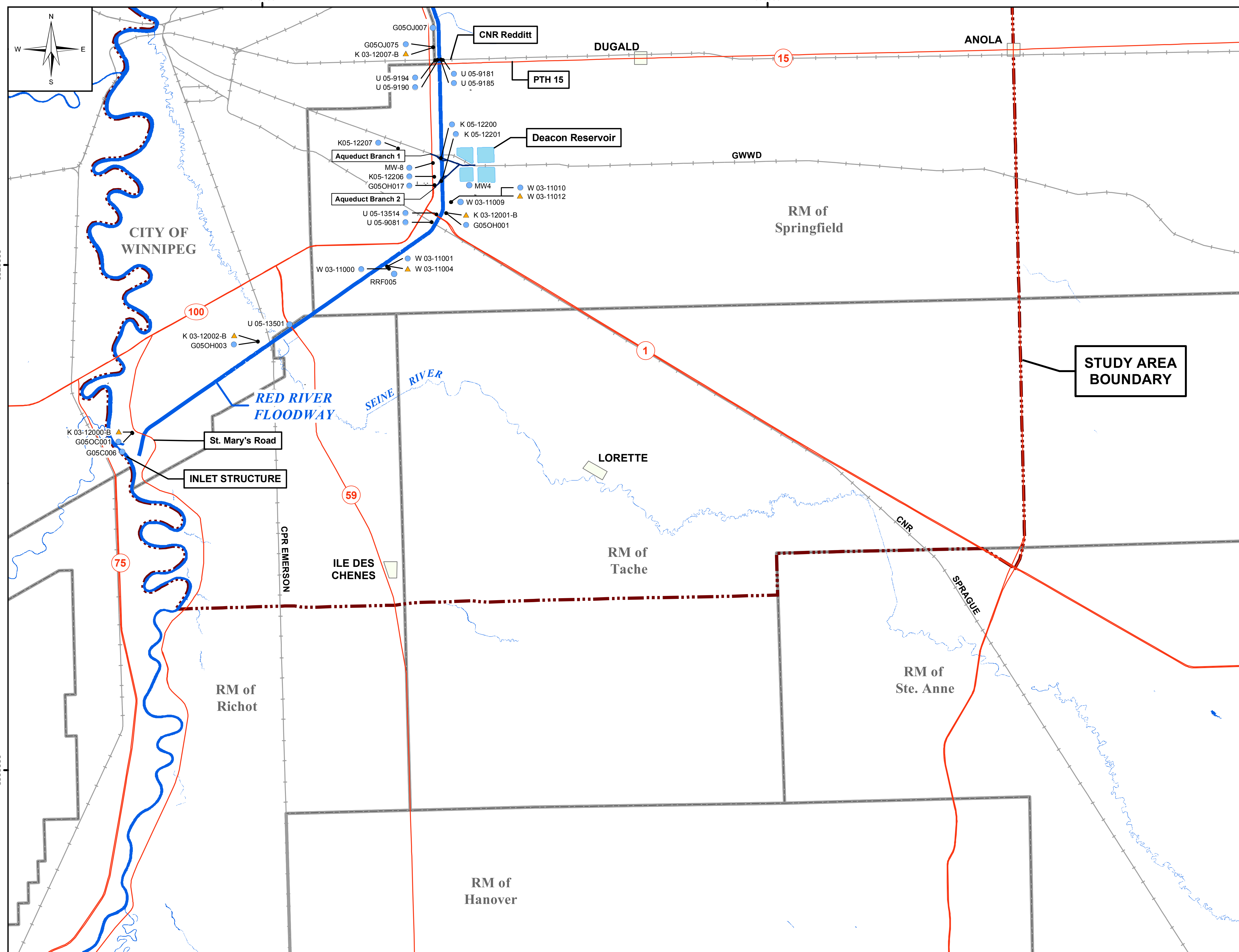

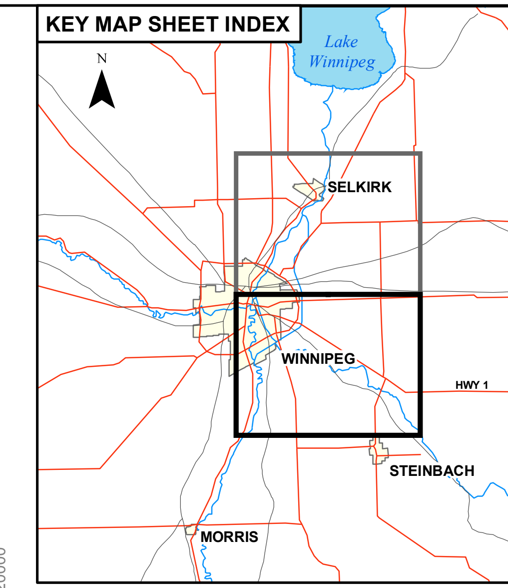

Monitoring Wells

- Bedrock Well
- Till Well
- Sand and Gravel Well

Topographic Features

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- Railway
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- RM Boundaries
- Study Area Boundary

1:150,000

0 1 2 4 6 8

Kilometres

All units are metric and in metres unless otherwise specified.
Universal Transverse Mercator Projection, NAD 1983, Zone 14
Elevations are in metres above sea level (MSL)

MEMO REFERENCE ....05-1100-01.9905228-HM38........

KGS GROUP

MANITOBA FLOODWAY AUTHORITY

RED RIVER FLOODWAY EXPANSION

2007 GROUNDWATER MONITORING ACTIVITY REPORT

MONITORING PROGRAM
MONITORING WELL LOCATIONS
(SOUTH SHEET)

MARCH 2008	HM38-5	REV: A

APPENDIX C

Referenced Drawings

TABLE HM38-F-1-1
SURFACE WATER QUALITY
RED RIVER FLOODWAY - SURFACE WATER MONITORING

Sample No.	Date	Parameter (1)																													
		Turbidity (NTU)	pH (units)	E.C. (µS/cm)	Alkalinity as $CaCO_3$	Bicarbonate as HCO_3	Carbonate as CO_3	Hydroxide as OH	Hardness as $CaCO_3$	Chloride (Soluble)	Fluoride (Soluble)	Sulphate (Soluble)	Ortho-Phos. (Soluble as P)	Ammonia (NH_3) (Soluble)	Nitrate+ Nitrite-N (Soluble)	Calcium	Magnesium	Potassium	Sodium	Iron	Manganese	D.O.C	Total Phos.	Total Dissolved Phos.	T.D.S.	T.S.S.	T.K.N.	T.O.C.	Ion Bal. (%)	Total Coliform (MPN/100mL)	E. Coli (MPN/100mL)
EQL		*0.05*	*0.01*	*0.4*	*1*	*2*	*0.6*	*0.4*	*0.07*	*9*	*0.1*	*9*	*0.001*	*0.01*	*0.01*	*0.05*	*0.01*	*0.05*	*0.02*	*0.01*	*0.0002*	*1*	*0.001*	*0.001*	*5*	*5*	*0.2*	*1*	*-*	*0*	*0*
CCME (2)																															
Freshwater Aquatic Life		Narrative (4)	6.5 - 9.0	-	-	-	-	-	-	-	-	-	-	(3)	-	-	-	-	-	0.3	-	-	-	-	-	Narrative (5)	-	-	-	-	-
CON D/S	20-Apr-06	110	8.23	411	121	148	<0.6	<0.4	178	14	0.2	68	0.254	0.185	2.26	43.3	17.1	7.26	13.6	**0.58**	0.144	9	0.363	0.253	246	120	1.3	10	98.6	Overgrown	<10
	9-Apr-07	40	7.97	409	128	157	<0.6	<0.4	180	18	0.3	59	0.402	0.094	1.8	38	20.8	10	12.9	**0.46**	0.0428	18	0.436	0.387	244	47	1.4	19	99.4	790	<10
	3-Jul-07	25	8.31	413	180	217	1.1	<0.4	185	17	0.2	23	0.061	0.059	0.068	42.2	19.5	5.77	8.91	**0.43**	0.0789	16	0.289	0.262	224	24	16	1.2	93	2350	90
CON U/S	20-Apr-06	85	8.19	401	120	146	<0.6	<0.4	171	15	0.3	68	0.268	0.145	2.08	41.2	16.6	7.15	12.9	**0.58**	0.109	10	0.331	0.239	242	91	2.4	10	94.8	1790	30
	9-Apr-07	110	8.06	547	124	152	<0.6	<0.4	233	25	0.3	127	0.386	0.279	2.87	53.1	24.3	9.38	23	**0.61**	0.118	15	0.426	0.272	350	90	1.8	15	97.2	170	<10
	3-Jul-07	10	8.36	591	191	227	2.6	<0.4	256	20	0.3	109	0.218	0.028	0.343	58.0	27.2	7.79	19.9	0.22	0.1780	15	0.342	0.315	358	29	15	1.2	92.8	1190	10
S-01	4-Apr-05	200	7.67	422	118	144	<0.6	<0.4	187	25 (8)	0.2 (8)	54 (8)	0.733	0.56 (8)	2.07 (8)	42.7	19.6	10.8	18.6	**2.89**	0.234	12	0.866	0.567	250	290	2.7	13	-	>200	>200
Red River	12-Apr-05	190	7.82	401	125	152	<0.6	<0.4	192	18 (8)	0.2 (8)	52 (8)	0.322	0.25 (8)	1.43 (8)	46.3	18.6	8.65	14.1	**0.78**	0.323	12	0.569	0.29	240	250	1.7	13	-	>200	4
Upstream	10-May-05	220	8.24	662	208	254	<0.6	<0.4	331	33	0.2	166	0.429	0.37	0.91	75.9	34.4	7.57	28.9	**1.89**	0.44	14	0.417	0.166	475	370	1.8	15	-	>200	29
of Inlet	24-Jun-05	55	7.88	561	175	214	<0.6	<0.4	256	21	0.2	119	0.233	0.1	0.65	58.9	26.4	7.34	19	**0.38**	0.0765	14	0.343	0.282	360	55	1.1	15	92.5	Overgrown	50
	18-Jul-05	80	8.02	620	200	244	<0.6	<0.4	272	21	0.2	116	0.377	0.04	0.34	62.9	28	7.47	24.3	**0.69**	0.31	15	0.463	0.369	381	110	1.1	16	95.2	Overgrown	220
	20-Apr-06	110	8.2	409	120	147	<0.6	<0.4	177	15	0.2	72	0.264	0.196	2.32	42.6	17.1	7.22	13.5	**0.62**	0.149	10	0.358	0.249	250	120	1.3	10	95.5	1520	<10
	9-Apr-07	180	8.07	550	126	154	<0.6	<0.4	237	25	0.3	128	0.51	0.358	3.26	54.8	24.2	8.22	19.4	**0.85**	0.272	15	0.606	0.29	350	230	2	16	94.1	240	20
	3-Jul-07	30	8.37	602	190	225	3.1	<0.4	263	21	0.3	116	0.174	0.040	0.298	59.6	27.7	7.63	21.6	**0.36**	0.1340	15	0.392	0.329	369	91	15	1.2	93.5	1100	10
S-02	4-Apr-05	150	7.73	419	116	142	<0.6	<0.4	196	25 (8)	0.2 (8)	51 (8)	0.732	0.56 (8)	2.06 (8)	44.7	20.6	11.4	18.9	**3.34**	0.258	12	0.873	0.569	250	300	2.7	12	-	>200	>200
Red River	12-Apr-05	200	7.79	399	124	151	<0.6	<0.4	190	19 (8)	0.2 (8)	54 (8)	0.334	0.27 (8)	1.42 (8)	45.6	18.5	8.63	14.1	**0.81**	0.326	12	0.557	0.29	240	260	1.7	12	-	>200	8
Upstream	10-May-05	220	8.25	660	209	255	<0.6	<0.4	344	33	0.3	167	0.433	0.39	0.92	78.8	35.7	7.99	30.4	**1.96**	0.45	14	0.42	0.165	483	380	1.8	15	-	>200	22
of Inlet	24-Jun-05	60	7.87	561	175	213	<0.6	<0.4	257	21	0.2	117	0.235	0.1	0.63	59.1	26.5	7.32	19.3	**0.36**	0.0779	15	0.341	0.282	358	54	1.1	15	93.8	Overgrown	40
	18-Jul-05	85	8.01	621	199	243	<0.6	<0.4	275	21	0.2	120	0.387	0.05	0.37	63.8	28.1	7.56	24.4	**0.8**	0.339	17	0.474	0.367	386	130	1.2	16	95.1	Overgrown	<10 (9)
	20-Apr-06	110	8.2	410	120	147	<0.6	<0.4	178	15	0.3	72	0.261	0.198	2.27	42.8	17.2	7.28	13.6	**0.66**	0.143	10	0.359	0.243	249	130	1.4	9	96	Overgrown	30
	9-Apr-07	200	8.09	551	130	158	<0.6	<0.4	241	25	0.3	128	0.471	0.352	3.25	55.4	24.9	8.31	20.2	**0.91**	0.279	17	0.602	0.289	354	270	2	15	95.1	90	40
	3-Jul-07	34	8.37	605	190	227	2.6	<0.4	269	21	0.3	117	0.296	0.040	0.29	60.7	28.6	7.57	21.7	**0.37**	0.1390	15	0.379	0.326	372	85	15	1.2	94.9	950	20
S-03	4-Apr-05	180	7.69	420	116	142	<0.6	<0.4	198	24 (8)	0.3 (8)	49 (8)	0.765	0.70 (8)	2.08 (8)	44.8	20.8	11.3	19	**3.3**	0.268	11	0.917	0.568	248	310	2.7	12	-	>200	>200
Red River	12-Apr-05	200	7.8	399	121	148	<0.6	<0.4	190	19 (8)	0.1 (8)	54 (8)	0.327	0.26 (8)	1.44 (8)	45.8	18.3	8.67	13.9	**0.88**	0.324	12	0.566	0.286	238	270	1.8	12	-	>200	4
Upstream	10-May-05	220	8.24	661	209	255	<0.6	<0.4	341	33	0.3	166	0.45	0.37	0.91	77.9	35.7	7.98	30.8	**1.73**	0.428	15	0.447	0.167	481	410	2	14	-	>200	32
of Inlet	24-Jun-05	55	7.88	561	175	214	<0.6	<0.4	266	21	0.2	122	0.236	0.1	0.64	60.8	27.8	7.61	20.2	**0.38**	0.0799	14	0.343	0.283	368	58	1.1	16	95.7	Overgrown	30
	18-Jul-05	80	8	619	199	243	<0.6	<0.4	275	21	0.2	121	0.402	0.06	0.35	63.3	28.4	7.58	25	**0.64**	0.294	16	0.498	0.367	388	110	1.2	16	95.2	Overgrown	170
	20-Apr-06	110	8.19	410	121	147	<0.6	<0.4	179	14	0.2	71	0.28	0.194	2.31	43.3	17.3	7.27	13.7	**0.62**	0.15	10	0.362	0.244	249	130	1.3	10	98	Overgrown	30
	9-Apr-07	230	8.11	550	128	156	<0.6	<0.4	236	25	0.3	128	0.481	0.342	3.27	54.6	24.2	8.1	20.4	**0.89**	0.274	15	0.589	0.28	351	270	2	15	94.1	120	40
	3-Jul-07	34	8.38	602	190	225	3.1	<0.4	268	21	0.3	120	0.294	0.042	0.285	60.9	28.1	7.65	22.0	**0.33**	0.1430	15	0.394	0.320	375	92	15	1.2	94	1090	20
S-04	4-Apr-05	190	7.71	421	117	143	<0.6	<0.4	188	25 (8)	0.2 (8)	52 (8)	0.756	0.53 (8)	2.02 (8)	43.1	19.6	10.5	19.2	**1.24**	0.211	12	0.863	0.557	249	270	2.5	12	-	>200	>200
Floodway	12-Apr-05	180	7.83	397	122	148	<0.6	<0.4	196	19 (8)	0.2 (8)	54 (8)	0.312	0.26 (8)	1.44 (8)	47.1	19	8.99	14.6	**0.81**	0.311	13	0.55	0.286	242	250	1.8	13	-	>200	3
Channel	10-May-05	30	8.01	782	240	293	<0.6	<0.4	367	35	0.3	136	0.028	0.02	<0.01	90.7	34.2	7.99	32.3	**0.65**	0.506	11	0.103	0.03	481	54	0.9	12	-	>200	12
Downstream	24-Jun-05	65	7.94	561	175	214	<0.6	<0.4	265	21	0.2	128	0.236	0.1	0.64	61.1	27.5	7.5	19.9	**0.57**	0.138	14	0.421	0.279	373	72	1.6	15	93.5	Overgrown	70
of Inlet	18-Jul-05	65	8.05	619	198	242	<0.6	<0.4	283	21	0.2	118	0.371	0.05	0.32	65.3	29.1	8	26	**0.51**	0.273	15	0.447	0.368	388	82	1.2	16	99.3	Overgrown	160
	20-Apr-06	110	8.19	411	121	147	<0.6	<0.4	178	15	0.2	71	0.284	0.193	2.29	43	17.1	7.22	13.4	**0.66**	0.147	9	0.36	0.248	249	120	1.4	10	96.3	Overgrown	10
	9-Apr-07	160	8.06	553	125	153	<0.6	<0.4	222	25	0.3	128	0.425	0.292	3.05	51.2	22.9	8.3	21.2	**0.61**	0.149	14	0.494	0.275	346	130	1.7	16	91.2	250	<10
	3-Jul-07	14	8.38	599	192	228	3.1	<0.4	257	21	0.3	113	0.170	0.013	0.202	58.0	27.1	7.61	21.2	0.19	0.0736	15	0.348	0.324	364	19	15	1.2	91.6	900	30
S-13	19-Jul-05	65	8.02	582	193	235	<0.6	<0.4	249	20	0.2	99	0.357	0.04	0.35	56.8	26	7.92	21.2	**0.44**	0.197	16	0.493	0.368	348	76	1.2	16	93.8	Overgrown	90
Floodway	20-Apr-06	100	8.24	413	124	151	<0.6	<0.4	177	15	0.3	71	0.267	0.171	2.15	42.6	17.2	7.03	13.2	**0.6**	0.13	10	0.352	0.242	250	120	1.4	10	94.5	Overgrown	10
Channel	9-Apr-07	18	8.13	339	128	156	<0.6	<0.4	153	16	0.3	28	0.291	0.067	1.45	33.7	16.7	8.13	9.23	0.24	0.0191	17	0.343	0.307	194	22	1.1	18	98.8	260	30
D/S Grande Pointe	3-Jul-07	27	8.43	479	198	232	4.6	<0.4	219	18	0.3	35	0.120	0.057	0.092	50.1	22.9	6.24	12.3	**0.33**	0.0612	16	0.304	0.276	263	25	16	1.3	97.4	1690	30
S-14	18-Jul-05	140	7.6	197	75	92	<0.6	<0.4	87.6	10	0.2	31	0.451	0.13	0.47	16.8	11.1	8.22	4.02	**0.63**	0.0344	16	0.62	0.477	128	99	1.5	17	86.6	Overgrown	430
Floodway	20-Apr-06	110	8.26	412	121	148	<0.6	<0.4	176	15	0.3	70	0.266	0.167	2.26	42.1	17.1	7.11	13.3	**0.68**	0.142	9	0.362	0.249	247	120	1.5	9	95.2	Overgrown	20
Channel	9-Apr-07	19	7.91	261	88	108	<0.6	<0.4	103	14	0.2	19	0.571	0.048	1.04	21.4	12.1	11.4	5.52	0.17	0.02	16	0.64	0.579	141	27	1.2	15	98.1	430	<10
D/S North Bibeau	3-Jul-07	13	8.40	437	180	212	3.7	<0.4	200	17	0.3	34	0.111	0.039	0.566	44.8	21.5	6.89	11.2	**0.45**	0.0621	15	0.310	0.323	245	5	16	1	96.4	1460	70

