Birdtail / Assiniboine West (05ME) Integrated Watershed Management Plan: State of the Watershed Report Groundwater Resources

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Summary

Groundwater is the responsibility of the province and therefore the province has a number of Acts and regulations to protect and regulate the development this resource. To understand groundwater in the Birdtail / Assiniboine West watershed the province, starting in 1958, has undertaken a number of studies and currently operates three monitoring wells. In addition the province licenses water well drillers and also collects and stores information about water wells. There are approximately 2550 well logs on file for this watershed.

Over 85% of the wells on record within the Birdtail / Assiniboine West watershed are used to provide water for domestic users. Production wells are almost equally split between those completed into overburden aquifers and bedrock sources. Groundwater can be had from either of these sources from most areas of the watershed.

Sand and gravel aquifers are found in the overburden commonly as discrete buried lenses or layers. Major buried sand and gravel aquifers are located in the Birtle area. Shallow aquifers exist in the McAuley / Beulah area and on the western side of the watershed, within a few kilometers of the provincial border. At the extreme south and in central and northern portions of the watershed sand and gravel aquifers are sparse. The upper surface of sand and gravel aquifers range from the near surface up to 150 metres deep and average 40 metres deep. The reported well yield is highly variable from place to place but is generally sufficient for most domestic requirements.

Water quality within sand and gravel aquifers is also highly variable. Most groundwater sources exceed one or more of the aesthetic objectives for drinking water. Total dissolved solids average 1,440 mgL^{-1}; the water is generally hard and iron and manganese are commonly present. The dissolved solids are mostly made up of calcium, magnesium, sodium, bicarbonate and sulphate; and with increasing TDS greater concentrations of sodium, sulphate and chloride are common.

The Odanah shale, which is present throughout most of the watershed, forms the bedrock water source. Wells completed into bedrock yield between 0.02 Ls^{-1} and 50 Ls^{-1} ; averaging 2 Ls^{-1}. The TDS is somewhat higher than water from sand and gravel aquifers, with greater than 3,000 mgL^{-1} maximum and 1,530 mgL^{-1} average. In addition to TDS, water quality is also affected by iron, manganese and hardness.

Overburden thickness is highly variable. The greater the thicknesses of the till overburden will restrict the amount of recharge to underlying aquifers but it will also provide a greater amount of protection to these same aquifers.

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Introduction

Groundwater, like most natural resources, is the jurisdictional responsibility of the provinces. The transfer of responsibility for water from the federal government to the provinces began with *The Natural Resource Transfer Agreement* in 1930, and although groundwater was not specified, it was assumed to be included. In the same year Manitoba passed the *Water Rights Act* which was consequently amended in 1959 to include groundwater. The 1959 *Water Resources Administration Act* was established to create a comprehensive water management agency. Shortly after, *The Ground Water and Water Well Act* (1963) passed and was meant to address drilling practices and groundwater data collection. Groundwater is regulated under a number of provincial acts including *The Environment Act, The Water Protection Act, The Health Act, The Drinking Water Safety Act, The Water Resources Conservation Act, The Planning Act, The Water Rights Act, The Ground Water and Water Well Act* and subsequent Regulations.

Early regional studies of groundwater and aquifers in Manitoba were carried out by the federal government. These consisted of door to door well surveys, township summaries of water supply and quality, regional maps of surficial geology, well locations and producing zones. Formal studies of groundwater were initiated by the province in the late 1950's and by the mid 60's the Groundwater Management Section began operating a monitoring well network.

The Groundwater Management Section (GMS) of Water Stewardship advises on groundwater management issues including allocation of groundwater and groundwater protection. The GMS operates a monitoring well network, from which data on groundwater conditions such as water levels and water quality is collected, stored and compiled. Studies meant to address specific aquifer or groundwater concerns have been carried out by the section as have regional groundwater resource mapping. Systematic hydrogeologic mapping was conducted from the 1960's through the 1980's consisting of regional stratigraphic drilling, pump testing, well data and quality compilations resulting in 11 regional groundwater availability map series on a scale of 1:250,000. The Section has also prepared reports on hydrogeology and groundwater resources at various scales including towns, drainage basins, municipalities, planning districts and watersheds over the years.

The Ground Water and Water Well Act and Well Drilling Regulation require that water well drillers be licensed by the province and that the driller supply the province with a report of wells drilled. The report should contain information on date, ownership, the well location, a description of the material drilled, and information on well construction and pump testing if completed. This information is stored within a database in the Groundwater Management Section.

A glossary of select terms used in this report is provided in Appendix A.

Groundwater Backgrounder

Groundwater is water that fills the pores and fractures in the ground. At some point as water recharges the soil and moves down through the profile all of the pore space will be saturated. The surface where this occurs is called the water table. Not only must sediment or rock be saturated to recover groundwater, it must also be permeable enough to allow the water to move at a reasonable rate. Because these properties are largely controlled by the material the water is moving through the geology of the formations are important in understanding water movement. Additionally the natural water quality which the water acquires is highly dependent upon the materials it flows through.

Aquifers and Aquitards

A geologic formation from which economically significant quantities of water flows to a spring or can be pumped for domestic, municipal, agricultural or other uses is called an aquifer. From glacial times (the Quaternary period of geologic time) and on, aquifers are primarily formed within sand or gravel deposits. Within pre-glacial or bedrock formations, aquifers are formed from sandstone, hard fractured shale/siltstone, permeable limestone, or fractured granitic or metamorphic rocks. Aquifers can be separated vertically by less permeable layers; layers that do not readily allow water flow or act as barriers to flow. These confining layers are called aquitards and are principally formed from glacial till or clay deposits in Quaternary sediments or by unfractured or soft shale, massive or unfractured limestone, or gypsum in bedrock layers.

During recharge water moves vertically through the soil and shallow geologic horizons until it reaches the water table. The water table can be determined within a shallow dug or drilled hole by allowing the water level to come to a static or resting position. In permeable material the water table forms the top of an unconfined aquifer. In an unconfined aquifer the water table and consequently the amount of water in storage, changes over the seasons or longer climatic periods as water levels fluctuate in response to recharge or discharge from the aquifer.

If an aquifer is situated between aquitards and the water level in a well rises above the base of the upper confining unit the aquifer is called a confined aquifer. In a confined aquifer all of the pore space is filled with water and any addition or reduction of water in storage results in a change of water pressure in the aquifer. When the pressure in the aquifer is above the local ground surface, drilling into this formation will result in a flowing artesian well. Confined aquifers are recharged either at a location of higher elevation where the aquifer is no longer confined or it is recharged slowly, through the layers that confine it.

