Southeast Regional Groundwater Management Plan

April 2010

April 30, 2010

Honourable Christine Melnick
Minister, Manitoba Water Stewardship

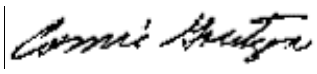
Dear Minister Melnick:

As a life-long resident of the Steinbach area, water has always been a big part of my life, and I have always known it in abundance. In southeastern Manitoba, groundwater is the primary source of drinking water and is our most essential natural resource. The opportunity of participating in the development of the Southeast Regional Groundwater Management Plan has, more so than ever before, made me realize how important our groundwater, and groundwater management, is to the entire region. We are the stewards of this resource and we all have a role to play in protecting it and ensuring that it will be as fresh and abundant for our children, as it was for me and generations past.

Over the past two and a half years, comprised of 16 full-day meetings, two field tours, and seven public Open Houses, the Planning Group was exposed to an immense amount of groundwater related information, and held numerous discussions on a wide range of regional groundwater issues and concerns. The planning process was a tremendous learning opportunity for everyone involved, and as a result, the planning group came to understand that although there are Provincial groundwater management scientists, and environmental legislation is in place, every southeastern Manitoba resident still has an important groundwater stewardship role to play, and there is still a lot of work to do regarding groundwater education and awareness, enforcement of existing environmental legislation, and enhancing our knowledge of our valuable groundwater resources through sustained monitoring programs, further research, and advances in computer technology.

On behalf of the planning group, I would like to thank you and your staff at Manitoba Water Stewardship for the assistance with this initiative, and look forward to your continued support and leadership with plan implementation.

Yours truly,



Cornie Goertzen
Planning Group Chairperson
Southeast Regional Groundwater Management Plan

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1.0 Introduction

In December 2007, Manitoba Water Stewardship invited 73 agencies having a potential interest in the management of the groundwater resources of a portion of southeastern Manitoba to attend preliminary informational meetings. The purpose of these meetings was to present a proposal for the development of a stakeholder-driven groundwater management plan for the area shown on Figure 1 and to solicit interest in participation in this process. The presentations at the meetings relayed the following information:

- Groundwater in southeast Manitoba comprises a large inter-connected flow regime.
- Development pressure on the regime, particularly the east side of the capital region, has grown to the point where a long-term groundwater management plan was desired to guide future resource management and development.
- Participation in the planning process would be solicited from a spectrum of stakeholder agencies representing municipalities, conservation districts, first nations, environmental groups, and the provincial and federal government.
- The process was to be led by the local stakeholder agencies and was expected to take two to three years.
- The outline for the proposed planning process document was for review and edit at the first planning group meeting.
- Manitoba Water Stewardship – Basin and Aquifer Planning Section would provide co-ordination and secretariat support to the group, and would cover the costs of holding meetings and logistics.

The meetings were held in Steinbach on December 4 and East St. Paul on December 5. Twenty-four people attended the Steinbach meeting and 39 attended the meeting in East St. Paul. On December 6, a third meeting was held in Winnipeg with representatives from ten provincial and federal agencies and the University of Manitoba. The focus of this meeting was somewhat different in that it was hoped that these agencies could provide science input to the process.

Most participants in the meetings agreed that development of a groundwater management plan for the proposed area would be a valuable exercise. They also agreed, in general, to the process being proposed: leadership by local stakeholders with co-ordination and support provided by Manitoba Water Stewardship. It was anticipated that it would take two to three years for this process to complete the development of a plan. It would then be submitted to the Minister of Water Stewardship for approval. The first meeting of the planning group was held on January 21, 2008.

1.1 Purpose and Components of a Plan

Aquifer (groundwater) management plans have been developed in many jurisdictions in North America. Many of these plans have been developed to respond to specific local or regional issues such as declining groundwater levels or concerns about overdevelopment of local aquifers. In other areas, plans have been developed to meet general planning objectives of resource definition followed by a decision-making process

for sustainable development, allocation or use of the resource. A common element is local involvement in plan development and implementation.

Three aquifer management plans were developed in Manitoba between 1997 and 2005, for the Winkler, Oak Lake and Assiniboine Delta aquifers. These plans included local stakeholder involvement and were meant to address issues of water supply development, protection and allocation. There were concerns about groundwater quality in the Oak Lake and Assiniboine Delta aquifers since these are shallow sand bodies that are susceptible to contamination. Similarly, for the Winkler aquifer, there were concerns that overdevelopment may lead to salt water intrusion. Groundwater withdrawals from the Winkler aquifer were thought to exceed rates of recharge. Similarly, the sustainable development capacity of the Assiniboine Delta aquifer was a concern, particularly with respect to the amount of water available for irrigation.

In the SRGMP study area, there are similar concerns, although perhaps not so immediate. Groundwater withdrawal from a number of aquifers has increased substantially over the past several decades and there is concern that we may gradually be approaching our sustainable development capacity for these aquifers. A recent groundwater development proposal met with considerable opposition. Following a review by the Clean Environment Commission, they recommended that it not proceed without management plans being in place. There is little understanding at present about groundwater/surface water interaction, which is a concern for many people. Finally, many residents in the area are concerned about the quality of their water and that water quality may deteriorate over time if development is not undertaken in a sustainable fashion. This is particularly the case for those relying on groundwater near fresh water/saline water boundaries.

Given these concerns and uncertainties, development of a groundwater management plan for the area is a first step to address local issues.

1.2 Planning Process

At the first planning group meeting, the group elected a chairperson and vice-chairperson, agreed that the meetings would be rotated between Steinbach, Beausejour and Oakbank, and agreed to a planning process that included the following three steps:

1) Collect and study the area's groundwater information (science and local information)
2) Itemize and prioritize the groundwater issues (including public input)
3) Formulate a groundwater management plan (public to review a draft)

It was also understood that the plan would be approved by the planning group followed by submission to the Minister of Water Stewardship.

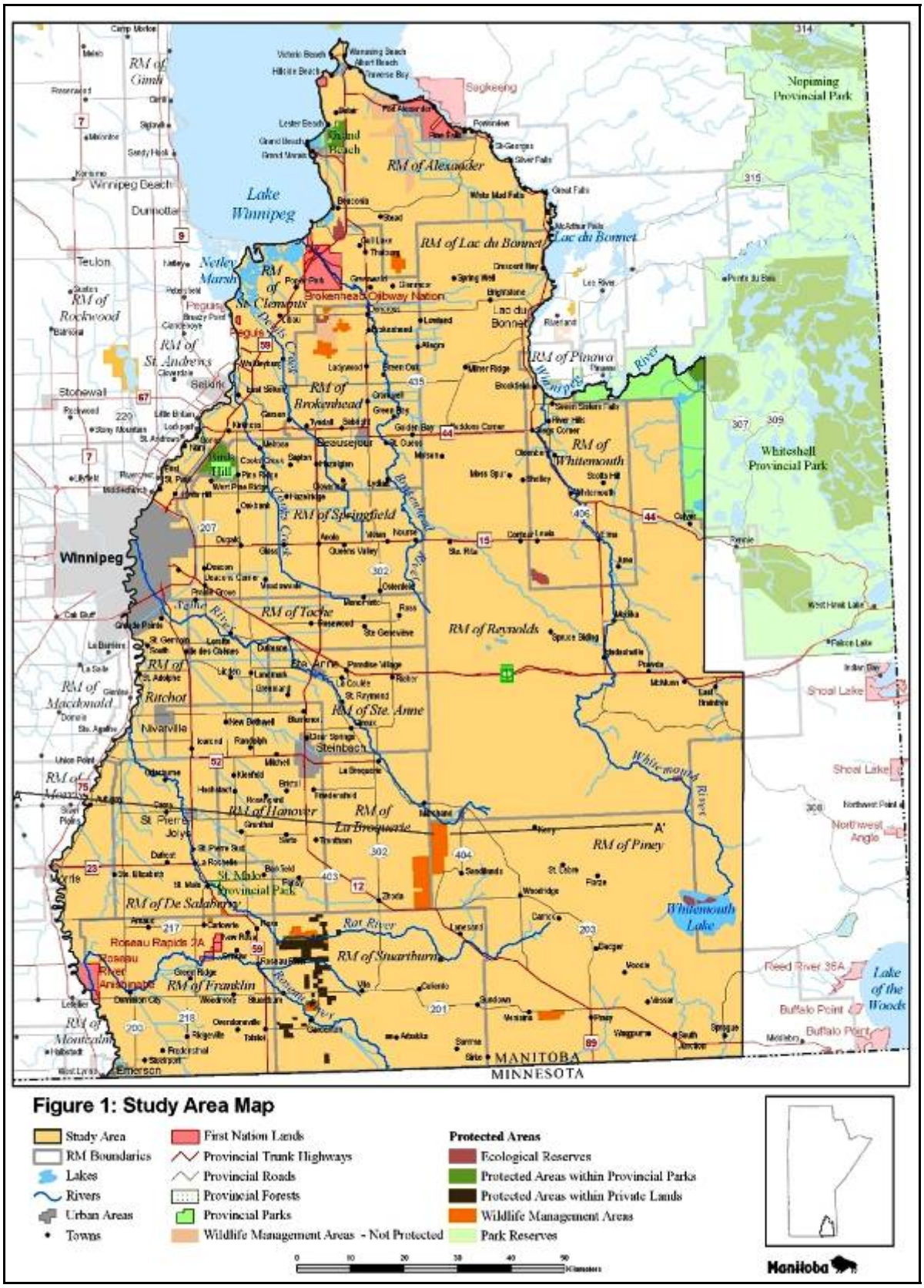


Figure 1: Study Area Map

- Study Area
- RM Boundaries
- Lakes
- Rivers
- Urban Areas
- Towns
- First Nation Lands
- Provincial Trunk Highways
- Provincial Roads
- Provincial Forests
- Provincial Parks
- Wildlife Management Areas - Not Protected

Protected Areas

- Ecological Reserves
- Protected Areas within Provincial Parks
- Protected Areas within Private Lands
- Wildlife Management Areas
- Park Reserves

0 10 20 30 40 50 Kilometers

Manitoba

1.3 Planning Group

The planning group for the SRGMP was comprised of 54 organizations as listed below.

Agriculture and Agri-Food Canada	Pansy Groundwater Committee
Canadian Gold Beverages	Pembina Valley Water Cooperative
City of Steinbach	Red River Basin Commission
Concerned Citizens of the RM of Piney and Buffalo Point	RM of Alexander
Cooks Creek Conservation District	RM of Brokenhead
Dairy Farmers of Manitoba	RM of De Salaberry
Devils Creek Watershed Coalition	RM of East St. Paul
Schaible Industrial Water Bottling	RM of Franklin
Keystone Agricultural Producers	RM of Hanover
Local Government District of Pinawa	RM of La Broquerie
Manitoba Agriculture, Food and Rural Initiatives - Agri-Environment Knowledge Centre	RM of Lac du Bonnet
Manitoba Cattle Producers Association	RM of Morris
Manitoba Conservation, Forestry	RM of Piney
Manitoba Conservation, Parks and Natural Areas	RM of Reynolds
Manitoba Conservation, Regional Operations	RM of Ritchot
Manitoba Conservation, Wildlife and Ecosystem Protection	RM of Springfield
Manitoba Eco-Network	RM of St. Clements
Manitoba Floodway Authority	RM of Ste. Anne
Manitoba Forage Council	RM of Stuartburn
Manitoba Local Government, Community Planning and Development	RM of Taché
Manitoba Métis Federation Inc.	RM of Victoria Beach
Manitoba Pork Council	RM of Whitemouth
Manitoba Innovation, Energy and Mines, Manitoba Geological Survey	Sagkeeng First Nation
Manitoba Water Stewardship, Planning and Co-ordination Branch	Seine-Rat River Conservation District
Manitoba Water Stewardship, Groundwater Management Section	Sky Blue Water Inc
Manitoba Water Stewardship, Water Use Licensing	Town of Beausejour
Manitoba Water Stewardship, Office of Drinking Water	Town of Lac du Bonnet

Appendix 1 includes a list of the other stakeholder organizations that were invited to participate in the planning process.

The planning group held four meetings between January 21, 2008 and April 21, 2008, to hear and discuss science stakeholder presentations on, and relating to, the area's groundwater regime. They also held four advertised public workshops in March 2008 in Oakbank, Steinbach, Beausejour and Ile des Chênes to inform the general public of the planning process and solicit public input on groundwater issues in the study area.

Six meetings were held between October 6, 2008 and March 23, 2009. The meetings included presentations from provincial representatives and stakeholder groups and a workshop on prioritizing groundwater issues. Following these meetings, the group decided it had completed the first two steps of the process and to postpone further meetings until the fall of 2009.

Three meetings were held between October 5, 2009 and December 14, 2009 to prepare the draft Southeast Regional Groundwater Management Plan.

The draft plan was approved by the planning group on December 14, 2009. It was presented to the general public for comments at open houses during the last week of January 2010 at Ile des Chênes, Steinbach and Beausejour.

2.0 Study Area

The study area is over 16,700 square kilometres and includes 22 rural municipalities. It includes the land area east of the Red River to the western edge of Whiteshell Provincial Park and north from the international border to Lake Winnipeg and the Winnipeg River. It is underlain by a common groundwater flow regime that discharges predominantly into the Red River, the Red River Floodway, Winnipeg River and Lake Winnipeg.

The area includes the eastern half of the city of Winnipeg, the city of Steinbach and numerous other towns and villages including the First Nations communities of Brokenhead Ojibway, Roseau River and Sagkeeng, and reserve lands for the Peguis First Nation. Land tenure in the study area is 63 per cent private lands, 29 per cent provincial forest and eight per cent other Crown land.

The total population of the study area, based on 2006 census data, is estimated to be 335,000. The portion of the population living outside the city of Winnipeg is estimated to be 100,000 and is projected to continue growing rapidly. During the period from 2001 to 2006 Manitoba's population grew by 2.6 per cent. Of the eight census regions in the province two lost population and six gained. The southeast region (excludes the city of Winnipeg and extends east beyond the study area to the Ontario border) had the largest population gain at 7.6 per cent. Projections for 2026 estimate Manitoba to grow by 23 per cent. The southeast region's growth is projected to be the second greatest at 32 per cent. Given these population projections demand for additional water supply in this area will be high.

2.1 Landscapes and Land Cover

Figure 2 shows the landscape topography of the study area. It is characterized by level plains in the Red River Valley, trending eastward to higher elevations and upland areas that extend north-south through the central and eastern part of the area. It includes the highest elevation lands of the Sandilands, Birds Hill, Mars Hills and Milner Ridge environments.

Figure 3 show the land cover for the study area. Agricultural and forest covers represent an approximately equal percentage of the study area at around 40 per cent each.

Soil texture classes for the area include clay soils in the Red River Valley region, giving way to sand, loam and organic soils into the eastern parts of the area. The soil classes correlate to regional surficial geology and post glacial landscape features including the Red River Valley clay plain, glacial till plain features and esker, moraine and glacial outwash deposits of sands and gravels.

The agricultural portion of the study area is comprised of intensive mixed cropping in approximately a 20 to 30 kilometre wide band along the Red River then mainly grass and rangeland towards the centre of the study area. Regional areas of mixed crop agriculture also occur in the eastern half of the area mainly around Lac du Bonnet, the Whitemouth River and Piney. Intensive livestock operations, primarily hog production, occur in dense concentrations in the rural municipalities of Hanover, La Broquerie, De

Salaberry and Ste Anne. The majority of lands classified as agricultural are privately owned.

