Willow Creek Watershed

Groundwater Input to Technical Process

Hydrogeology

(the manner in which this is written assumes that Mines Branch has provided a write-up and maps on the surficial and bedrock geology and the geology section is placed immediately prior to the hydrogeology section)

General Description

The Willow Creek watershed is underlain by bedrock consisting of limestone and dolostone inter-layered with several argillaceous units. The limestone and dolostone form a major fresh water aquifer called the Carbonate aquifer that is the primary source of water supply throughout the Interlake region. Groundwater movement in the aquifer is primarily through fractures, bedding planes and solution features (Figure ##). The limestone and dolostone is underlain by sandstone and shale forming the Winnipeg Formation. While the sandstones are a productive aquifer, water quality is likely quite saline, at least in the southern part of the watershed.

Figure ##: Exposure of carbonate rock showing sub-vertical fractures and sub-horizontal bedding planes that form the principal pathways for groundwater movement in the Carbonate aquifer.

Bedrock is overlain by a variable thickness of overburden materials consisting of clay, silt, sand and sand/gravel (Figure #). Clay forms the uppermost overburden along the eastern part of the watershed and overlies glacial till. Till forms the uppermost surficial unit throughout the rest of the watershed. Sand and gravel is found locally at the contact between the till and the limestone/dolostone bedrock and in some areas (parts of Townships 18-21, Ranges 2E to 4E) is sufficiently thick to form a productive aquifer (the province has records for about 50 wells completed into sand/gravel in this part of the watershed). There are a number of areas where sand/gravel has been mapped at the surface – while the lower parts of these units may be saturated they are generally not developed for groundwater supply as shallow wells into these units would be susceptible to drought.

Figure ##: outcrop of glacial till. Note the stony nature to these deposits. Most tills in the Interlake are composed of about 50% silt sized particles, and the remainder of the consisting of about equal portions of sand and clay.

A major argillaceous (shale rich) unit occurs in the upper part of the Stony Mountain Formation which underlies the western portion of the watershed (Figure #). This unit forms an extensive aquitard and restricts the movement of water between the overlying limestone and dolostone and the older carbonate rocks below the aquitard. In some areas it has been found that

groundwaters in the portion of the Carbonate aquifer overlying this aquitard are contaminated but groundwaters in the aquifer beneath the aquitard have not been impacted. In these areas wells can be completed into the aquifer below the aquitard and obtain good quality groundwater.

It is generally accepted that most recharge to the Carbonate aquifer occurs in areas where bedrock is exposed at surface or is overlain by a thin cover of glacial till. However, slow downward seepage through the tills overlying the aquifer may also contribute significant amounts of recharge over a large area. The primary recharge area for the aquifer is likely located in the central Interlake where overburden cover is generally thin or absent and a large groundwater mound has formed. Groundwater moves away from this mound in all directions, creating the dominant flow patterns observed in the Willow Creek watershed. Regional groundwater movement in the Carbonate aquifer in the watershed is primarily from west to east, becoming more northwest to southeast in the Chatfield/Narcisse area; however, groundwater movement may locally be significantly different from the regional system, for instance near creeks and streams that form discharge areas.

Groundwater discharge is poorly understood, although it is known that discharge occurs as springs into a number of streams, forming the base-flow component of these streams. Flowing wells along the western shore of Lake Winnipeg indicate an upward directed groundwater flow (discharge area) but thick clay deposits in this area and beneath the lake restrict discharge to diffuse seepage. Flowing wells also occur near Malonton and east of Chatfield, with the main flowing well area being found in the Sky Lake area, just northeast of the Willow Creek watershed, where water levels in wells may be as much as 6 m above ground. It seems that in these areas the west to east movement of groundwater is “dammed” by the argillaceous aquitard in the Stony Mountain Formation and pressures build up in the aquifer to the west of this aquitard. Flowing wells and springs in these areas are a source of groundwater loss from the regional system. The upward groundwater gradient may also lead to reduced agricultural productivity.

The role of small lakes and marshes in groundwater recharge and discharge is also poorly understood. In some areas the occurrence of surface water may simply result from a local topographic low being underlain by lacustrine clay deposits which restrict downward flow. In other areas, wetlands may be present due to groundwater discharge as springs or seeps,

or they may be locations where surface waters collect and so function as slow recharge zones. Local studies will need to be undertaken to examine the groundwater/surface water interaction in these areas, particularly if land use changes such as drainage are being considered.

Groundwaters in sand/gravel aquifers occurring at the bedrock/overburden contact are likely local occurrences where bedrock surface depressions have been infilled with sand/gravel and these materials have not been removed during subsequent glacial events. In most cases these aquifers are expected to be hydraulically connected to the underlying Carbonate aquifer and much of the long-term yield of the aquifers will be drawn from the underlying or adjacent bedrock.

Groundwater has not been developed from the Winnipeg Formation sandstone at any location in the watershed. Consequently, little is know about the aquifer in this area. Regional studies in 1986 and 2007 indicate groundwater movement in the aquifer is west to east at a slow rate and that groundwater quality is brackish to saline, although water quality may improve somewhat to the north.