Groundwater discharge can be dispersed over large areas or focused, such as in springs and commonly discharge areas are topographically controlled. Springs form where the water table intersects the ground surface, commonly in depressions or hillsides, including river banks.

If a higher permeability layer overlies a lower permeability layer on a hillside or river bank the vertical flow of groundwater may be impeded by a low permeability layer causing the water to move laterally to discharge as a spring. Some springs are formed from flowing artesian aquifers where water moves up along fractures or are man-made resulting from unsealed boreholes or blow-outs at the bottom of excavations. Groundwater may also discharge over larger areas resulting in perennially wet areas, bogs or swamps.

Groundwater Flow

Groundwater moves from higher elevation to lower elevation or from higher pressure to lower pressure. The height of the water table or the pressure in an aquifer is called the hydraulic head. The difference in hydraulic head in an aquifer between two locations is used to determine the hydraulic gradient. The groundwater flow direction is from the higher to lower hydraulic pressure along the maximum slope of the hydraulic gradient. Under ambient conditions, groundwater typically moves quite slowly. In a prairie pothole landscape, sloughs will focus recharge into very localized flow systems. In these settings the water table may be high under the sloughs; the amount of recharge coming from sloughs will greatly depend upon the location of the slough in the landscape and the material underlying the slough. The ability for a geologic material to move water is called hydraulic conductivity. The amount of groundwater that moves through a geologic material will depend upon the hydraulic gradient, the hydraulic conductivity and the thickness of the aquifer or aquitard. In unconfined aquifers the water table loosely mimics the surface elevation and in areas of low topographic relief the typical hydraulic gradient is in the range of one metre of water head decline per kilometer distance.

Aquifer Studies and Groundwater Data

The Birdtail / Assiniboine West watershed lies totally within the Riding Mountain (62K) map sheet (Sie, 1978). The groundwater resources in this map series was compiled by the province on a 1:250,000 map scale in 1978. The province also completed a number of planning district and municipal groundwater reports including the Groundwater Resources in the Town of Birtle Planning District (A Synopsis) (Rutulis, 1985), Groundwater Resources in the R.M. of Miniota Planning District (A Synopsis) (Rutulis, 1982), Groundwater Resources in the R.M of Rossburn Planning District (A Synopsis) (Rutulis, 1989), Groundwater Resources in the Town of Russell (A Synopsis) (Rutulis, 1983), and Groundwater Resources in the Russell - Binscarth Planning District (A Synopsis) (Rutulis, 1985).

The provincial Groundwater Availability Studies include a set of diagrams showing the map sheet location, drift thickness, bedrock topography, surface deposits, a number of cross-sections and a table of selected well water chemistry. The Groundwater Availability series have formed the main regional scale compilation of groundwater data to date. The groundwater synopsis consists of a brief description of groundwater resources and includes maps.

Groundwater Data and Monitoring

The Groundwater Management Section of Water Stewardship maintains a database of well logs for the province. There are approximately 2550 wells and test hole records in the Birdtail / Assiniboine west watershed (Figure 1).

Within the watershed approximately 1,500 logs were completed as production wells and 930 logs were from test holes. The remainder was classified as monitoring wells or other uses. Eight hundred and thirty drill holes ended in shale; the remainder ended in overburden. There is an almost equal split of wells completed in overburden and wells completed in bedrock. Almost 690 wells or just under one-half the production wells were completed within shale aquifers. The bulk of the remainder was reported to be completed in sand and gravel aquifers.

The province initiated test drilling in 1958 in the Russell area, followed by test drilling in the Rossburn, Miniota and Russell during the early 1960's, and Binscarth and Angusville during the latter 1960's. There are 234 records of provincial test drilling (Figure 2). Of these, 102 were completed as observation wells with at least one observation; three of which are currently actively monitoring water levels. The longest running monitoring well has collected water level measurements since 1964 (Figure 3) and is located at SE 36-19-25 W1, near Rossburn. The hydrograph from this well clearly shows the lower water conditions during the 1980's drought conditions.

The province also warehouses groundwater chemistry information from provincial monitoring wells, private wells sampled during various groundwater projects and results that are supplied to the province from drillers or other sources. Only three provincial test / observation wells have chemical analysis. The chemistry from the provincial monitoring wells is available to the public.

Bedrock Aquifers

The Odanah member of the Pierre Shale Formation consists of brittle layers of rock separated by of softer clay layers, commonly bentonite. Fractures can form within the brittle layers which store and transmit water. The Odanah forms the uppermost bedrock unit beneath most of the watershed. The soft Millwood shale aquitard underlies the Odanah and forms the uppermost bedrock unit in areas where the Odanah has been eroded. These areas lie along the Assiniboine and Birdtail and associated valleys.

Water supply from wells completed in the Odanah shale is less than adequate to adequate for most domestic needs. Driller's well test yields from the Odanah shale vary from less than 0.02 Ls^{-1} to 50 Ls^{-1} and average 2 Ls^{-1}. The total dissolved solids (TDS) of the Odanah ranges from 420 to greater than 3,000 mgL^{-1} and averages 1530 mgL^{-1} (Figure 4). The dissolved constituents primarily consist of sodium, (Na) calcium (Ca), magnesium (Mg), sulphate (SO_4), bicarbonate (HCO_3) and occasionally chloride (Cl). Lower TDS waters are predominantly Ca-Mg-HCO_3 with increasing sulphate, sodium and chloride associated with increasing TDS. Hardness ranges from 50 to greater than 1000 mgL^{-1} $CaCO_3$ (approximately 3 to 60 grains per gallon) and averages 400 mgL^{-1} $CaCO_3$. Iron and manganese range from less than detection to greater than 3 mg/L and 1.8 mg/L, respectively. This corresponds to almost 40% of the Fe and 90% of the Mn sample results are above the aesthetic value for drinking water quality.

The top of the Millwood shale should adequately define the base of potable groundwater exploration throughout most of the watershed. Groundwater from bedrock below this will be increasingly brackish or saline.

Valleys cut into the bedrock may contain permeable sediment. Extensive erosion and deposition prior to glaciation formed aquifer systems such as the Hatfield Valley which has been quite well defined on the Saskatchewan side of the border. These valleys may be infilled with Tertiary age sediments and / or Quaternary (glacial) sediments. The extension of the Hatfield Valley in Manitoba lies between Roblin and Russell but has not been well defined. The glacial Assiniboine River has cut into the underlying bedrock during glacial melt; the lower portion has been infilled with alluvial sediments. Further work is required to explore and define buried valleys that contain sediments suitable for forming aquifers.