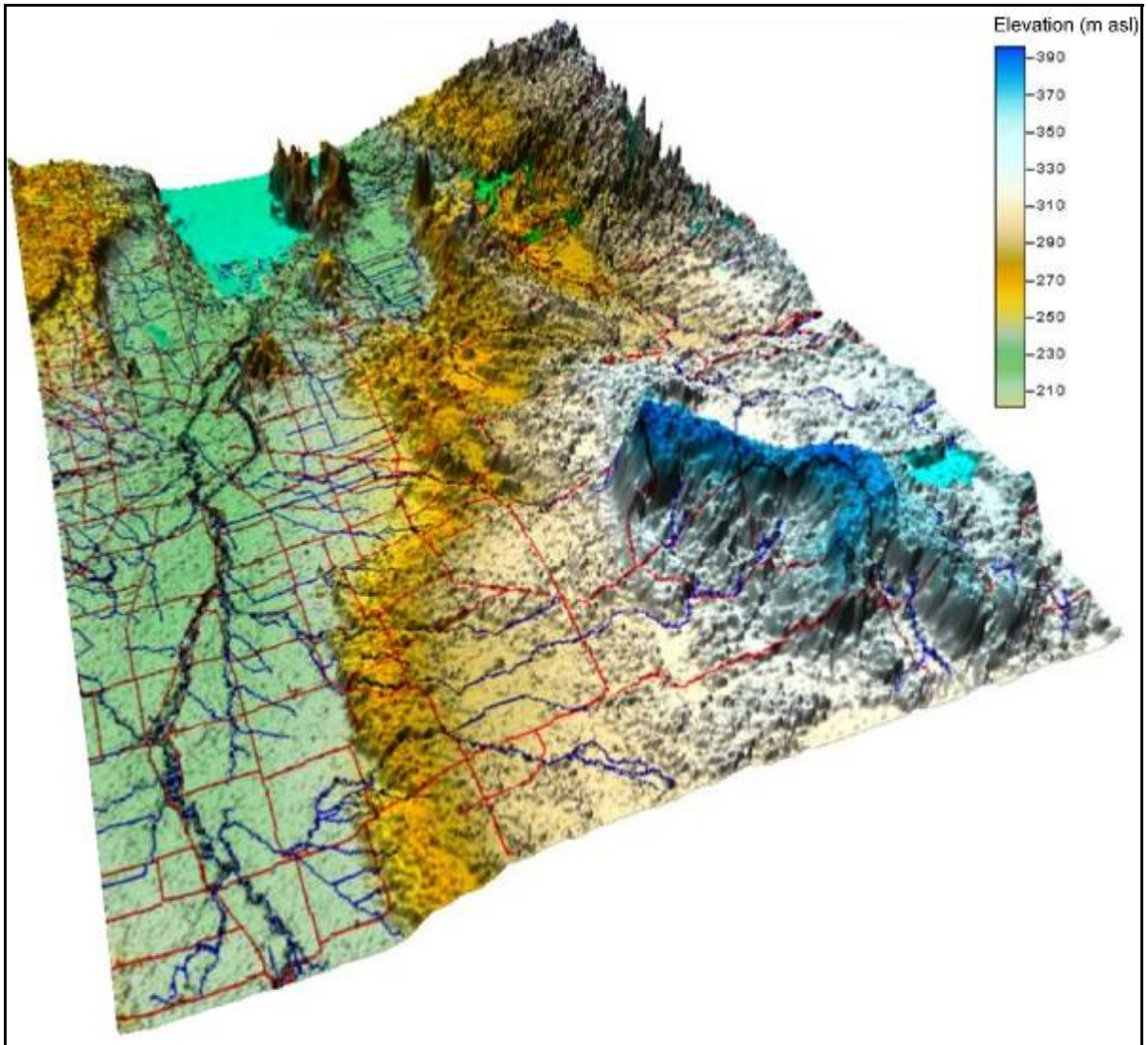


Figure 2 - Study Area Topography

The west half of the study area is mainly privately owned aspen parkland while the east half is mainly Crown owned boreal forest. The composition of the boreal forest portion is 26 per cent jack pine and pine mix, 29 per cent spruce and spruce mix, 13 per cent tamarack and 32 per cent other softwoods and hardwoods. The majority of lands classified as forest are Crown.

The study area comprises portions of three basins and nine watersheds as shown on Figure 4. The watersheds in the study area include the Roseau River, Rat River, Seine River, Upper Red River, Cooks Creek, Brokenhead River, Whitemouth River, Whiteshell River and Winnipeg River.

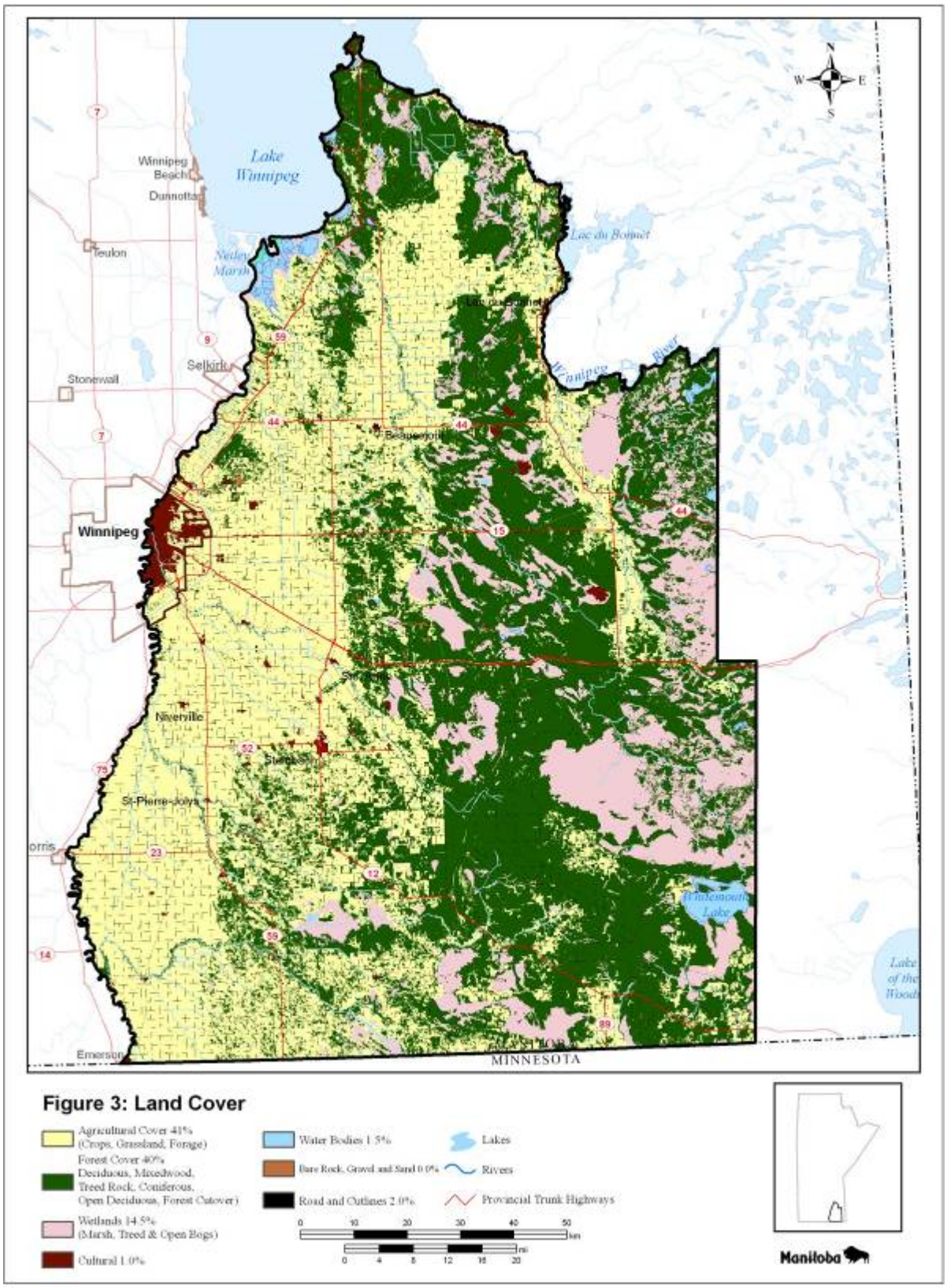


Figure 3: Land Cover

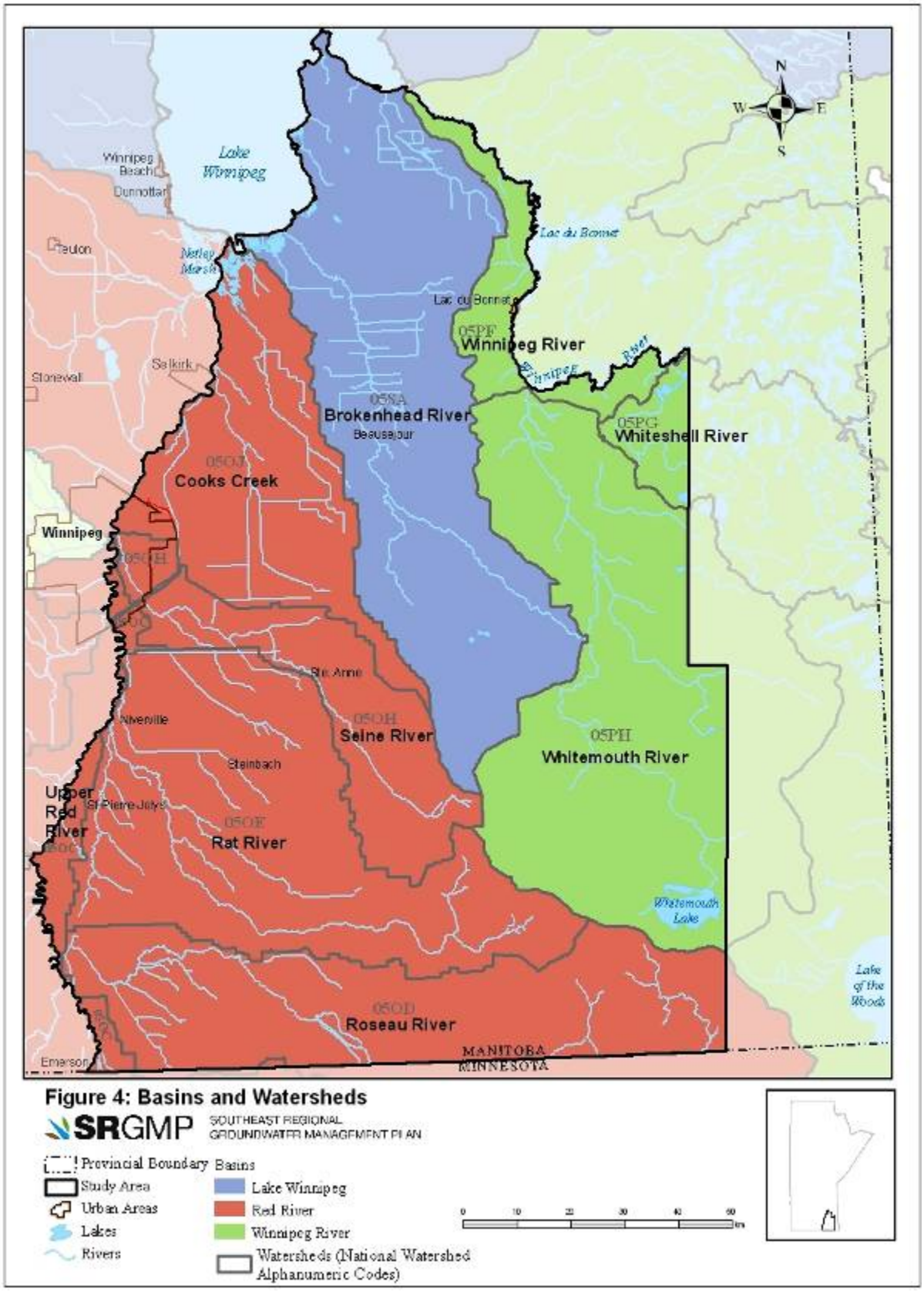


Figure 4: Basins and Watersheds

SRGMP SOUTHEAST REGIONAL GROUNDWATER MANAGEMENT PLAN

3.0 Groundwater Resources

3.1 Introduction

Water is often spoken of as either surface or groundwater. *The Water Protection Act* in Manitoba is more precise. It defines water as “all surface water and groundwater, whether in solid or liquid form”. It also defines groundwater as “all water under the surface of the ground, whether in solid or liquid form”. It defines water body as, “any body of flowing or standing water, whether the flow or presence of water is continuous, intermittent or occurs only during a flood, including but not limited to a lake, creek, stream, slough, marsh, swamp and wetland, including ice on any of them”.

The global water cycle is portrayed in a western Canada landscape in Figure 5. It shows the pathways used by water as it cycles on, and through, the earth and its atmosphere and the connections between surface water and groundwater. The general cycle of events is that when precipitation hits the ground, it either soaks into the ground or runs into a water body. The permeability and saturation of the substrate is a factor in how much water seeps into the ground. Finer substrate like clay does not allow water infiltration as well as more coarse material like sand, gravel or fractured rocks. Groundwater flow may be in any direction and may intersect the surface as it moves through its cycle. Surface water/groundwater interaction is an important part of the water cycle, especially in situations where the groundwater discharge provides a source of water to a biologically diverse wetland or contributes a base flow to a water body.

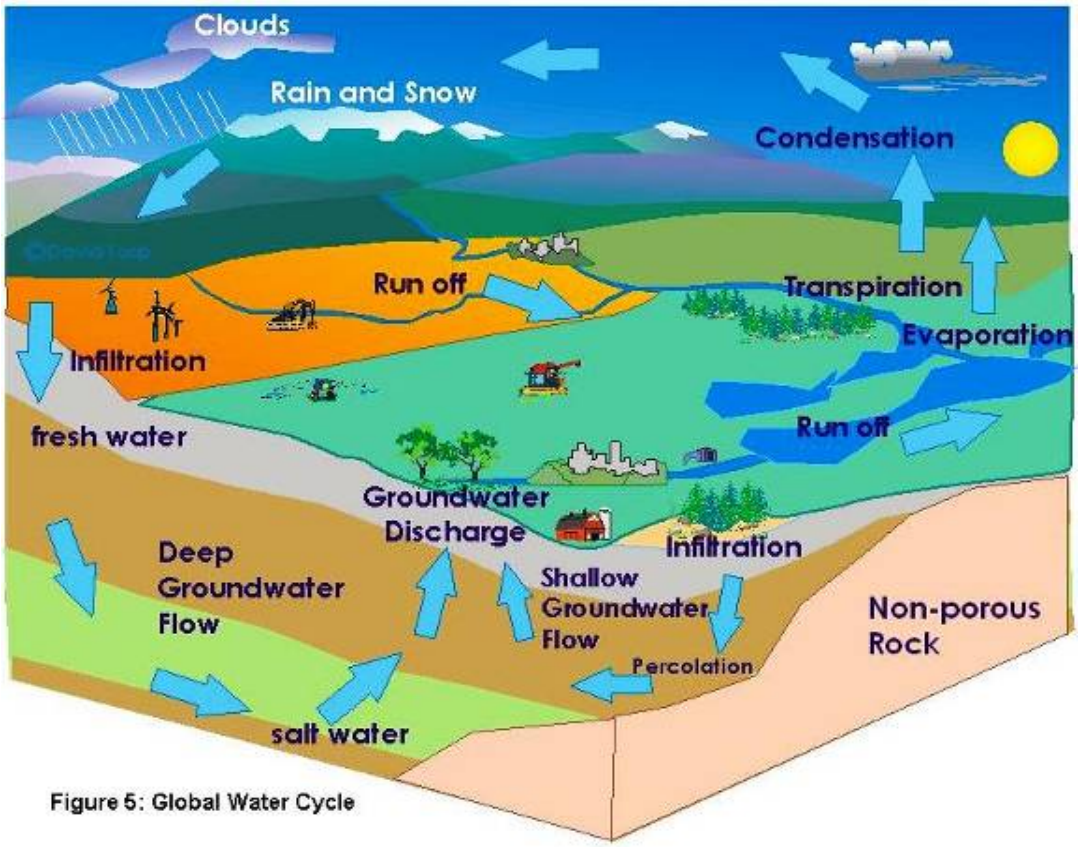


Figure 5: Global Water Cycle

The surface water regime is often better understood than the groundwater regime, likely because it can be observed. Some parallels and a key difference between the movement of surface water and groundwater are of interest. Surface water flows over the landscape driven by the force of gravity from high to low land elevations. Flows are quickly concentrated into open waterways and through water bodies. Flow velocities in the waterway network of the study area range from a low of less than 0.3 metres per second (in summer: low flows) to a high of three metres per second (in spring: very high flows).

Groundwater flows within the landscape by seeping through subsurface materials (pore spaces between soil particles and fractures and bedding planes in rock). This flow is also driven by the force of gravity from high to low groundwater table elevations. Groundwater flow velocities are very slow compared to those of surface water due to the nature of flow resistance. In the study area, groundwater flow velocities range from a low of centimetres per year (in fine clay soils and slightly fractured rocks) to a high of metres or tens of metres per year (in fractured rock and coarse, sandy soils). Highly fractured rock and solution channels in limestone rock are unusual exceptions where velocities would be higher. Other exceptions are great thicknesses of very fine clays or un-fractured rock that prevent the movement of water.

3.2 Geology

The geology of the study area consists of a variable thickness of unconsolidated surficial deposits of clay, silt, sand, sand and gravel, and till overlying bedrock consisting of carbonates, shale and sandstone to the west, and Precambrian crystalline rocks to the east and north. Surficial and bedrock geology maps are shown in Figure 6 and 7.

Surficial Geology

Surficial deposits in the western half of the study area consist of clays deposited in the deep water portion of glacial Lake Agassiz that covered much of the region near the end of the last glacial period. Clay thickness increases from north to south. It ranges in thickness from only a few metres in the area north of Winnipeg near the Red River, to about 30 metres near Emerson. These clays overlay glacial tills containing local sand/gravel lenses that in turn rest on bedrock. Total overburden thickness is shown in Figure 8.

Progressing eastward from the Red River, the thickness of clay diminishes and eventually terminates against a series of glacial uplands and till plains. These uplands (Sandilands, Milner Ridge, Belair moraine, Mars sand hills) and till plains were formed as a result of glacial processes during which large volumes of material were transported by the glaciers or rivers associated with the glaciers and re-deposited. These areas have a complex geology but generally consist of glacial till containing local sand and gravel deposits. Sand, or sand and gravel deposits are also found along the western flanks of some of the uplands, representing beach sediments formed along the edges of Lake Agassiz during stable lake level periods. Glacial tills are recognized from at least two major glacial advances. The Birds Hill deposit and several additional sand, gravel and till features lying to the south of Birds Hill are somewhat unique in that they lie entirely within the clay plain.