TABLE HM38-F-1-1
SURFACE WATER QUALITY
RED RIVER FLOODWAY - SURFACE WATER MONITORING

Sample No.	Date	Parameter [(1)] Turbidity (NTU)	pH (units)	E.C. (µS/cm)	Alkalinity as $CaCO_3$	Bicarbonate as HCO_3	Carbonate as CO_3	Hydroxide as OH	Hardness as $CaCO_3$	Chloride (Soluble)	Fluoride (Soluble)	Sulphate (Soluble)	Ortho-Phos. (Soluble as P)	Ammonia (NH_3) (Soluble)	Nitrate+ Nitrite-N (Soluble)	Calcium	Magnesium	Potassium	Sodium	Iron	Manganese	D.O.C	Total Phos.	Total Dissolved Phos.	T.D.S.	T.S.S.	T.K.N.	T.O.C.	Ion Bal. (%)	Total Coliform (MPN/100mL)	E. Coli (MPN/100mL)
EQL		*0.05*	*0.01*	*0.4*	*1*	*2*	*0.6*	*0.4*	*0.07*	*9*	*0.1*	*9*	*0.001*	*0.01*	*0.01*	*0.05*	*0.01*	*0.05*	*0.02*	*0.01*	*0.0002*	*1*	*0.001*	*0.001*	*5*	*5*	*0.2*	*1*	*-*	*0*	*0*
CCME [(2)]																															
Freshwater Aquatic Life		Narrative [(4)]	6.5 - 9.0	-	-	-	-	-	-	-	-	-	-	[(3)]	-	-	-	-	-	0.3	-	-	-	-	-	Narrative [(5)]	-	-	-	-	-
S-21	4-Apr-05	5.2	7.57	286	78	95	<0.6	<0.4	91.6	28	0.1	21	0.486	0.38	1.44	19.4	10.5	9.05	15.6	**0.39**	0.023	13	0.537	0.493	157	19	1.6	12	-	>200	27
Floodway	12-Apr-05	160	7.81	426	123	150	<0.6	<0.4	188	28	0.2	79	0.27	0.31	1.56	44.7	18.6	8.99	19.9	**0.78**	0.261	11	0.525	0.296	279	210	1.7	12	-	>200	18
Channel Keewatin Weir	10-May-05	38	8.43	754	254	285	12.1	<0.4	355	40	0.2	110	0.072	<0.01	0.1	72.3	42.3	5.64	33	**0.44**	0.039	14	0.105	0.055	456	36	0.8	14	-	>200	41
Field Dupl.	10-May-05	39	8.43	759	255	285	13	<0.4	363	40	0.3	111	0.078	0.04	0.1	74.1	43.3	5.89	34	**0.54**	0.0391	15	0.113	0.055	462	46	0.9	14	-	>200	43
	24-Jun-05	50	7.88	564	177	215	<0.6	<0.4	243	21	0.2	123	0.236	0.09	0.64	56.2	24.8	6.96	18.1	**0.4**	0.105	13	0.325	0.273	359	48	1.1	13	86.4	Overgrown	190
	19-Jul-05	130	7.97	457	167	204	<0.6	<0.4	209	15	0.2	59	0.324	0.07	0.32	47.4	21.9	6.81	13.8	**0.81**	0.199	16	0.553	0.328	266	170	1.6	16	98.5	Overgrown	40
	20-Apr-06	110	7.98	404	121	148	<0.6	<0.4	180	15	0.2	73	0.244	0.166	2.28	43.2	17.6	7.25	13.5	**0.7**	0.145	13	0.352	0.234	252	120	1.3	12	96.4	Overgrown	20
	9-Apr-07	100	7.96	392	115	140	<0.6	<0.4	167	19	0.3	64	0.397	0.183	2.11	37.4	17.8	9.01	12.3	**0.6**	0.0592	16	0.427	0.333	238	83	1.4	17	94.6	930	<10
	3-Jul-07	28	8.32	433	188	226	1.5	<0.4	200	17	0.2	22	0.099	0.077	0.080	45.2	21.2	5.66	9.97	**0.4**	0.0784	16	0.263	0.237	234	17	16	1.1	97.3	1750	120
S-23	4-Apr-05	4.8	7.58	240	95	117	<0.6	<0.4	98.7	11	0.2	22	0.62	0.72	1.07	19	12.5	11.3	3.59	**0.32**	0.0562	17	0.716	0.659	141	17	2.6	17	-	>200	>200
Floodway	12-Apr-05	120	7.9	420	149	182	<0.6	<0.4	202	19	0.2	61	0.259	0.27	0.99	44.1	22.3	8.9	11.8	**0.6**	0.17	13	0.457	0.293	261	140	1.5	13	-	>200	22
Channel	10-May-05	21	8.38	864	247	277	12	<0.4	358	67	0.2	123	0.05	0.04	0.12	69.8	44.6	6.34	52.6	0.22	0.0301	13	0.078	0.043	512	20	0.8	13	-	>200	130
Spring Hill Weir	24-Jun-05	60	7.98	563	180	219	<0.6	<0.4	261	21	0.2	119	0.247	0.1	0.63	59.5	27.4	7.24	19.3	**0.33**	0.105	13	0.325	0.272	364	54	1.2	14	93.2	Overgrown	130
Field Dupl.	24-Jun-05	60	8.04	563	179	218	<0.6	<0.4	232	21	0.2	114	0.204	0.09	0.64	54	23.6	6.58	16.7	0.27	0.101	13	0.326	0.317	346	55	1.1	13	84	Overgrown	130
	19-Jul-05	85	7.72	306	125	153	<0.6	<0.4	146	10	0.1	35	0.611	0.05	0.23	30.8	16.7	8.64	5.67	**0.78**	0.0983	18	0.792	0.634	183	100	1.5	18	95.6	Overgrown	1030
	20-Apr-06	120	8.02	404	121	147	<0.6	<0.4	180	15	0.2	76	0.248	0.167	2.29	43.3	17.6	7.29	13.5	**0.67**	0.142	13	0.356	0.233	256	140	11.6	12	95.5	Overgrown	10
	9-Apr-07	45	7.98	398	126	153	<0.6	<0.4	176	18	0.3	58	0.399	0.1	1.77	37.5	20	9.95	12.2	**0.5**	0.043	20	0.436	0.367	239	53	1.3	19	98.6	450	<10
	3-Jul-07	25	8.33	429	190	228	1.6	<0.4	196	18	0.3	22	0.090	0.071	0.062	43.7	21.1	6.03	9.09	**0.49**	0.0719	17	0.301	0.274	234	28	17	1.2	93.5	1940	70
S-25	4-Apr-05	14	7.68	229	82	100	<0.6	<0.4	93.1	14	0.1	26	0.531	0.43	1.48	19.4	10.8	9.24	5.76	**0.57**	0.0355	12	0.6	0.541	141	36	1.8	11	-	>200	4
Floodway	12-Apr-05	170	7.93	392	129	158	<0.6	<0.4	187	20	0.1	73	0.266	0.28	1.33	44	18.8	8.49	12.8	**0.63**	0.236	12	0.526	0.296	261	190	1.6	13	-	>200	3
Channel	10-May-05	21	8.32	895	239	279	6.2	<0.4	363	73	0.3	137	0.046	0.04	0.17	69.4	46.2	6.45	56.9	0.25	0.0337	11	0.078	0.04	533	24	0.7	11	-	>200	41
Dunning Weir	24-Jun-05	65	8.02	564	177	216	<0.6	<0.4	269	21	0.2	118	0.238	0.1	0.77	61.3	28.2	7.54	20.3	**0.37**	0.117	14	0.338	0.272	367	59	1.2	14	97.2	Overgrown	150
	19-Jul-05	70	8.01	538	181	220	<0.6	<0.4	237	19	0.2	90	0.358	0.04	0.94	54.1	24.8	7.48	19.6	**0.45**	0.183	15	0.5	0.362	328	84	1.3	15	95.1	Overgrown	160
	20-Apr-06	120	8.03	404	121	147	<0.6	<0.4	178	15	0.2	75	0.256	0.183	2.29	43.1	17	7.25	13.3	**0.8**	0.153	9	0.362	0.234	254	150	1.8	9	94.4	Overgrown	20
	9-Apr-07	160	7.98	460	113	138	<0.6	<0.4	205	22	0.3	95	0.486	0.203	2.39	48	20.7	8.17	17.3	**0.95**	0.285	16	0.529	0.293	290	280	1.9	16	100	450	120
Field Dupl.	9-Apr-07	190	8.03	457	114	139	<0.6	<0.4	188	22	0.3	94	0.396	0.174	2.41	43.2	19.4	8.11	17.2	**0.65**	0.174	15	0.415	0.291	283	120	1.5	15	93.3	310	20
	3-Jul-07	26	8.34	418	181	217	2.0	<0.4	198	17	0.2	24	0.058	0.066	0.077	45.4	20.6	5.91	9.87	**0.36**	0.0585	15	0.280	0.258	232	23	15	1.1	98.3	1580	90
S-28	5-Apr-05	8	7.74	261	101	123	<0.6	<0.4	115	14	0.1	21	0.366	0.25	1.07	23.8	13.5	7.85	6.13	**0.45**	0.032	11	0.447	0.373	152	29	1.8	12	-	>200	27
Floodway	12-Apr-05	160	7.92	403	132	161	<0.6	<0.4	208	20	0.2	69	0.255	0.26	1.36	48	21.4	8.9	14.4	**0.65**	0.259	11	0.489	0.288	267	200	1.6	12	-	>200	2
Channel	10-May-05	11	8.44	766	277	310	13.9	<0.4	380	31	0.3	116	0.02	<0.01	<0.01	74.2	47.2	4.4	26.8	0.13	0.0224	15	0.048	0.026	466	14	0.8	15	-	>200	14
Hwy #44 Weir/Outlet	24-Jun-05	75	8.01	564	177	215	<0.6	<0.4	265	22	0.2	121	0.233	0.1	0.66	60	27.9	7.29	19.8	**0.4**	0.121	13	0.339	0.274	367	81	1.1	13	94.5	Overgrown	170
	19-Jul-05	100	8.09	557	192	234	<0.6	<0.4	248	19	0.2	89	0.303	0.04	0.33	56.5	25.9	6.82	19.2	**0.67**	0.226	16	0.497	0.318	333	130	1.3	15	95.4	Overgrown	50
Field Dupl.	19-Jul-05	95	8.09	557	193	235	<0.6	<0.4	254	19	0.2	97	0.305	0.04	0.33	58	26.6	6.94	19.4	**0.71**	0.24	15	0.503	0.314	344	120	1.4	15	94.9	Overgrown	70
	20-Apr-06	140	8.04	405	120	147	<0.6	<0.4	178	16	0.2	78	0.275	0.151	2.3	43.2	17.1	7.27	13.3	**0.81**	0.153	13	0.367	0.235	258	170	1.4	14	92.9	Overgrown	10
Field Dupl.	20-Apr-06	140	8.03	405	120	147	<0.6	<0.4	178	16	0.2	78	0.285	0.148	2.29	43.1	17.1	7.17	13.1	**0.77**	0.155	11	0.371	0.234	256	160	1.4	13	92.5	Overgrown	20
	9-Apr-07	110	8.02	452	113	138	<0.6	<0.4	177	22	0.3	89	0.41	0.189	2.44	40.9	18.1	8.19	16.8	**0.56**	0.0996	14	0.415	0.292	274	100	1.5	15	90.8	290	10
	3-Jul-07	19	8.34	390	172	206	1.8	<0.4	180	16	0.2	26	0.090	0.023	0.025	40.1	19.3	6.04	8.32	**0.44**	0.0544	16	0.252	0.238	219	6	16	1	92.5	2190	50
Field Dupl.	3-Jul-07	19	8.23	391	172	210	<0.6	<0.4	174	16	0.2	20	0.102	0.026	0.028	39.9	18.2	6.23	8.48	**0.50**	0.0546	6	0.262	0.230	213	9	15	1.1	93	2790	40

Notes:

EQL = Estimated Quantitation Limit = The lowest level of the parameter that can be quantified with confidence

"-" = No Data

E.C. = Electrical Conductivity

B.O.D. = Biochemical Oxygen Demand   C.O.D. = Chemical Oxygen Demand

D.O.C. = Dissolved Organic Carbon   T.O.C. = Total Organic Carbon

MPN = Most Probable Number

T.K.N. = Total Kjeldahl Nitrogen

T.D.S. = Total Dissolved Solids   T.S.S. = Total Suspended Solids

1. All values are expressed in milligrams per litre (mg/L) unless indicated otherwise.
2. CCME 2003 - Canadian Council of Ministers of the Environment. Canadian Environmental Quality Guidelines; Chapter 4 - Aquatic Life (1999, Updated 2003.)
3. Guideline for un-ionized ammonia is 0.019 mg/L. Un-ionized ammonia is pH and Temperature dependant. See Factsheet for details.
4. Turbidity Guidelines (see fact sheet for complete details):
   Clear Flow: Maximum increase of 8 NTUs from background levels for a short-term exposure (e.g. 24 hr period).
   Maximum average increase of 2 NTUs from background levels for a longer exposure (e.g. 30 d period).
   High Flow or Turbid Waters: Maximum increase of 8 NTUs from background levels at any one time when background levels are between 8 and 80 NTUs.
   Should not increase more than 10% of background levels when background is >80 NTUs.
5. Suspended Sediments Guidelines (see fact sheet for complete details):
   Clear Flow: Maximum increase of 25 mg/L from background levels for any short-term exposure (eg. 24 hr period).
   Maximum average increase of 5 mg/L from background levels for longer term exposures (eg. Inputs lasting between 24 hrs and 30 days).
   Maximum increase of 25 mg/L from background levels at any time when background levels are between 25 and 250 mg/L.
   High Flow: Should not increase more than 10% of background levels when background is >250 mg/L.
6. Lab Note: Insufficient sample remaining to analyse for Turbidity.
7. Total coliform laboratory results for August 19, 2005 were reported by the lab as E.Coli values because the overgrown condition was not recorded.
8. Parameter was analyzed as dissolved at the laboratory.
9. Value shown is suspect. (Likely a laboratory error.)