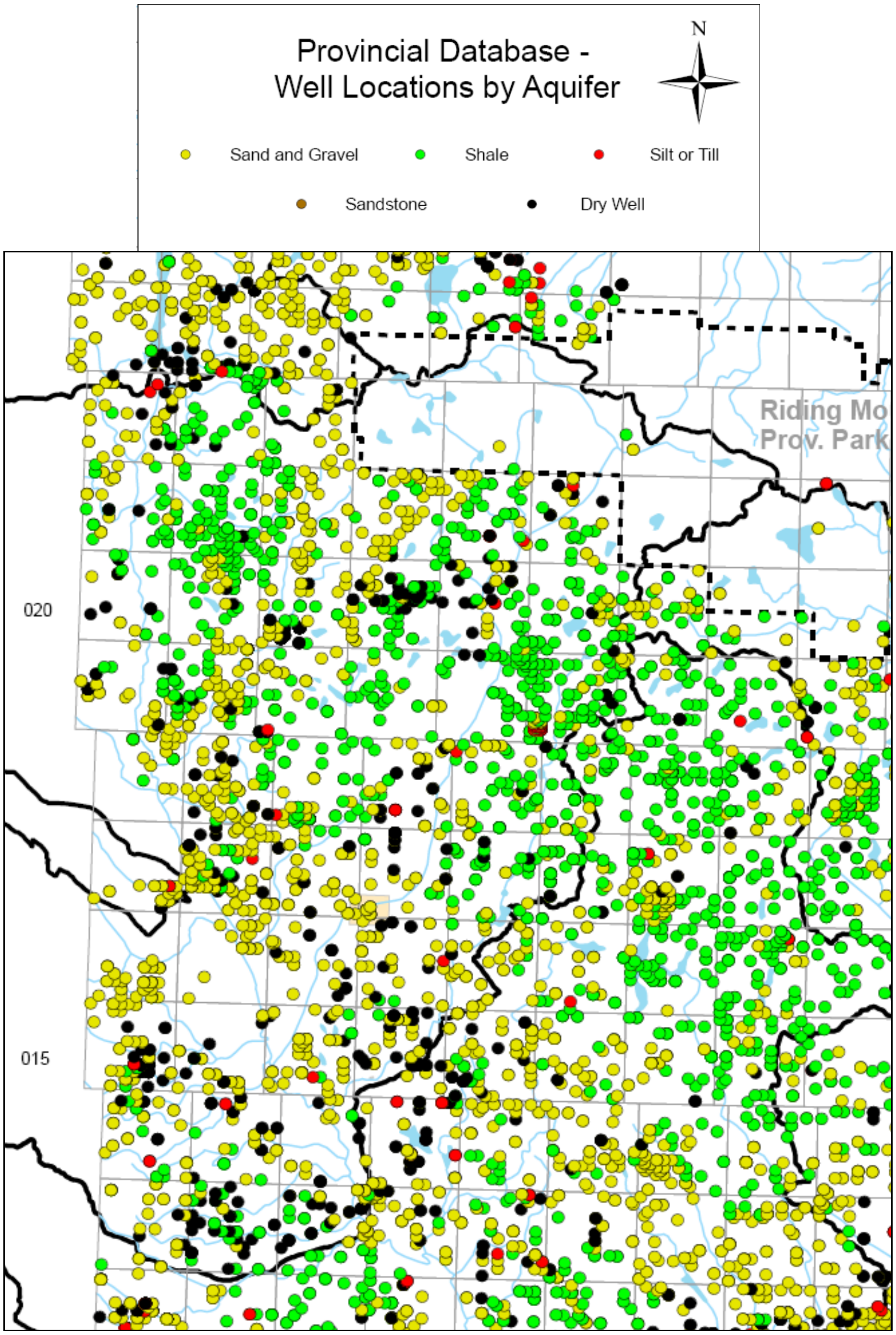

Figure 1. Well log locations from the provincial well database coded by aquifer material in which the borehole ended or was completed into. Wells are displayed in the centre of the quarter-section in which they are drilled unless more accurate information is available. Multiple wells may be stacked at any one location. There are approximately 2550 well logs recorded within the watershed.