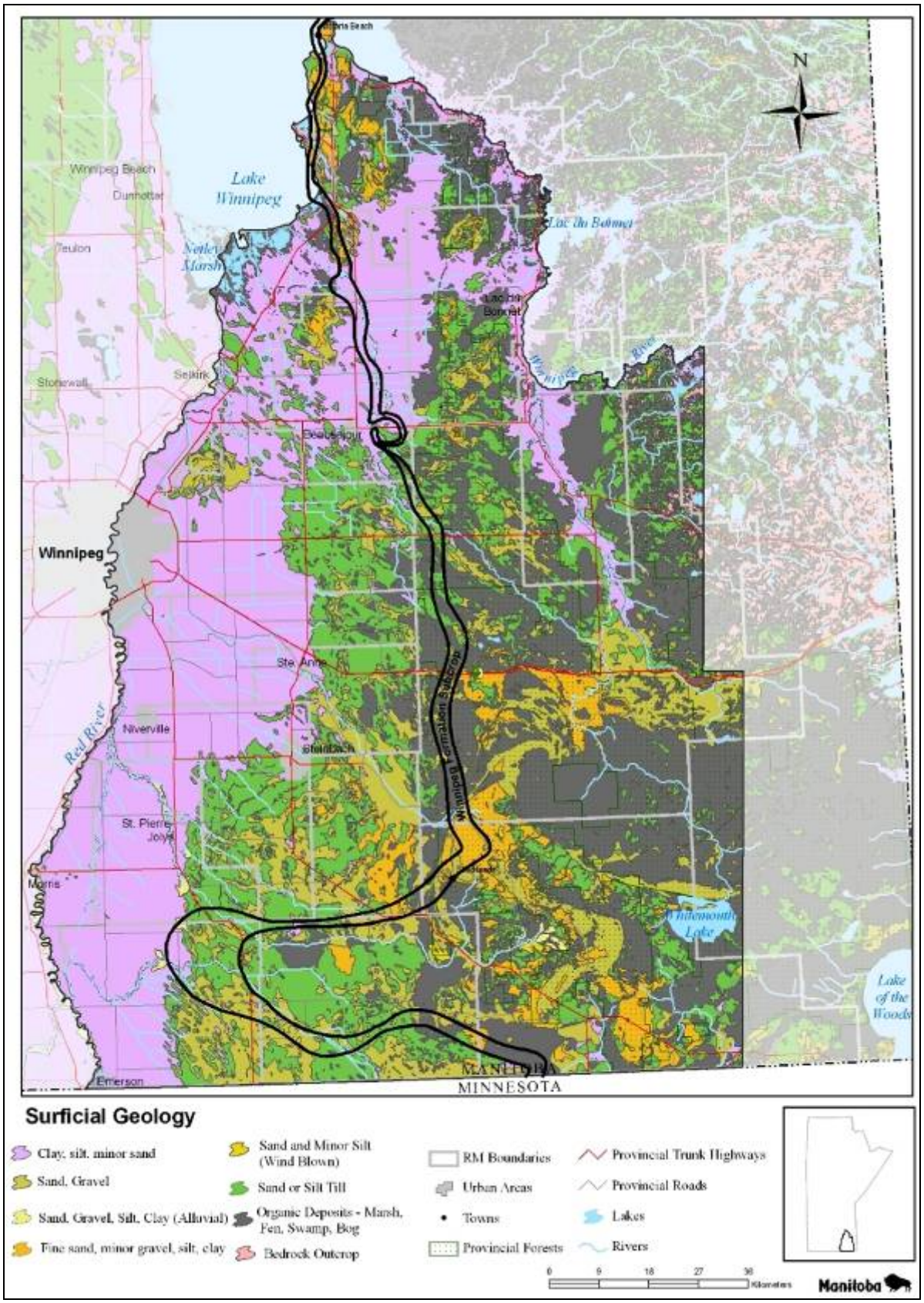


Figure 6: Surficial Geology

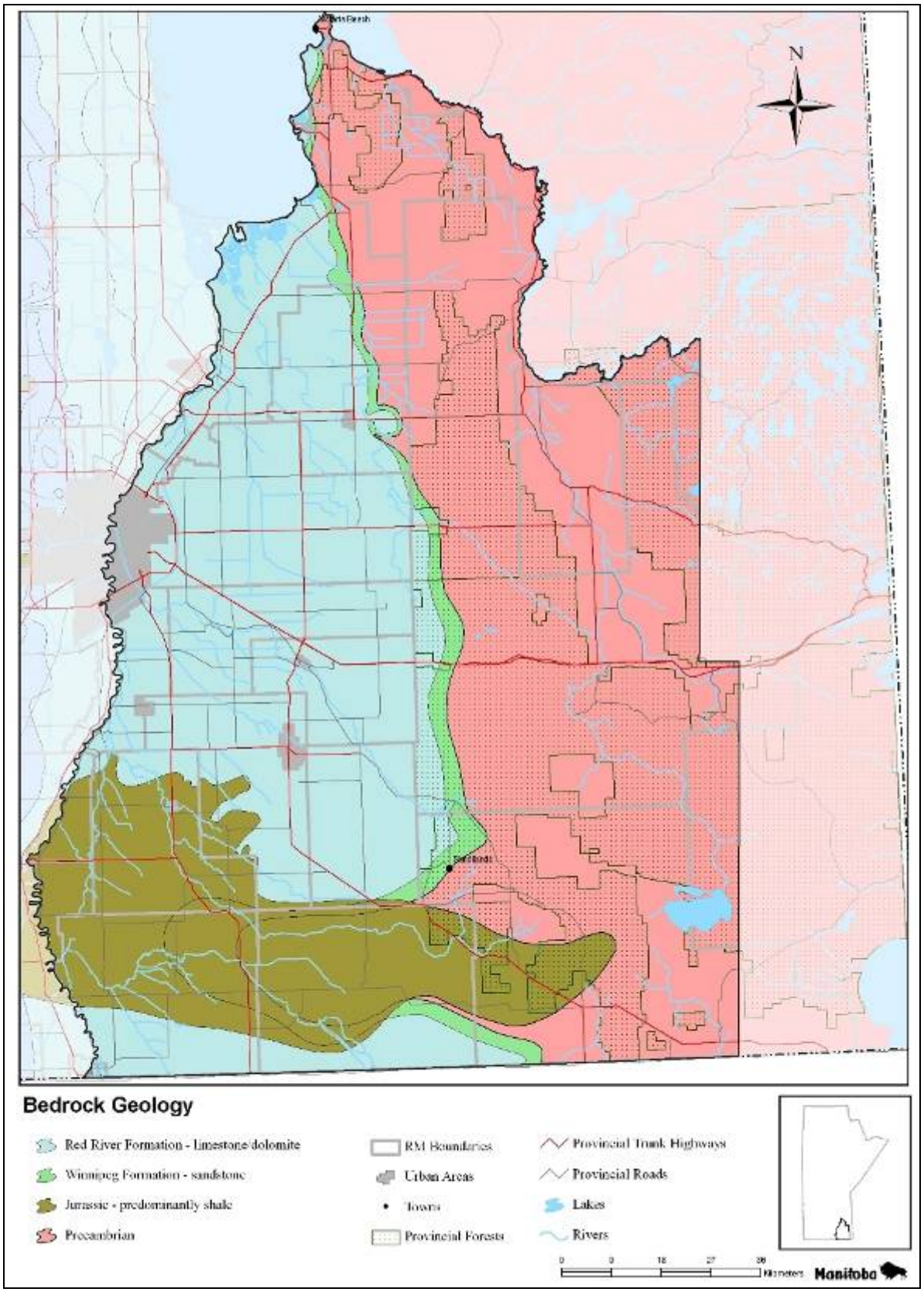


Figure 7: Bedrock Geology

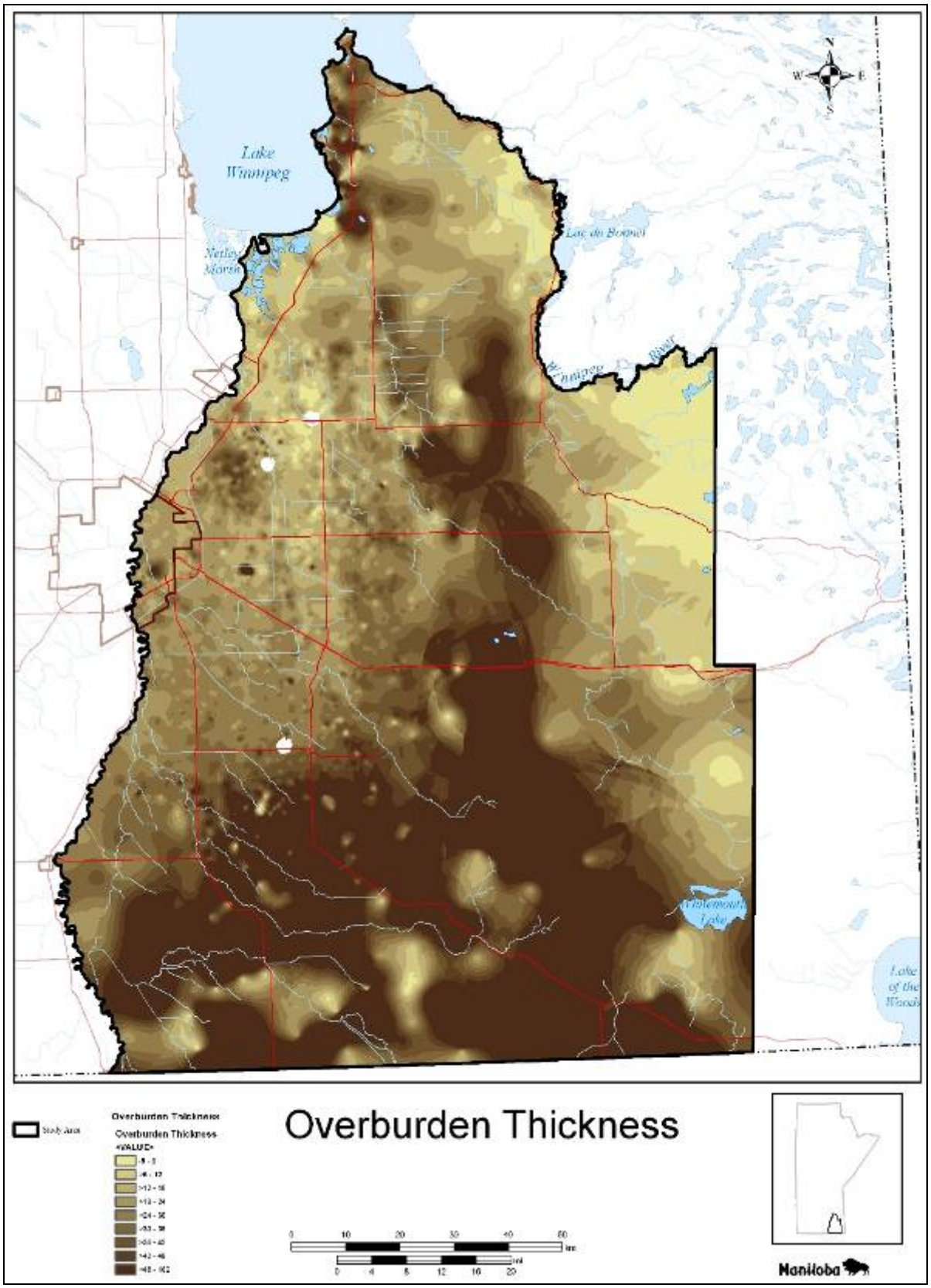


Figure 8: Total Overburden Thickness

Extensive areas of peat land are found in the eastern part of the study area. They were formed in areas where water remains at the surface for extended periods of time and the downward movement of water is inhibited due to the low permeability of underlying sediments (tills and clays).

Bedrock Geology

Bedrock in the western part of the study area is composed of limestone, dolostone, sandstone and shale, and in the eastern part, Precambrian crystalline rocks.

The upper part of the bedrock in the western portion of the study area consists of a carbonate (limestone and dolostone) unit. The thickness of this carbonate unit decreases from west to east. It is about 100 metres near the Red River but was removed by erosion in the eastern part of the area (Figure 7 – previously referenced and displayed). This unit is underlain by the Winnipeg Formation that consists of an upper green to grey shale underlain by inter-layered silica sandstone and shale. The Winnipeg Formation is typically about 40 metres thick. The eastern extent of the Winnipeg Formation is formed by an erosional edge as shown in Figure 7. A few outliers of the Winnipeg Formation likely exist to the east of the boundary. The carbonate unit and the Winnipeg Formation extend beyond the study area to the north, south and west.

South of Ste. Agathe, and extending almost to the U. S. border, this bedrock sequence is interrupted by an east-west trending tongue of geologically younger sandstone, siltstone, gypsum and shale (Figure 7). These deposits were laid down in an ancient river channel that was deeply eroded into the older sediments. Gypsum deposits were mined from these sediments near Aubigny until the mine flooded in 1975. For ease of reference, these rocks will be referred to as Jurassic sediments since they were deposited during the Jurassic period about 140 to 200 million years ago.

Precambrian-age crystalline rocks form the bedrock to the east of the erosional edge of the sediments discussed above. They extend beyond the study area in all directions.

A generalized east-west geologic cross-section “A” through the study area is presented in Figure 9. The location of this cross-section within the study area is displayed in Figure 1 running from just north of Morris east to just north of Whitemouth Lake. While the full complexities of the geology have not been shown in this cross-section, it does present a useful schematic for understanding the area’s groundwater flow regime.