Groundwater Productivity and Quality

The Carbonate aquifer is generally highly productive with almost all wells drilled into the aquifer being capable of producing sufficient water for a single family dwelling. The aquifer has also been developed with a number of high capacity wells to provide municipal and industrial water supply. Municipal systems relying on groundwater service the Town of Gimli. Other villages in the watershed obtain their water from individual wells.

Although specific studies have not been undertaken to evaluate recharge rates to the Carbonate aquifer in the Interlake, current

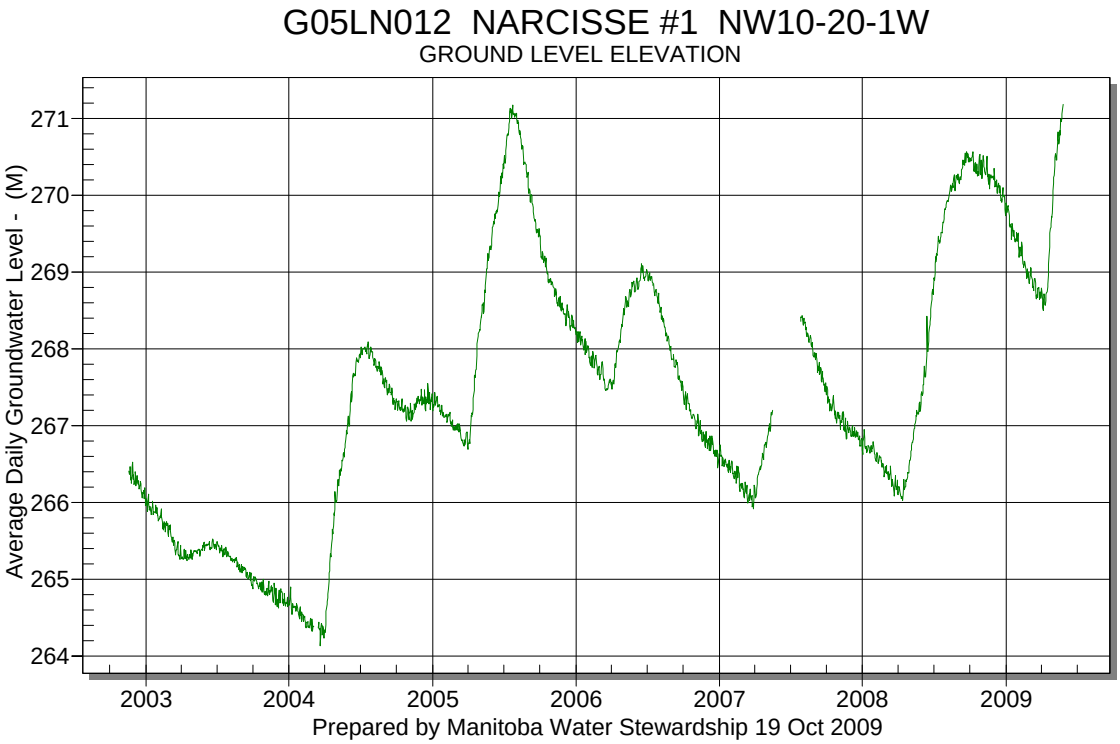

Figure ##: hydrograph showing groundwater level response in the Carbonate aquifer near Narcisse. Note the rises in water level associated with spring to early summer recharge and declining water levels through most of the summer, fall and winter.

anthropogenic rates of withdrawal are likely only a very small portion of the average recharge rates in the watershed. Long-term hydrographs from observation wells located distant from significant pumping centers are generally used to record groundwater level (and groundwater quality) changes due to short to long period climatic fluctuations and short term weather events. Unfortunately, no good quality long-term records exist within the watershed but a hydrograph for a provincial monitoring well located near Narcisse which has about a 9 year water level record is shown in Figure #. This hydrograph shows the normal season water level response expected in Manitoba with recharge occurring in late spring to early summer followed by declines in water levels until the next recharge event. A small fall recharge even was observed in 2004 – fall recharge can occur in years where significant precipitation occurs as rain following the cessation of plant growth. Note that water levels in the Carbonate aquifer at this site have varied by about 7 m over the term of record. The locations of all provincial monitoring wells are shown on Figure #. This does not include monitoring

wells established at contaminated sites or sites where a potential contaminating source is being monitored.

Groundwater quality is generally good, although the hardness is often high enough that a water softener may be required. Iron and manganese may also be present at concentrations that cause staining issues. Trace metal concentrations (arsenic, barium, boron, fluoride and uranium) have not been found to exceed drinking water guidelines.