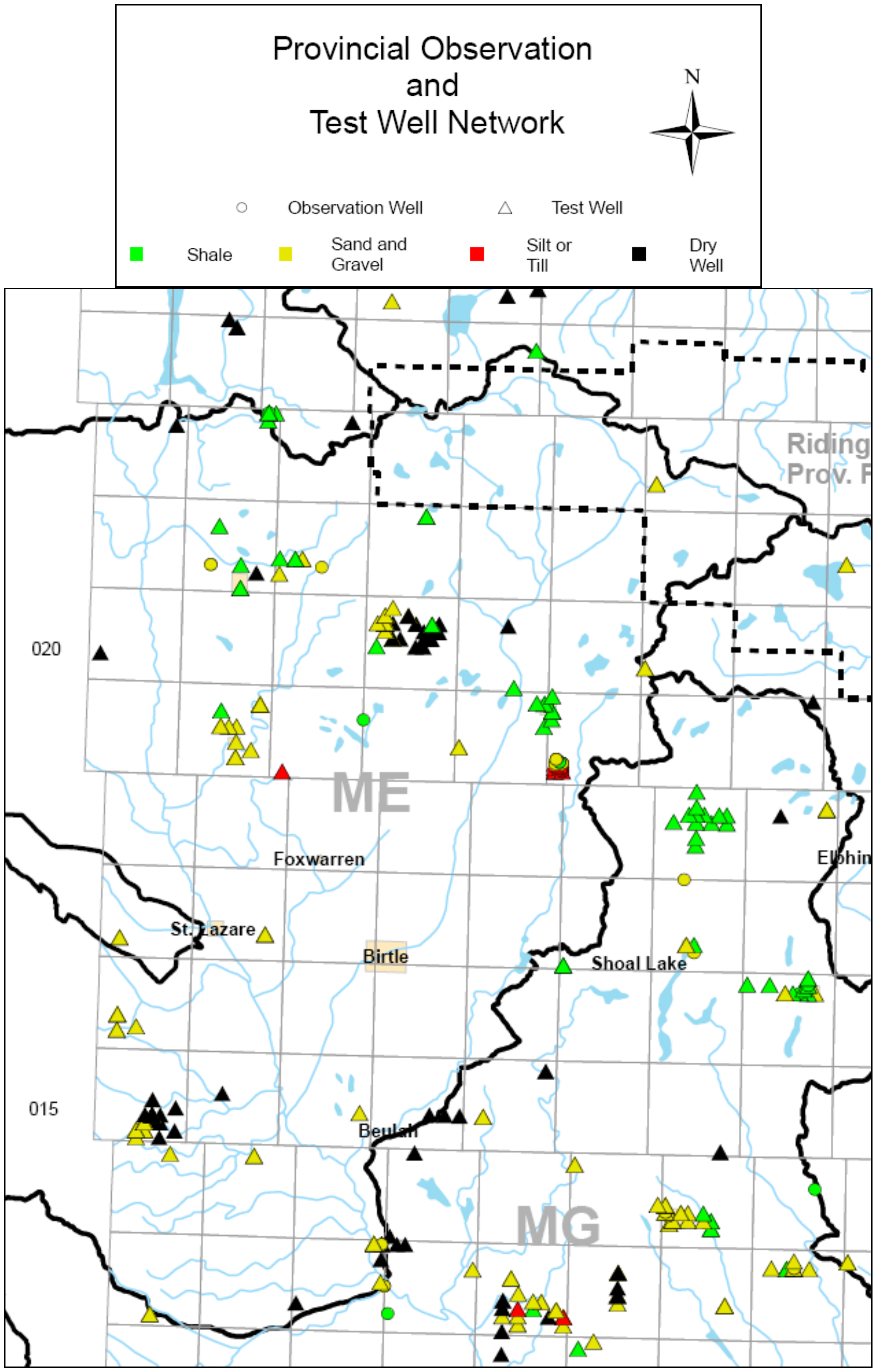

Figure 2. Location of Groundwater Management's drilling activity including status for the watershed and surrounding area. There are currently three active stations in the watershed.

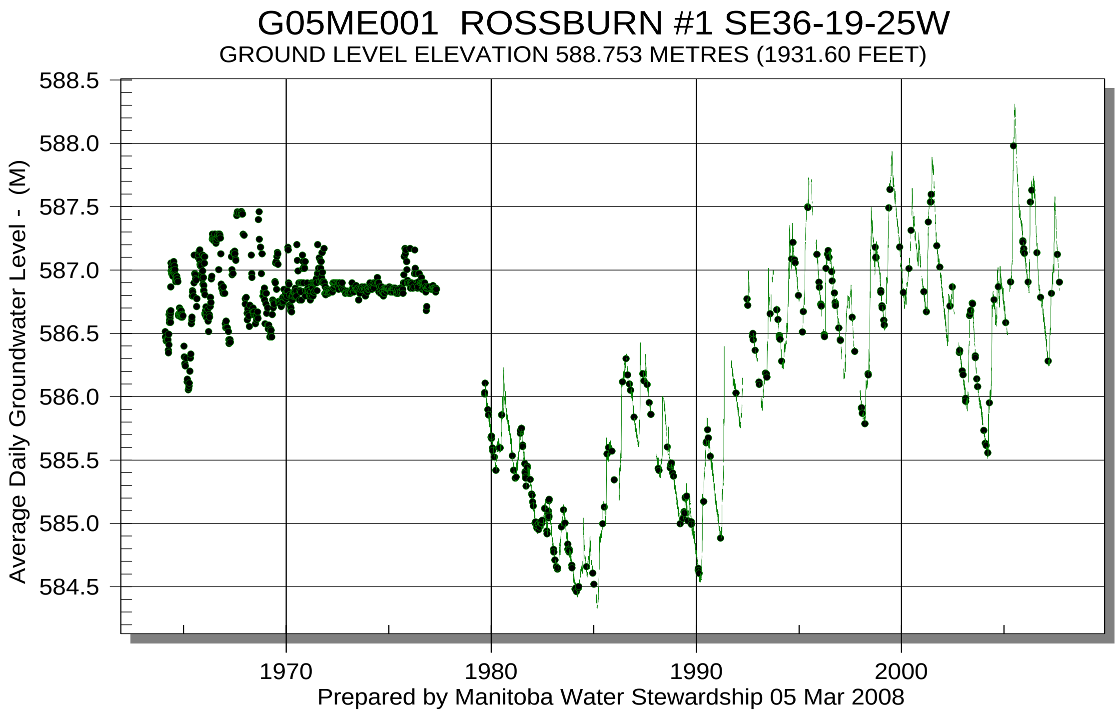

Figure 3 Groundwater elevations were manually monitored at station G05ME001 until 1979 when a Stevens continuous recorder was installed. This station is completed into shale with perforations between 6 and 16 metres below ground.