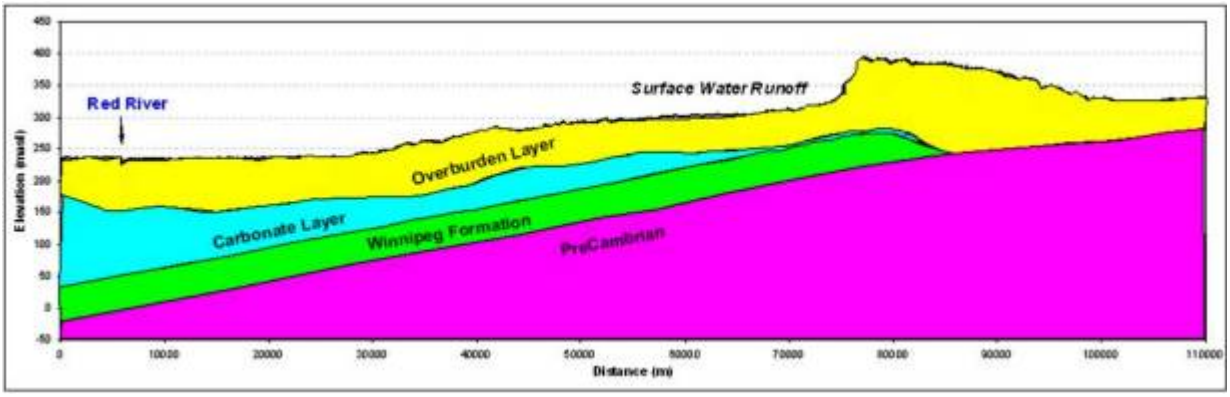


Figure 9: Geological and Hydrogeological Cross Section

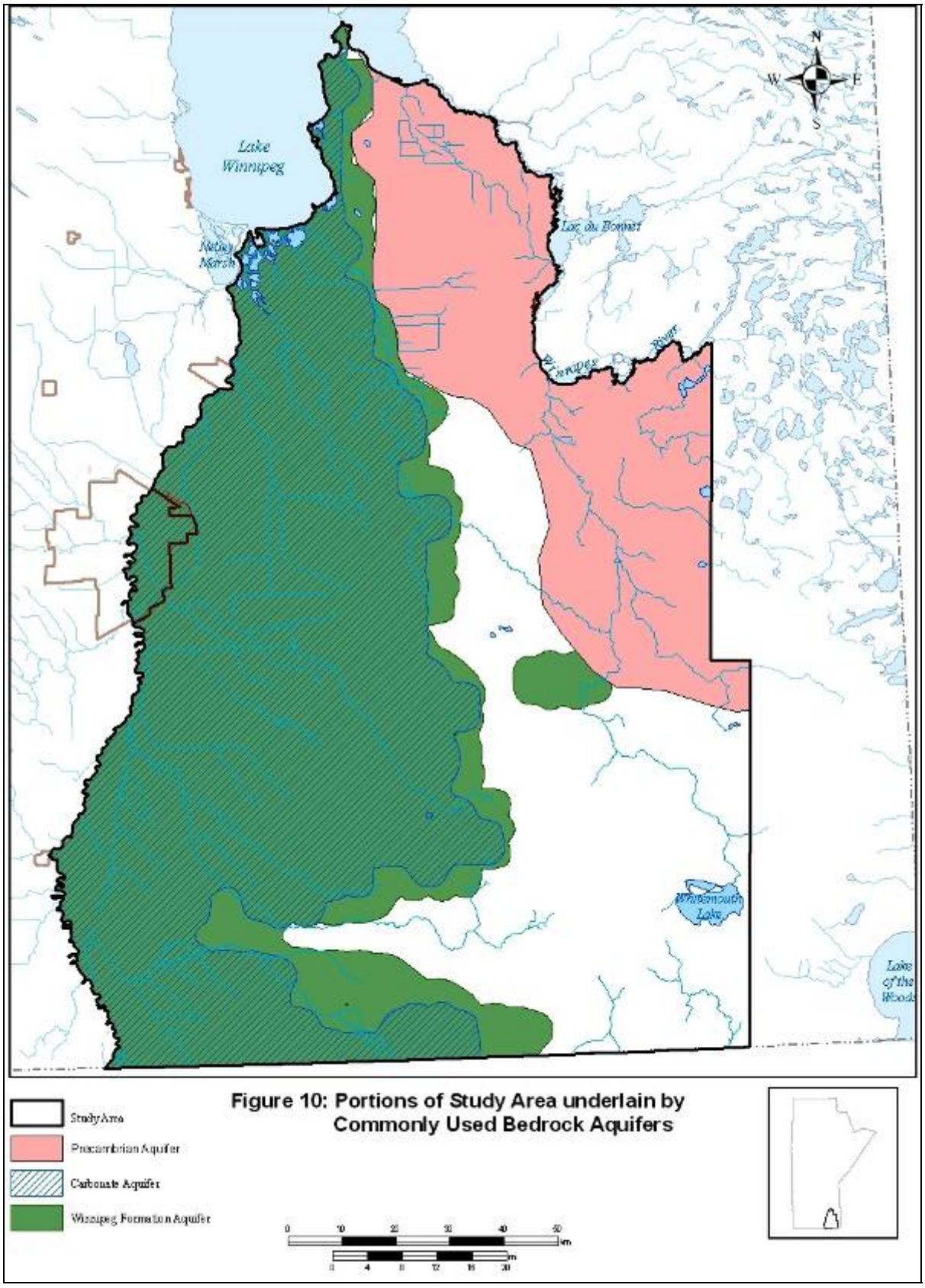


Figure 10: Portions of Study Area underlain by Commonly Used Bedrock Aquifers

3.3 Hydrogeology

The geologic entities discussed previously can be classed as aquifers or aquitards. Aquifers are saturated permeable geologic units that can transmit significant quantities of water under ordinary hydraulic gradients. In general, this means that wells completed into these units will produce sufficient water to supply a single family dwelling. Aquitards are low-permeability geologic units that can transmit significant quantities of water on a regional scale but are not sufficiently permeable to provide enough water to a well completed in the unit to supply a single family dwelling.

In the study area, the most extensive bedrock aquifers are formed by sandstones in the Winnipeg Formation and fractured parts of the limestone and dolostone Carbonate Unit. Precambrian crystalline rocks and sandstone beds in the Jurassic rocks form local bedrock aquifers while sand or sand and gravel aquifers are widely distributed in the uplands, till plain and areas further east. Aquitards are formed by silts, clays, tills, shales and the unfractured zones of limestone, dolostone and crystalline rocks.

Descriptions of the aquifers in the study area are given below. The portions of the three bedrock aquifers commonly used for water supply are displayed in Figure 10.

Carbonate Aquifer

The Carbonate Bedrock unit is a productive aquifer, known as the Carbonate aquifer, throughout its extent in the study area depicted in Figure 10. Groundwater movement is primarily through an extensive network of interconnected sub-vertical fractures and joints and horizontal bedding planes as pictured in Figure 11. Fracturing is generally considered to be most pronounced in the upper portion of the aquifer where glacial stresses and weathering have enhanced the number and size of fractures. Below this zone, water well records indicate that water yielding fractures will typically be intersected. There are, however, numerous reports, particularly in the eastern part of the study area, where no additional fractures were intersected below the shallow zone of enhanced fracturing. On the other hand, in some areas shallow, intermediate and deep fracture zones have been mapped in the Carbonate aquifer. Well yields from the aquifer are generally sufficient for single family dwellings and in most areas high capacity wells can be installed which are suitable for industrial, livestock and municipal purposes.

Figure 11: Carbonate Layer as exposed in Gilles Quarry

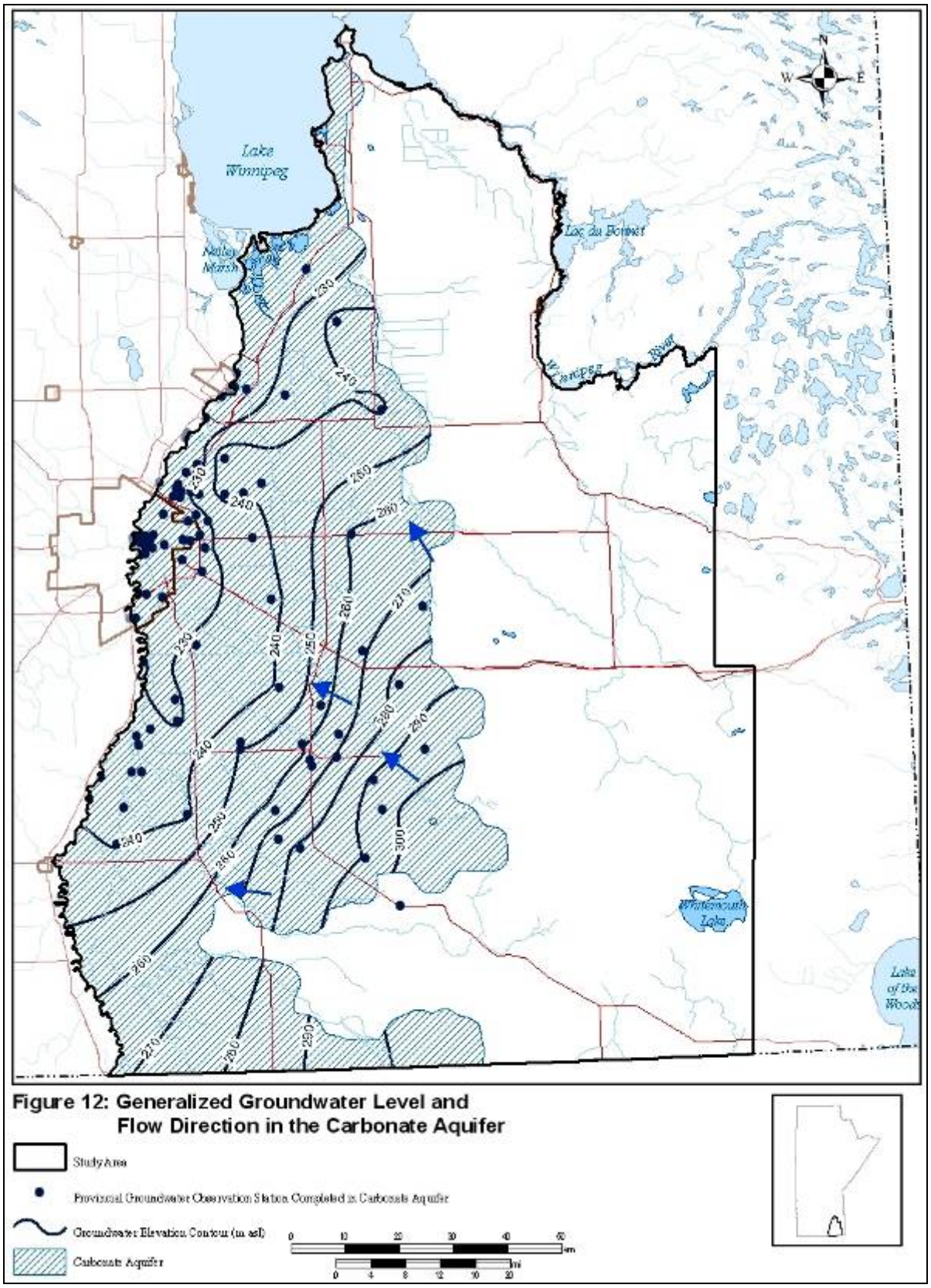


Figure 12: Generalized Groundwater Level and Flow Direction in the Carbonate Aquifer

Groundwater movement in the aquifer is from areas of highest groundwater elevation to areas with lower groundwater elevation. Regional flow is generally east to west in the study area with the highest water levels found in the upland areas, particularly the Sandilands upland. The lowest water levels are near the Red River. A distinct groundwater mound is also found in the vicinity of the Birds Hill upland. A map showing regional groundwater flow in the Carbonate aquifer is given as Figure 12. Based on the regional groundwater flow pattern and water quality distribution, groundwater recharge to the Carbonate aquifer is believed to be focused in those areas where glacial uplands overlie the aquifer. To date, there have been no studies undertaken to quantify the rate of recharge to the aquifer. Current research being done by the province is directed toward evaluating the mechanisms, locations and rates of recharge.

Groundwater quality in much of the aquifer is generally acceptable for most purposes. The groundwater is quite hard, however, and sulfate concentrations may be excessive, particularly just to the east of Winnipeg. Total dissolved solids concentrations (a measure of the amount of dissolved mineral in the water) range from about 300 to 600 milligrams per litre (mg/L) throughout most of the area. This increases rapidly near the Red River from the central part of Winnipeg to the south, and near the Rat River. This marks a boundary in the aquifer between fresh groundwater on the east and north and very saline groundwater to the west and south. The stability of this boundary is unknown.

Winnipeg Formation Aquifer

Sandstones of the Winnipeg Formation aquifer are pictured in Figure 13. They form a productive aquifer throughout most of the western part of the study area as shown in Figure 10. The aquifer is hydraulically separated from the overlying Carbonate aquifer by a shale layer at the upper part of the formation; consequently, we find significant differences in groundwater quality and some differences in groundwater flow direction between the two aquifers. Groundwater levels are currently higher in the Winnipeg Formation aquifer than in the overlying Carbonate aquifer throughout most of the study area that results in upward movement of groundwater in open-hole wells that interconnect the two aquifers.

Figure 13: Winnipeg Formation Layer as seen on Black Island

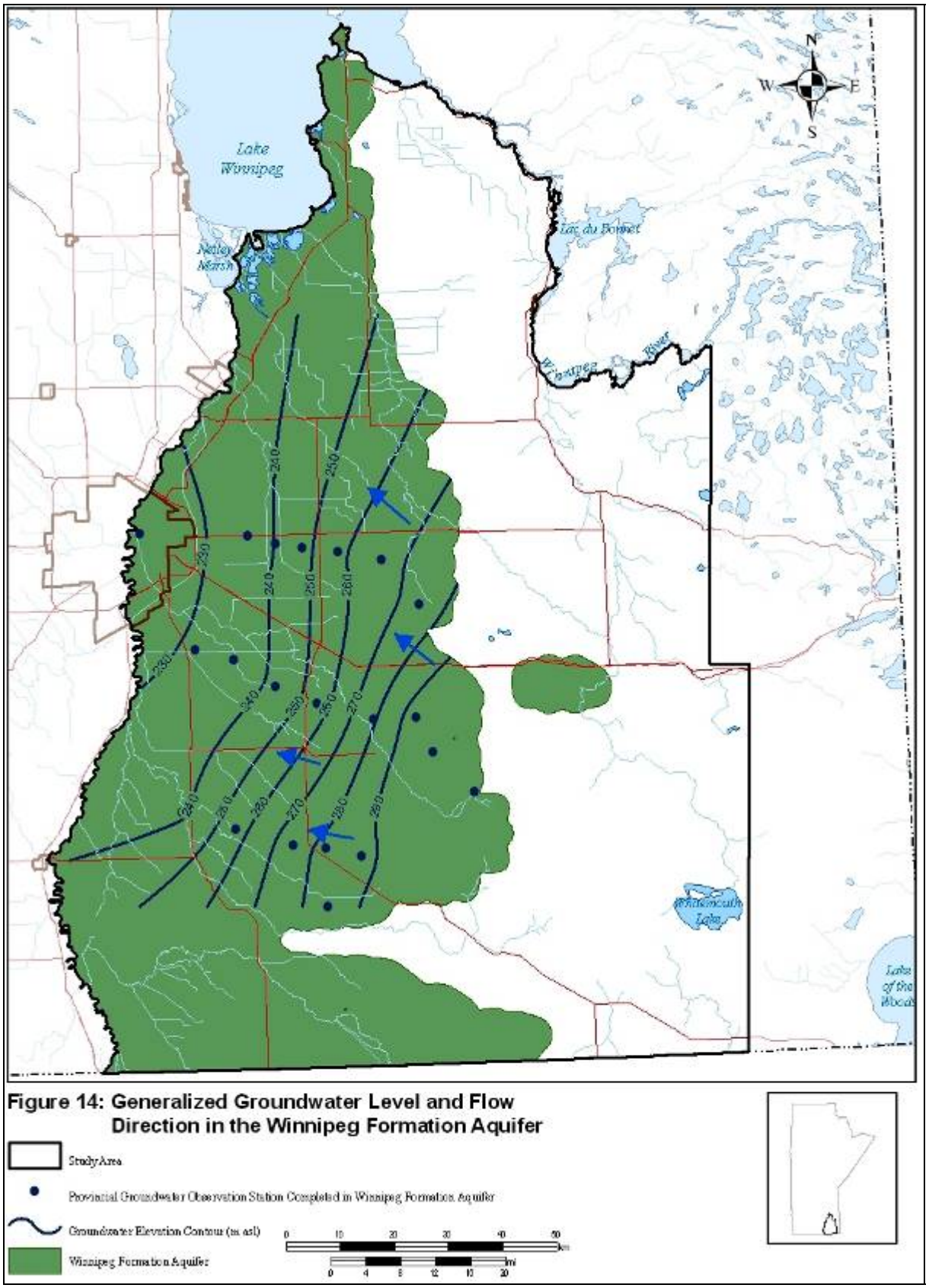


Figure 14: Generalized Groundwater Level and Flow Direction in the Winnipeg Formation Aquifer

Regional groundwater movement in the Winnipeg Formation aquifer is generally southeast to northwest, indicating that the major recharge area is associated with the Sandilands upland. A map showing regional groundwater flow direction in the Winnipeg Formation aquifer is given in Figure 14. The distribution of groundwater quality in the aquifer supports this interpretation and also indicates a second, but less significant, recharge area on the east side of a glacial upland southeast of Beaconia. The rate of recharge to the aquifer has not, as yet, been quantitatively assessed but a regional study carried out in 1986 estimated the rate of movement of groundwater in the aquifer to be about 10 metres per year from east to west near the Sandilands upland. This can be used to estimate the volumetric rate of recharge to the aquifer but it is preferable to evaluate recharge rates through a number of independent means (physical hydrogeology, age dating and other geochemical techniques, modeling).

A map showing the total dissolved solids concentration in groundwater in the aquifer is given in Figure 15. Fresh groundwater is found to the west and north of the Sandilands moraine and south and west of Beaconia. A rather abrupt transition to brackish and saline groundwater occurs to the east of the Red River (east of the similar water quality boundary in the Carbonate aquifer) then extends northeast to the erosional edge of the formation east of Beausejour. As in the Carbonate aquifer, the stability of this boundary is unknown.

Groundwater quality in the fresh water portion of the aquifer is typically 250 to 400 mg/L total dissolved solids but increases near the fresh water-saline water boundary. Near the transition to saline water, the hardness of groundwater in the Winnipeg Formation is extremely low. This characteristic has led to the development of groundwater from this part of the aquifer for rural residential developments. Some local issues with fluoride and barium concentrations exceeding current guidelines have also been noted.

Jurassic Sandstone Aquifer

Sandstones in the Jurassic sediments extending west-east across the southern part of the study area form another bedrock aquifer. There has been very little development of this aquifer due to poor water quality and low well yields. Fortunately, much of this area is overlain by sand and gravel aquifers within the glacial till uplands that generally provide abundant supplies of excellent quality groundwater.

