RAT MARSH RIVER WATERSHED

GROUNDWATER RESOURCE INFORMATION

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1.0 INTRODUCTION

Groundwater is a major source of water supply for private domestic use as well as for municipal, industrial, commercial and agricultural purposes within the Rat Marsh River watershed. Groundwater discharge also provides base flow to rivers and streams and contributes water to marshes and wetlands. This makes groundwater a vitally important resource to the watershed.

A review of available groundwater resource information within the Rat Marsh River watershed has been completed using three main sources: groundwater reports, aquifer maps and the provincial computer data base GWDrill (containing well and chemistry information reports). This includes information from a groundwater resource evaluation currently being undertaken by Manitoba Water Stewardship to aid in the understanding of the aquifer systems and aquifer sustainability within the south-eastern region of the province which includes the Rat Marsh River watershed (Wang and Betcher, in preparation).

This report summaries the groundwater information within the Rat Marsh River watershed, and provides a brief overview on the geology and groundwater conditions, provincial groundwater monitoring, acts and regulations, and groundwater issues and concerns within the watershed. A listing of reference material pertaining to the groundwater resources of the watershed is also provided.

2.0 GEOLOGY AND GROUNDWATER CONDITIONS

2.1 Geological Framework

The geological framework of the watershed is somewhat complex. It consists of overburden deposits of silt, clay, till and sand and gravel which are underlain by bedrock deposits. The thickness of the overburden is typically a minimum of about 30 metres (100 feet) in the western lowland portion of the watershed (Red River plain) and increases to greater than 120 metres (400 feet) in the eastern upland portion (Sandilands) of the watershed (Little, 1980). In general,

- overburden materials in the lowland portion of the watershed are primarily lacustrine clay overlying glacial till but also include lenses of sand and gravel as intertill deposits; and

- overburden materials in the upland portion of the watershed include lacustrine clay (which thins and terminates eastwardly), glacial till and fairly extensive (and in some areas complex) glacial deposits of surficial, near-surface, lenses of, and major buried sand and gravel.

The bedrock deposits consist of, in descending order, gypsum/anhydrite, shale and limestone/dolomite of Jurassic age, carbonate (limestone/dolomite) rocks of the Ordovician Red River Formation, shale, sandstone and sand of the Ordovician Winnipeg Formation and Precambrian rocks.

A more detailed description of the geological, geochemical and hydrogeological conditions of the aquifer system can be found in Betcher et al. (1995), Wang et al. (2008), and Phipps et al. (2008).

2.2 Groundwater Availability and Quality

The availability of groundwater varies across the watershed. In general, there is a lack of potable groundwater in the lowland portion of the watershed (ranges 2E, 3E and the western portion of 4E) but potable groundwater is generally available elsewhere in quantities sufficient for private, domestic use. Larger quantities may also be available locally for municipal, industrial, commercial and agricultural uses.

The principle aquifers in the watershed are:

- overburden deposits of sand and gravel;
- carbonate (limestone/dolomite) rocks of the Ordovician Red River Formation; and
- sandstone of the Ordovician Winnipeg Formation.

A description of the availability of groundwater in these aquifers is summarized below.

2.2.1 Sand and Gravel Aquifers

Overburden aquifers occur mainly as areas of major buried sand and gravel and lenses of sand and gravel as shown on Figure 1 (modified after Rutulis, 1986b). They are mostly exploited within the upland areas of the watershed (neighbouring and eastward of the Rat River). Few sand and gravel wells exist to the west of this area (within the Red River plain) as groundwater tends to be of poor quality.

The areas of the major buried sand and gravel include:

- an area that extends from near Grunthal and southeast through the Pansy area. Well information reports from production wells drilled in more recent years suggest this aquifer also extends further south within 4-5E.
- an area between Rosa and Woodmore; and
- an area near Woodridge.

The lenses of sand and gravel occur mainly as intertill and intra-till aquifers and may be found at depths ranging from the shallow subsurface to more than 60 m (200 feet). They can range in thickness from a metre to ten's of metres and can be less than a hectare to several square kilometres in area. In some areas, sand and gravel aquifers are very common but in others they are scarce; two or more sand and gravel aquifers separated in depth by till or clay deposits are also common.