BOLD - Exceedance of Criteria

TABLE HM38-1
MONITORING PROGRAM FOR MONITORING AND DOMESTIC WELLS

DATE	Monitoring Period	Monitoring Wells[2]										Domestic Well Samples								
		No. of Wells	Parameter Sets[1]									No.of Wells	Parameter Sets[1]							
			C	D	E	F	G	H2	I	J	L		A	B	C	G	H1	I	J	L
2003	October 2003	19	x	x		x						25	x	x	x					x
												175			x					x
2005	Phase 1 March 2005	30	x	x	x							449	x		x					x
	Phase 2A April/May 2005 (Spring Floodway Operation)	27	x	x	x						x	216	x		x					x
	Phase 2B July 2005 (Summer Floodway Operation)	29	x	x								202	x		x					x
		9					x	x	x	x		10				x	x	x	x	x
	Phase 3 October 2005[3]	31	x	x								153[4]	x		x					x
		9					x	x	x	x		10				x	x	x	x	
2006	Event 1-06 March 2006	31	x	x								169	x		x					x
	Event 2A-06 April 2006	52	x	x								163	x		x					x
	Event 2B-06 July 2006	0	x	x								160	x		x					x
	Event 3 September/October 06	40	x	x								159	x		x					x
		9					x	x	x	x		10				x	x	x	x	
2007	Event 1-07 March 2007	33	x	x								189	x		x					x
	Event 2A-07 April 2007	51	x	x								199	x		x					x
	Event 2B-07 July 2007	14	x	x								43	x		x					x
	Event 3-07 September 2007	33	x	x								213	x		x					x
		9					x	x	x	x		10				x	x	x	x	
	Construction Monitoring June- December 2007											48	x		x					x

Notes:
1. For list of parameters analyzed in each set, see Table HM38-2
2. For location of wells sampled see Figure HM38-1, HM38A-2-1 &, HM38-5
3. 7 Samples were re-sampled in 2005.

TABLE HM38-2

MONITORING PARAMETERS

DOMESTIC WELLS
SET A
Turbidity (NTU)
pH (units)
Conductivity (µS/cm)
Alkalinity, Total (as $CaCO_3$)
Bicarbonate (HCO_3)
Carbonate (CO_3)
Hydroxide (OH)
Hardness (as $CaCO_3$)
Chloride (Cl) - Soluble
Fluoride (F) - Soluble
Sulphate (SO_4) - Soluble
Nitrate+Nitrite-N - Soluble
Calcium (Ca) - Extractable
Magnesium (Mg) - Extractable
Potassium (K) - Extractable
Sodium (Na) - Extractable
Iron (Fe) - Extractable
Manganese (Mn) - Extractable
TDS (Calculated)
Total Coliform (MPN/100 mL)
E.Coli (MPN/100 mL)
SET B
Nitrate (as N)
Nitrite (as N)
Copper
Zinc

FIELD TESTING
SET C
Specific Conductivity
Temperature
pH
Water Level (monitor wells)

MONITORING WELLS	
SET D	
Turbidity (NTU)	
pH (units)	
Conductivity (µS/cm)	
Alkalinity, Total (as $CaCO_3$)	
Bicarbonate (HCO_3)	
Carbonate (CO_3)	
Hydroxide (OH)	
Hardness (as $CaCO_3$)	
Chloride (Cl) - Dissolved	
Fluoride (F) - Dissolved	
Sulphate (SO_4) - Dissolved	
Nitrate & Nitrite as N - Dissolved	
Calcium (Ca) - Dissolved	
Magnesium (Mg) - Dissolved	
Potassium (K) - Dissolved	
Sodium (Na) - Dissolved	
TDS (Calculated)	
Total Coliform (MPN/100 mL)	
E.Coli (MPN/100 mL)	
SET E	
Iron (Fe) - Dissolved	
Manganese (Mn) - Dissolved	
SET F	
Aluminum	Molybdenum
Antimony	Nickel
Arsenic	Rubidium
Barium	Selenium
Beryllium	Silver
Bismuth	Strontium
Boron	Tellurium
Cadmium	Thallium
Cesium	Tin
Chromium	Titanium
Cobalt	Tungsten
Copper	Uranium
Iron	Vanadium
Lead	Zinc
Lithium	Zirconium
Manganese	

PESTICIDES
SET G
Phenoxy/Neutral
Herbicide Screen
- Bromoxynil
- Diacamba
- MCPA
- Triallate
- 2, 4-D
- Diclofop-methyl
- Picloram
- Trifluralin
SET H1
Soil Sterilant Screen
by HPLC/UV for Atrazine
SET H2
Soil Sterilant Screen
by HPLC/UV for
- Atrazine
- Diuron
- Simazine
- Bromacil
- Linuron
- Tebuthion
SET I
MISCELLANEOUS PESTICIDES
- By GCMS and LCMS
- Includes:
Pentachloropenal
MCPP
SET J
Glyphosate/AMPA Screen

SET K
SURFACE WATER PARAMETERS
TSS
Ammonia
Ortho-phosphorus
Total phosphorus
Total Dissolved phosphorus
Dissolved Organic Carbon
Total Organic Carbon
Total Kjeldahl Nitrogen

SET L
BACTERIA
Total coliform
E.coli

Notes:

1. Total Coliform and E.Coli analysed those monitoring wells that were disinfected during April 2005.
2. Analysis is done by ALS Laboroatories, Winnipeg, accredited by Canadian Accredited Environmental . Analytical Laboratory (CEAEL)

APPENDIX D

Report Tables

TABLE 4-1 Water Quality Comparison, Seep vs Local Groundwater

KGS Seep ID	General Area	Nearest Well ID	Hardness		Sulphate		Nitrate+Nitrite	
			Seep	Well	Seep	Well	Seep	Well
SPR-2	HWY 15	G05OJ007	799	676	608	290	<0.01	0.01
SPR-3	HWY 15	G05OJ075	688	526	490	569	<0.01	0.02
SPR-4	Deacon	G05OH017	600	585	419	395	<0.01	0.008
SPR-5	Deacon	G05OH017	1230	585	583	395	0.24	0.008
SPR-6	Deacon	G05OH017	405	585	175	395	<0.01	0.008
SPR-7	HWY 15	G05OJ075	885	526	711	569	<0.01	0.02
SPR-8	Keewatin	W03 11017	281	263	42	25	<0.01	0.01
SPR-9	Springfield Road	W03 11018	264	532	29	152	<0.01	0.02
SPR-10	Birds Hill	RRF072	225	231	13	14	<0.01	0.005

Table 4.2a Median Overburden Concentrations, Comparison of Sensitive Areas to Overall Data Set

Wells within 0 to 100 m - Overburden (0ne well only)

		Flood				Non-Flood			
Data Set	Material	Nitrate (mg/L)	Sulphate (mg/L)	Hardness (mg/L)	Conductance (µS/cm)	Nitrate (mg/L)	Sulphate (mg/L)	Hardness (mg/L)	Conductance (µS/cm)
All MW Data	Till Updgradient	-	-	-	-	-	-	-	-
	Tilll Downgradient	-	-	-	-	-	-	-	-
	Sand and Gravel Updgradient	0.54	49	259	262	0.2	49	278	326
	Sand and Gravel Downgradient	-	-	-	-	-	-	-	-
Birds Hill	Sand and Gravel Updgradient	0.54	49	259	549	0.2	49	278	326
	Sand and Gravel Downgradient	-	-	-	-	-	-	-	-
Hwy 15	Till Updgradient	-	-	-	-	-	-	-	-
	Tilll Downgradient	-	-	-	-	-	-	-	-
CPR Keewatin	Till Updgradient	-	-	-	-	-	-	-	-
	Tilll Downgradient	-	-	-	-	-	-	-	-
Lockport	Till Updgradient	-	-	-	-	-	-	-	-
	Tilll Downgradient	-	-	-	-	-	-	-	-

Wells within 100 to 200 m - Overburden

		Flood				Non-Flood			
Data Set	Material	Nitrate (mg/L)	Sulphate (mg/L)	Hardness (mg/L)	Conductance (µS/cm)	Nitrate (mg/L)	Sulphate (mg/L)	Hardness (mg/L)	Conductance (µS/cm)
All MW Data	Till Updgradient	0.27	1710	2140	3455	0.03	1320	1580	2980
	Tilll Downgradient	0.84	79	715	350	0.59	75	565	1035
	Sand and Gravel Updgradient	0.07	43	315	482	0.09	42	245	482
	Sand and Gravel Downgradient	-	-	-	-	-	-	-	-
Birds Hill	Sand and Gravel Updgradient	-	-	-	-	-	-	-	-
	Sand and Gravel Downgradient	-	-	-	-	-	-	-	-
Hwy 15	Till Updgradient	-	-	-	-	-	-	-	-
	Tilll Downgradient	-	-	-	-	-	-	-	-
CPR Keewatin	Till Updgradient	0.264	1730	2120	3305	0.03	1580	1934	3120
	Tilll Downgradient	-	-	-	-	-	-	-	-
Lockport	Till Updgradient	-	-	-	-	-	-	-	-
	Tilll Downgradient	-	-	-	-	-	-	-	-

Wells within 200 to 300 m - Overburden

		Flood				Non-Flood			
Data Set	Material	Nitrate (mg/L)	Sulphate (mg/L)	Hardness (mg/L)	Conductance (µS/cm)	Nitrate (mg/L)	Sulphate (mg/L)	Hardness (mg/L)	Conductance (µS/cm)
All MW Data	Till Updgradient	-	-	-	-				
	Tilll Downgradient	0.09	1260	1540	2940	9	814	1545	2945
	Sand and Gravel Updgradient	0.08	45	231	475	0.08	45	242	479
	Sand and Gravel Downgradient	-	-	-	-	-	-	-	-
Birds Hill	Sand and Gravel Updgradient	0.082	45	231	475	0.081	45.5	242	478.5
	Sand and Gravel Downgradient	-	-	-	-	-	-	-	-
Hwy 15	Till Updgradient	-	-	-	-	-	-	-	-
	Tilll Downgradient	25.6	871	1605	3025	18.7	778	1370	2940
CPR Keewatin	Till Updgradient	-	-	-	-	-	-	-	-
	Tilll Downgradient	-	-	-	-	-	-	-	-
Lockport	Till Updgradient	-	-	-	-	-	-	-	-
	Tilll Downgradient	-	-	-	-	-	-	-	-

Wells within 300 to 400 m - Overburden

		Flood				Non-Flood			
Data Set	Material	Nitrate (mg/L)	Sulphate (mg/L)	Hardness (mg/L)	Conductance (µS/cm)	Nitrate (mg/L)	Sulphate (mg/L)	Hardness (mg/L)	Conductance (µS/cm)
All MW Data	Till Updgradient	0.04	275	1052	2329	0.04	1280	1550	2770
	Tilll Downgradient	0.02	112	710	1320	0.2	132	652	1280
	Sand and Gravel Updgradient	0.08	40	225	549	0.085	45	247	482
	Sand and Gravel Downgradient	-	-	-	-	-	-	-	-
Birds Hill	Sand and Gravel Updgradient	0.174	39	221	458	0.113	42	248	499
	Sand and Gravel Downgradient	-	-	-	-	-	-	-	-
Hwy 15	Till Updgradient	-	-	-	-	-	-	-	-
	Tilll Downgradient	-	-	-	-	-	-	-	-
CPR Keewatin	Till Updgradient	0.037	275	1052	2328.5	0.152	330.5	667	1465
	Tilll Downgradient	-	-	-	-	-	-	-	-
Lockport	Till Updgradient	-	-	-	-	-	-	-	-
	Tilll Downgradient	-	-	-	-	-	-	-	-

Table 4.2b Median Bedrock Concentrations, Comparison of Sensitive Areas to Overall Data Set

Monitor Wells within 0 to 100 m - Bedrock only

		Flood				Non-Flood			
		Nitrate (mg/L)	Sulphate (mg/L)	Hardness (mg/L)	Conductance (µS/cm)	Nitrate (mg/L)	Sulphate (mg/L)	Hardness (mg/L)	Conductance (µS/cm)
All MW Data	Upgradient	0.118	45.5	269	563.5	0.051	55	277	587
	Downgradient	0.019	201	433	1260	0.008	217	404	1260
Hwy 15 area	Upgradient	0.010	43	172	620	0.013	705	920	2010
	Downgradient	0.020	201	433	1260	0.008	217	404	1260
Birds Hill	Upgradient	0.033	22.8	232	544	0.051	48	233.5	559.5
	Downgradient	-	-	-	-	-	-	-	-
CPR Keewatin	Upgradient	-	-	-	-	-	-	-	-
	Downgradient	-	-	-	-	-	-	-	-
Lockport	Upgradient	3.2	72	367.5	762.5	2.3	96.5	308	736.5
	Downgradient	-	-	-	-	-	-	-	-

Monitor Wells within 100 to 200 m - Bedrock only

		Flood				Non-Flood			
		Nitrate (mg/L)	Sulphate (mg/L)	Hardness (mg/L)	Conductance (µS/cm)	Nitrate (mg/L)	Sulphate (mg/L)	Hardness (mg/L)	Conductance (µS/cm)
All MW Data	Upgradient	0.020	39.5	270.5	559.5	0.014	37	270	583
	Downgradient	0.010	146	409	876	0.010	107	449	947
Hwy 15 area	Upgradient	0.008	36	154	597	0.014	36	179	594
	Downgradient	0.007	598	851	1900	0.006	586	816	2025
Birds Hill	Upgradient	-	-	-	-	-	-	-	-
	Downgradient	-	-	-	-	-	-	-	-
CPR Keewatin	Upgradient	0.020	23	260	510	0.004	27	262	523
	Downgradient	-	-	-	-	-	-	-	-
Lockport	Upgradient	-	-	-	-	-	-	-	-
	Downgradient	-	-	-	-	-	-	-	-