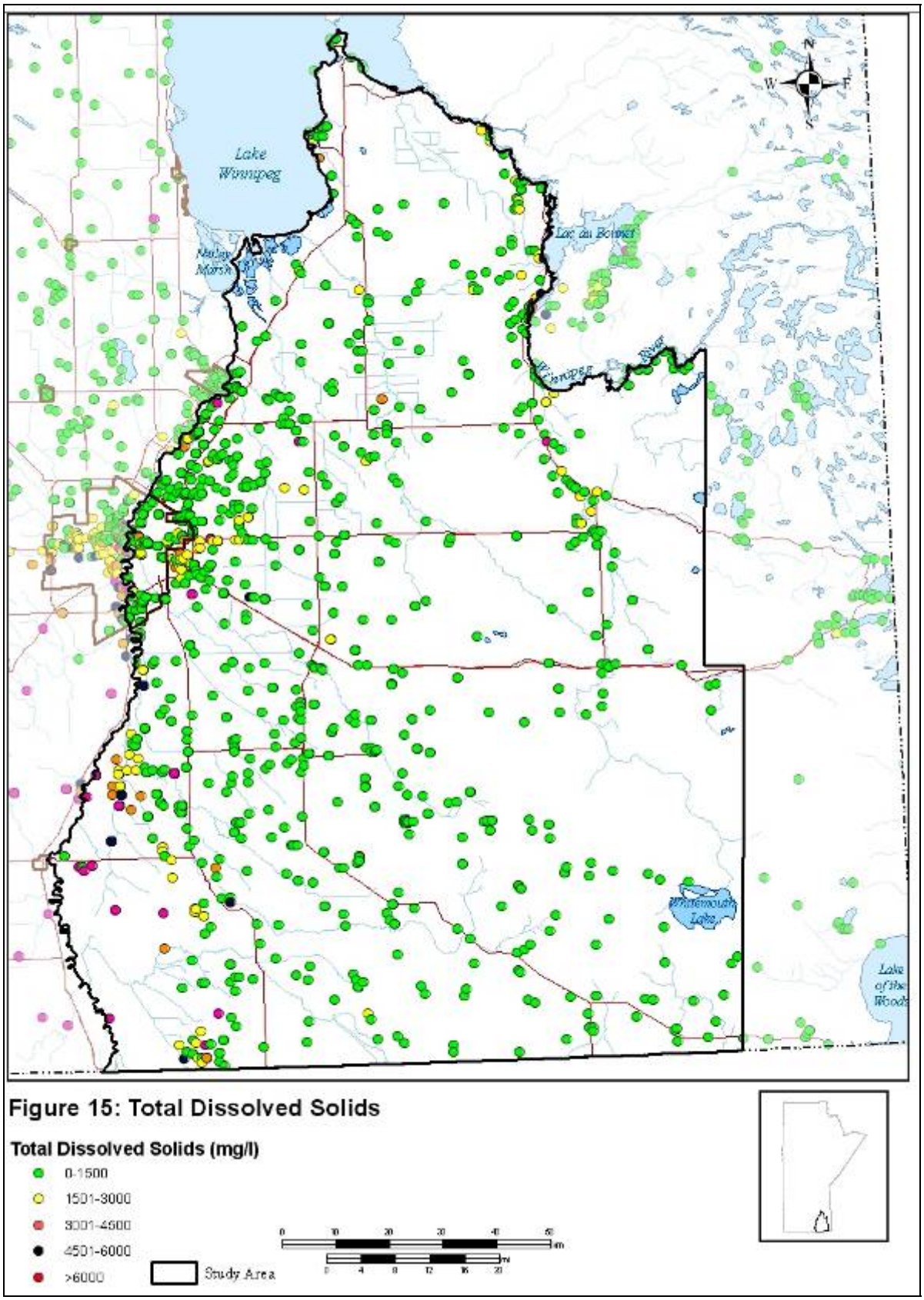


Figure 15: Total Dissolved Solids

Precambrian Aquifers

Precambrian rocks, as pictured in Figure 16, form the bedrock through much of the eastern part of the study area. These crystalline rocks are generally fractured but the occurrence of fractures is unpredictable as is the ability of the fractures to provide water. Groundwater development from Precambrian rocks has only occurred where other reliable aquifers are not present. Almost all development has taken place east of the Brokenhead River as shown in Figure 10. Well yields are highly variable, ranging from a few tens of litres per second to dry holes. Well depth is also highly variable, reflecting the uncertainty with intersecting productive fractures in vertical boreholes. Groundwater quality also varies locally and regionally, with total dissolved solids concentrations ranging from less than 100 mg/L to several thousand mg/L just east of Lac du Bonnet. Issues with excessive concentrations of uranium, arsenic and fluoride occur locally. There is insufficient information and considerable local variability in groundwater levels or quality to allow maps to be developed showing either regional groundwater flow directions or groundwater quality in these rocks.

Figure 16: Precambrian Layer as seen in the Whiteshell Area

Sand or Sand/Gravel Aquifers

Sand or sand/gravel aquifers (hereafter referred to as sand/gravel aquifers) in the study area have generally been formed as a result of glacial processes. The coarser sediments (gravels or sand/gravel) are associated with glacial river environments that resulted from the huge amounts of water that were released when glaciers were present or nearby. Finer sediments are associated with both river and lake deposition.

Sand/gravel aquifers occur in a number of different geological environments. They are commonly found at the contact between glacial tills and the underlying bedrock for instance, or as individual aquifers of relatively local occurrence within the tills. Sand/gravel aquifers are also found as distinct units deposited in glacial lake environments such as is found in the Sandilands area, or as surface sand units, which are formed by sand washed off from adjacent uplands. Extensive deposits of sand/gravel are typically found associated with glacial uplands located at Mars Hills and Milner Ridge.

A feature of all these deposits is that they are they are not individually as extensive as the bedrock aquifers discussed above. Consequently, each of these aquifers must be assessed individually in terms of recharge and discharge, groundwater flow, well productivity and sustainable yield and water quality. There are likely dozens or hundreds of individual sand/gravel aquifers in the study area ranging anywhere in size from perhaps less than a square kilometre up to hundreds of square kilometres. None of these aquifers have been well characterized. However, several sand/gravel aquifers have been developed for municipal, agricultural or rural residential supplies (Moose Nose aquifer west of Oakbank, the Birds Hill aquifer, East St. Paul) which indicate that they do have a significant sustainable yield.

A map showing the distribution of domestic wells completed into the various aquifers in the study area is presented in Figure 17. While this map cannot be used to outline the extent of individual aquifers, it can be used as a proxy to indicate where sand/gravel aquifers most commonly occur. However, in areas where productive bedrock aquifers underlie sand/gravel, groundwater development may occur primarily from the bedrock aquifers and the presence of sand/gravel will not be indicated on the map.

Groundwater quality is generally good in sand/gravel aquifers although saline groundwater do occur in areas near the Red River. Brackish groundwater is found in some thin sand/gravel aquifers overlain by clay in Precambrian terrain. In most areas however, the total dissolved solids content of groundwater will range from <200 to 600 mg/L. Local issues with uranium are found east of Lac du Bonnet.

3.4 Aquifer Development

Planning for groundwater development, as with most natural resources, is done in concert with the development of the resource and in accordance with the principles of sustainable development. The normal planning approach is to begin development while monitoring for negative impacts and resource definition. This approach works well for water resources, in general, because extended periods of monitoring data are required to capture the variety of climatic circumstances that determine the magnitude of the resource. The magnitude used for planning purposes is the long-term average resource availability. This approach works very well for groundwater resources because groundwater flow is tremendously slower than surface water and because the local and regional groundwater response to development is integral to the process of defining the magnitude of the resource.

Water from study area aquifers has been used since early settlement of the area. Water levels and chemistry has been monitored since the early 1960s. The Carbonate aquifer began to be developed significantly in the 1880s. Early wells into this aquifer flowed freely at ground surface under the aquifer's pressure. It is estimated there are 20,000 wells in this aquifer. The Winnipeg Formation aquifer began to be developed in the 1890s. Early wells flowed freely to 20 feet above the ground surface. It is estimated there are 1,500 wells in this aquifer. It is noted that the water supply for the city of Winnipeg is from the surface water source of Shoal Lake, located at the Manitoba Ontario border. The main use of groundwater in Winnipeg is non-consumptive use for heating and cooling.

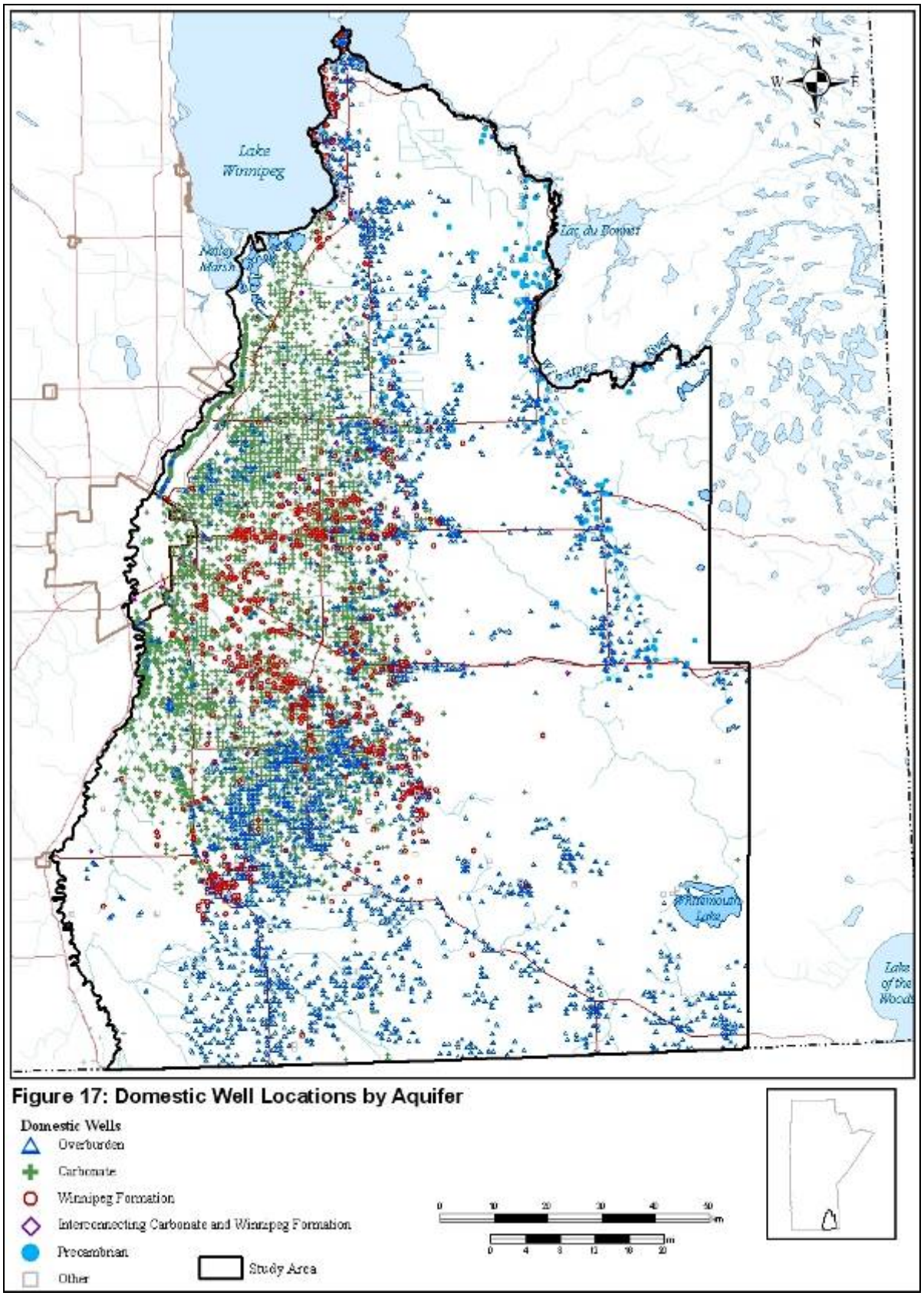


Figure 17: Domestic Well Locations by Aquifer

As a well draws groundwater from an aquifer, the water table is lowered in a cone shape above and around the point of extraction. As pumping continues, the water table is lowered further and the size of the cone increases. With continued pumping the cone increases until the contributing area is sufficiently large to supply groundwater at the rate of the pumping. The dimensions of that cone vary according to the ability of the aquifer materials to transmit water. If the materials transmit water readily, the cone will be relatively shallow and with a wide top. If, on the other hand, the materials transmit water poorly, the cone will be relatively deep and with a narrow top. When hydrogeologists conduct pumping tests to determine groundwater availability, the size and shape of the cone, and the time required for the cone to refill with water after pumping ceases, are key measurements in their assessment.

The construction of the Red River Floodway channel around the east side of Winnipeg in the mid-1960s had a significant impact on local groundwater. It resulted in lowering the groundwater table in the vicinity of the floodway channel by approximately six metres as shown in Figure 18. Monitoring station OH001 is located just north of the Trans Canada Highway #1 bridge over the floodway. As a result of the impacts, the province assisted many landowners with constructing deeper wells. Also, to prevent additional groundwater flow through the floodway, the recent floodway expansion project of 2008/09 only widened the channel rather than making it deeper. The channel intercepts groundwater moving west in the overburden aquifer several miles before it reaches the Red River and redirects this water north to the Red River at the floodway outlet. These flows are estimated to be 3,150 cubic decametres (3.15 billion litres or 832 million imperial gallons) per year.

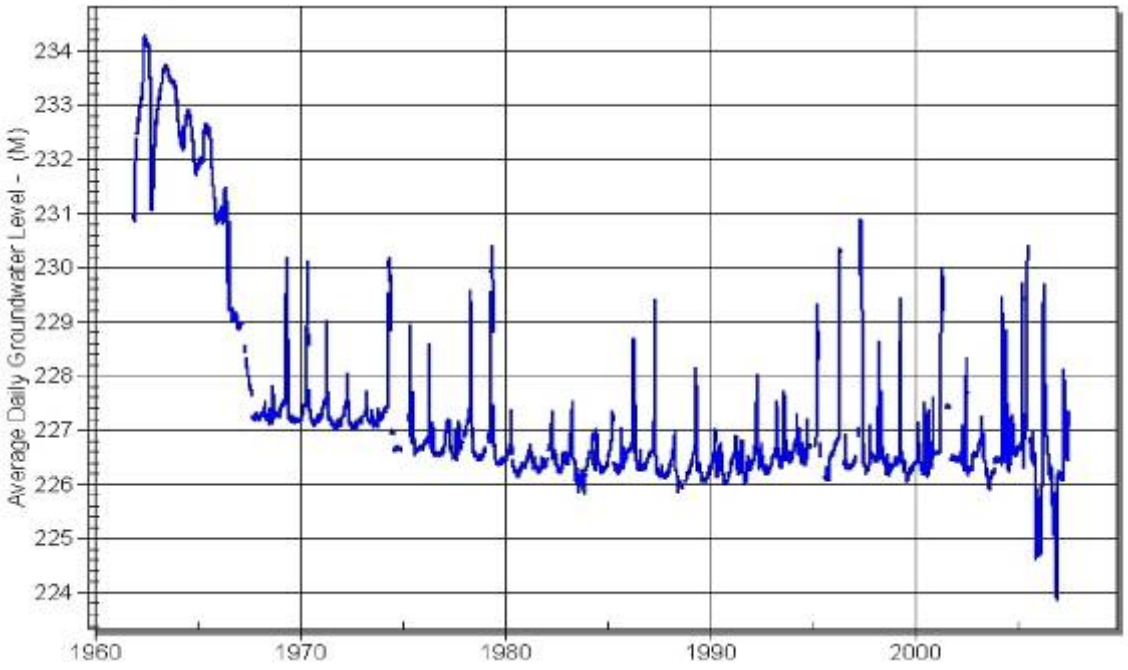
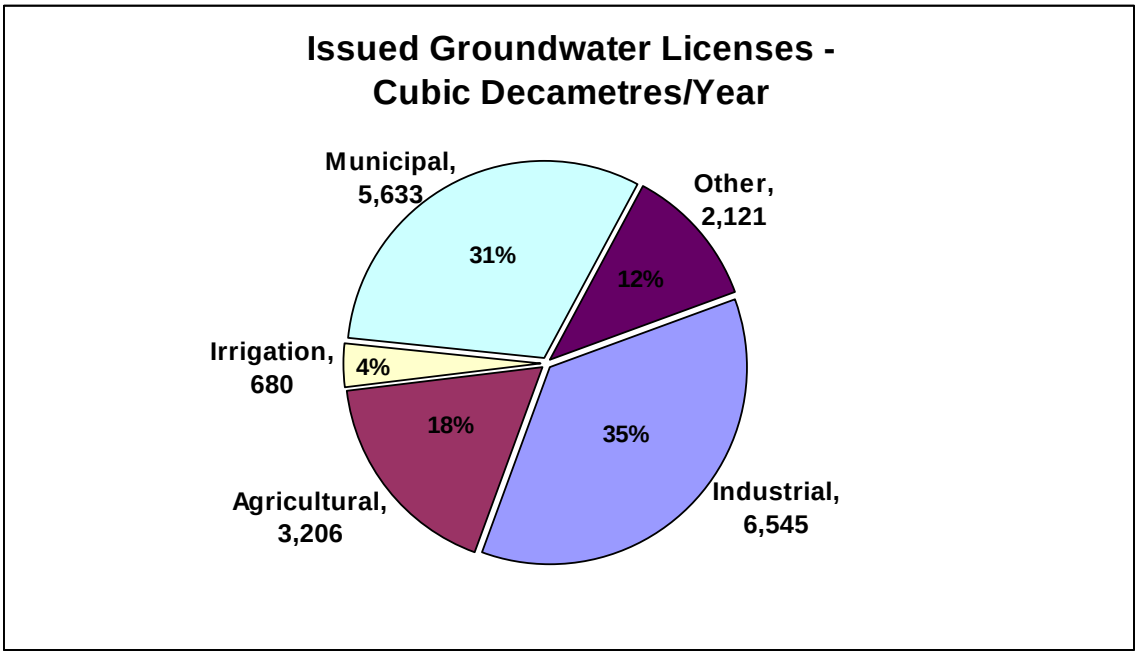


Figure 18: Water Level Graph from Monitoring Station OH001

Water volumes are referenced throughout this plan in units of cubic decametres. A decametre is ten metres. The volume contained in a cube ten metres each side is a cubic decametre. One cubic decametre contains one million litres.