Shallow sand aquifers less than 7 metres (25 feet) in depth also occur throughout parts of the upland areas of the watershed. These aquifers are less commonly exploited because they are more susceptible to contamination from surface sources, often have limited yield because of their shallow depth and more reliable groundwater sources often occur in deeper underlying aquifers.

Well yield in the sand and gravel aquifers is quite variable, typically ranging from about 5 to 25 Imperial gallons per minute (Igpm) (23 to 115 L/min). Higher capacity wells producing in the range of 50 to >100 Igpm (115 to >450 L/min) are common in some areas.

The chemical quality of groundwater in the sand and gravel aquifers within the upland regions of the watershed is generally good to excellent with total dissolved solids (TDS) typically ranging from about 200 to 600 mg/L. Concentrations of naturally occurring arsenic have been found above the drinking water quality guidelines in a small number of wells scattered across the watershed (Figure 3). Hardness, iron and manganese pose aesthetic water quality problems. Nitrate concentrations in the groundwater are typically low.

2.2.2 Carbonate Aquifer

Permeable zones in the carbonate rocks of the Red River Formation consist of fractured zones, bedding planes or solution features through which groundwater can readily flow and be extracted for water supply purposes. It is these permeable zones which form and is termed the carbonate aquifer. The intact carbonate rock matrix itself has a low permeability and does not transmit water at sufficient quantities for water supply purposes. The rock matrix however, as part of the overall carbonate rock system, may receive and transmit substantial quantities of water over long periods of time.

The carbonate aquifer is an important source of water supply in the western and central portions of the watershed. Its approximate boundaries are shown on Figure 2 (modified after Rutulis, 1986a). The depth to the top of the carbonate aquifer varies. It is typically deepest in the south-western portion of the watershed (60 top 90 metres) and becomes shallower from south to north and west to east. It is mostly exploited within townships-ranges 5 & 6-3E, 4, 5 & 6-4E, 4 & 5-5E and 4 & 5-6E.

Well yield in the carbonate aquifer is quite variable. Most often the most highly permeable zones are found in the upper 15 metres (50 feet) of the carbonate rock although permeable zones can occur at any depth. The areal extent, thickness and hydraulic properties of the permeable zones are typically quite variable. Domestic wells generally yield a minimum of 5 to 10 Igpm (23 to 45 L/min). High capacity wells for municipal and other non-domestic uses are common, with yields of 50 to >100 Igpm (115 to >450 L/min) in some areas.

A natural fresh water-salt water boundary exists within the carbonate aquifer. The Red and Rat Rivers represent the approximate boundary between the fresh and salt water. To the west of the Red and Rat Rivers groundwater is brackish to saline (TDS greater than 1,000 mg/L) and usually not a suitable source of potable water. To the east of the boundary, groundwater is fresh. Here, the chemical quality of groundwater in the carbonate aquifer is typically good to fair with TDS usually less than 1,000 mg/L. Concentrations of naturally occurring barium and fluoride have been found above the drinking water quality guideline in water samples from some wells (Figures 4 and 5, respectively). This includes barium within township 5, range 5E and fluoride within township 6, range 3E and townships 4 & 5, range 4E. Hardness and iron pose aesthetic water quality problems. Nitrate concentrations in the groundwater are typically very low.

2.2.3 Sandstone Aquifer

The Winnipeg Formation sandstone aquifer extends throughout the western portion of the watershed and terminates within the central and eastern regions as shown on Figure 6 (Betcher, 1992). The depth to the top of the sandstone varies. It is deepest in the western portion of the watershed, typically ranging from about 120 to 140 metres (390 to 460 feet) below ground surface and becomes shallower from west to east (in some places less than 75 metres (250 feet) deep). It is separated from the overlying carbonate bedrock by a thin layer of low permeability shale which effectively acts as an aquitard except near the eastern boundary of the carbonate rock.