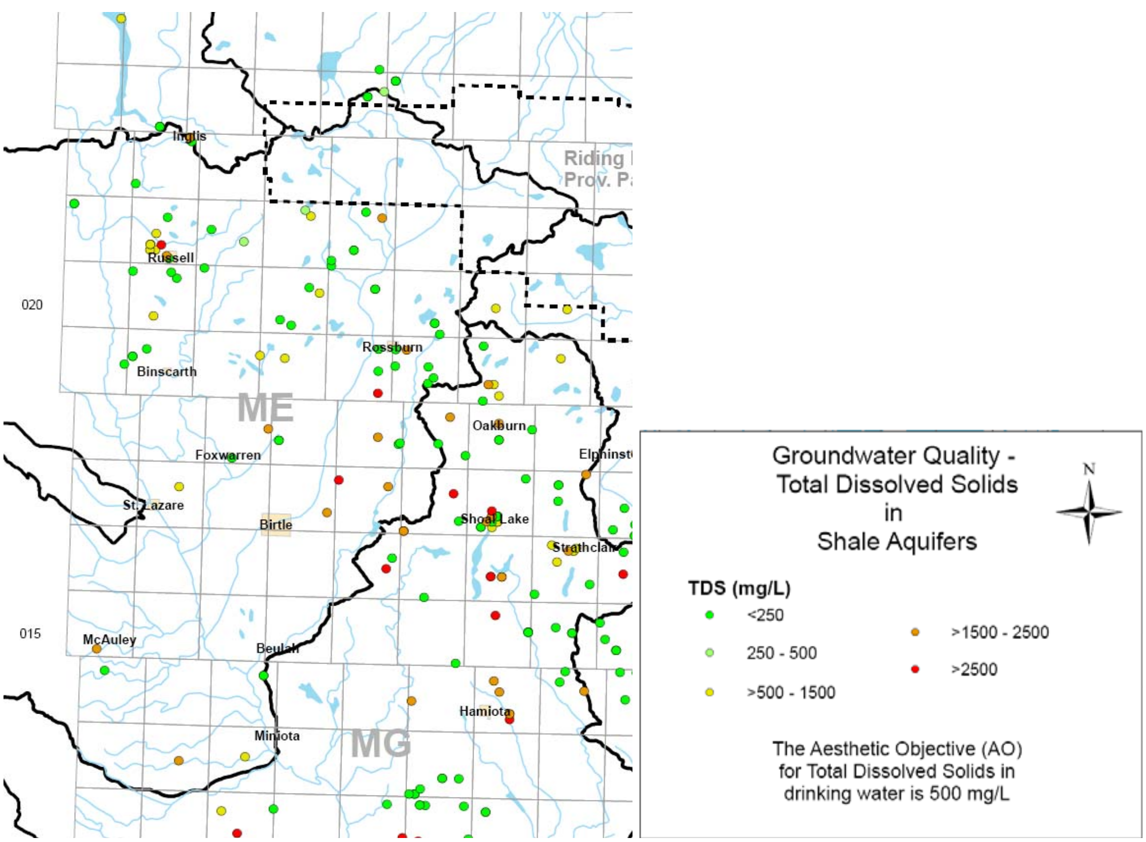

Figure 4. Display of total dissolved solids (TDS) in groundwater from shale wells within the watershed and surrounding area.

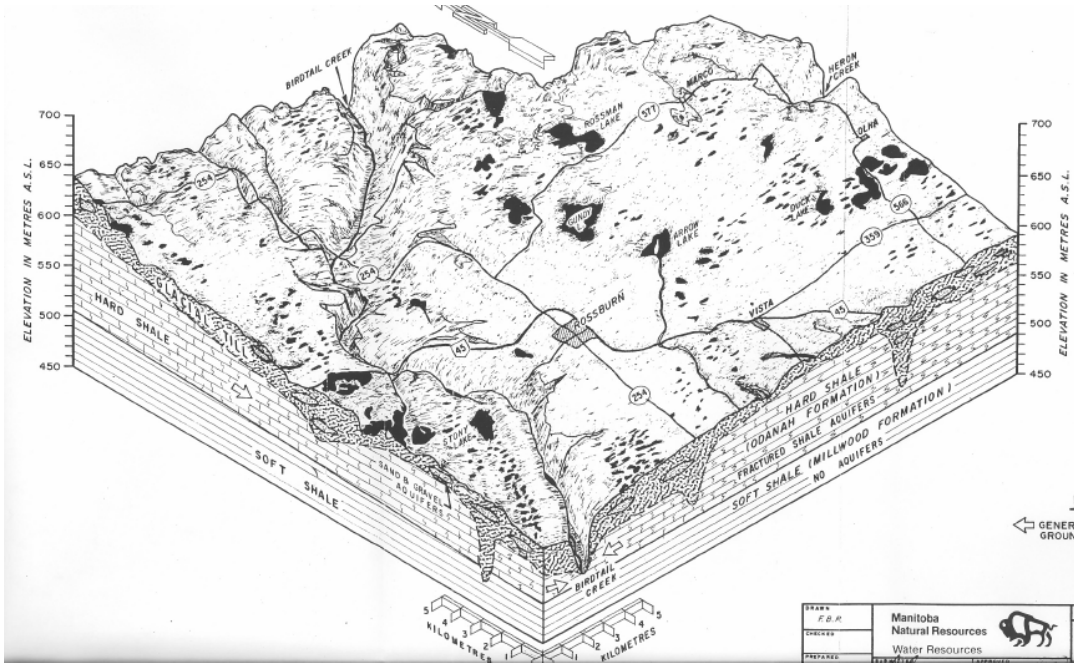

Figure 5. Block Diagram of the Rossburn planning district showing a schematic depiction of the distribution of aquifers in the area. Few sand and gravel aquifers are scattered throughout the area; whereas most of the area is underlain by shale aquifers (Rutulis, 1986). Arrows indicate a generalized flow of fresh water. Recharge to confined sand and gravel aquifers will be highly dependant upon the characteristics of the overlying glacial till.

Sand and Gravel Aquifers

Within glacial and recent sediments aquifers are formed as sand and gravel within or at the base of glacial till, surface or near surface outwash or alluvial sand deposited from modern or ancient rivers. Most sand and gravel aquifers within the watershed consist of buried lenses of sand and or gravel. These occur throughout the central and much of the northern areas of the watershed (Figure 6). Unconfined aquifers are found on the western edge of the watershed, north of St. Lazarre and between McAuley and Beulah (Figure 6). Major buried sand and gravel aquifers are present within an arch centered above Birtle. There are significant areas where there are only few scattered sand and gravel aquifers. In these areas users must rely upon the Odanah shale, if possible, for their groundwater supply. Sand and gravel aquifers range from a few metres below ground up to 150 metres depth. Thicker till units will restrict the recharge rate but will provide a greater amount of protection to the underlying aquifers. The recharge rate to most confined sand and gravel aquifers will be highly dependant upon the thickness and also the properties of the overlying glacial till material..