In 1930, when *The Water Rights Act* came into effect, Manitoba took management control of its natural resources that had previously been administered by the federal government. In accordance with the act, water is a provincial Crown resource, and all use, except domestic use, which refers to water use less than 25,000 litres (5,500 imperial gallons) per day or 9.1 cubic decametres (9.1 million litres) per year, requires a water rights licence. Water rights licensing for water use is done under the authority of *The Water Rights Act* by Manitoba Water Stewardship, Water Use Licensing Section. A licence may be granted for beneficial use, without waste, on a first-come first-served basis, if the requested use will not impact existing domestic users, licence holders, or the environment, or if the impacts can be mitigated. Also, depending on the size/class of a development (as defined in *The Environment Act*), Manitoba Conservation, Environmental Licensing Branch may become involved in assessing environmental impacts. If a license application for water use will impact existing uses and those impacts can not be mitigated, the application is denied.

As of November 2009, the Water Use Licensing Section has issued 211 licenses and a volume of 18,185 cubic decametres of groundwater per year from the study area. The following pie chart illustrates the licensed groundwater allocations by category.



In addition to the licensed allocation of 18,185 cubic decametres/year, there are approximately 45,000 domestic wells (no license required) in the study area that use an estimated 8,200 cubic decametres of groundwater per year. The total annual groundwater used is therefore estimated at 26,385 cubic decametres/year.

The larger volume licenses are concentrated in the portion of the study area east of the City of Winnipeg as shown on Figure 19 below.

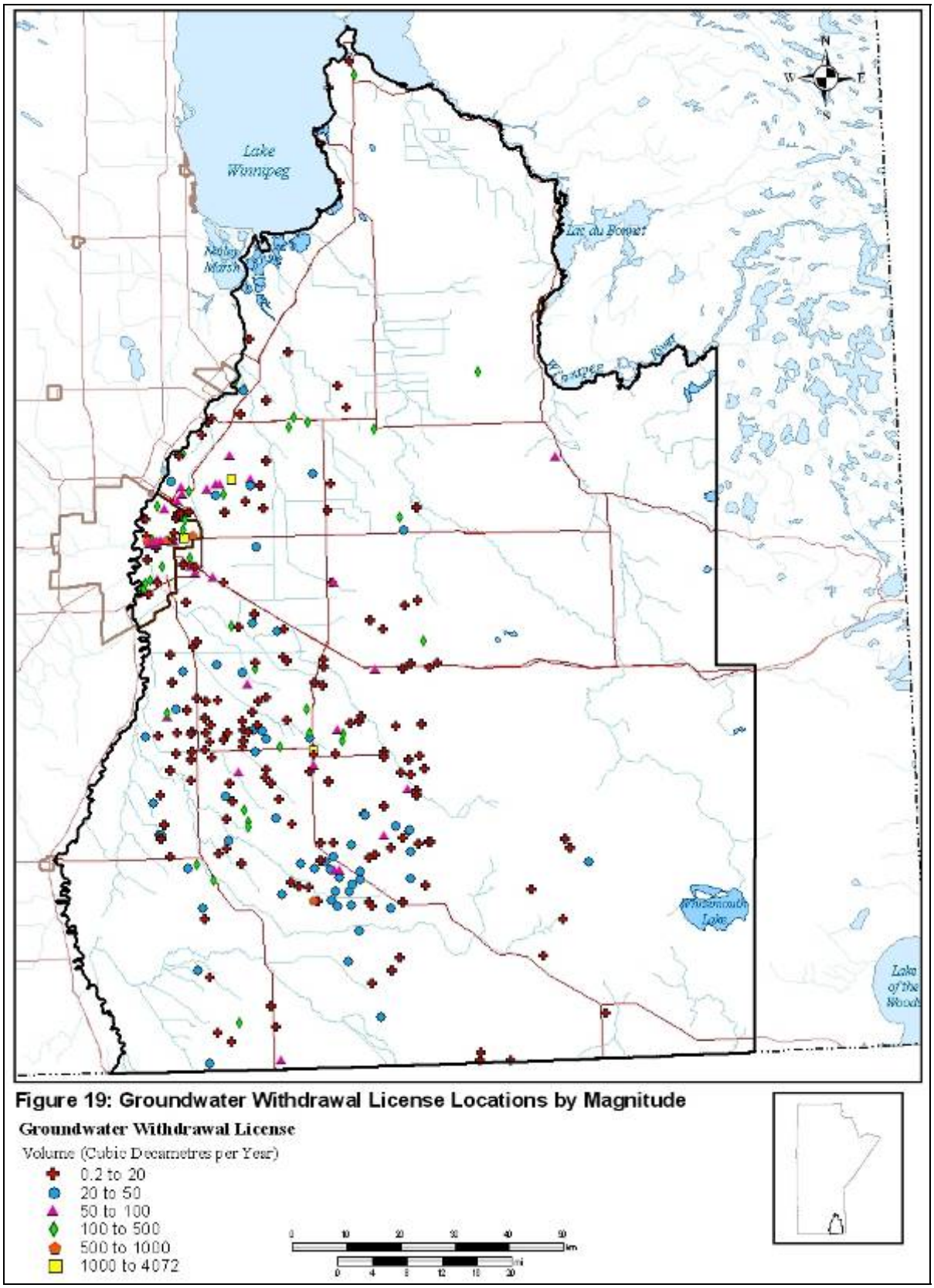


Figure 19: Groundwater Withdrawal License Locations by Magnitude

3.5 Groundwater Studies

Groundwater in the study area was no doubt observed by First Nations and Métis people and by early settlers who understood various components (springs, fresh and saline water areas) of the regime. Eventually the federal government, then the provincial government and the University of Manitoba became active in groundwater observations and study. A chronology of some key activities related to the groundwater regime is described below.

Date	Activities
1900	• First formal groundwater studies conducted by the city of St. Boniface as it develops wells in the carbonate aquifer
1934	• Geological Survey of Canada (GSC) paper on southern and central Manitoba including the first regional groundwater mapping, a compilation of well logs and information on aquifers, flowing wells and saline groundwater areas
To mid 1950s	• GSC published information on groundwater inventories, well inventories, water quality sampling, geology, aquifers and groundwater occurrence
1959	• Manitoba's *Water Rights Act* amended to include groundwater • Province hired its first hydrogeologist
Early 1960s	• Various provincial studies related to planned construction of the Winnipeg floodway and local and regional groundwater mapping
1960s through 1990s	• First groundwater observation wells installed • GSC shifted from regional inventories to more detailed scientific work on groundwater flow systems, regional aquifer mapping, geochemical studies, well inventories and the fresh water/saline water boundary • General understanding of most aquifers and aquitards was compiled • Province worked on: o groundwater mapping o expansion of groundwater monitoring network o groundwater vulnerability mapping o regional studies with federal agencies o local water supply studies o water quality studies o fresh water/saline water interface

2000s	• Several consulting studies associated with water supply development for Oakbank, Dugald, Winnipeg and East St. Paul • Several regional and local studies including: o GSC and Manitoba Mines rotasonic drilling o Kennedy thesis on three dimensional modeling of groundwater o floodway expansion studies o groundwater quality study in Oakbank • GSC studies groundwater trace elements issues and assists Cherry thesis on recharge rates to shallow sand aquifers
2000s	• Province studies water quality along fresh water/saline water boundary south of Winnipeg • Province conducts regional groundwater quality sampling • Province studies agricultural impacts relating to seepage to groundwater from: o lagoons o manure application over shallow aquifers o cattle pens and feedlots o solid manure storage piles
Currently underway	• Province is increasing groundwater monitoring network, conducting short-term pumping tests, groundwater sampling, isotopic studies, age dating, rotasonic drilling and developing three dimensional model of flow regime • Conservation districts are identifying and sealing abandoned wells, and conducting well inventories and water quality surveys • GSC is continuing to study shallow aquifer recharge rates and conducting seismic reflection work in the Sandilands area • Consultants are studying the development potential in Sandilands area and other groundwater supplies
Planned additional studies	• Province has designed regional groundwater mapping studies focusing on discharge and recharge areas and on surface water/groundwater interactions, additional test drilling and monitoring well installation in Sandilands area and studies to calibrate three dimensional model • GSC has additional recharge assessment studies planned • Conservation districts will continue with well inventories and groundwater protection programs

3.6 Groundwater Monitoring Network

The first observation well in the study area was installed in 1962 into the Carbonate aquifer near the floodway to monitor potential construction impacts. Today there are a total of 172 groundwater observation wells in the study area operated by the Groundwater Management Section of Manitoba Water Stewardship. The network consists of 70 wells completed into aquifers in the overburden materials, 80 in the Carbonate aquifer and 22 in the Winnipeg Formation aquifer. The locations of the observation well network by aquifer are shown in Figure 20. Water level information is gathered on a continuous basis from most wells and is used to evaluate the rate and

direction of movement of groundwater, recharge and discharge rates. This is related to climate and weather, and long-term water level responses to groundwater development. Groundwater samples are also collected occasionally from all wells and analyzed for a suite of constituents which indicate overall drinking water quality, the age and origin of the water, and water quality changes that may be related to downward migration of contaminants from the surface.

Observation wells have also been installed and operated by other agencies. The Geological Survey of Canada operates several in the Sandilands upland which have been used to evaluate the rate of recharge occurring to the upper sand unit in this area.

The University of Manitoba maintains a few wells in which occasional down-hole temperature measurements are collected. Temperature profiles have been used to estimate the rates of groundwater flow through sub-surface materials and can also be used for climate change studies. Observation wells have also been installed by the owners of a number of waste disposal grounds, lagoons and earthen manure storages. Periodic water sampling of these wells is used to determine if contaminants are leaching from the sources and, if so, whether this may affect local aquifers. Where monitoring is done to meet the requirements of a permit or licence, results are reported to Manitoba Conservation.

Monitoring has also been undertaken by provincial agencies and conservation districts to assess “point-in-time” water quality over broad areas for selected parameters. This is a form of long-term monitoring that uses private wells in addition to dedicated observation wells. One example of this type of monitoring is occasional sampling along the fresh water/saline water boundary near the Red River south of Winnipeg by the province since the early 1970’s to evaluate whether there is evidence of long-term movement of this water quality boundary. A second example is well inventories currently being carried out by conservation districts that include sampling for general water quality, nitrate and bacteria. This information can be used as baseline water quality for subsequent similar studies that may be carried out in the future, allowing an assessment of long-term water quality changes.

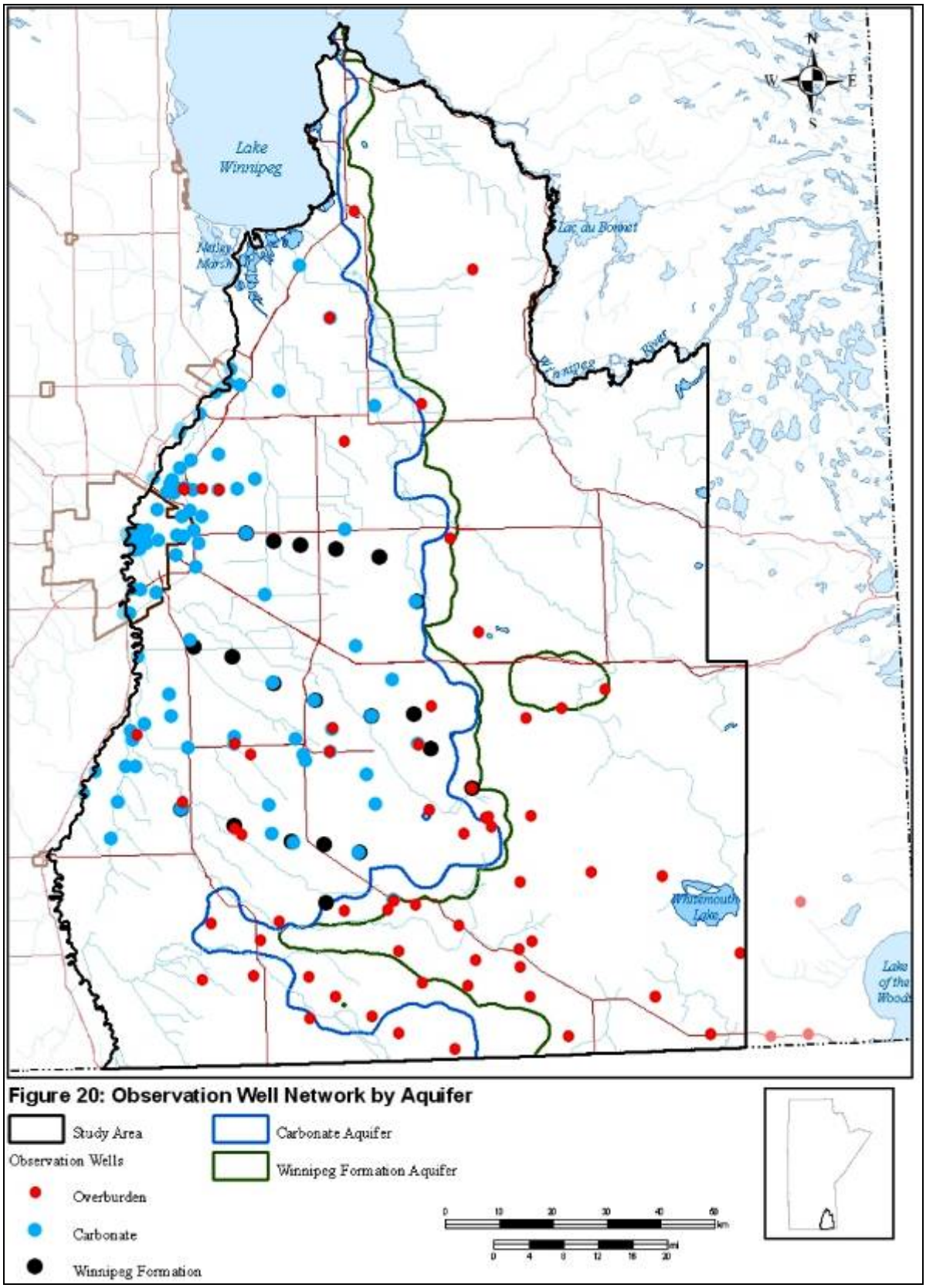


Figure 20: Observation Well Network by Aquifer

3.7 Water Quality

Groundwater quality in the study area is generally acceptable for most purposes, although the quality degrades significantly near the fresh water-saline water boundary and eventually becomes too saline for most uses. Fresh groundwater tends to be quite hard (mineralized) in most of the deeper aquifers, a consequence of the widespread occurrence of soluble limestone and dolomite in both overburden and bedrock units. The exception is in the Winnipeg Formation where the hardness is generally much lower than in overlying aquifers. Many residences relying on well water will employ a household water treatment device to deal with water hardness issues. Iron and manganese commonly occur at concentrations that can cause staining and taste problems while some trace metal concentrations locally exceed health-based drinking water guidelines, as discussed below. Shallow groundwater may be impacted by leaching of contaminants from the soil zone but regional sampling programs have shown that most aquifers used in the area for household or municipal water supply have not been affected to any significant degree.

The bedrock aquifers in this area are protected by overlying layers of clay and till and, for some deeper aquifers, shale. For much of the study area, these layers significantly limit the risk of contamination from the surface. In addition, the very low transmission rates of water movement in these aquifers would limit the spread of contaminants, if introduced. The sand/gravel aquifers within the overburden layer are relatively deep and usually protected by overlying till. Areas where sand and gravel extend to the surface provide the greatest risk of contaminant entry to groundwater.

Sampling to date has detected isolated occurrences of natural contaminants in some study area groundwater. Some concentrations of arsenic in excess of Canadian drinking water standards, which can be associated with various cancers, have been found in sand and gravel aquifers in the southwest portion of the study area. A few elevated concentrations of uranium, which can be associated with kidney disease, have been found. Elevated concentrations of fluoride, which can be associated with fluorosis of teeth and bones, have been found primarily in the Winnipeg Formation aquifer where natural softening has occurred. Elevated concentrations of barium, which can be associated with high blood pressure, have been found primarily in the Winnipeg Formation aquifer where sulfate concentrations are very low.

Sampling has also detected isolated occurrences of human generated contaminants in study area groundwater. Wells, in some localized areas with coarser textured soils, have occasionally recorded nitrates and bacteria exceeding drinking water guidelines. These occurrences have most often been attributed to poor well construction or maintenance. Elevated nitrate levels have been detected beneath older and poorly constructed manure storage lagoons and cattle confinement areas. Bacterial contamination can occur from wildlife or from surface runoff in and around gravel pits and quarries. Fortunately, the lifetime of such bacteria introduced to groundwater is only days to a few months. It dies over fairly short groundwater travel distances.