Typically, shallower aquifers (carbonate and sand and gravel) overlying the sandstone aquifer are utilized for water supply purposes providing they produce a satisfactory yield and water quality. However, the sandstone aquifer is used in some areas where the overlying Carbonate aquifer is absent or thin or where it has the potential to provide higher well yields and in some cases softer water. The sandstone aquifer is commonly utilized within the R.M. of De Salaberry, especially in areas located south and east of St. Malo. In particular, portions of township 4 within ranges 4E and 5E have seen significant development and demand for groundwater from this aquifer in the past 10 years.

Well yield from the sandstone aquifer typically ranges from about 20 to 50 Igpm (90 to >230 L/min). Higher capacity wells in the range of 100 to >200 Igpm (450 to >900 L/min) are common in some areas.

A natural fresh water-salt water boundary exists within the sandstone aquifer. The boundary is located to the east of the Red River as illustrated on Figure 6. Groundwater is brackish to saline to the west of the boundary (TDS greater than 1,000 mg/L) and is usually not a suitable source of potable water. To the east of the boundary, groundwater is fresh. Here, the chemical quality of groundwater is typically good with TDS generally less than 1,000 mg/L. Concentrations of naturally occurring fluoride (Figure 5) have been found above the drinking water quality guideline in wells in townships 4 & 5, range 4E. Hardness and iron pose aesthetic water quality problems. Nitrate concentrations in the groundwater are typically very low.

2.3 Recharge and Discharge

Groundwater exists in a long-term balance between recharge and discharge of water within an aquifer system. The fundamental mechanisms contributing to groundwater recharge and discharge are generally well understood. However, details regarding recharge/discharge processes and rates, surface water/groundwater interactions and aquifer/aquitard dynamics are often not well developed. Until recently this was largely the case for the Rat Marsh River Watershed. However, numerical modelling completed as part of the groundwater resource evaluation within the south-eastern region of the province has improved the understanding of recharge processes and rates in the Rat Marsh River watershed (Wang and Betcher, in preparation). The results suggest that recharge rates vary with time and area. For modelling purposes, the rate of recharge has been estimated for several zones within the south-eastern region which includes the clay covered lowlands within the Red River plain, the glacial till covered uplands (area east of the Red River plain to approximately range 8E) and the forest covered area approximately east of range 8E. The average estimates of recharge vary from 10 mm/yr for the clay covered lowlands, to 20 mm/yr for the glacial till covered uplands, to 220 mm/yr for the forest covered area.

3.0 GROUNDWATER MONITORING

Groundwater monitoring is undertaken on a broad provincial scale by the Groundwater Management Section of Manitoba Water Stewardship. This Section maintains an extensive network of over 500 observation wells primarily within agro-Manitoba. Monitoring is carried out to establish trends and observe long-term changes in groundwater levels and water quality in most major aquifers in the province. Groundwater monitoring may also be mandated at specific sites in licences or permits issued under *The Environment Act* or licences issued under *The Water Rights Act*.

Within the Rat Marsh River watershed, a network of observation wells is maintained within the sand and gravel and bedrock (carbonate and sandstone) aquifers. This network has been significantly expanded during the recent groundwater resource evaluation studies within the south-eastern region of the province Wang et al. (2008). The locations of the observation wells in the sand and gravel and bedrock aquifers are shown on Figures 7 and 8 respectively.

Details of the geology, well construction and testing information for the observation wells are contained within the provincial GWDrill data base. Records of water level and water quality are maintained within the provincial GWDrill and HYDATA data bases. Information on well records, water levels and water quality is available upon request from the Groundwater Management Section.

4.0 ACTS AND REGULATIONS

Groundwater is a provincial resource that is regulated under a number of Acts (*The Environment Act, The Water Protection Act, The Drinking Water Safety Act, The Water Rights Act, The Ground Water and Water Well Act, The Health Act* and others) and regulations. Groundwater may also be impacted by developments and so may be considered within *The Mines and Minerals Act* for instance.