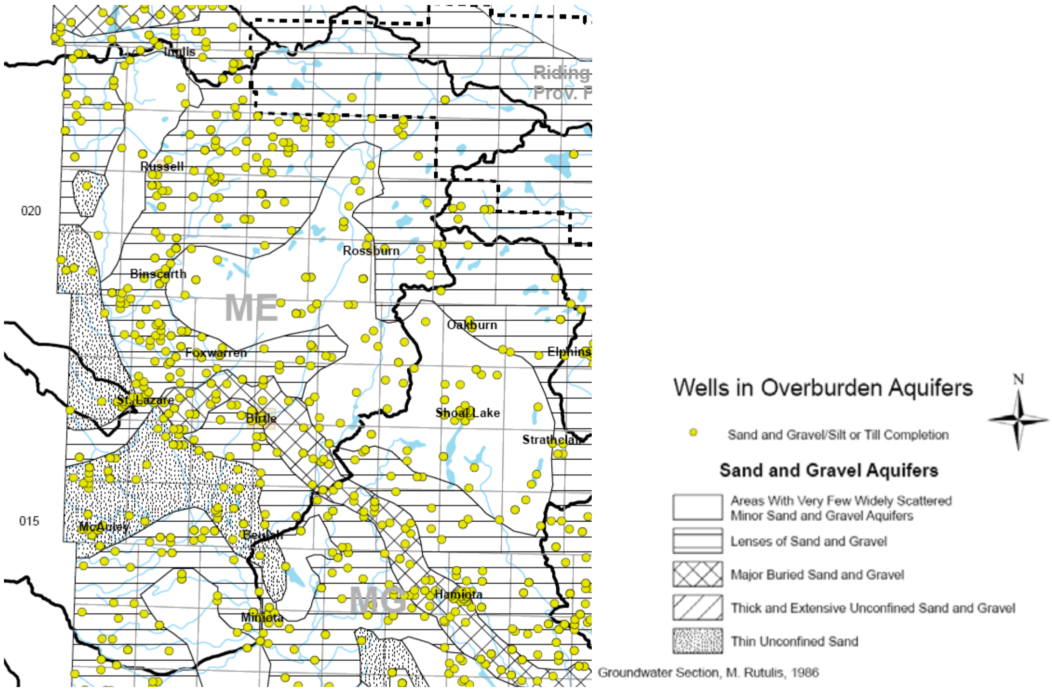

Figure 6. Diagram showing locations of major sand and gravel areas and where minor or scattered smaller aquifers are expected (after Rutulis 1986).

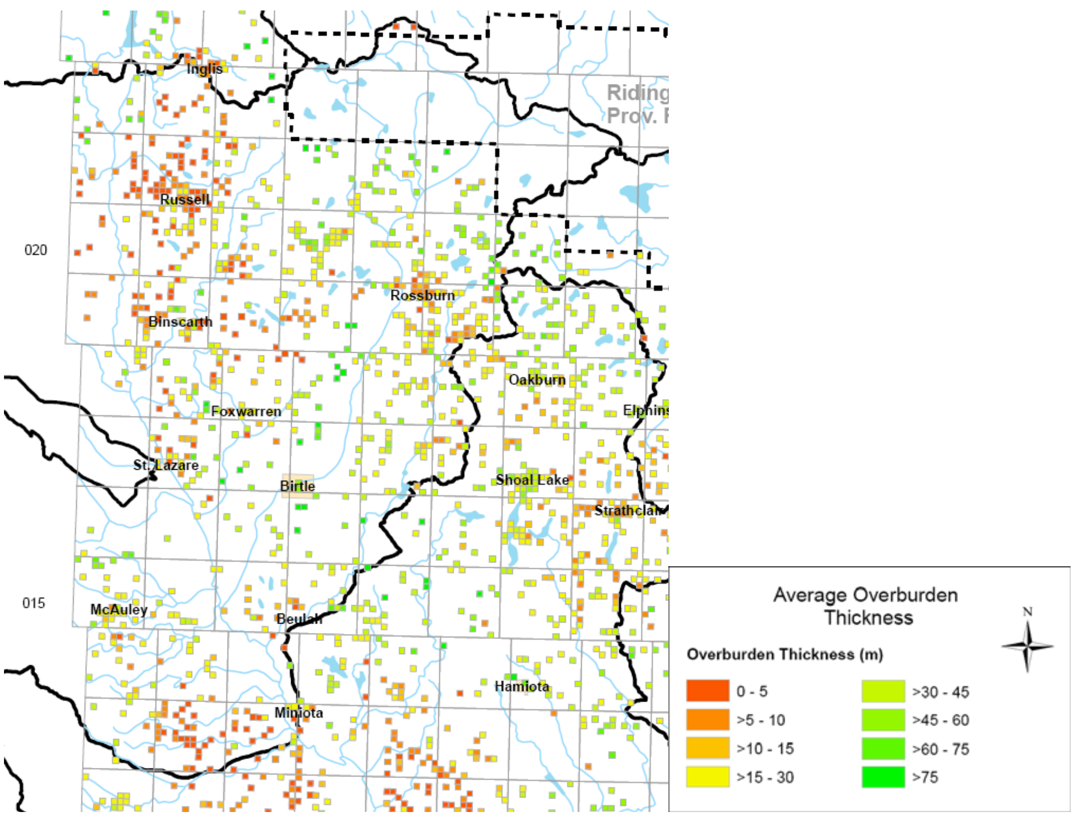

Figure 7. Diagram showing the average overburden (drift) thickness where bedrock was encountered in a drill hole. Large areas of the watershed have thin overburden such as in the St. Lazarre to Inglis area and the Rossburn and Miniota areas.

Most sand and gravel aquifers (Figure 6) are accessed by drilled wells and less than 20 percent of the wells recorded are wide diameter (>30 cm). Wide diameter (bored) wells are most commonly used where the well yield in shallow aquifers is low and additional storage within the well is required. Well yield from sand and gravel aquifer is variable, but generally adequate for individual domestic uses. The average reported well yield is 2.2 Ls^{-1} and there is potential in some aquifers for high capacity wells. Most wells are reported to yield greater than 0.8 Ls^{-}. The average total depth of wells completed into sand and gravel aquifers is 40 metres and the average depth to the top of the aquifer is greater than 30 metres; these values are highly variable.

Alluvial aquifer deposits of silt, sand and gravel are associated with rivers and streams such as the Assiniboine, Birdtail Rivers and other streams. These deposits will be restricted to each valley. Materials in alluvial deposits are commonly quite variable in vertical and horizontal extent. In this type of setting there may be interconnection between groundwater and surface water.

Because of the wide range in aquifer depths and conditions the chemistry of water from sand and gravel aquifers is also highly variable. The total dissolved solids (TDS) ranges from greater than 200 mgL^{-1} to more than 9,000 mgL^{-1}, with an average concentration around 1,440 mgL^{-1} (Figure 8). The hardness averages approximately 700 ppm $CaCO_3$ with a range from less than 100 to greater than 5,000. Values greater than 200 are considered poor for drinking water and values over 500 are generally considered undesirable for most domestic purposes. In groundwater with low TDS values, the dissolved solids predominantly consist of calcium (Ca), magnesium (Mg), sodium (Na), bicarbonate (HCO_3) and sulphate (SO_4). With increasing TDS a greater proportion of the solids are dominated by Na and SO_4 and an increasing proportion of chloride (Cl).