Monitor Wells within 200 to 300 m - Bedrock only

		Flood				Non-Flood			
		Nitrate (mg/L)	Sulphate (mg/L)	Hardness (mg/L)	Conductance (µS/cm)	Nitrate (mg/L)	Sulphate (mg/L)	Hardness (mg/L)	Conductance (µS/cm)
All MW Data	Upgradient	2.57	57	459.5	881.5	1.98	66	240	539
	Downgradient	0.01	257	604.5	1375	0.011	264	632	1350
Hwy 15 area	Upgradient	-	-	-	-	-	-	-	-
	Downgradient	0.006	514	677	2000	0.005	459	648	1950
Birds Hill	Upgradient	-	-	-	-	-	-	-	-
	Downgradient	-	-	-	-	-	-	-	-
CPR Keewatin	Upgradient	-	-	-	-	-	-	-	-
	Downgradient	0.007	27.5	254	527	0.008	31	255	558
Lockport	Upgradient	-	-	-	-	-	-	-	-
	Downgradient	-	-	-	-	-	-	-	-

Monitor Wells within 300 to 400 m - Bedrock only

		Flood				Non-Flood			
		Nitrate (mg/L)	Sulphate (mg/L)	Hardness (mg/L)	Conductance (µS/cm)	Nitrate (mg/L)	Sulphate (mg/L)	Hardness (mg/L)	Conductance (µS/cm)
All MW Data	Upgradient	0.12	358.5	599.5	1150	0.008	610	799	1650
	Downgradient	-	-	-	-	-	-	-	-
Hwy 15 area	Upgradient	-	-	-	-	-	-	-	-
	Downgradient	-	-	-	-	-	-	-	-
Birds Hill	Upgradient	-	-	-	-	-	-	-	-
	Downgradient	-	-	-	-	-	-	-	-
CPR Keewatin	Upgradient	-	-	-	-	-	-	-	-
	Downgradient	-	-	-	-	-	-	-	-
Lockport	Upgradient	-	-	-	-	-	-	-	-
	Downgradient	-	-	-	-	-	-	-	-

Wells within 400 to 500 m - Bedrock only

		Flood				Non-Flood			
		Nitrate (mg/L)	Sulphate (mg/L)	Hardness (mg/L)	Conductance (µS/cm)	Nitrate (mg/L)	Sulphate (mg/L)	Hardness (mg/L)	Conductance (µS/cm)
All MW Data	Upgradient	-	-	-	-	-	-	-	-
	Downgradient	0.71	127	632	1120	0.38	160	623	1150
Hwy 15 area	Upgradient	-	-	-	-	-	-	-	-
	Downgradient	-	-	-	-	-	-	-	-
Birds Hill	Upgradient	-	-	-	-	-	-	-	-
	Downgradient	-	-	-	-	-	-	-	-
CPR Keewatin	Upgradient	-	-	-	-	-	-	-	-
	Downgradient	-	-	-	-	-	-	-	-
Lockport	Upgradient	-	-	-	-	-	-	-	-
	Downgradient	-	-	-	-	-	-	-	-

TABLE D-1 SUMMARY OF MEAN AND MEDIAN CHEMISTRY - SURFACE WATER
Human Health Risk Assessment, Red River Floodway
Manitoba Floodway Authority
Jacques Whitford Project No. 1025616

SURFACE WATER CHEMISTRY			Parameter [1]																						
			Sodium	Potassium	Calcium	Magnesium	Bicarbonate as HCO_3	Chloride (Soluble)	Fluoride (Soluble)	Sulphate (Soluble)	Nitrate+ Nitrite-N (Soluble)	Ammonia (NH_3) (Soluble)	T.K.N.	Turbidity (NTU)	pH (units)	E.C. (µS/cm)	Alkalinity as $CaCO_3$	Carbonate as CO_3	Hardness as $CaCO_3$	Iron	Manganese	T.D.S.	T.S.S.	Total Coliform	E. Coli
		EQL	*0.02*	*0.05*	*0.05*	*0.01*	*2.0*	*9.0*	*0.1*	*9.0*	*0.01*	*0.01*	*0.2*	*0.05*	*0.01*	*0.4*	*1.0*	*0.6*	*0.07*	*0.01*	*0.0002*	*5*	*5*	*1*	*1*
		GCDWQ	*200*	*-*	*-*	*-*	*-*	*250*	*1.5*	*500*	*10*	*-*	*-*	*5*	*6.5-8.5*	*-*	*-*	*-*	*200*	*0.3*	*0.05*	*500*	*-*	*0*	*0*
	No. Stations	No. samples	Summary Statistic	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(NTU)	(units)	(µS/cm)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(N/100 ml)	(N/100 ml)
Summary Statistics (During Floodway Operation; N=39; Stations S13, 14, 21, 23, 25, 27)	8	39	Minimum	3.6	6.6	16.8	10.5	92.0	10.0	0.1	19.0	0.23	0.04	1.10	5	7.57	197	75	-	88	0.17	0.02	128	17	260	2
			Maximum	21.2	11.4	61.3	28.2	235.0	28.0	0.3	123.0	2.44	0.72	11.60	190	8.26	582	193	-	269	0.95	0.29	367	280	930	1030
			Mean	13.8	8.1	42.3	19.4	163.2	18.0	0.2	71.6	1.36	0.17	1.76	92	7.95	420	134	-	185	0.57	0.13	260	105	446	104
			Median	13.5	7.9	43.2	18.4	150.5	19.0	0.2	74.0	1.35	0.16	1.45	100	7.98	409	124	-	180	0.60	0.14	260	100	430	27
			Std. Dev.	5.1	1.2	12.9	5.1	42.6	4.3	0.1	31.5	0.76	0.14	1.76	52	0.17	110	35	-	53	0.19	0.08	72	63	228	194
Summary Statistics (Outside of Floodway Operation; N=13; Stations S13, 14, 21, 23, 25, 27)	8	13	Minimum	8.3	4.4	39.9	18.2	206.0	16.0	0.2	20.0	0.03	0.02	0.70	11	8.01	390	172	1.5	174	0.13	0.02	213	5	1460	14
			Maximum	56.9	6.9	74.2	47.2	310.0	73.0	0.3	137.0	0.57	0.08	17.00	39	8.44	895	277	13.9	380	0.54	0.08	533	46	2790	130
			Mean	22.7	6.0	55.8	30.7	247.3	30.8	0.3	65.0	0.13	0.05	9.58	24	8.33	585	213	6.6	266	0.38	0.05	339	21	1914	62
			Median	11.8	6.0	47.8	22.2	230.0	18.0	0.3	34.5	0.09	0.04	15.00	23	8.36	458	194	4.6	210	0.42	0.05	254	22	1750	47
			Std. Dev.	17.8	0.6	14.6	12.5	36.9	20.4	0.1	48.7	0.15	0.02	7.77	9	0.10	202	38	5.1	88	0.13	0.02	132	12	454	36
Summary Statistics (Red River Upstream; During Floodway Operation; N=24; Stations S1, 2, 3, 4)	4	24	Minimum	13.4	7.2	42.6	17.1	142.0	14.0	0.2	71.0	0.32	0.04	1.10	55	7.67	397	116	0.0	177	0.36	0.08	238	54	90	3
			Maximum	26.0	11.4	65.3	29.1	244.0	25.0	0.3	128.0	3.27	0.36	2.70	230	8.20	621	200	0.0	283	3.34	0.34	388	310	1520	220
			Mean	18.6	8.4	51.8	22.6	175.3	20.4	0.2	109.9	1.62	0.17	1.68	135	7.95	494	144	#DIV/0!	222	1.01	0.23	307	178	444	83
			Median	19.1	8.1	49.2	21.9	152.5	21.0	0.2	119.5	1.46	0.15	1.65	130	7.97	486	125	#NUM!	210	0.74	0.26	298	130	240	40
			Std. Dev.	4.0	1.3	8.3	4.3	39.5	3.8	0.0	23.3	1.22	0.11	0.54	58	0.17	89	32	#DIV/0!	38	0.86	0.09	63	91	606	83
Summary Statistics (Red River Upstream; During Floodway Operation; N=8; Stations S1, 2, 3, 4)	4	8	Minimum	21.2	7.6	58.0	27.1	225.0	21.0	0.2	113.0	0.20	0.01	0.90	14	8.01	599	190	2.6	257	0.19	0.07	364	19	900	10
			Maximum	32.3	8.0	90.7	35.7	293.0	35.0	0.3	167.0	0.92	0.39	15.00	220	8.38	782	240	3.1	367	1.96	0.51	483	410	1100	32
			Mean	26.1	7.7	70.3	31.4	245.3	27.3	0.3	137.6	0.55	0.16	8.31	100	8.28	647	204	3.0	305	0.94	0.29	425	188	1010	22
			Median	25.5	7.6	68.4	31.4	241.0	27.0	0.3	128.0	0.30	0.04	8.50	34	8.31	633	200	3.1	300	0.51	0.29	425	92	1020	21
			Std. Dev.	4.9	0.2	12.1	3.9	23.9	6.7	0.0	24.7	0.35	0.18	7.16	99	0.13	62	17	0.3	45	0.78	0.18	59	167	100	8

Notes:

1. mg/L = milligrams per litre; µS/cm = microSiemens per centimetre; NTU - Nephelometer Turbidity Units; (-) = not analyzed or no guideline; E.C. - Electrical conductance
2. EQL = Reportable Detection Limit;
3. (<) = less than laboratory detection limit;
4. GCDWQ = Guidelines for Canadian Drinking Water Quality, 2006 update; Maximum Acceptable Concentrations (MAC) or the Interim Maximum Acceptable Conentrations (IMAC) unless otherwise indicated (Bold-Underlined exceeds)

TABLE D-2 SUMMARY OF MEAN AND MEDIAN CHEMISTRY - OVERBURDEN WELLS

Human Health Risk Assessment, Red River Floodway
Manitoba Floodway Authority
Jacques Whitford Project No. 1025616

OVERBURDEN MONITOR WELL GROUNDWATER CHEMISTRY				Parameter [1]																					
				Sodium	Potassium	Calcium	Magnesium	Bicarbonate as HCO_3	Chloride (Soluble)	Fluoride (Soluble)	Sulphate (Soluble)	Nitrate+ Nitrite-N (Soluble)	Ammonia (NH_3) (Soluble)	T.K.N.	Turbidity (NTU)	pH (units)	E.C. (µS/cm)	Alkalinity as $CaCO_3$	Carbonate as CO_3	Hardness as $CaCO_3$	Iron	Manganese	T.D.S.	Total Coliform	E. Coli
			EQL	*0.02*	*0.05*	*0.05*	*0.01*	*2.0*	*9.0*	*0.1*	*9.0*	*0.01*	*0.01*	*0.2*	*0.05*	*0.01*	*0.4*	*1.0*	*0.6*	*0.07*	*0.01*	*0.0002*	*5*	*1*	*1*
			GCDWQ	*200*	*-*	*-*	*-*	*-*	*250*	*1.5*	*500*	*10*	*-*	*-*	*5*	*6.5-8.5*	*-*	*-*	*-*	*200*	*0.3*	*0.05*	*500*	*0*	*0*
	No. Wells	**No. samples**		**(mg/L)**	**(mg/L)**	**(mg/L)**	**(mg/L)**	**(mg/L)**	**(mg/L)**	**(mg/L)**	**(mg/L)**	**(mg/L)**	**(mg/L)**	**(mg/L)**	**(NTU)**	**(units)**	**(µS/cm)**	**(mg/L)**	**(mg/L)**	**(mg/L)**	**(mg/L)**	**(mg/L)**	**(mg/L)**	**(N/100 ml)**	**(N/100 ml)**
All Monitor Wells	20	100	Mean	48.0	5.4	117.5	88.3	503.0	18.0	0.4	51.0	1.09	-	-	2054	7.86	420	419.7		361	0.31	0.11	898	-	-
			Median	8.7	4.6	61.2	42.8	333.0	16.0	0.4	42.0	0.085	-	-	170	7.88	686	273.0		248	0.10	0.03	414	-	-
			No.Wells	2	-	-	-	-	3	0	6	7	-	-	all	0	-	-		all	6	8	12	-	-
Bedrock/Rubble (all Dates)	1	3	Mean	95.0	4.7	121.1	56.0	522.7	144.3	0.3	151.7	0.02	-	-	1569	7.46	1407	428.7	<0.6	532	0.36	0.25	826	-	-
			Median	96.7	4.7	129.0	58.3	539.0	170.0	0.3	153.0	0.02	-	-	700	7.53	1470	442.0	<0.6	567	0.36	0.25	881	-	-
		No Wells Exceeding		0	-	-	-	-		0	0	0	-	-	1	0	-	-		1	1	1	1	-	-
Bedrock/Rubble (Flood Dates)	1	1	Mean	98.5	5.4	144.0	58.3	483.0	234.0	-	154.0	0.02	-	-	4000	7.31	1680	396.0	<0.6	598	-	-	932	-	-
			Median	98.5	5.4	144.0	58.3	483.0	234.0	-	154.0	0.02	-	-	4000	7.31	1680	396.0	<0.6	598	-	-	932	-	-
Bedrock/Rubble (Non-Flood Dates)	1	2	Mean	93.3	4.3	109.6	54.8	542.5	99.5	0.3	150.5	0.01	-	-	353	7.54	1270	445.0	<0.6	499	0.36	0.25	773	-	-
			Median	93.3	4.3	109.6	54.8	542.5	99.5	0.3	150.5	0.01	-	-	353	7.54	1270	445.0	<0.6	499	0.36	0.25	773	-	-
Sand & Gravel (All Dates)	7	45	Mean	6.8	4.7	64.7	43.9	315.5	17.2	0.2	108.7	0.21	-	-	2163	8.03	645	259.9	5.3	347	0.28	0.09	404	-	-
			Median	5.6	4.4	45.1	32.3	253.5	17.0	0.2	46.5	0.12	-	-	130	8.08	484	208.0	4.0	249	0.13	0.04	276	-	-
		No Wells Exceeding		0	-	-	-	-	0	0	0	0	-	-	7	0	-	-		7	1	1	2	-	-
Sand & Gravel (Flood Dates)	5	11	Mean	6.3	4.2	48.4	31.2	255.4	16.1	-	52.2	0.26	-	-	2314	8.17	499	211.7	8.0	250	-	-	290	-	-
			Median	5.6	4.2	43.4	31.5	246.0	16.0	-	44.0	0.09	-	-	140	8.17	473	202.0	8.0	233	-	-	272	-	-
Sand & Gravel (non-Flood Dates)	7	33	Mean	7.0	4.9	69.8	48.0	334.3	17.5	0.2	126.5	0.19	-	-	2114	7.99	691	275.0	4.0	372	0.28	0.09	435	-	-
			Median	5.5	4.4	45.5	32.5	253.5	17.0	0.3	47.0	0.13	-	-	130	8.05	488	208.0	4.0	249	0.06	0.00	276	-	-
Sandy Silt (all Dates)	2	4	Mean	19.6	5.2	46.3	71.6	664.0	27.4	0.5	8.5	0.02	-	-	9251	8.01	792	544.5	-	411	0.15	0.06	505	-	-
			Median	20.6	5.2	47.6	72.1	707.5	27.5	0.5	7.3	0.02	-	-	9500	8.01	804	580.0	-	418	0.15	0.06	539	-	-
		No Wells Exceeding		0	-	-	-	-	0	0	1	0	-	-	2	0	-	-		2		2	1	-	-
Sandy Silt (Flood Dates)	0	0	Mean	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
			Median	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sandy Silt (non-Flood Dates)	2	4	Mean	19.6	5.2	46.3	71.6	664.0	27.4	0.5	8.5	0.02	-	-	9251	8.01	792	544.5	<0.6	411	0.15	0.06	505	-	-
			Median	20.6	5.2	47.6	72.1	707.5	27.5	0.5	7.3	0.02	-	-	9500	8.01	804	580.0	<0.6	418	0.15	0.06	539	-	-
Till (all Dates)	10	48	Mean	87.0	6.2	173.8	134.3	668.2	116.0	0.4	**<u>547.6</u>**	2.10	-	-	1303	7.71	1883	562.0	101.7	982	0.33	0.11	1387	-	-
			Median	52.5	5.7	112.0	102.0	637.0	22.5	0.4	132.0	0.04	-	-	190	7.76	1365	522.5	2.75	703	0.09	0.02	829	-	-
		No Wells Exceeding		2	-	-	-	-	3	0	5	1	-	-	10	0	-	-		10	5	5	8	-	-
Till (Flood Dates)	10	23	Mean	108.0	6.7	224.0	156.8	796.6	191.1	0.5	**<u>658.8</u>**	2.49	-	-	2219	7.72	2328	681.9	200.9	1195	0.01	0.01	1770	-	-
			Median	120.0	6.5	132.0	148.0	664.0	26.0	0.3	136.0	0.09	-	-	390	7.80	2140	544.0	200.9	1240	0.01	0.00	1470	-	-
Till (non-Flood Dates)	10	25	Mean	67.7	5.7	127.5	113.6	550.0	40.9	0.4	441.0	1.75	-	-	250	7.71	1474	451.6	2.6	786	0.43	0.14	1021	-	-
			Median	45.8	5.4	101.0	89.7	604.0	22.0	0.4	109.5	0.03	-	-	11	7.73	1240	495.0	2.55	641	0.14	0.04	717	-	-