An occurrence of gasoline contamination of private groundwater wells arose in the mid-1970s within the carbonate aquifer in the Birds Hill community area. Various studies and activities have been conducted to determine the source and to solve the problem.

Contamination levels are low and the source could not be determined. Manitoba Conservation has assisted some well owners to install carbon filters or hook-up to a subsequently installed water distribution system. With the cooperation of the local residents, this issue continues to be monitored and mitigated.

The University of Manitoba, Department of Soil Science conducted studies from 2003 to 2009 at a field site near La Broquerie because of the concern of manure spreading affecting local water quality. They concluded the application of liquid hog manure at a range of typical rates to forage crops presents minimal risk of nutrients leaching to the underlying groundwater in the study area.

3.8 Sustainable Yield

The concept of sustainable yield is used in the management of most natural resources. Basically, it is the determination of a yield/harvest/use rate for the resource that is equal to its natural replenishment rate. The management goal is to limit the use of the resource, including natural uses, to the rate at which it is replenished so its magnitude will not be diminished.

The sustainable yield of a groundwater system has been defined in Manitoba as, “the amount of water that can be removed on a long-term basis from an aquifer or aquifer system without compromising the ability of the aquifer or aquifer system to provide water to future generations and not imposing an unacceptable impact on parts of the ecosystem which depend on groundwater discharge, or causing other unacceptable impacts”.

This definition has been applied, in slightly differing ways based on local circumstance, to the management of three major sand/gravel aquifers in Manitoba. The Winkler aquifer is a distinct sand/gravel body with a footprint of approximately 90 square kilometres and with no discharges to wetlands, water bodies or waterways. In this case the aquifer’s long-term average annual recharge was estimated and this value is used as the aquifer’s sustainable yield. The magnitude of annual water use licensing is limited to this maximum amount.

The Oak Lake aquifer is a distinct sand/gravel body with a footprint of approximately 2,100 square kilometres and with discharges to wetlands, water bodies and waterways. In this case, the aquifer was divided into three sub-basins, based on the internal flow regime, and a long-term average annual recharge value was estimated for each sub-basin. The sustainable yield for each sub-basin was determined to be one-half of this value, the other half reserved for domestic and natural discharges/uses. The magnitude of annual water use licensing in each sub-basin is limited to these maximum amounts.

The Assiniboine Delta aquifer is a distinct sand/gravel body with a footprint of approximately 3,900 square kilometres and with discharges to wetlands, water bodies and waterways. Approximately one-third of this aquifer’s area is Crown land. In this case, the aquifer was divided into 13 sub-basins and the sustainable yield for 11 of the sub-basins determined to be one half of the estimated long-term average annual recharge value in the accessible portion of the sub-basin. The other two sub-basins contained waterways with major reliance on aquifer discharge hence the sustainable yield was reduced to only 15 and 30 per cent of the estimated long-term average annual

recharge value. The magnitude of annual water use licensing in each sub-basin is limited to these maximum amounts.

The determination and use of one sustainable yield value for an aquifer or a large portion of an aquifer has a limitation in that it assumes development will happen evenly over the entire area. This limitation is best understood in the exaggerated example of trying to withdraw the entire sustainable yield from one location in an aquifer. This could work in an aquifer comprised of large boulders where the ability to transmit water would be very large (similar to a surface water body), but this does not work well in a sand and gravel aquifer that transmits water more slowly. It was for this reason, in the Oak Lake and Assiniboine Delta aquifers, that sub-basins were established and in the Assiniboine Delta aquifer the sustainable yield values were reduced to accommodate the areas unavailable for development.

Sustainable yield values will eventually be determined for the various isolated sand/gravel aquifers within the overburden layer. However, given the size and interconnected nature of the Carbonate and Winnipeg Formation aquifers, their low rates of transmitting water and the density of development in some portions, the approach of determining one sustainable yield value or even separate values for large areas and using these values as licensing limits is not workable.

The approach to sustainable yield and water use licensing limits in the study area needs to be more continuous, integrated and comprehensive. Such an approach has been initiated in the design of a three dimensional digital model for the groundwater flow regime.

The three dimensional digital model is being formulated using available data on aquifer parameters (size, composition, water transmission rates and pumping tests). A first generation model has been calibrated to existing steady state conditions using the monitoring data. The final task of calibrating the model to transient conditions based on historic and current production and water level data is underway. As shown in Figure 21, the preliminary results from the initial transient calibration show good correlation from observed water levels (existing monitoring network) and simulated (modeled) results.

The model is expected to be completed for initial use by 2011, at which time it will be used to evaluate recharge areas and volumes, local and regional water tables, potential water level and water regime impacts from proposed developments, adequacy of the monitoring network and as a key management tool to assess local, regional and regime sustainable yield values. It will be refined through use as it becomes evident in which areas more detail is required. This information will then need to be obtained, incorporated into the model and the model recalibrated. Through this iterative process subsequent generations of the model will be more elaborate and its results more detailed and accurate.

Some comment of the sustainability of current use of the study area's groundwater regime was desirable in this report. The hydrogeologists have made it clear they feel stipulating one number for this regime is scientifically inappropriate. They are confident, based on the fact that progressive water level declines are not being observed anywhere, that we are still within sustainable use rates and that the three dimensional model will provide our best approach to estimating sustainable yield values for this regime and for managing these water resources.

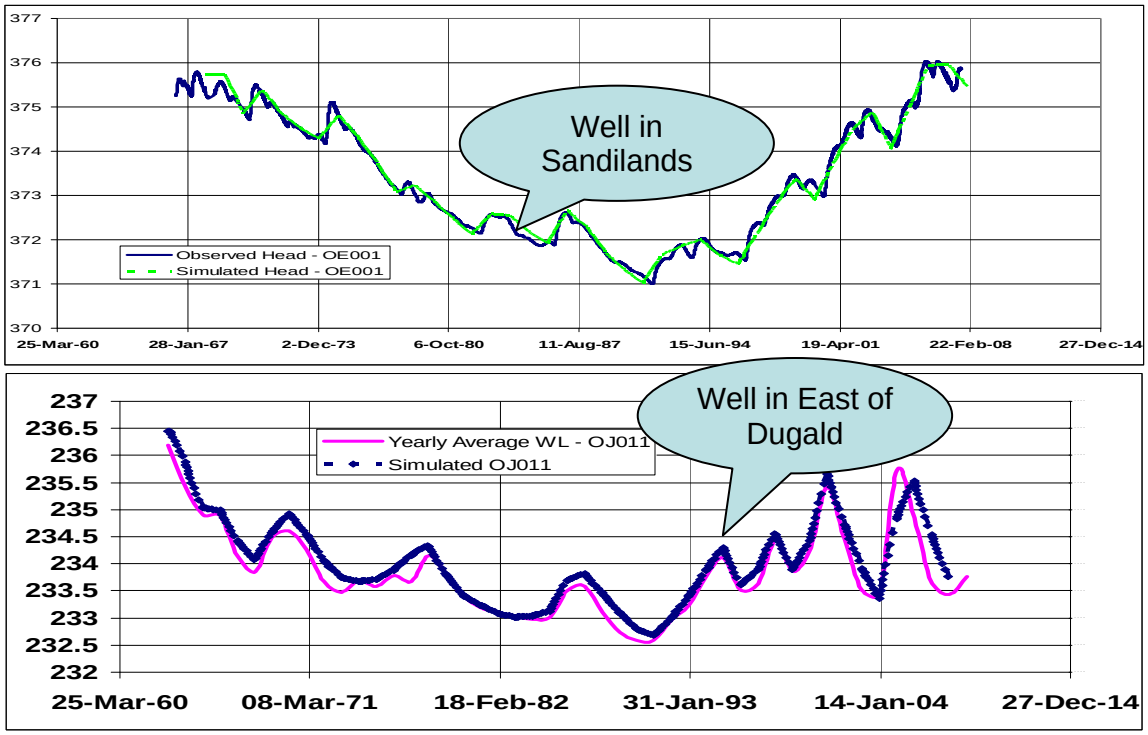


Figure 21: Transient Calibration of Three Dimensional Groundwater Model

4.0 Groundwater Management

During the SRGMP process, a number of issues regarding the region's groundwater resources have been identified by members of the planning group and the general public. Most of the issues relate to sustaining groundwater quality and quantity for future residents of the study area. Dealing with these issues will require significant further definition of the region's groundwater regime, the cooperation of a variety of groups in coordinated activities and the increasing of public awareness and understanding of groundwater and the approaches to its development, conservation and protection.

This management plan is focused on the groundwater regime underlying the entire study area. Future resource and land use management plans (integrated watershed management plans and municipal development plans) will be able to relate to the portion of the plan that underlies their respective areas, confident their actions are in accordance with a co-ordinated approach to the entire groundwater regime. The study area contains portions of nine surface watersheds and 17 planning districts.

4.1 Management Responsibilities and Efforts

The following agencies have responsibilities and/or are putting forth efforts towards the management of the region's groundwater resources.

Manitoba Water Stewardship (MWS) is responsible for the administration and application of Manitoba's Water Policies (1990) and The Manitoba Water Strategy (2003). The current provincial policy objective for water supply focuses on working to develop and manage the province's water resources to ensure that water is available to meet priority needs and to support sustainable economic development and environmental quality.

Manitoba Water Stewardship – Groundwater Management Section provides monitoring and groundwater data compilation and evaluation for the province and advises on groundwater management and protection. The section conducts groundwater studies to enhance knowledge of groundwater resources, provides maps and reports describing local and regional groundwater resources and quality, identifies where groundwater quality problems may/may not occur, and administers GWDrill – a provincial digital database containing geological, hydrogeological, geochemical, and well construction information for test holes and water wells from well driller's reports.

Manitoba Water Stewardship – Water Use Licensing Section evaluates water development proposals and issues or denies water rights licences based on resource availability and third party impacts to meet, in a sustainable fashion, the needs of the environment and of domestic and licensed users.

Manitoba Water Stewardship – Office of Drinking Water seeks to assure the provision of safe, adequate, aesthetically pleasing and acceptable drinking water supplies from source to tap. In this role, they assess water infrastructure, the monitoring of water plants and operators and provide assistance to private and municipal water system owners and operators. Drinking water officers assist water plant operators and are involved in the enforcement of *The Drinking Water Safety Act*, *The Environment Act*, and *The Public Health Act*.

Manitoba Water Stewardship – Water Control Works and Drainage Licensing is responsible for the licensing of (surface) water control works and enforcement of *The Water Rights Act*. Water resource officers assess water rights license applications based on a set of criteria and potential impacts to the area.

Manitoba Conservation - Regional Operations Branch, Environmental Operations and Environmental Services conducts review, inspection, monitoring, investigation and enforcement activities to minimize and mitigate potential impacts to groundwater resulting from livestock manure management practices, leaking or faulty onsite wastewater management systems, petroleum storage facilities or contaminated/hazardous waste or solid waste disposal sites.

Manitoba Conservation – Environmental Assessment and Licensing Branch has a mission to ensure that developments are regulated in a manner that protects the environment and public health, and sustains a high quality of life for present and future Manitobans. The branch carries out its mission by:

- Administering development approval requirements of *The Environment Act, The Dangerous Goods Handling and Transportation Act*, *The Public Health Act*, and the *Pesticides Regulation*.
- Controlling municipal, industrial and hazardous waste sources of pollutants.
- Minimizing environmental impact of development proposals.

- Minimizing adverse effects to the environmental and public health from pesticide use.
- Administering the Water and Wastewater Facility Operators Regulation.

Manitoba Conservation - Regional Operations Branch and Wildlife and Ecosystem Protection Branch conducts review, inspection, monitoring, investigation and enforcement activities to minimize and mitigate potential impacts to endangered species (*The Endangered Species Act* - Manitoba) and protected species (*The Wildlife Act* - Manitoba) and the natural resources that they depend on.

Manitoba Local Government applies the provincial land use policies as it co-ordinates the review and approval of municipal development plans and as it co-ordinates the review of subdivision proposals.

Manitoba Innovation, Energy and Mines seeks to promote wise land management and environmentally sustainable economic development of Manitoba's mineral resources including peat soils.

Manitoba Agriculture, Food and Rural Initiatives (MAFRI) guides and assists the development of sustainable agriculture and rural communities. Some agricultural activities have the potential to improve or adversely affect groundwater resources.

Fisheries and Oceans Canada (DFO) has a regulatory role in assessing the impacts of proposed development projects occurring in and around fish habitat that sustains fisheries resources. They also have many other responsibilities under the Fisheries Act, Species at Risk Act (SARA), and the Canadian Environmental Assessment Act (CEAA).

Cooks Creek Conservation District is responsible for the maintenance of most of the drainage infrastructure within its watershed area east of Winnipeg, and provides input to all water control licensing projects within its district boundaries. They are also involved in tree planting, wetlands/wildlife habitat enhancement, sealing abandoned wells and water retention projects.

Seine-Rat River Conservation District is a watershed-based organization that works to promote the sustainable management of land and water resources in the Seine River and Rat River watersheds southeast of Winnipeg. They are involved in groundwater protection, riparian rehabilitation, youth environmental education, tree planting, water quality monitoring, wildlife habitat enhancement, soil conservation, wetland protection and restoration, and water retention projects.

Rural Municipalities are local government entities established under authority of *The Municipal Act* with the purpose of providing good government, necessary services, desirable facilities, and community safety and protection. Municipalities have certain infrastructure responsibilities that may include water supply, waste water, solid waste, transportation and drainage.

Planning Districts are established, and operate in accordance with, *The Planning Act*. Their key responsibilities include the adoption, administration and enforcement of the development plan for the district, administration and enforcement of member municipal by-laws, or a district-wide zoning by-law and any secondary plans; and building by-laws.

Citizens play an important role in looking after and making wise use of their local water resources. Many common activities such as house and yard water use, on-site wastewater management and drainage can affect surface water and groundwater.

Figure 22 illustrates which agencies and stakeholders are involved in groundwater management and how they interact with one another. The bottom of the pyramid includes stakeholders that are involved in activities that could have potential affects on groundwater. The middle of the pyramid shows the agencies that are involved in groundwater assessment, project approvals and licensing. Manitoba Water Stewardship – Groundwater Management Section is at the top of the pyramid because they hold responsibilities for overall groundwater management and are involved with all activities related to groundwater.

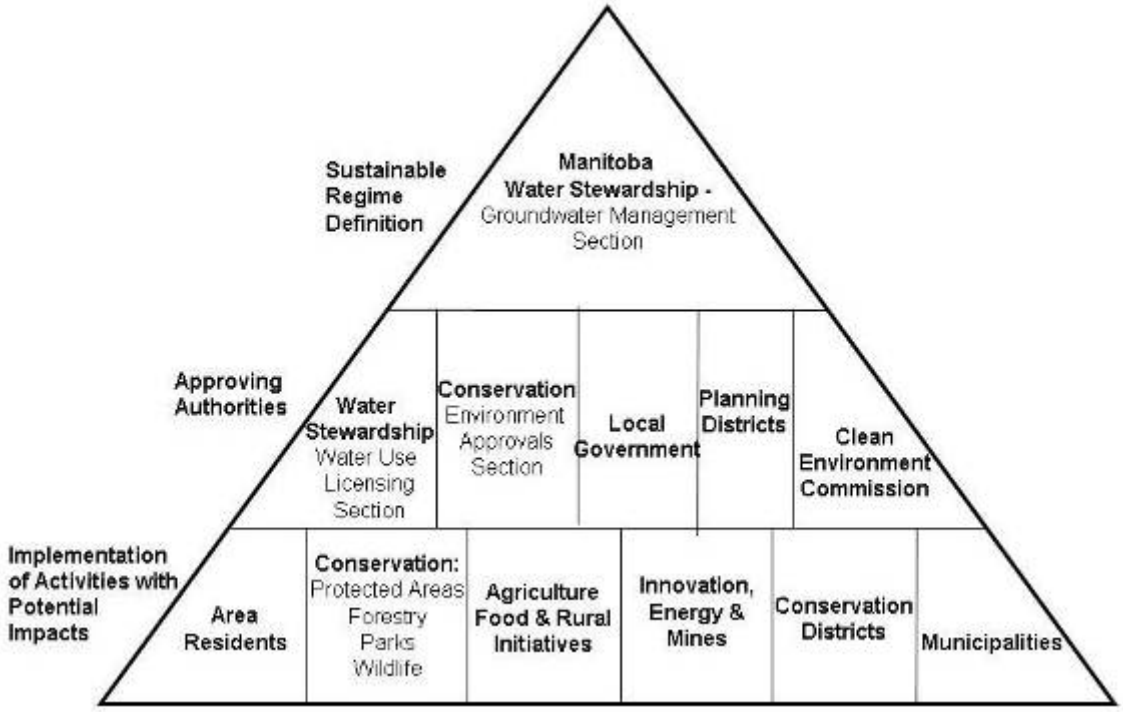


Figure 22: Groundwater Management Responsibilities Pyramid

4.2 Co-ordinating Planning Efforts

During the process of developing municipal development plans and integrated watershed management plans, the planning authorities (municipalities, planning districts or water planning authorities) will consider the SRGMP as a resource to ensure a co-ordinated approach to regional groundwater management.