A relatively high percentage of groundwater samples from sand and gravel aquifers exceed one or more of the drinking water aesthetic objectives. Aesthetic objectives apply to constituents in the water that impart a taste, colour or odour that may affect the enjoyment or acceptance of that water. Over 60% of the samples exceed the aesthetic objectives for iron (0.3 mgL^{-1}) and over 80% exceeded the objective for manganese (0.05 mgL^{-1}). Thirty-five percent exceed the aesthetic objective of 500 mgL^{-1} for sulphate; fluoride was below the guideline value in all results. There are very few analyses of complete chemistry; only four samples include comprehensive metal analysis. Aluminum, antimony, arsenic, barium, boron, cadmium, chromium, copper, lead, uranium and zinc were all below drinking water guideline concentrations in these samples; one sample is above the health guideline for selenium.

Eight percent of the 104 nitrate results are above the drinking water guideline of 10 mg per litre of nitrate as nitrogen. Measurable nitrate generally occur in wells less than 20 metres depth and the highest nitrate concentration occur in wells less than 10 metres deep.

Total coliform bacteria are routinely detected in private well water. The presence of coliform bacteria is an indicator that the factors may exist where there are pathways for well water to be contaminated with water from the ground surface or from near surface . Over one-third of the 33 samples had detectable coliform bacteria. E. coli is an indicator of contamination from a fecal source; 3 percent of the 34 samples had measurable E. coli. Well owners that have had positive bacteria results need to assess their well for security and maintenance, and proximity to potential sources of contamination. Fact sheets are available from the province to help in sampling and interpreting the results of tests.

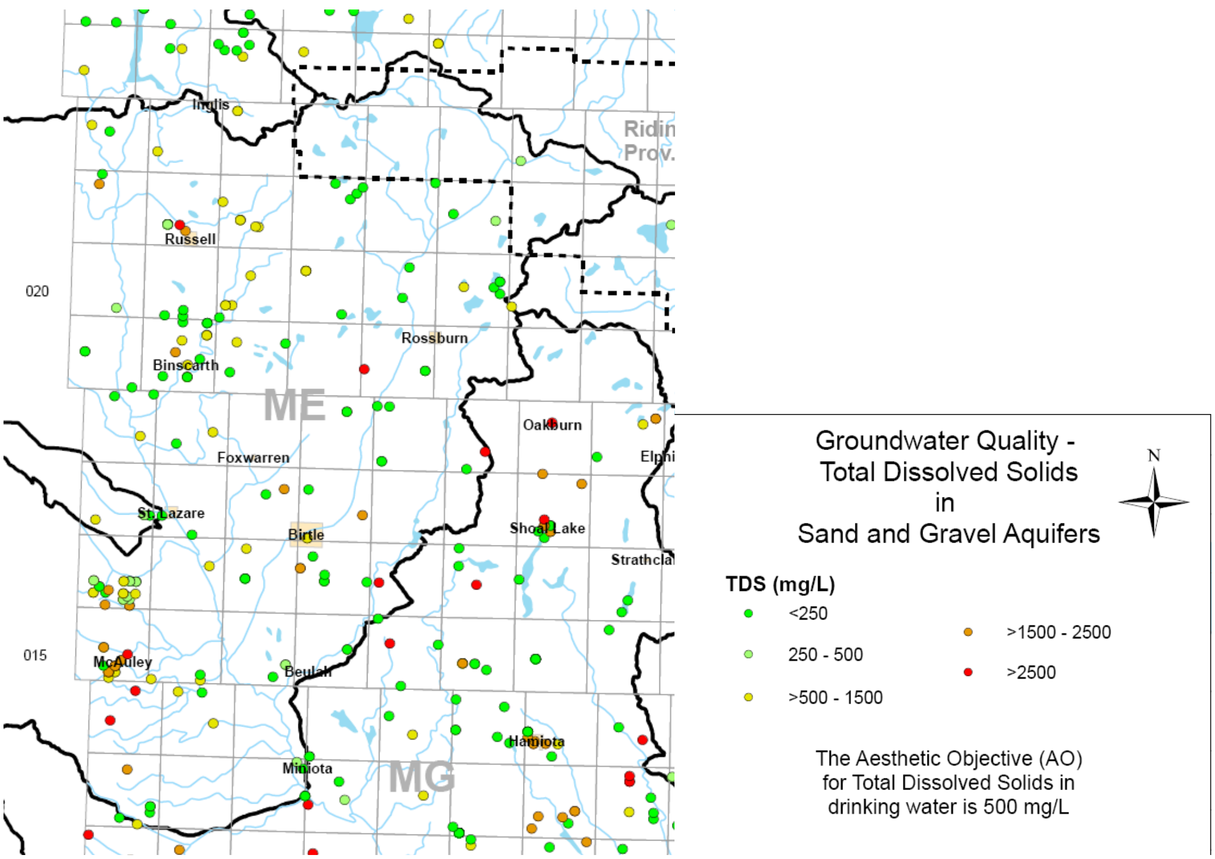

Figure 8. Distribution of total dissolved solids (TDS) in sand and gravel aquifers. TDS is a measure of the minerals and salts dissolved in the water.

Groundwater Use

Driller logs specify the intended water use for new production wells. The well use can be recorded as a single or multiple uses. Within the Birdtail / Assiniboine West watershed the following water uses are recorded (Figure 9): 774 domestic, 129 livestock, 462 combined domestic and livestock, 63 municipal, 8 industrial, 6 irrigation and other uses. Over 85% of the wells provide water to private domestic applications.

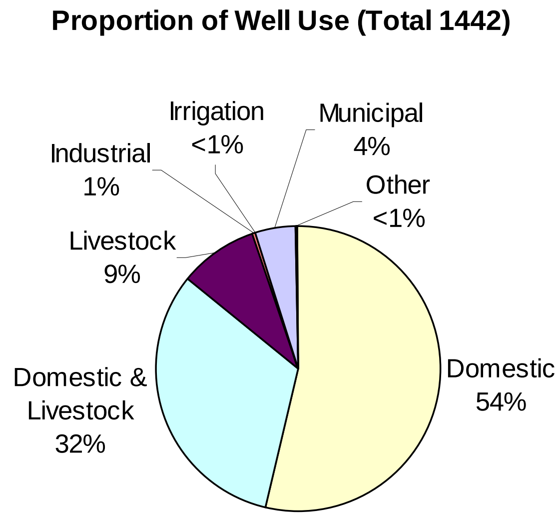

Figure 9. Proportion of production well use within the watershed: over 85% of the wells provide private domestic water supplies.