Notes:

1. mg/L = milligrams per litre; µS/cm = microSiemens per centimetre; NTU - Nephelometer Turbidity Units; (-) = not analyzed or no guideline; E.C. - Electrical conductance
2. EQL = Reportable Detection Limit;
3. (<) = less than laboratory detection limit;
4. GCDWQ = Guidelines for Canadian Drinking Water Quality, 2006 update; Maximum Acceptable Concentrations (MAC) or the Interim Maximum Acceptable Conentrations (IMAC) unless otherwise indicated (Bold-Underlined exceeds)

TABLE D-3 SUMMARY OF MEAN AND MEDIAN CHEMISTRY - BEDROCK WELLS

Human Health Risk Assessment, Red River Floodway

Manitoba Floodway Authority

Jacques Whitford Project No. 1025616

BEDROCK MONITORING WELLS GROUNDWATER CHEMISTRY			Parameter (1)	Sodium	Potassium	Calcium	Magnesium	Bicarbonate as HCO_3	Chloride (Soluble)	Fluoride (Soluble)	Sulphate (Soluble)	Nitrate+ Nitrite-N (Soluble)	Turbidity (NTU)	pH (units)	E.C. (µS/cm)	Alkalinity as $CaCO_3$	Carbonate as CO_3	Hardness as $CaCO_3$	Iron	Manganese	T.D.S.	Total Coliform	E. Coli
			EQL	*0.02*	*0.05*	*0.05*	*0.01*	*2.0*	*9.0*	*0.1*	*9.0*	*0.01*	*0.05*	*0.01*	*0.4*	*1.0*	*0.6*	*0.07*	*0.01*	*0.0002*	*5*	*1*	*1*
			CCME (2)	*200*	*-*	*-*	*-*	*-*	*250*	*1.5*	*500*	*10*	*5*	*6.5-8.5*	*-*	*-*	*-*	*200*	*0.3*	*0.05*	*500*	*0*	*0*
	No. Wells	**No. samples**		**(mg/L)**	**(mg/L)**	**(mg/L)**	**(mg/L)**	**(mg/L)**	**(mg/L)**	**(mg/L)**	**(mg/L)**	**(mg/L)**	**(NTU)**	**(units)**	**(µS/cm)**	**(mg/L)**	**(mg/L)**	**(mg/L)**	**(mg/L)**	**(mg/L)**	**(mg/L)**	**(N/100 ml)**	**(N/100 ml)**
All Bedrock MWs	29	274	Mean	52.2	5.0	75.1	68.7	406.1	47.7	0.33	205.7	0.24	870.5	7.9	1041.0	333.8	4.9	469.5	0.22	0.03	658.7	-	-
			Median	30.4	4.7	70.6	60.0	363.5	20.0	0.30	111.0	0.02	40.0	7.9	908.5	297.5	3.7	430.0	0.10	0.02	554.0	-	-
Exceedences			Events	7	-	-	-	-	3	0.00	37	0	most	0	-	-	-	most	3	5	138	-	-
Exceedences			N Wells	3	-	-	-	-	2	0.00	6	0	-	0	-	-	-	-	3	4	19	-	-
Monitor Wells - Flood	29	114	Mean	57.9	5.2	76.3	66.9	398.8	57.1	0.34	199.4	0.30	1295	7.90	1057	327.5	5.1	463.7	0.10	0.03	663	-	-
			Median	29.4	4.7	70.7	59.8	352.0	21.0	0.30	107.0	0.02	65	7.89	876	292.0	3.5	430.0	0.08	0.01	537	-	-
Monitor Wells - Non Flood	29	160	Mean	47.6	4.9	73.7	69.4	410.8	40.6	0.30	205.6	0.19	599	7.85	1021	337.8	4.9	469.5	0.36	0.03	649	-	-
			Median	31.8	4.8	68.6	62.0	370.0	20.0	0.30	113.5	0.02	34	7.88	923	305.0	3.7	430.0	0.21	0.02	573	-	-
BEDROCK - DOMESTIC WELLS < 1000 m	**Wells**	**N**																					
All Domestic wells < 1000 m from Center Line	286	1560	Mean	47.7	5.1	79.7	66.7	401.9	52.4	0.35	178.7	0.3	4.8	7.92	1023.0	401.9	7.5	473.4	0.36	0.02	625	<1	<1
			Median	32.3	4.1	75.7	55.5	347.0	24.0	0.30	154.0	0.008	1.6	7.92	910.0	286.0	347.0	417.0	0.13	0.01	558	<1	<1
Exceedences			Samples	368	39	-	-	-	51	1	58	7	-	-	-	-	-	1538	446	62	829	184	11
Exceedences			N Wells	5					11	1	13	3										86	9
Domestic Wells - Flood	155	503	Mean	46.2	4.8	79.9	67.1	401.0	51.6	0.3	176.6	0.34	5	7.96	1024	331.3	8.3	475.8	0.35	0.02	625	<1	<1
			Median	34.1	4.2	75.7	60.7	346.0	25.0	0.3	166.0	0.01	2	7.96	964	287.0	6.4	446.0	0.13	0.01	589	<1	<1
Domestic Wells - Non-Flood	286	1049	Mean	48.4	5.2	79.6	66.6	402.3	52.8	0.3	179.6	0.27	5	7.90	1023	330.5	6.9	472.3	0.36	0.02	625	<1	<1
			Median	31.4	4.1	75.8	53.9	348.0	23.0	0.3	144.0	0.01	1	7.91	890	286.0	5.8	409.0	0.13	0.01	544	<1	<1

Notes:

1. mg/L = milligrams per litre; µS/cm = microSiemens per centimetre; NTU - Nephelometer Turbidity Units; (-) = not analyzed or no guideline; E.C. - Electrical conductance
2. EQL = Reportable Detection Limit;
3. (<) = less than laboratory detection limit;
4. GCDWQ = Guidelines for Canadian Drinking Water Quality, 2006 update; Maximum Acceptable Concentrations (MAC) or the Interim Maximum Acceptable Conentrations (IMAC) unless otherwise indicated (Bold-Underlined exceeds)

TABLE D.4 ANNUAL RECORD OF FLOODWAY OPERATION (1969 - 2007)
Human Health Risk Assessment, Red River Floodway
Manitoba Floodway Authority
Jacques Whitford Project No. 1025616

Year	Operational Period			No. of Days Operating	Season	Date of Peak Flow	No. of Days to Peak	Peak Flow (m^3/s)
1969	14-Apr	-	18-May	35	spring	3-May	20	623
1970	17-Apr	-	21-May	35	spring	1-May	15	646
1971	11-Apr	-	21-Apr	11	spring	14-Apr	4	257
1972	14-Apr	-	21-Apr	8	spring	18-Apr	5	33.4
1973	-	-	-	0	-	-	-	-
1974	11-Apr	-	30-May	41	spring	24-Apr	14	1040
1975	30-Apr	-	19-May	20	spring	7-May	8	267
1976	7-Apr	-	18-Apr	12	spring	11-Apr	5	292
1977	-	-	-	0	-	-	-	-
1978	9-Apr	-	3-May	25	spring	16-Apr	8	513
1979	19-Apr	-	29-May	41	spring	9-May	21	1190
1980	-	-	-	0	-	-	-	-
1981	-	-	-	0	-	-	-	-
1982	15-Apr	-	21-Apr	8	spring	18-Apr	4	17.8
1983	9-Apr	-	13-Apr	5	spring	11-Apr	3	26.4
1984	-	-	-	0	-	-	-	-
1985	-	-	-	0	-	-	-	-
1986	1-Apr	-	14-Apr	20	spring	3-Apr	3	278
1987	5-Apr	-	18-Apr	14	spring	10-Apr	6	507
1988	-	-	-	0	-	-	-	-
1989	21-Apr	-	1-May	11	spring	24-Apr	4	136
1990	-	-	-	0	-	-	-	-
1991	-	-	-	0	-	-	-	-
1992	7-Apr	-	12-Apr	6	spring	8-Apr	2	101
1993	-	-	-	0	-	-	-	-
1994	-	-	-	0	-	-	-	-
1995	22-Mar	-	25-Apr	35	spring	29-Mar	8	387
1996	18-Apr	-	9-Jun	53	spring	30-May	43	1100
1997	19-Apr	-	2-Jun	45	spring	3-May	15	1880
1998	30-Mar	-	6-Apr	8	spring	1-Apr	3	191
1999	3-Apr	-	1-May	29	spring	18-Apr	16	445
2000	-	-	-	0	-	-	-	-
2001	5-Apr	-	20-May	46	spring	26-Apr	22	598
2002	-	-	-	0	-	-	-	-
2002	13-Jun	-	26-Jul	30	summer	6-Jul	24	159
2003	-	-	-	0	-	-	-	-
2004	31-Mar	-	21-Apr	22	spring	5-Apr	6	446
2004	10-Jun	-	30-Jun	21	summer	12-Jul	33	294
2005	2-Apr	-	22-Apr	21	spring	8-Apr	7	433
2005	9-Jun	-	3-Aug	51	summer	4-Jul	26	657
2006	5-Apr	-	7-May	33	spring	15-Apr	11	941
2007	3-Apr	-	16-Apr	14	spring	12-Apr	10	119
2007	28-Jun	-	2-Jul	5	summer	29-Jun	2	23

Source: KGS Group, Table HM38-F-1-2

APPENDIX E

Public Consultation Information

Jacques Whitford

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Final Report

Summary of Round 1 and 2 Public Consultation Human Health Risk Assessment Red River Floodway Expansion Project Winnipeg, Manitoba

MANITOBA FLOODWAY AUTHORITY

PROJECT NO. 1025616

PROJECT NO. 1025616

REPORT TO	**Manitoba Floodway Authority** **200-155 Carlton St.** **Winnipeg, Manitoba** **R3C 3H8**
FOR	**Red River Floodway Expansion Project** **Winnipeg, Manitoba**
ON	**Summary Round 1 and 2 Public Consultation Sessions** **Human Health Risk Assessment**

July 31, 2008

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Attachments

1.0 INTRODUCTION

The Minister of Manitoba Conservation issued License No. 2691 under the Environment Act to the Manitoba Floodway Authority (MFA) respecting the Red River Floodway Expansion Project (the Project). The License requires that the MFA provide to the Director of the Environmental Assessment and Licensing Branch, a Human Health Risk Assessment (HHRA) with respect to exposures to groundwater contamination that may result from the Project. Additional details and background on the project is provided in the Public Involvement Plan (PIP) for Human Health Risk Assessment dated July 2007. The goal of the PIP for this HHRA is to provide a framework for the involvement of the public that might be affected or have an interest in using groundwater along the Floodway.

The public consultation and involvement program focuses on stakeholders, aboriginal communities and peoples. However, all interested parties were welcome to participate. The PIP is intended to provide early and ongoing opportunities for potentially affected and interested parties to receive information on, and express their views about groundwater impacts associated with the Floodway widening, the HHRA process, and the predicted health impacts.

1.1 Objective

Jacques Whitford Limited has been retained by the MFA to conduct the independent HHRA for the project. As part of that work, the above noted PIP was developed to provide a framework for public communication and involvement. The plan included, among other things, a requirement to conduct two separate public consultation sessions with interested parties; once at the start of work, and a second after the draft findings and conclusions had been prepared.

The first round of consultation under the PIP was intended to identify the range of concerns from local citizens and municipal representatives relating to potential concerns relating to the local groundwater aquifer arising from the project. The second round of consultation was held to present the findings, solicit feedback and document concerns; where appropriate, key concerns were brought forward into the final report. This document summarizes the process and outcomes of both rounds of public meetings which were conducted in July, 2007 and July 2008.

1.2 Key Community Participants

While there is a broad group of stakeholders associated with the overall project including Metis and other aboriginal groups, this consultation focused on the rural municipalities and major communities located along the floodway alignment, including the following:

- Rural Municipality of East St. Paul;
- Rural Municipality of Springfield; and
- Rural Municipality of St. Clements.

1.3 Notice and Location of Meetings

The public consultation sessions were held in three communities within the above noted municipalities, and included Dugald, East St. Paul, and Lockport. One week prior to the sessions, advertisements were posted in several local newspapers. The dates, times and locations for each are noted below:

1) **Dugald**	Date	Round 1 - July 24, 2007, Round 2 July 22, 2008
	Location	Dugald Community Centre, 544 Holland St.,
	Time	5:30 pm
2) **Birds Hill**	Date:	Round 1 - July 25, 2007, Round 2 July 23, 2008
	Location	East St. Paul Arena Banquet Hall, 266 Hoddinott Road
	Time	5:30 pm
3) **Lockport**	Date	Round 1 - July 26, 2007, Round 2 July 24, 2008
	Location	Gaffer's Restaurant, Lot 164 Hwy 44, Lockport Bridge
	Time	5:30 pm

1.4 Meeting Sessions and Presentations

Each of the sessions was held in a meeting hall suitable for screening a PowerPoint slideshow. Sessions were hosted by Jacques Whitford Limited, and were observed by a representative of the Manitoba Floodway Authority. The sessions were chaired by Mr. Michael Charles, P.Eng, Project Manager. The first session was also attended by Mr. Dwayne Hogg, P.Eng, Senior Project Hydrogeologist. The second session was attended by Mr. Charles and Rebecca Ferguson, M.Sc, P.Eng who contributed to the modeling and data analysis.

For each session, a PowerPoint slideshow was presented to explain the project and provide context of the HHRA work. A copy of each presentation is provided in Attachment A. After the presentation, the public was engaged to bring up concerns and ask questions about the work. All questions were documented and are presented in Attachment B. At the end of each session, the public was encouraged to contact the Jacques Whitford Project Manager should they have had other concerns or questions after sessions were complete.

For each session, a registry of attendees was also kept to document persons who attended each session. The list of attendees is provided in Attachment C.

2.0 SUMMARY OF PUBLIC CONSULTATION SESSION ROUND 1

2.1 General

The formal presentation component at the first public consultation session included the following:

- An introduction of the HHRA team; and

- an overview of what the HHRA is, and is not, and how it will be completed.

Specific objectives of the session included the following:

- Listen and document the concerns expressed by the public;
- incorporate public concerns into the HHRA where they relate to the overall scope; and
- identify future public involvement opportunities.

2.2 Summary of Feedback

A summary of feedback collected during the Lockport session is presented in Attachment B. In addition to this, one e-mail was also forwarded in mid August which is also included in Attachment B. The feedback collected from the public consultation has been summarized and grouped into one of three categories, depending on the relationship of the comment to the project scope. These categories include the following:

- "Directly Considered": including issues, questions or concerns which are directly related to the work scope and would specifically be addressed in the human health risk assessment;
- "Indirectly Considered": issues, questions or concerns which are relevant to the scope and would be addressed as part of various tasks to be completed during the work; and
- "Not Addressed, out of scope": issues, questions or concerns which do not relate directly or indirectly to the work, but were documented for information purposes.