Groundwater Vulnerability and Contamination Issues

Groundwater is considered vulnerable to contamination where contaminants may leach from the ground surface into an underlying aquifer within a relatively short period of time. In the Willow Creek watershed groundwaters in the Carbonate aquifer and non-surficial sands and gravels are generally overlain by some thickness of glacial till and lacustrine clay. Tills and clays have a relatively low permeability; consequently, groundwater (and contaminant) movement through these materials is quite slow, typically only a few centimetres to a few tens of centimetres per year. Areas with thick clay or till cover over the Carbonate aquifer are considered to be at low risk (vulnerability) of contamination while areas at relatively high risk would be locations where bedrock is exposed at surface or overlain by a thin cover of till or clay. A very simple yet workable vulnerability mapping scheme is simply to map the thickness of clay and till overburden over an aquifer and assign risk categories based on overburden thickness. This mapping method has been applied in Manitoba since the 1970's and has considered portions of aquifers overlain by less than 6 m of clay or till to be vulnerable to contamination. The thickness of overburden overlying the Carbonate aquifer in the Willow Creek watershed is shown in Figure # and the occurrence of nitrate in groundwater in the underlying aquifer is also shown on the map. Elevated nitrate concentrations are typically found in areas where there is less than about 6 m of clay and glacial till overlying the bedrock aquifer, indicating that this is a reasonable criterion for vulnerability mapping.

Bacterial contamination of groundwater is also associated with areas of thin overburden cover; however, the relationship is not very strong. While some wells may produce bacterially contaminated groundwater as a result of direct entry of bacteria into the aquifer, in most cases other factors may lead to contamination. This may include the installation of only a short length of

well casing in areas of shallow bedrock, failure to adequately grout the borehole annulus, inadequate well maintenance, leakage at the snappy connection, or failure of the casing through corrosion. Bacteria may also be introduced directly into the bedrock aquifer via rock quarries, although the author is not aware of any studies which have shown this to be a significant issue in Manitoba.

There are numerous potential sources of groundwater contamination in the watershed. These include waste disposal grounds, manure solid or liquid storage sites, agricultural practices, direct recharge to the aquifer through sinkholes or areas of exposed bedrock, abandoned wells or drainage wells, municipal lagoons, and industrial activities. While many potential sources of contamination exist, it is generally only in areas with thin overburden cover that contamination of groundwater in the underlying aquifer actually occurs. In areas with thick clay and till overburden, transport of contaminants to the aquifer may take decades or even thousands of years. Appropriate engineering practices can also reduce the risk of leaching and groundwater contamination, for instance by installing a liner in municipal or agricultural lagoons.

Groundwater Concerns in the Watershed

The main groundwater concern in the watershed remains the vulnerability of groundwater to contamination in areas with thin overburden overlying the bedrock aquifer. Contamination with bacteria or nitrate is the most common occurrence. This is most applicable to communities in these areas relying on individual wells for water supply, particularly if there are livestock operations in the immediate vicinity or septic systems serve as the means of waste disposal. Rural residents relying on wells for water supply in these vulnerable areas should also be concerned about their water quality. The province is currently reviewing the Ground Water and Water Well Act and Regulations and will be considering requiring a minimum casing length for new wells in these areas and cement or bentonite grouting of the casing annulus.

A second series of concerns relate to the construction of older wells, casing deterioration, well maintenance, abandonment of wells and the interconnection of shallow and deep parts of the Carbonate aquifer through open-hole individual wells. In shallow overburden areas many older wells

were constructed with only sufficient casing to reach a meter or less into the bedrock. The annulus around this casing was typically filled with drill cuttings. Reports of wells producing discoloured water in the spring or after heavy rainfall often relate to these poor construction practices. Groundwaters produced from these wells would be expected to be contaminated with bacteria during at least a part of every year. Microbial contamination may also be associated with casing deterioration (steel well casing may have a life expectancy of only a few decades in certain geologic/hydrogeologic circumstances), improper well maintenance (not maintaining a sloping surface to direct surface water away from the well; not ensuring the well cap is water tight), failure to properly grout the well annulus (the annular space should be grouted with a liquid bentonite or cement mixture) or the continued use of a well pit which may flood seasonally. As well, owners should ensure that any abandoned wells on their property are properly sealed as these wells may be a source of contamination to them or their neighbors. Finally, issues are emerging about private wells having been drilled so that they intersect multiple water producing zones in the Carbonate aquifer. This may lead to the exchange of groundwaters between contaminated and uncontaminated zones. As well, this is a significant issue with respect to well head protection for public wells. A number of these issues will be dealt with through proposed changes to *The Ground Water and Water Well Act*.

Programs and Recommendations

1. A well inventory program should be undertaken to map the location of all rural wells (and wells in communities if this proves feasible) and to obtain some initial information on the quality of water being produced by each well. The inventory program should be used as an opportunity to locate abandoned wells and to provide information to well owners on well maintenance.
2. A concerted effort should be made to find and seal any drainage wells that may still exist in the watershed.
3. A program to assist well owners with the re-construction of wells that are currently producing groundwaters with bacterial contamination or wells located in pits could be considered.
4. As part of the development of a watershed plan, current activities that may cause groundwater contamination that are being carried out in areas of the watershed with thin overburden over the bedrock aquifer

should be mapped. This would include all quarries, whether active or abandoned.

5. The watershed plan should encourage studies be carried out to examine the interaction between surface water and groundwater in this watershed and other parts of the Interlake. It should also encourage studies be undertaken to examine recharge processes and rates, and groundwater quality in recharge areas.