The Ground Water and Water Well Act and Well Drilling Regulation are key pieces of legislation for the management and protection of the province's groundwater resources. The Act and Regulation are administered by Manitoba Water Stewardship. The Act applies to all sources of groundwater and to all water wells whether drilled or developed before or after the Act was established in 1963.

5.0 ISSUES AND CONCERNS

There are several issues and concerns related to groundwater within the Rat Marsh River watershed that could be considered in the development of the watershed management plan. These are summarized below.

5.1 Vulnerable Groundwater Areas

Vulnerable groundwater areas are often defined as those areas having high potential for contamination of groundwater from sources at or near ground surface regardless of how local or extensive an aquifer may be. The degree to which aquifers are vulnerable to contamination from the surface will largely depend upon the thickness and properties of the material overlying the aquifer and the properties of the contaminant. As a general "rule of thumb" aquifers that are overlain by six metres (20 feet) or more of low permeability material (such as clay or till) are considered as having low potential for contamination from surface sources. Aquifers consisting of sand and/or gravel or fractured bedrock that are exposed at or near the surface are more vulnerable to water quality degradation from surface activities and would be considered as having higher potential for contamination.

Existing well information records and groundwater maps can be used to help assess the vulnerability of a groundwater area. For example, a surficial geology map for the watershed (Figure 9, after Matile and Keller, 2007) shows the location of surficial sand and gravel deposits (as beach, beach and near shore and glaciofluvial deposits). These areas could be considered as having greater potential for contamination of groundwater because of their relatively unconfined nature. However, additional information on the depth and properties of the deposits, whether they comprise an aquifer and on the type and properties of potential groundwater contaminates would need to be evaluated to assess the actual aquifer vulnerability. In fact, a site specific investigation may need to be undertaken to assess the vulnerability and potential for contamination of groundwater. The degree of detail for a site specific investigation would depend on the proposed site use and potential for contamination of the underlying soil and groundwater.

5.2 Groundwater Quality

The natural quality of groundwater is variable throughout the watershed. The water quality parameters most commonly found naturally at concentrations exceeding drinking water guideline values are total dissolved solids and iron which are based on aesthetic considerations. Hardness is also a common aesthetic problem. Elevated concentrations of naturally occurring trace elements (primarily arsenic in sand and gravel aquifers, barium and fluoride in carbonate aquifers and fluoride in sandstone aquifers) have also been found at concentrations exceeding health guidelines in some areas of the watershed.

Bacteria and nitrate are the most common types of well water contamination found in water samples from private wells. Bacterial contamination tends to be associated with localized sources, as well as shallow and poorly constructed or maintained wells. Nitrate contamination tends to be associated with localized nitrate sources, particularly for shallow wells. The occurrence of bacteria and nitrate is more common in shallow wells completed in unconfined aquifers or in aquifers located close to ground surface rather than in wells completed in confined and/or deep aquifers. In addition, both bacteria and nitrate levels may change over time, varying with both the season and the weather.

Well owners should test their well water regularly to better understand its quality and identify possible health related and aesthetic concerns. However, regular testing is most often not done. Measures could be undertaken as part of the watershed plan to promote the regular testing of well water quality, particularly for the following parameters:

- bacteria
- nitrate
- trace elements (especially arsenic, barium and fluoride)

5.3 Fresh water-Salt water Boundary

The location and potential migration of the natural fresh water-salt water boundary within both the carbonate and sandstone aquifers has been an on-going concern for the RM of De Salaberry and Seine Rat River Conservation District. There is considerable information on the historical position of the boundary and more recently from water quality data (fluid conductivity) collected by the Seine-Rat River Conservation District as part of their well inventory program. A plan of action should be developed to review existing information, assess the current location of the boundary and determine the need for an on-going monitoring program (including short- and long-term objectives) to monitor movement of the boundary. This task could be jointly undertaken by the Seine-Rat River Conservation District, rural municipalities and the Groundwater Management Section.

5.4 Groundwater Monitoring

Significant development and subsequent demand for groundwater has occurred in some parts of the watershed, particularly in the St. Malo area. Areas of significant growth and groundwater use should be identified to determine if there is adequate monitoring of groundwater levels and water quality in these areas, and if not, the need for such monitoring. This task could be jointly undertaken by the Seine-Rat River Conservation District, rural municipalities and the Groundwater Management Section.