In summary, there were four questions which were directly relevant to the scope of the work, and which have been carried forward for inclusion in the HHRA. These include the following:

- "Do we know accurately where the 'blow-outs' are?, what impacts do they have"
- "Once the impacted floodway water gets into the aquifer, how long does it take to get back and how far is this water pushed into the aquifer?"
- "We are not confident that modeling can't be manipulated to bias the outcome. Has there been any work (modeling) done at the Lockport area in the wedge between the channel and river?"
- "Have we reviewed other submissions for the 3 regional municipalities? There is a public concern that the previous modeling had used some wrong base assumptions."

Three questions which are seen as relevant and which will be answered indirectly through the modeling and risk assessment include the following:

- "In Springfield, there is a public perception that the existing blow-outs have lowered the water levels; will the expansion not create more blow-outs and lower the water table more?"
- "Have any wells been impacted with e-coli from the Floodway already?"
- "Will the construction phase affect wells along Henderson Road to the north along the river? "

Finally, there were relevant statements made that were documented for the purposes of completing the work. These were as follows:

- "Are the outfalls near Lockport the only spot where the low-flow channel is being lowered".
- "Some of the assumptions used in the regional model were faulty – i.e. conductivity or transmissivity at the Kildare Falls. Please check this."
- "During the removal of the expansion lip in the Springfield area, a well has been experiencing high turbidity over the last year. This is a bedrock well that is about 50ft away. Is this related to the Floodway expansion?"

Points that were "directly" or "indirectly" relevant from the first round of public consultation have been carried forward into identifying study areas and issues for the groundwater modeling work. An explanation of how each comment from the public was to be carried forward is presented in the Table of Attachment B.

3.0 SUMMARY OF PUBLIC CONSULTATION SESSION ROUND 2

3.1 General

The formal presentation component at the second public consultation session included the following:

- An introduction of the HHRA team; and
- Review of the HHRA process and how it was completed.
- Detailed discussion respecting data analysis
- Conclusions and Recommendations

Specific objectives of the session included the following:

- Listen and document the concerns expressed by the public;
- Incorporate public concerns into the final HHRA where they relate to the overall scope; and
- identify issues that may be needed to be considered by MFA after the work is completed.

3.2 Summary of Feedback

A summary of feedback collected during the Lockport session is presented in Attachment B. The same categories used to categorize comments in round 1 were adopted in summarizing feedback obtained in Round 2 consultations (i.e. Directly Considered, Indirectly Considered, or Not Addressed, out of scope). Items that were carried forward in preparing the final document are as follows:

- Why is there an increase in conductance on the west side of the Floodway. This appears to be a Floodway influence, since conductance on the east side of the Floodway is lower?
- Did we look at the previous consultants reports, and consider these in the HHRA. Particularly, the independent consultant reports done for the RMs.
- Have the outfalls been assessed, as they contribute significantly to poor water quality within the Floodway?
- Clarification on which wells were included and excluded in the HHRA work.

P:\enveng\102xxxx\1025616 Manitoba Floodway Modeling\Risk Assessment\Final Document\Appendices\Appendix E\PIP Summary.docx

Attachment A
Presentation Slideshow

Public Information Session
Round 2
Human Health Risk Assessment

Gaffers Restaurant, Lockport

Jacques Whitford

Overview

- Our mandate
- Why we are here today
- Our Human Health Risk Assessment team
- An overview of Human Health Risk Assessments
- How we did this work, overview of our process
- Outcome, conclusions, and recommendations
- Discussion with you

Jacques Whitford

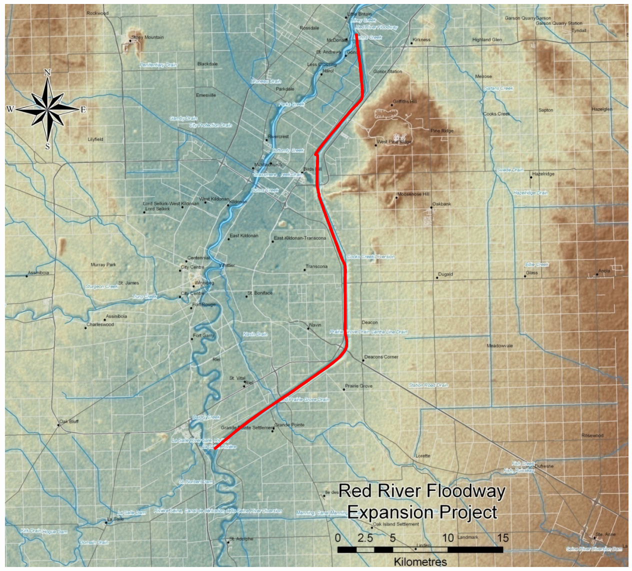
Why Are We Here Today?

1. We want to explain exactly how we did the work.
2. We want to explain how this information was used in our work.
3. Answer your questions about Risk Assessment Work.
4. Did we get it right?

Our Mandate

We are here to give an independent opinion of potential human health risk from groundwater that could be caused from operation of the expanded Red River Floodway.

Area We Looked At



Our Risk Assessment Team

Project Manager

- Michael Charles, P.Eng,

Technical Specialists

- Dwayne Hogg, M.Sc, P.Eng, Sr. Modeling expert
- David MacFarlane, M.Sc, P.Geo, Sr Hydrogeologist
- Rebecca Ferguson, M.Sc, P.Eng, Hydrogeologist/Modeling specialist

Risk Assessment Specialists

- John Henderson, P.Eng, Senior Risk Assessor

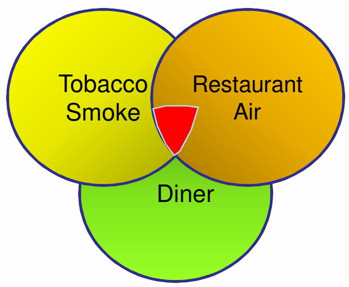
Supporting Specialists

- Dr. Kerry MacQuarrie, Surface/Groundwater expert

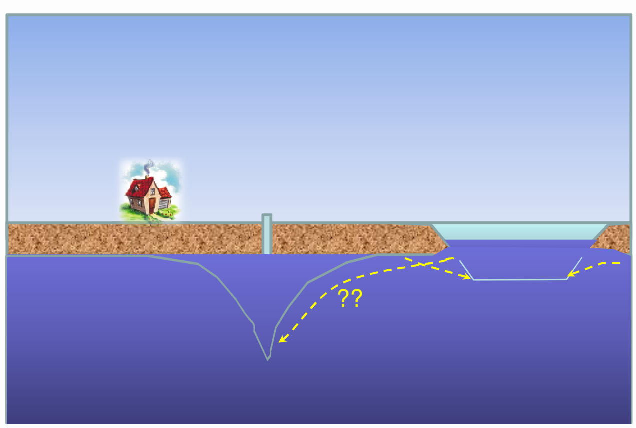
Human Health Risk Assessments

- What is “Risk Assessment”

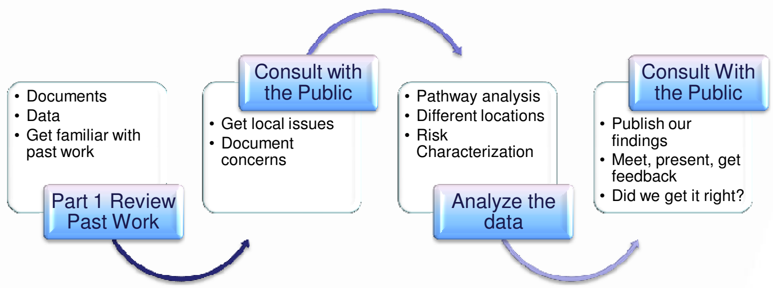
Issues Identification → Risk Assessment → Risk Characterization



Groundwater Flow



An Overview of Our process



Jacques Whitford

An Overview of Our process

- Part 1 Review of Past Work
  - Reviewed documents
  - Examined the model work to date
  - We identified gaps that should be looked at more closely
  - We documented sensitive areas/issues of concern
- Part 2 Consulted with the Public
  - Got a clear understanding of your concerns and issues
  - Clearly identified public issues
  - Brought these issues forward as into the assessment work

Jacques Whitford

An Overview of Our process

- Part 3 Conducted Numerical 2-D Modeling
  - Evaluated 3 key locations of concern.
  - Modeling could not be used as data was too limited.
  - Had to move focus to extensive groundwater chemistry database analysis.
- Part 4 Water Chemistry Interpretation
  - Conducted a detailed analysis of existing data.
  - Characterized the risk, provided an opinion whether we feel there is a human health risk.
- Part 5 Consult with the Public

Jacques Whitford

Round 1 Public Consultation Main Concerns/Issues

- Impact of groundwater seeps(blow-outs).
- Use of groundwater models to predict impacts.
- Potential impacts to the Lockport area.
- Lack of public accessibility to historic water quality data.

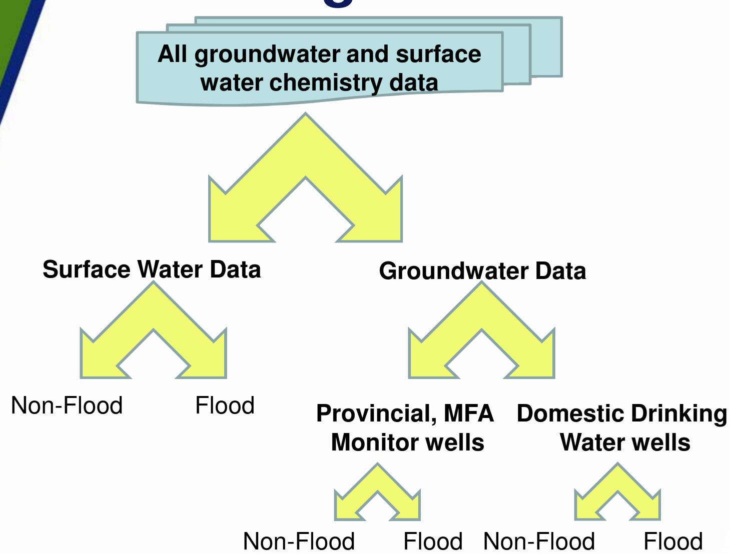
Jacques Whitford

How Data Was Evaluated

- We looked at all available groundwater and surface water data.
- Looked at surface water and groundwater separately.
- For groundwater, we broke out different well types:
  - Provincial and MFA monitor wells; and
  - domestic (bedrock) drinking water wells.
- Separated well data based on geology.

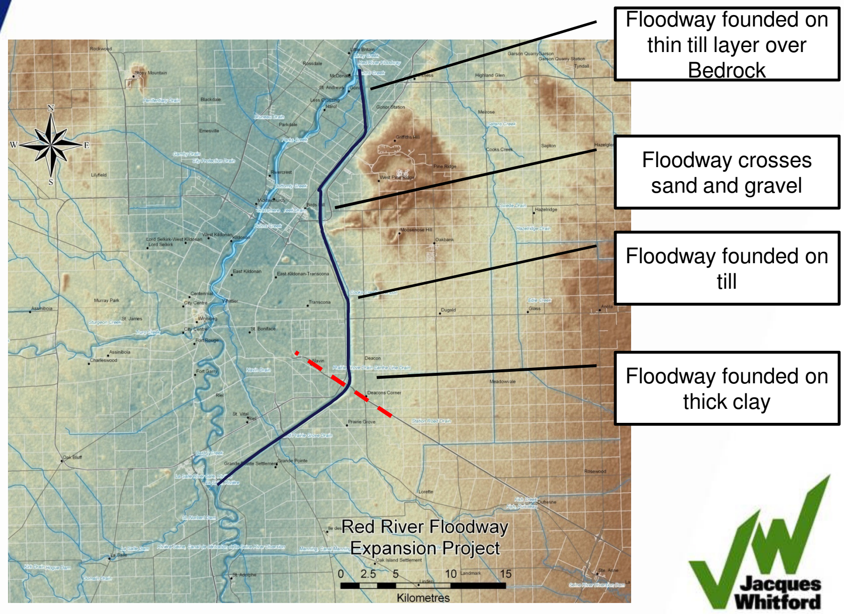
Jacques Whitford

Sorting Out The Data



Jacques Whitford

Separated Data By Geology



Jacques Whitford

Focusing on Key Sensitive Areas

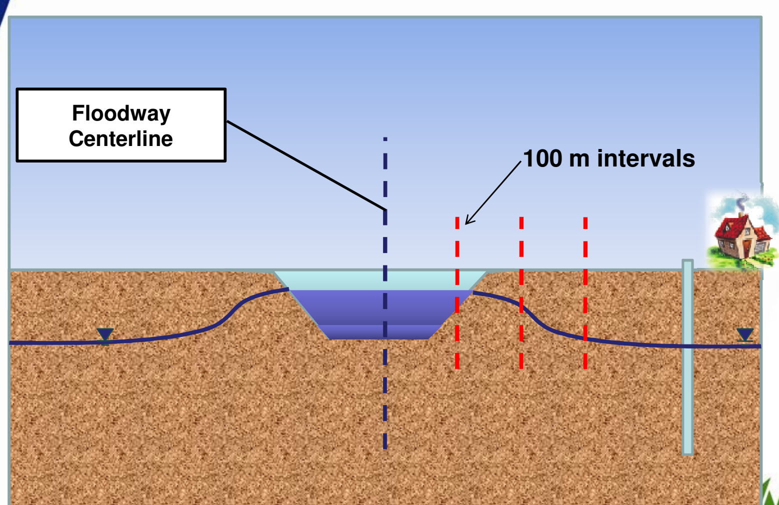
- Looked at groundwater seeps (TransCanada to Hwy 15).
- All data (north of Hwy 15) used in analysis.
- Excluded clay areas (south of Hwy15).
- Some data couldn't be used:
  - Groundwater from wells influenced by water softeners; and
  - 7 of 200+ well locations that could not be determined.

Jacques Whitford

What We Did

- We looked for flood-event surface water chemistry “indicators”.
- We included nitrate, bacteria (they have health guidelines).
- We compared the flood surface water to overburden and bedrock *monitor wells* first.

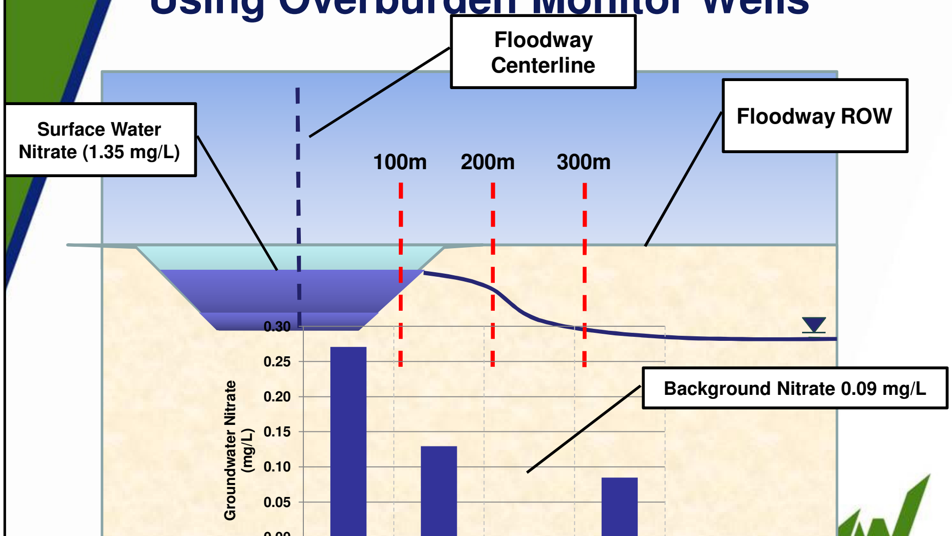
Checked Zone of Influence Using MFA Monitor Wells



Refining Monitor Well Data

- Monitor well data sorted from Floodway centerline.
- Calculated median for select indicator parameters (e.g. nitrate, TSS, major ions, conductance).
- Median values plotted for both flood and non-flood events to determine trends over distance.
- Compared surface water values to groundwater for flood and non-flood events.