Availability of Data and Information Gaps

Well log and groundwater information is stored by the Groundwater Management Section. Results from past well surveys indicate that only about half of the wells in service have an associated well record and the accuracy of the location of the majority of wells is only to the quarter section on which it is drilled. Wells are often located in areas of convenience, in the same general areas as potential contamination sources and neglected, abandoned or unused wells can act as a direct conduit for contaminants to enter aquifers from the surface. Abandoned and unused wells located in these areas should be sealed to lessen the potential spread of contaminants to an aquifer. The knowledge of accurate well location is an important step in identifying sites for future well sealing. The province does not have access to well surveys conducted by other organizations; additional information on wells and locations would be beneficial in managing the provinces groundwater resources.

Groundwater forms the baseflow to streams. When run off from the land surface ceases the water sustaining the flow in streams comes from groundwater. The contribution of baseflow to streams and rivers has not been well quantified nor has water quality impact from these waters been assessed.

The province has undertaken several groundwater investigations within this watershed resulting in a number of test holes being completed; currently are three active groundwater monitoring wells. There is a lack of information on many water quality parameters from groundwater sources.

Issues, Concerns and Recommendations

- Shallow aquifers and aquifers of limited extent will be more prone to reduction in water quantity during prolonged droughts.
- High use groundwater withdrawals require assessment on an individual project basis.
- In cooperation with CD a well inventory should be completed. It should include a well inventory, GPS coordinates, information on construction and rudimentary water quality.
- Comprehensive groundwater chemistry is lacking from this area including many solutes with drinking water guidelines. This could be completed on wells selected during the well inventorying process.
- The Groundwater Management Section is currently evaluating the provincial monitoring well network to determine where there are redundancies or areas that could benefit from new or additional monitoring locations. This watershed will be included in that evaluation.
- Regional scale stratigraphic and hydrogeologic mapping and compilation would be beneficial in providing an increased knowledge of the extent, properties and relationships between stratigraphy, aquifers and surface water.
- The Groundwater Management Section is committed to completing new set of digital maps based on the watershed scale.

Vulnerable Groundwater Areas / Well-head Protection

Previous well surveys by Manitoba and other provinces show that well location, construction and maintenance are important factors in man-made water quality problems. Many of the parameters measured that lead to less than desirable potable water quality such as TDS or hardness, occur naturally and not the result of man's influence on the environment. However there are local impacts commonly measured in well water throughout the province and the watershed authority should encourage owners of private wells to self-assess or have their well assessed for physical conditions that may affect water quality such as poor wellhead conditions, well construction, location or maintenance. Water testing should be encouraged for all drinking water sources on a regular basis.

Community or municipal wells require well specific assessment to determine the vulnerability during the development of well head protection policies. As a minimum the individual characteristics of each well, aquifer and geology should be considered to assess vulnerability in relationship to potential contaminant sources.

References

Betcher, B., Grove, G., and C. Pupp., 1995. Groundwater in Manitoba: Hydrogeology, Quality Concerns, Management. National Hydrology Research Institute report CS-93017. 47pp.

Johnson, W.A., 1934. Surface Deposits and Ground-water Supply of Winnipeg Map-area, Manitoba. Canada Department of Mines, Bureau of Economic Geology, Geological Survey, Ottawa. Memoir 174

Little, J., and D. Sie, 1976. Groundwater Availability Series Duck Mountain Area (62-N), Province of Manitoba

Maathuis, H., J. Campbell, J. Fahlman and B. Betcher, 1999. Geology and Groundwater Resources in the Upper Assiniboine River Basin. Saskatchewan Research Council. SRC Publication No. 10421-1E99.

Sie, D., 1978. Groundwater Availability Series Riding Mountain Area (62-K), Province of Manitoba

Rutulis, M., 1986. Groundwater Resources in the Roblin Planning District (A Synopsis). Hydrogeology Section Hydrotechnical Services.

Sewyn, 1890, referenced within W.O Karvinen and M. L. McAllister, 1994. Rising to the Surface: Emerging Groundwater Policy Trends in Canada. Queen’s University 143 pp.

Appendix A

Definition of Terms

Definitions

Alluvial	Sediment deposited by moving water.
Aquifer	A porous and permeable geologic formation that is saturated and capable of producing useful quantities of water to wells or springs.
Aquifer, confined	An aquifer that is overlain by a layer of material with considerably lower permeability. The water within the aquifer is under pressure so that it rises above the top of the aquifer material in a well drilled into the aquifer; synonym: artesian.
Aquifer, unconfined	An aquifer where the water table forms the upper boundary.
Aquitard	A saturated low permeability unit that does not yield water readily.
Bedrock	Material that is older than the Quaternary period; it may be very well consolidated (rock) or only poorly consolidated.
Drift	or glacial drift = glacial deposit
Guideline for Canadian Drinking Water Quality	The current edition of *Guidelines for Canadian Drinking Water Quality*.
Hardness	A property of water that reduces the effectiveness of soap. It is primarily caused by calcium and magnesium ions; expressed in ppm (parts per million) CaCO3, or as gpg (grains per gallon U.S.) where one gpg equals 17.1 ppm.
Hydraulic conductivity	The rate that water moves through water is able to move through a permeable material.
Hydraulic gradient	The change in hydraulic head over a given distance in a direction which produces the maximum rate of decrease of hydraulic head.
Hydraulic head	The total water pressure, generally expressed as elevation.
Lacustrine sediment	Sediment deposited within lakes.
mg/L or mgL^{-1}	milligrams per litre; a common unit of measure for solutes, in most groundwater it is equivalent to a part-per-million.
Outwash	Stratified sand and gravel washed out from a glacier by meltwater streams and deposited in front of an active glacier.

Overburden	Unconsolidated material overlying bedrock. In Manitoba overburden is derived during glaciation or more recent time.
Permeability	The property or capacity of a porous rock, sediment or soil to transmit water, it is a measure of ease that water will flow.
Quaternary	The period of geologic time most noted for glaciation beginning between 2 and 3 million years ago and extending to the present.
Specific capacity	It is an expression of the productivity of a well obtained by dividing the rate of discharge of a well per unit of drawdown during pumping.
Total Dissolved Solid	(TDS) a measure of the concentration of dissolved minerals in water expressed in mg/L or ppm.
Water table	The surface where all the pore space is filled with water and can be observed by measuring the water level in shallow wells installed into the zone of saturation.
Well yield	The volume of water discharged from a well, frequently determined during short-term pump tests immediately after drilling the well.