5.5 Water Well Construction, Maintenance and Protection

The responsibility lies with the owner of a water well to ensure their well and water distribution system is properly constructed and maintained and that the well provides water that is safe for drinking. Unfortunately, groundwater investigations conducted by Manitoba Water Stewardship throughout regions of the province indicate that well water contamination is often caused by improper or poorly constructed or maintained wells. Wells and water distribution systems also deteriorate over time and at some point will need repair or replacement.

The following measures are recommended to help reduce the risk of well water contamination:

- retain an experienced and licensed well drilling contractor for the drilling and construction of a water well;
- locate the water well at a safe distance from potential sources of contamination and in an area away from surface runoff from potential sources;
- ensure an experienced and licensed contractor completes the hook-up of the water well to the water distribution system (using pitless well construction);
- after the water well has been completed but before it is put into operation, ensure the well, pump and water distribution system are disinfected to kill any bacteria that may be present;
- wells within any designated flood area within the watershed should have adequate well head protection to ensure flood waters do not enter directly into the well; and
- ensure old wells are properly sealed to the guidelines recommended in Manitoba's Guide for Sealing Abandoned Water Wells (Manitoba Conservation, 2002).

The above measures could be incorporated into future source water/well head protection plans for the watershed.

5.6 Flowing Well Areas

The approximate boundaries of major flowing well areas within the watershed are illustrated on Figure 10 (Rutulis, 1978). The main concern regarding flowing well areas is the potential for the uncontrolled discharge of water from a well and the resulting loss of the valuable groundwater resource. The uncontrolled discharge of water could also contribute to local drainage and foundation problems. In order to avoid these potential problems it is advisable to ensure that proper well construction methods are used in these areas so that any discharge of water from the well can be controlled.

Note that the map does not reflect flowing well information that may have been collected since 1978. Subsequently, caution should be taken in using it to define all flowing well areas within the watershed.

6.0 GLOSSARY OF GROUNDWATER RELATED TERMS

Aquifer – A water bearing geologic formation that is capable of producing water to wells or springs in sufficient quantities to serve as a source of water supply.

Aquifer System – A hydraulically interconnected layered rock sequence including both aquifers and aquitards, which forms an identifiable unit between the recharge and discharge areas of a groundwater flow system.

Aquitard – A confining bed that retards but does not prevent the flow of water to or from an adjacent aquifer. An aquitard does not readily yield water to wells or springs, but may serve as a storage unit for groundwater.

Arsenic – Most of the arsenic found in Manitoba well water occurs naturally. It is a result of groundwater coming into contact with rocks or soils containing arsenic. The maximum acceptable concentration for arsenic in drinking water is 0.01 mg/L.

Bacteria – A microscopic organism that includes total coliform and E.coli bacteria. Groundwater is not a natural medium for total coliform bacteria, so their presence is used as an indicator of water contamination. The maximum acceptable concentration for drinking water is zero total coliform organisms per 100 mL.

Barium – Barium found in Manitoba well water usually occurs naturally. It is the result of groundwater coming into contact with bedrock or minerals containing barium. The maximum acceptable concentration for arsenic in drinking water is 1.0 mg/L.

Base Flow – That part of the stream flow that is derived from inflow of groundwater to the stream.

Confined Aquifer – An aquifer bounded above and below by impermeable beds, or by beds of distinctly lower permeability than that of the aquifer itself; an aquifer containing confined groundwater.

Discharge – As related to aquifer discharge, groundwater flows towards the surface and may escape as a spring, seep, or base flow or by evaporation or transpiration.

Electrical Conductivity (EC) – Capability of a unit volume of water containing dissolved inorganic chemical constituents to conduct electric current. Electrical conductivity generally increases linearly with increases in total dissolved solids. The values are expressed as the reciprocal of electric resistance at 25 degrees C, as microsiemens per centimeter (µS/cm).