Checked Zone of Influence Using Overburden Monitor Wells



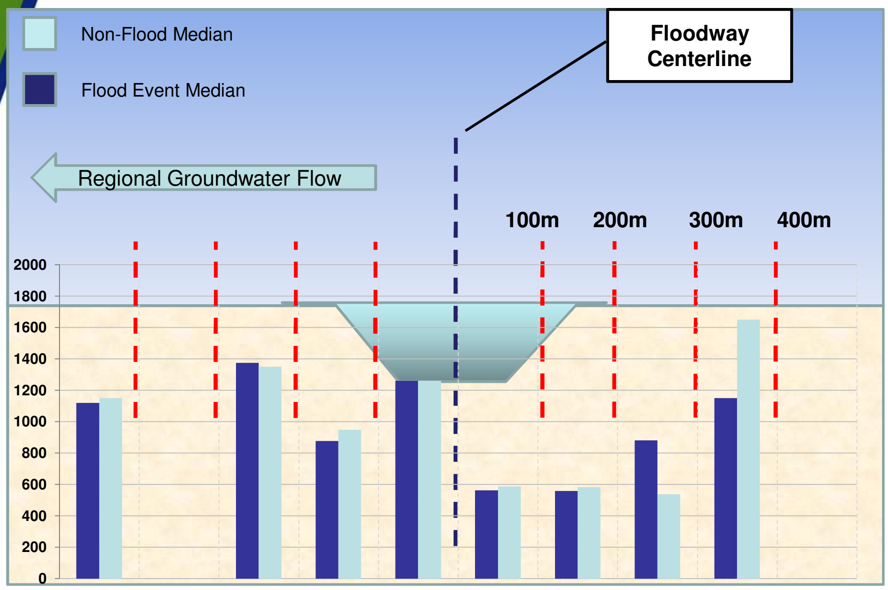
For Wells in Overburden, We Found…

- Some wells within 300 m of the existing floodway centerline are showing an influence during flood events.
- Beyond 300 m, overburden groundwater chemistry is consistent with background values.

Next We Looked at Bedrock Within 500m of Centerline

- We compared chemistry of groundwater:
  - In non-flood periods; and
  - During flood periods.
- We used many indicators, nitrate, sulphate, and conductivity.

Checked Influence On Bedrock Groundwater Using Monitor Wells (Conductance)

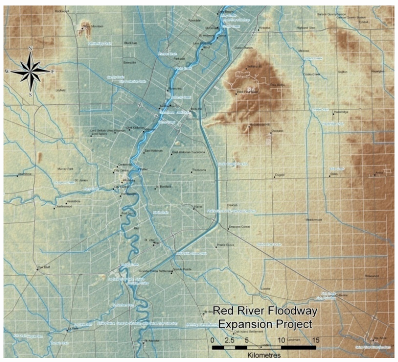


Groundwater Seeps

- Compared groundwater seep data (2005) to average groundwater value for sulphate, hardness, and nitrate.
- The chemistry from most seeps were similar to groundwater and not surface water.

Jacques Whitford

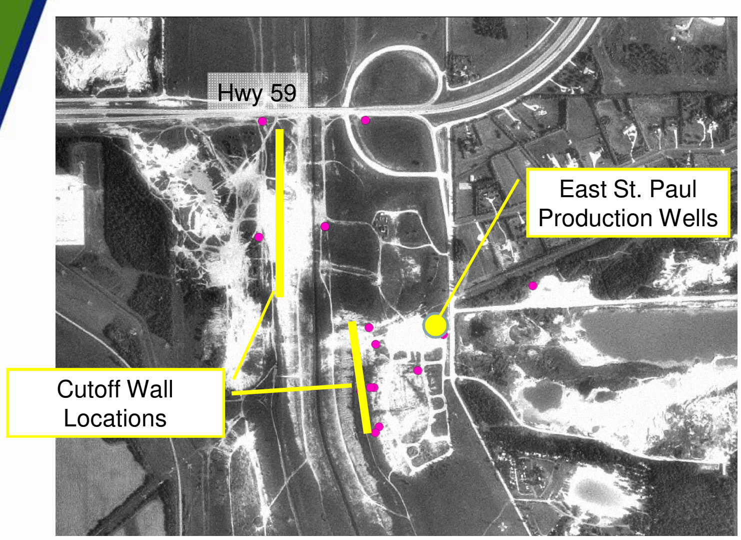
How Far Away Does the Floodway Influence Overburden Wells?



- In bedrock – very limited distance from the Floodway centerline.
- In sand and gravel (Birds Hill) – about 300 m from the Floodway centerline.
- In till – about 300 m from the Floodway centerline.

Jacques Whitford

Monitor Wells Near East St. Paul



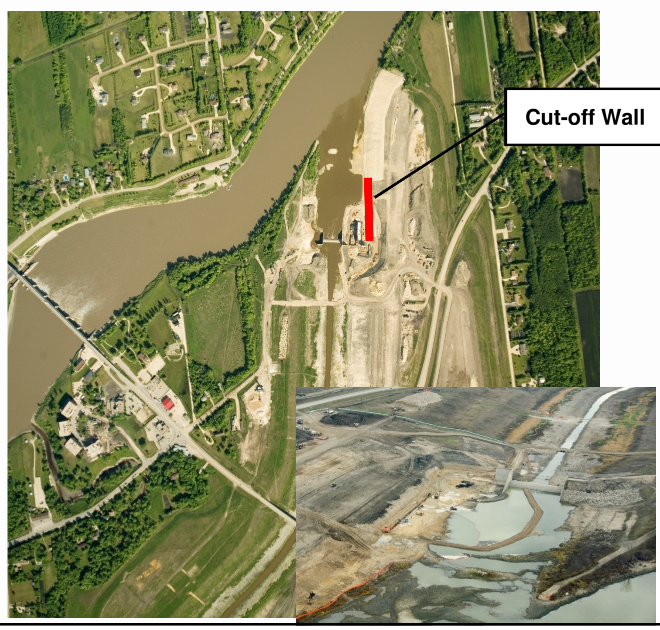
Jacques Whitford

How Did the Wells Compare in East St. Paul?

- Using select parameter for 16 wells in the area,
  - nitrate and conductance showed similar overall trends
  - At approx 200m from centerline, flood and non-flood groundwater chemistry were similar
  - 300m zone of influence would apply to this area as well.

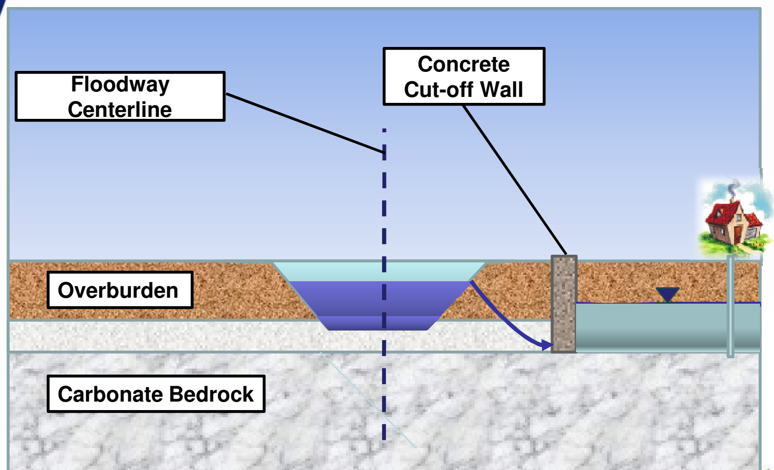
Jacques Whitford

Lockport Outlet Cutoff Wall



Jacques Whitford

Outlet Cutoff Wall



Conclusions

- The most sensitive groundwater area is between Birds Hill to Lockport.
- By comparing surface water to groundwater data we confirmed there is a zone of influence in till overburden which extends up to 300 m out from the Floodway centerline.

Conclusions

- In an expanded Floodway, where excavations are expected to extend up to 100 m beyond the existing Floodway limits, the zone of influence can be expected to extend proportionally in a lateral direction.
- The zone of influence falls within the Floodway right-of-way, which has well development restrictions.

Jacques Whitford

Conclusions

- Surface water effects bedrock groundwater in a limited way.
- In the 4 years of sampling, only one well in Lockport showed consistent and multiple nitrate exceedences. But these were not coincident with Floodway operations; consequently, we expect there are other issues effecting this well.

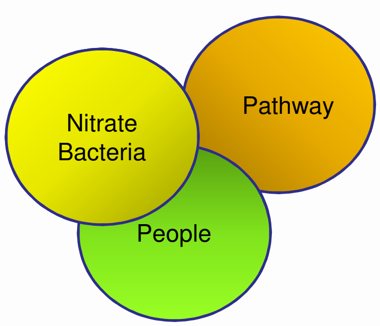
Jacques Whitford

Conclusions

- Although the data did not show an influence on groundwater near large-scale production wells, MFA have installed cut-off walls as a precautionary measure, which we support.
- Data did not show a major influence in domestic wells at Lockport, but MFA have installed cut-off walls there as a precautionary measure, which we support.

Jacques Whitford

What Is the Human Health Risk?



Based on the results of the human health risk assessment, no unacceptable risk has been identified to domestic water supply wells within the identified Floodway zone of influence.

Jacques Whitford

Recommendations

Develop a post-construction monitoring plan:

- Include existing monitoring and domestic wells in zone of influence (of the widened Floodway).
- Include existing wells where health based parameters (bacteria and nitrates) have been identified previously.
- Some well improvements may be required in some individual cases.
- Install sentinel wells in the Floodway Right-of-Way in areas with wells at higher risk.
- Re-assess the frequency of groundwater sampling (possibly increasing after Floodway operation)
- Monitor for at least two years after construction, and include at least two flood events.

Recommendations

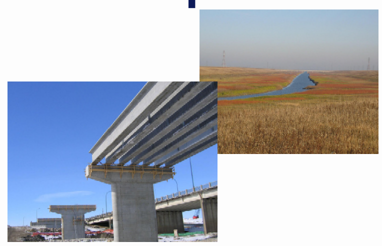
- Review plan after two Floodway operation events to determine future monitoring needs.
- Investigate individual wells which have historically exceeded health based criteria throughout the past monitoring periods.

Discussion

- If you have more thoughts, contact me Michael Charles, P.Eng. CEA
- Email: michael.charles@jacqueswhitford.com
- Phone: (902) 468-0428
- Comments will be received for the next 2 weeks

Jacques Whitford

Public Information Session 1
Human Health Risk Assessment
Groundwater Aquifer



Lockport, Gaffers Restaurant

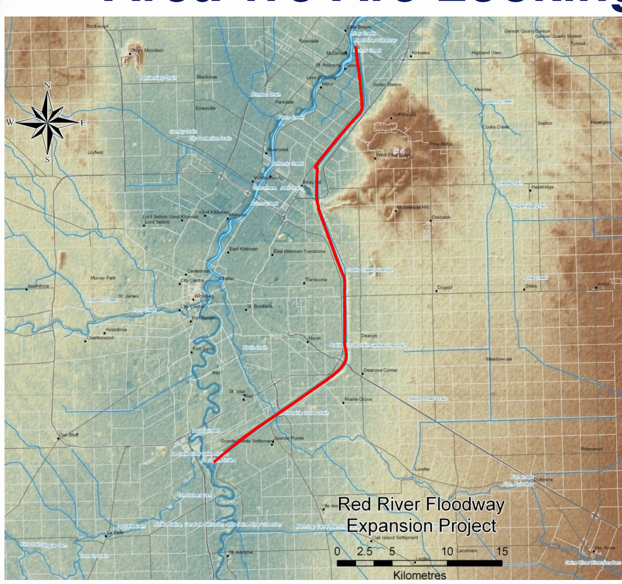
Overview

- Our Mandate
- Who is our HRA team
- Human Health Risk Assessments, an overview
- Why are we here today?
- How will we be doing this work, overview of our process?
- How HHR will be used on this project
- How we intend to use your feedback.
- Project Timelines
- Discussion with you

Our Mandate

We are here to give an independent opinion of potential human health risk from groundwater that could be caused from operation of the expanded Red River Floodway.

Area We Are Looking At



Our Risk Assessment Team

<u>Project Manager</u>

- Michael Charles, P.Eng,

<u>Technical Specialists</u>

- Dwayne Hogg, P.Eng, Sr. Modeling expert
- David MacFarlane, P.Geo, Sr Hydrogeologist
- Rebekah Ferguson, P.Eng, hydrogeologist/model specialist

<u>Supporting Specialists</u>

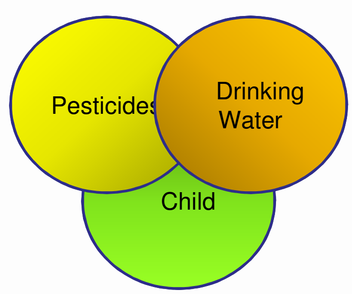
- Dr. Chris Olsen, Corporate Risk Director
- Dr. Kerry MacQuarrie, Surface/Groundwater expert

Jacques Whitford

Human Health Risk Assessments

- What is "Risk Assessment"

Issues Identification → Risk Assessment → Risk Characterization



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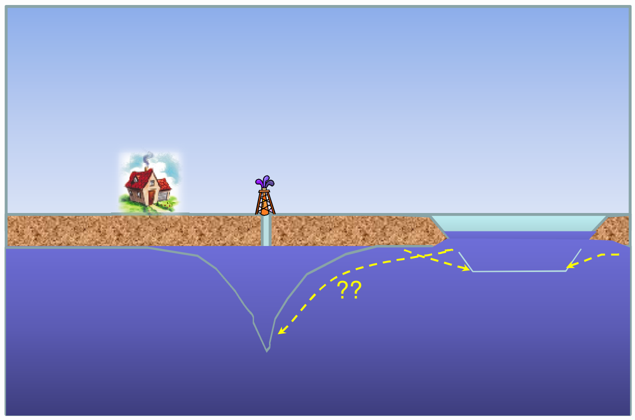
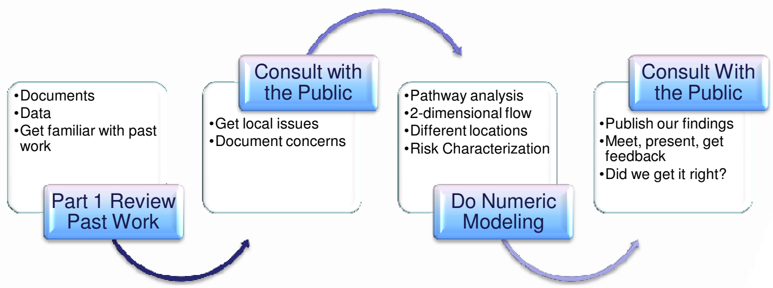
Groundwater Flow



Why Are We Here Today?

1. We want to explain exactly what we are doing and why
2. We want to hear first hand what you see are key issues.
3. Explain how this information will be used in our work.
4. Help us understand your perspectives and recognize them as we move through the work.

An Overview of Our process



An Overview of Our process

- Part 1 Review of Past Work
  - Reviewed documents
  - Examined the model work to date
  - We have begun to identify gaps that should be looked at more closely
  - We're developing a list of sensitive areas/issues of concern
- Part 2 Consult with the Public
  - Get a clear understanding of your concerns and issues
  - Clearly identify public issues
  - Bring these issues forward as we do our assessment work

An Overview of Our process

- Part 3 Do Numeric 2-D Modeling
  - Evaluate at least 3 key locations of concern
  - Conduct 2-D “transient state” groundwater modeling
  - Use flow tracking to assess surface water/groundwater movement
  - Characterize the risk: state whether we feel there is a human health risk.
- Part 4 Consult with the Public
  - Post a draft of our study findings
  - Explain our findings at another session like this.