Land Use Planning
Land use planning in Manitoba is legislated by *The Planning Act* and guided by the Provincial Land Use Policies (PLUPs) (regulation under *The Planning Act*). A requirement of *The Planning Act* is for all municipalities (individual or as part of a planning district) to adopt a development plan by-law and a zoning by-law. Once a municipality adopts a development plan, the PLUPs no longer apply over the affected jurisdiction. The PLUPs are intended to guide sustainable land use and development and contain policies that pertain to water protection, sustainability, agriculture, infrastructure, natural areas, conservation lands, heritage resources, pollution prevention and restrictions on land uses and the locating of structures. Through the process of drafting a development plan, a municipality is required to consider any integrated watershed management plans approved under *The Water Protection Act* and any regulations made under the act that govern, regulate or prohibit any use, activity or thing in a water quality management zone designated under the act.

Groundwater Protection
Manitoba Conservation and Manitoba Water Stewardship play important roles in assessing the impact of developments and activities on groundwater. They issue licenses only after they are confident that the risks associated with the activity have been addressed or minimized. Due to the wide range of potentially hazardous developments and activities that occur throughout the study area, there are many potential risks of groundwater contamination. Although many of these risks are minimized through development licensing processes that place limitations or restrictions on certain things, there are of course, many situations where potentially hazardous activities are not subject to the licensing process and the onus for stewardship remains with the individual.

Source Water Protection Planning
As identified in *The Water Protection Act*, integrated watershed management plans (IWMPs) are required to identify issues related to the protection, conservation and restoration of water, aquatic ecosystems and drinking water sources. This includes source water assessments that are intended to identify all potential threats to source water areas. These are detailed assessments involving mapping and field investigations followed by the development of source water protection plans. Manitoba Water Stewardship is continually improving the source water protection planning process and is ensuring that all IWMPs include a source water protection component.

In the study area, the status of IWMPs is as follows:

- Seine River watershed – planning process was 2006 to 2009. Final Plan is presently going through provincial review. Implementation has started.
- Rat River watershed – planned to begin in early 2010.
- Cooks Creek – Devils Creek watershed – planned to begin in late 2010.

The provincial goal is to have IWMPs for approximately 30 watersheds across municipal Manitoba by 2015. There are currently 22 IWMPs in different stages of development.

Conservation Districts
Conservation districts (CDs) are watershed-based organizations formed as a partnership amongst municipalities and Manitoba Water Stewardship. There are 18 CDs in Manitoba and since 1999 the number of municipalities participating in the program has increased by 197 per cent, from 78 to 154.

Through their abandoned well sealing program, the Seine-Rat River and Cooks Creek Conservation Districts have sealed over 300 abandoned wells over the past 20 years. The program is available to district residents at little to no cost. The conservation districts also provide landowners with groundwater management literature and information on other available water management programs like riparian rehabilitation, water retention, wetland protection/enhancement, and water quality testing.

4.3 Provincial Legislation Related to Groundwater

The Ground Water and Water Well Act
Groundwater resources are managed under *The Ground Water and Water Well Act* and *Well Drilling Regulation*. The act applies to all sources of groundwater and all wells, whether drilled or developed before or after the act was established in 1963. With the exception of controlling the flow from wells and the prevention of polluting groundwater and wells, the act does not apply to a well that is drilled or developed by an owner of his land, using equipment owned by him, for the purpose of obtaining water solely for his domestic use. Specifically, the act:

- licenses all persons engaged in the business of drilling water wells
- allows access and inspection of all wells or operations, and to all records, plants or equipment
- allows undertaking of surveys of groundwater resources and studies of the conservation, development, and utilization of groundwater
- allows control of flow from wells
- requires all reasonable precautions be taken to prevent contamination of groundwater via wells
- allows establishment of regulations related to the conservation, development, and control of groundwater resources and the drilling and operation of wells and the production of groundwater there from

The Well Drilling Regulation provides for:

- the terms of licensing
- collecting well drilling and testing information, maintaining well logs, and submitting well reports
- construction requirements
- control of flow (artesian conditions)
- prevention of contamination of wells and aquifers
- sealing of abandoned wells

The Water Protection Act

The act recognizes that:

- social and economic well-being are dependent on a supply of high quality water
- water and land planning are inextricably connected
- aquatic ecosystems, riparian areas and wetlands require protection
- there is a need to guide decision making using scientific information

The purpose of the act is to protect and promote the stewardship of Manitoba's water resources and aquatic ecosystems. It complements *The Drinking Water Safety Act, The Planning Act* and *The Water Rights Act* and provides for the protection and conservation of water from source to tap. The following outlines the key content areas of the Act.

1. Water protection measures – authority to make regulations to:
    - Establish water quality standards, objectives and guidelines.
    - Designate areas of land as water quality management zones and prescribing activities that are prohibited in those zones.
    - Prohibit activities that adversely affect water quality, water quantity, aquatic ecosystems or a drinking water source.
    - Control the importation and intentional movement and transfer of invasive exotic species in the province.
    - Declare a state of serious water shortage in all or parts of Manitoba and controlling the use of water during serious water shortages.

2. Watershed management planning – authority to make regulations to:
    - Govern the preparation, content, approval, authority and implementation of watershed management plans and to designate water planning authorities.

3. Establishment of the Manitoba Water Council to:
    - Advise and make recommendations on matters related to water, referred to the council by the Minister of Water Stewardship.
    - Co-ordinate the activities of other water related advisory boards established from time to time (ex. The Lake Winnipeg Stewardship Board).
    - Monitor watershed planning in the province being undertaken by water planning authorities.

4. Establishment of the Water Stewardship Fund – to provide grants, in partnership with other governments and stakeholders to;
    - Support research, projects and activities that further the purposes of the act.
    - Assist in the implementation of watershed management plans and water conservation programs.
    - Support other water quality or water management objectives.

5. Amendments to other Acts
    - Amendments to *The Water Rights Act* to require the consideration, establishment and application of in-stream flow and lake reserves to protect the aquatic ecosystem.

- Amendments to *The Ground Water and Water Well Act* to control the construction and decommissioning of groundwater wells and provide for the certification of well drillers.

The Environment Act

Private sewage disposal systems are regulated by the *Onsite Wastewater Management Systems Regulation* under *The Environment Act*.

Livestock operations and manure spreading are regulated under the *Livestock Manure and Mortalities Management Regulation* under *The Environment Act*. As well, the province has prepared a *Farm Practice Guidelines for Hog, Beef, Dairy and Poultry Producers in Manitoba*, and provides a technical review process for new and expanded operations. These processes have been developed to reduce the potential risk of groundwater contamination.

The Mines and Minerals Act

The establishment and operation of quarries are regulated by the *Quarry Minerals Regulation* under *The Mines and Minerals Act*. This regulation states that no operator shall contaminate groundwater, or permit the contamination of groundwater, through the establishment or operation of an aggregate quarry.

5.0 Goals and Recommendations

The four management goal statements are:

- **Further Research**
- **Protect Groundwater Quantity**
- **Protect Groundwater Quality**
- **Public Information and Awareness**

5.1 GOAL: Further Research

The planning process involved the review and study of the existing information on groundwater resources in the region. It has served to emphasize the extent and complexity of the area's hydrogeologic regime and that there is a need for further research within the region. While a good understanding of the groundwater regime has been assembled, the depth of that understanding is not extensive and several regime-related questions are not yet answered definitively. Little quantified information exists on groundwater recharge and discharge areas and magnitude, connectedness of surface water and groundwater, characterization of sand/gravel aquifers, stability of the salt water/fresh water boundaries, significance or potential mitigation of wells interconnecting the Carbonate and Winnipeg Formation aquifers and sustainable yield value or values for the groundwater regime regionally and locally.

Recommendations:

- Continued work to develop and maintain a digital groundwater model of the study area's groundwater regime for future use and application in:
  - defining and managing the groundwater regime
  - maintaining and extending the groundwater monitoring network
  - determining sustainable yield values for aquifers and regions
  - assessing contaminant transport potential and pathways
  - detailing the groundwater component of the area's water budget

  Provide, by 2012, a report on the competency of the model with respect to the above applications.
  Lead: Manitoba Water Stewardship – Groundwater Management

- Design and conduct necessary studies to:
  - identify groundwater recharge and discharge areas for surficial and bedrock aquifers in the region
  - better understand the inter-relationship between wetlands and other surface water bodies and groundwater
  - better understand the effects of forest management and other land use changes on shallow sand/gravel aquifers
  - identify groundwater vulnerability areas for consideration in future land use planning and development

  Lead: Manitoba Water Stewardship – Groundwater Management

- Inventory, evaluate and report on, by 2014, the location, volume, sustainable yield and connectivity of the major sand/gravel aquifers in the study area.
  Lead: Manitoba Water Stewardship – Groundwater Management

- Develop for public release, by 2012, up to date groundwater maps for the study area that identify:
  - aquifer locations and water quality
  - aquifer recharge and discharge areas
  - vulnerability of groundwater to impacts of land-based sources of contamination

  Lead: Manitoba Water Stewardship – Groundwater Management

5.2 GOAL: Protect Groundwater Quantity

The goal of protecting groundwater quantity is to ensure that there is a long-term sustainable quantity of water available for domestic, municipal, industrial, agricultural and ecosystem needs. Groundwater quantity was identified as a primary issue throughout the planning process with concerns expressed on land use planning and continued development, lack of regional water conservation initiatives, water export or diversion, and the threat of climate change. Although there is no evidence that the regional groundwater regime has been overdeveloped/over-allocated, the scientific information on the groundwater resources in the study area continues to be updated and improved.

Recommendations:

- Continue to collect and evaluate information on volumes of groundwater use in the study area.
  Lead: Manitoba Water Stewardship – Water Use Licensing, Groundwater Management, municipalities and local citizens

- Identify uncontrolled flowing wells in the study area and where necessary, work with the landowner to control these flows.
  Lead: Manitoba Water Stewardship – Groundwater Management, municipalities and local citizens

- Evaluate the existing groundwater level monitoring network and publish, by 2012, a report on it's adequacy to help regime definition, sustainable yield estimates, the identification and quantification of regime recharges and discharges, interconnections of the surface and groundwater regimes and predictions of climate change impacts on groundwater levels in the major aquifers. This network should be appropriately integrated with the surface water and precipitation monitoring networks.
  Lead: Manitoba Water Stewardship – Groundwater Management, Surface Water Management, Manitoba Conservation – Wildlife and Ecosystem Protection

- Encourage long-term water supply planning throughout the region.
  Lead: Manitoba Water Stewardship, Manitoba Local Government, municipalities, planning districts, city of Winnipeg and conservation districts

- Work with conservation districts and municipalities in the study area to make use of additional monitoring information from private wells towards a comprehensive well inventory and more comprehensive water level information.
  Lead: Manitoba Water Stewardship – Groundwater Management, municipalities, planning districts, and conservation districts

- Identify and protect groundwater recharge areas and ecologically significant areas dependant on groundwater discharges.
  Lead: Manitoba Water Stewardship – Groundwater Management, Manitoba Conservation – Wildlife and Ecosystem Protection, Parks and Natural Areas, Manitoba Innovation, Energy and Mines, municipalities, and conservation districts

- Maintain existing, and develop new, provincial groundwater conservation strategies, and regulations and policies that maximize the productivity of existing water supply infrastructure and water use through integrating water efficient/conservation technologies and practices, and public education initiatives.
  Lead: Manitoba Water Stewardship, municipalities, and local citizens

5.3 GOAL: Protect Groundwater Quality

The goal of protecting regional groundwater quality for safe, ongoing domestic, municipal, industrial and agricultural use within southeastern Manitoba is a key issue for the management plan to address. Threats to groundwater quality from various current and future land uses and developments throughout the region are perceived by many residents. There are concerns around connecting the Carbonate and Winnipeg Formation aquifers and around intrusion of saline water from the west into study area portions of the Carbonate and Winnipeg Formation aquifers.

Recommendations:

- Evaluate the existing groundwater quality monitoring network and publish, by 2014, a report on its adequacy to help regime definition and quality issues needing attention including;
  - Changes in groundwater quality over time due to natural and anthropogenic effects.
  - Movement of the salt water/fresh water boundary into study area portions of the Carbonate or Winnipeg Formation aquifers. Establish a comprehensive monitoring network dedicated to determining and reporting every three years to involved rural municipalities boundary movements in each aquifer. Incorporate information from existing wells.
  - Degradation of water quality in the Carbonate aquifer from interconnections with the Winnipeg Formation aquifer. Enforce existing legislation to prohibit further interconnections between these aquifers. Investigate the potential to mitigate existing interconnections and report by 2014 on the associated costs and benefits.

  Lead: Manitoba Water Stewardship – Groundwater Management, municipalities and local citizens

- Inventory and seal abandoned wells in the region.
  Lead: Manitoba Water Stewardship – Groundwater Management, Manitoba Agriculture, Food and Rural Initiatives, conservation districts, municipalities and local citizens

- Identify locations of potential sources of groundwater contamination (ex. waste disposal grounds, leaky or faulty septic systems, storage sites of solid and liquid manure) and undertake remediation activities where necessary.
  Lead: Manitoba Conservation – Environmental Services, Manitoba Water Stewardship - Groundwater Management, Manitoba Agriculture, Food and Rural Initiatives, conservation districts, municipalities and local citizens

- Maintain provincial programming to alert the general public of boil water advisories in the study area. Confirm the nature and extent of known or suspected bacteriological quality problem and undertake necessary recommendations to address the problem.
  Lead: Manitoba Water Stewardship - Office of Drinking Water, and Manitoba Health

- Develop appropriate policies and regulations that conserve and protect groundwater with respect to geothermal developments.
  Lead: Manitoba Water Stewardship - Groundwater Management, Manitoba Local Government

- Ensure the continuation of public programs that assist local citizens and agriculturalists with conserving and protecting groundwater resources from contamination.
  Lead: Manitoba Agriculture, Food and Rural Initiatives, Manitoba Water Stewardship and conservation districts

5.4 GOAL: Public Information and Awareness

The public information and awareness goal is intended to provide more groundwater information to regional stakeholders so they will see the value and importance of making the necessary changes in the way they use water, to ensure it remains safe and sustainable.

SRGMP implementation must include an on-going information exchange to regional stakeholders about the state of the region's groundwater resources including the status of resource definition and development, and on-going and planned management activities.

Recommendations:

- Maintain an SRGMP website, providing public access to information documents and maps of southeast region groundwater resources and management activities. The website will add reports and maps, listed in the first three goals, as they are completed. It will also contain a link to information on integrated watershed management planning efforts in Manitoba. Each of the municipalities,

conservation districts and environmental organizations in the region are requested to add a link to the SRGMP website on their websites.
Lead: Manitoba Water Stewardship

- Develop print media and SRGMP website messaging to promote the conservation of groundwater resources, and responsible, sustainable land use practices to protect groundwater.
  Lead: Manitoba Water Stewardship - Groundwater Management, conservation districts and municipalities

6.0 Plan Implementation

The overall success of plan implementation is a cooperative effort involving many agencies throughout the region. In the best interest of managing our valuable groundwater resources, all stakeholders are encouraged to become more active in groundwater protection, conservation and education and awareness initiatives.

Plan Review
The plan will be treated as a living document to allow for the incorporation of new issues or significant groundwater management challenges that arise, and will be reviewed and updated as required. A comprehensive review and revision of the plan will occur within a timeline not to exceed 10 years.

Annual Reporting
Manitoba Water Stewardship – Groundwater Management Section will conduct annual SRGMP progress report meetings involving the original planning group membership. The main purpose of the meetings will be to report on plan progress, research and implementation activities. Other items for discussion will include:

- new issues that require management consideration
- ways to improve the co-ordination of groundwater management activities amongst agencies
- plan review and updates

Appendix 1:

Stakeholder organizations invited to participate in SRGMP

Brokenhead Ojibway Nation	Peguis First Nation
Buffalo Point First Nation	Piney Fine Natural Spring Water
* City of Selkirk	* RM of Montcalm
* City of Winnipeg	* Save Our Seine River Environment Inc.
Custom Vending Corporation Ltd.	Shoal Lake No. 40 First Nation
* International Institute of Sustainable Development	* Town of Niverville
Manitoba Habitat Heritage Corporation	Town of Powerview – Pine Falls
Manitoba Naturalists Society	Town of Ste. Anne
* Manitoba Public Utilities Board	Village of St. Pierre-Jolys
Manitoba Rural Adaptation Council	Water Caucus
* Manitoba Wildlands	Winnipeg Chamber of Commerce
* Nature Conservancy of Canada	

* Audited – organizations that expressed an interest in the planning process but declared that they would audit the process where they would receive all correspondence via email but would not attend meetings