Fluoride – Fluoride is a naturally occurring trace element found in low concentrations in nature. It is present in most geologic environments but particularly in igneous and sandstone rocks. The maximum acceptable concentration for fluoride in drinking water is 1.5 mg/L.

Glacial Till – An unsorted glacial sediment deposited directly by the glacier. It may vary from clays to mixtures of clay, sand, gravel and boulders.

Groundwater – All water under the surface of the ground, whether in solid or liquid form.

Guidelines for Canadian Drinking Water Quality – Published by Health Canada on behalf of the Federal-Provincial-Territorial Committee on Drinking Water. Guidelines are either

- health-based which are established on the basis of comprehensive review of the known health effects associated with each contaminant, on exposure levels and on the availability of treatment and analytical technologies, and are listed as Maximum Acceptable Concentrations (MAC);
- based on aesthetic considerations (e.g., taste, odour) which take into account when these play a role in determining whether consumers will consider the water drinkable, and are listed as aesthetic objectives (AO); or
- based on operational considerations which factor in when the presence of a substance may interfere with or impair a treatment process or technology (e.g., turbidity interfering with chlorination or UV disinfection) or adversely affect drinking water infrastructure (e.g., corrosion of pipes), and are listed as Operational Guidance Values (OG).

Hardness – Water hardness is a traditional measure of the capacity of water to react with soap. Hard water requires a considerable amount of soap to produce a lather, and it also leads to scaling of hot water pipes, boilers and other household appliances. In fresh waters, the principal hardness-causing ions are calcium and magnesium. Although hardness may have significant aesthetic effects, a maximum acceptable level has not been established because public acceptance of hardness may vary considerably according to the local conditions.

Iron – The most common sources of iron in groundwater are naturally occurring, for example from weathering of iron bearing minerals and rocks. The aesthetic objective for iron in drinking water is ≤0.3 mg/L.

Inter-till – Deposits of glacial gravels, sands and silts positioned between layers of glacial till.

Intra-till – Deposits of glacial gravels, sands and silts positioned within a layer of glacial till.

Manganese – The most common sources of manganese in groundwater are naturally occurring, for example from weathering of manganese bearing minerals and rocks. The aesthetic objective for manganese in drinking water is ≤0.05 mg/L.

Natural Occurring Trace Elements – Trace elements are sometimes found in well water at concentrations exceeding health guidelines. In Manitoba, the trace elements arsenic, barium, boron, fluoride and uranium are naturally occurring and are a result of groundwater coming into contact with rocks, minerals or soils containing these elements.

Nitrate – The main form in which nitrogen occurs in groundwater. Decaying plant or animal matter, agricultural fertilizers, manure and domestic sewage are all sources of nitrate. The maximum acceptable concentration for nitrate (as nitrogen) in drinking water is 10 mg/L.

Observation Well – A well used for the purpose of collecting groundwater information such as groundwater levels or quality.

Permeability – The ability of a water bearing material to transmit water.

Pitless Well Construction – Refers to use of a specially designed underground discharge assembly which is attached to a water well casing to provide a frost-free connection and water tight seal.

Potable – Suitable or safe for drinking.

Recharge – As related to aquifer recharge, water that moves from the land surface or the unsaturated zone into the saturated zone.

Total Dissolved Solids (TDS) – TDS refers mainly to the inorganic substances that are dissolved in water. The effects of TDS on drinking water quality depend on the levels of its individual components; excessive hardness, taste, mineral deposition and corrosion are common properties of highly mineralized water. The aesthetic objective for TDS in drinking water is 500 mg/L.

Unconfined Aquifer – An aquifer in which there are no confining beds between the capillary fringe and land surface, and where the top of the saturated zone (the water table) is at atmospheric pressure.

Unsaturated Zone – The zone between the land surface and the water table.

Water Table – The upper surface of groundwater below which soil is saturated with water that fills all voids and interstices, and where the pressure of water in the soil equals the atmospheric pressure.

Well Head Protection – Refers to protecting the water well and immediate area around the well from sources of potential groundwater contamination.

7.0 REFERENCES

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