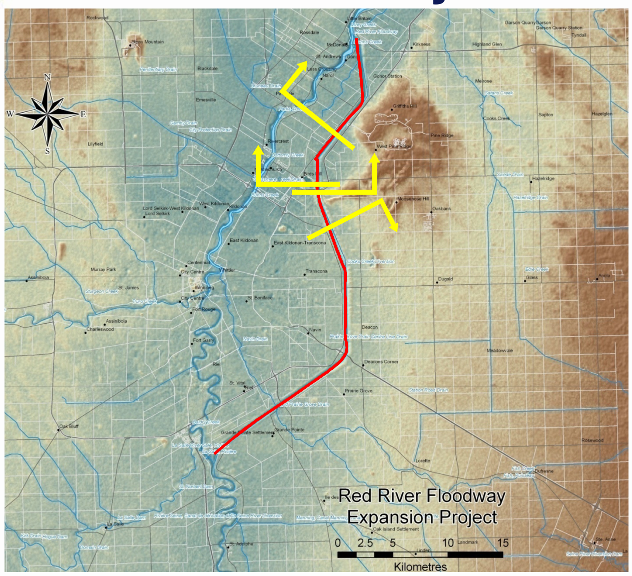
Jacques Whitford

How We Are locating Places to Model

- Groundwater quality changes
- Physically sensitive areas
  - Geologically sensitive (bedrock, sands, etc)
  - High groundwater demand areas
  - High density well clusters
- How close wells are to the Floodway
- Public input/concerns

Jacques Whitford

Areas Initially Modelled



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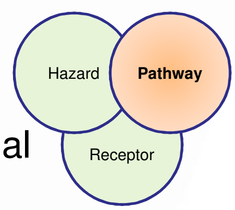
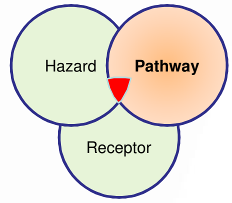
How will RA be used on this project



- We will evaluate if there are potential "pathways" to local wells;
- We are not going to develop potable water objectives, only use nationally published values
- Use the outcomes to determine if closer study is warranted, or additional risk management tools are needed

Jacques Whitford

What Will the Risk Characterization Be



- Qualitative risk statement
  - Low
  - Medium
  - High
- Specific to the potential groundwater quality effects in the study areas

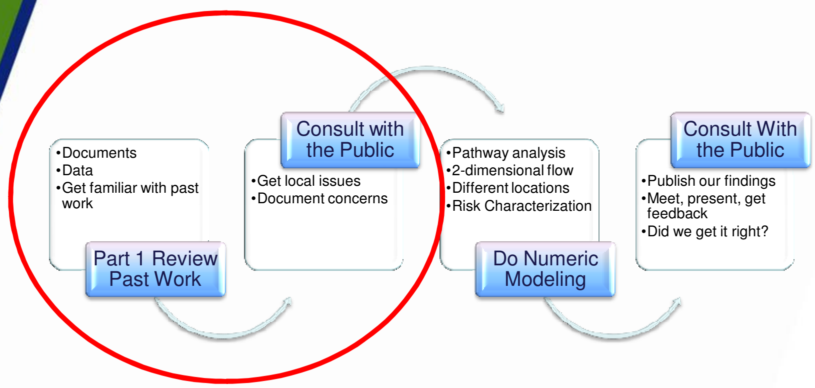
Jacques Whitford

How we will use your feedback in our work

- Document your concerns today for our assessment work.
- All key issues you raise will be addressed in our report.
- Finalize model point locations
- Amend the risk assessment plan if needed to ensure your concerns were appropriately considered and reflected

Jacques Whitford

Where We Are Now



Project Timelines

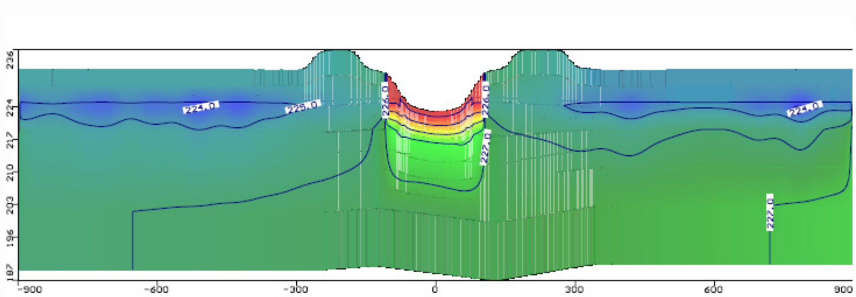
Document Review: Ongoing
Public Session 1: Today
Modeling: In 2 weeks
Risk Statement: Late September
Draft Report: November
Public Session 2: Late November/early December
Final report: After Session 2

Next Steps

- Part 1 Review Past Work
- Consult with the Public
- Do Numeric Modeling
- Consult With the Public

Jacques Whitford

Numeric Modeling Simulating Groundwater Flow



Jacques Whitford

Lets Talk

- If you have more thoughts, contact me Michael Charles, P.Eng. CEA
- Email: michael.charles@jacqueswhitford.com
- Phone: (902) 468-0428
- Comments will be received for the next 2 weeks

Jacques Whitford

Attachment B

Summary of Public Issues, Questions and Concerns

Summary of Public Issues Questions and Concerns
Manitoba Floodway Expansion Project - Human Health Risk Assessment

Questions	Summary	Comments	How this issue was addressed
1	Do we know accurately where the 'blow-outs' are?	KGS have documented the location of approximately 20 sites. The coordinates for these will be sent to Jacques Whitford for mapping and used in the selection of potential model locations.	Directly considered
2	Once the impacted floodway water gets into the aquifer, how long does it take to get back and how far is this water pushed into the aquifer?	This is the purpose of this study, to determine the potential pathway between wells and the floodway operation.	Directly considered
3	Has there been any work (modeling) done at the Lockport area is. In the wedge between the channel and river?	No. This area is under review as a potential candidate for groundwater modeling under this work scope.	Directly considered
4	Have we reviewed other submissions for the 3 RMs? There is a public concern that the previous modeling had used some wrong base assumptions	We have reviewed sumbissions made during the previous consultation work and have formed opinions about the relevance and technical merits of each. These documents are being used to assist idnetify constraints/potential study areas/issues for this scope of work.	Directly considered
5	In Springfield, there is a public perception that the existing blow-outs have lowered the water levels; will the expansion not create more blow-outs and lower the water table more?	This issue has been identified in our review of historic data and is now being considered in the modelling work as a possible issue to assess.	Indirectly considered
6	Have any wells been impacted with ecoli from the floodway already?	Historic impacts of contaminants in monitor wells adjacent to the Floodway are being assessed to determine if certain locations may be "sensitive" and modeling may be warranted.	Indirectly considered
7	Will the construction phase affect wells along Henderson Road to the north along the river?	We will review the location of this road and comment on this after modeling work is complete.	Indirectly considered
8	Is untreated water being used to construct the barrier during the construction phase? (unsure what construction was meant?)	Construction works are not within the scope of this study. We are looking at long-term operational aspects and their potential for human health risk through the groundwater pathway.	Not addressed, out of scope
9	What has happened to water wells from the existing floodway?	This is beyond the scope of our study	Not addressed, out of scope
10	There are 2 wells presently servicing some condos located near the floodway in Lockport now; if more condos go in will it not pull the water further back?	If there are wells in close proximity to the Floodway they will be considered under this study to determine if they are in a sensitive area and should be modeled. Lockport is an area currently being reviewed, and this localized area will be included for consideration. We will not be looking at the long-term urban development capacity/restrictions of this area due to groundwater constraints.	Not addressed, out of scope
11	Could JWs mandate by expanded to include the existing floodway conditions and not just the expanded floodway *conditions?*	The project scope is to assess whether or not there is a human health risk associated with the expansion and *ongoing operation of the floodway in the future. Past impacts will not be* evaluated through modeling, although any historic testing or data will be reviewed to help identify potential areas that should be modelled in this scope of work.	Not addressed, out of scope
12	Will we be commenting on the quality of the chemistry in the channel now or the quality of the surface water drops that gets into the aquifer now?	We will not be commenting on suitability of surface water in the Floodway and its suitability under existing conditions. We will be modeling the potential for contaminants to move from Floodway water to groundwater/wells. We will not be commenting or assessing the suitability of surface water chemistry from either the channel or surface water runnoff at this stage of the study.	Not addressed, out of scope
13	Could the blow-outs have been plugged?	This is beyond the scope of our study	Not addressed, out of scope
Statements			
1	Some of the assumptions used int the regional model were faulty – i.e. conductivity or transmissivity at the Kildare Falls	We will review this during our document review process. If we feel the assumptions are wrong, and have a significant effect on past conclusions, we may recommend adjusting our model efforts to look at effects/sensitivity of select hydrogeologic parameters.	Directly considered
2	During the removal of the expansion lip in the Springfield area a well has been experiencing high turbidity over the last year. This is a bedrock well that is about 50ft away	We understand one well has had seen chemistry changes. This will be considered in laying out our next work (modeling).	Directly considered

Summary of Public Issues Questions and Concerns

Manitoba Floodway Expansion Project - Human Health Risk Assessment

Questions	**Summary**	**Comments**	**How this issue was addressed**
1	Why is there an increase in conductance on the west side of the Floodway. This appears to be a Floodway influence, since conductance on the east side of the Floodway is lower?	This effect is likely not a Floodway influence since conductance in the Floodway waters is typically lower, particularly during operation, in conductance than that of the surrounding groundwater. However, looking at the overall medians may bias the results, and as a result, Jacques Whitford will assess the sensitive areas separately to ensure the medians are not biased.	Directly considered
2	Why is there only a cutoff wall installed on the east side of the Floodway, and no cutoff wall installed on the west side of the Floodway at the Outlet structure?	This is beyond the scope of our study.	Not addressed, out of scope
3	Was turbidity a parameter that was assessed in the HHRA? Respondent indicated that his well is within 75 m of the Floodway ROW, and he has noticed an increase in turbidity in the spring when the Floodway is operating, and a gradual decrease throughout the balance of the year. Respondent also indicated that the area of the well is sloped away from the well head, to ensure that no surface water intrusion would occur around the well head.	Turbidity was considered, but the distribution for domestic wells was very random with no apparent correlation between operation and non-operation periods. The assessment of the data confirmed that domestic wells in close proximity to the Floodway may be influenced (i.e. zone of influence appears to be approximately 300 m out from centerline). Thus, this well may be confirming the outcomes of the data assessment.	Directly considered
4	Did we look at the previous consultants reports, and consider these in the HHRA. Particularly, the independent consultant reports done for the RMs.	Yes, the independent consultants reports were reviewed.	Directly considered
5	Did we consider the 1997 flood in our work? How did we really know what the impact of a large-scale flood would be in the expanded Floodway, if our data only went back to 2004? No significant floods have occurred in the period assessed.	Jacques Whitford intended on addressing it in the modeling component; however, we could not achieve calibration of the models and were not able to move forward with the modeling. Data assessed was over the period of 4 years, commencing in 2004. Managed under risk uncertainties and recommendations for monitoring of the HHRA report.	Could not be considered
6	Is the Interim Report that we completed available to the public?	No.	Not addressed, out of scope
7	Have the outfalls been assessed, as they contribute significantly to poor water quality within the Floodway?	Yes, the surface water chemistry results reviewed include the effect of the outfalls on overall water quality within the Floodway.	Directly considered
8	Well at a nearby church has rusty colored water. What would cause this?	This is beyond the scope of our study, as further discussion with the respondent suggested that the problem was likely associated with the age and construction of the well.	Not addressed, out of scope
9	Did we consider wells along Hay Road in subdivision? Quality issues with some wells.	Did not consider them separately.	Indirectly considered with other data
10	What about the agricultural use well, located north of Highway 59? *The water cannot be consumed.*	This well was never licensed as a potable well, as it was intended only as a source of water for irrigation and other agricultural uses. The water quality has not been tested.	Not addressed, out of scope
Statements			
1	Page 11 of the HHRA report posted on the MFA website, appendix is referenced; however, the appendix is missing.	Jacques Whitford will review and correct the error.	Directly considered
2	HHRA report posted on the MFA website indicates that 700 wells were assessed. This is not correct, the number is much lower and it should be corrected.	Jacques Whitford will review, correct and add clarity to the number of wells actually assessed as part of the HHRA report.	Directly considered
3	When installing the pumping station at the Kildare Outfall, 7 feet or more drawdown occurred in wells a significant distance from the Floodway, for 13 m of drawdown at the Kildare Outfall. Respondent has a hard time believing that there will be no impact (to chemistry) if the water levels are affected so significantly.	The Floodway itself is known to be depressing the aquifer over the long term as its base is lower than the nearby groundwater table. Long-term pumping, such as that done during construction can be expected to have a large area of influence. The floodway is only operated for a few weeks of the year.	Directly considered
4	Respondent disagrees with our report, and indicated that more extensive monitoring should be conducted (more overall monitoring in more areas).	Jacques Whitford has recommended ongoing monitoring in the HHRA report.	Directly considered

Attachment C

List of Attendees, Lockport Session Round 1

Name	Contact Information
Bonni Book	453 9122
Tom and Marian Moir	meanl@mts.net
Marjorie Squibb	
Lorne Vaags	782-7869
Bob Backarak	224 3147
Mell Belluk	2225389
Jim Stinson	

FLOODWAY HEALTH RISK ASSESSMENT
PUBLIC OPEN HOUSE

Tuesday, July 22, 2008
Dugald, Manitoba

Sign-In Sheet

NAME	ADDRESS	TELEPHONE NUMBER
1. Mandy Walder	209 Tu-Pelo	669-8401
2. SHAWN TOSH	27055 OAKWOOD ROAD RM OF SPRINGFIELD - PUBLIC WORKS	444-2241
3.		
4.		
5.		
6.		
7.		
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11.		
12.		

FLOODWAY HEALTH RISK ASSESSMENT
PUBLIC OPEN HOUSE

Wednesday, July 23, 2008
East St. Paul, Manitoba

Sign-In Sheet

NAME	ADDRESS	TELEPHONE NUMBER
1. RANDY SARNA	55 SILVERFOX PL.	667-2253.
2. VAN Whitehead	31 SILVERFOX Pl.	669.4918
3. Chuck Henry	160 Spatuck Rd	668-8032
4. DOREEN LOZINSKI	366 PRITCHARD FARM	663-8182
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FLOODWAY HEALTH RISK ASSESSMENT
PUBLIC OPEN HOUSE

Thursday, July 24, 2008
Lockport, Manitoba

Sign-In Sheet

NAME	ADDRESS	TELEPHONE NUMBER
1. RAY FREY	4859 Henderson	663 3042
2. JERRY Oprobot	10 Pine St	22222765
3. John Basarab	4587 Rebeck Rd	661-1175
4. Bob Bodnaruk	2935 McGregor Farm Rd Springfield Mb	224-3147
5. PAUL CHANAS	EAST SELKIRK	482-5769
6. P. BAIAN	GONOR	757-2751
7. JIM STINSON	Lockport	757-4682
8.		
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E-mail Correspondence

Thank you Mr Whitford for your presentation on the 26th July 2007 at Lockport Manitoba concerning your assessment process into the health risks to residents due to the floodway. As a resident of the RM of St Clements and the Emergency Coordinator for the Municipality I am very interested in sustaining the quality of our most valuable resource: DRINKING WATER.

As indicted on the 26th I have numerous areas of concern and will attempt to briefly indicate them but will include my home phone number if you wish further explanation.

CONCERNS:

- The word "expanded" in your mandate as I believe the entire floodway should be included.
- Breaches in the low flow channel and the side wall of the floodway have the potential to be a pathway for surface water to enter the aquifer.
- The number, the exact location and size of these breaches must be identified.
- The possibility of 'sealing' or closing any or all of these breaches must be explored.
- The quality of the water in the low flow channel.
- The quality of any water that flows into the floodway from drains etc. must be checked to reduce any possibility of any contaminates ever entering the aquifer.
- It appears as only wells within ½ mile of the floodway right-of-way were included in the test zone.
- Only 541 locations were identified along the entire 27 kms. of the floodway.
- There is no indication in the annual report or any of the monitoring reports about the quality of water used to create a hydraulic barrier. See Se. 24 of the licence.
- What input has the Peer Review had to ensure the safety of the quality of water in the aquifer.
- The low flow channel at the Outlet is being expanded and it is in this area that there were previous breaches in the aquifer. Has the potential for further breaches been explored in this area.
- What is the size of the two aquifers that drain into the floodway?

My home phone number is 204-757-4682

Jim Stinson