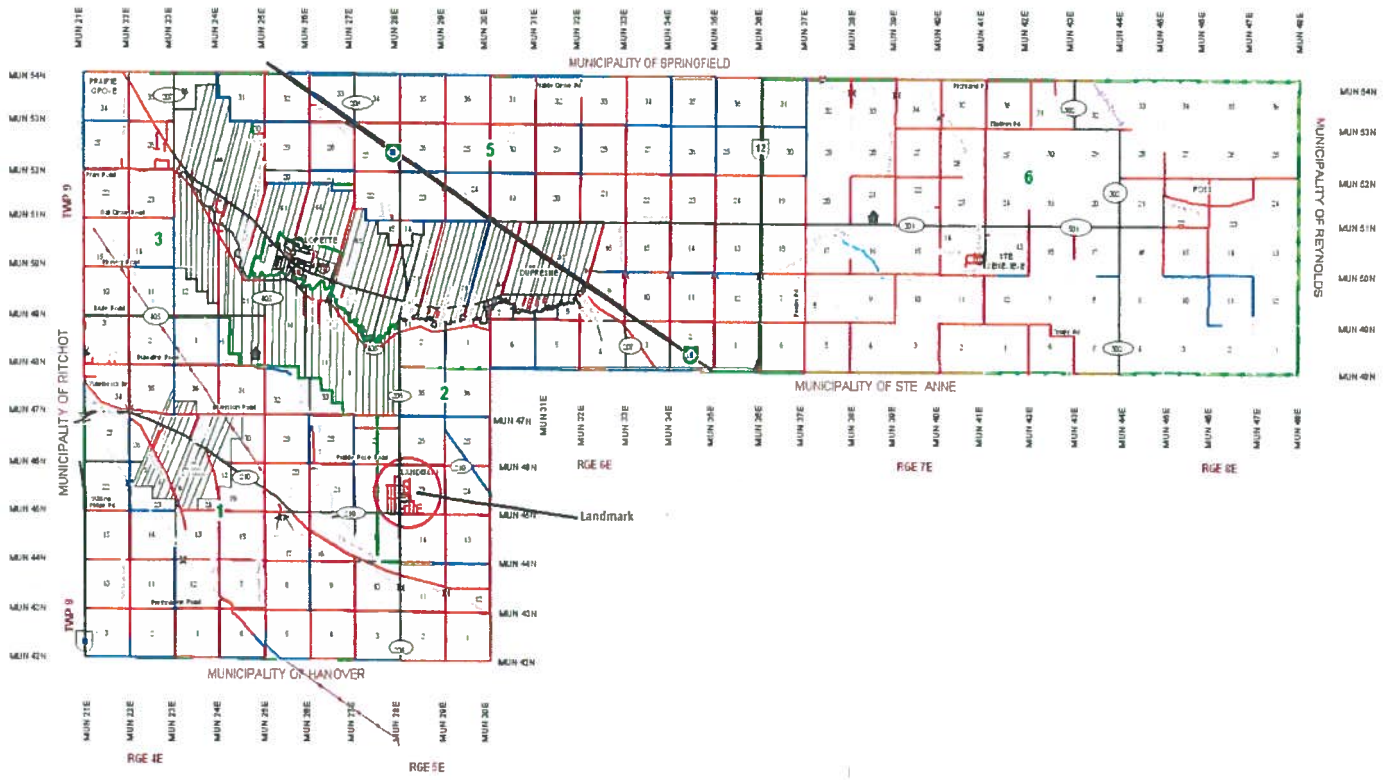
Municipal Groundwater Supply Expansion Investigation
Local Urban District of Landmark

Environment Act Proposal

Rural Municipality of Taché – Manitoba



Friesen Drillers Ltd.
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Report to:

RURAL MUNICIPALITY OF MUNICIPALITÉ RURALE DE **TACHÉ**

The Rural Municipality of Taché
Manitoba

Municipal Groundwater Supply Expansion Investigation Local Urban District of Landmark

Environment Act Proposal

Rural Municipality of Taché – Manitoba

PROVINCE OF MANITOBA
J. J.
BELL
Member
22621
July 23/2014
REGISTERED PROFESSIONAL ENGINEER

APEGM
Certificate of Authorization
Friesen Drillers Limited
No. 4016 Date: July 23/2014.

July 23, 2014

Prepared by: J.J. (Jeff) Bell, B.Sc.(G.E.), P.Eng. Date: July 23/2014.

Reviewed by: Rebeca Bethann Griffith Date: July 23/2014

Authorized by: Jason D. Friesen – General Manager Date: July 23/2014

307 PTH 12 N Steinbach, MB R5G 1T8 Phone 204-326-2485 Fax 204-326-2483 Toll Free-1-888-794-9355

Friesen Drillers Ltd.
307 PTH 12 N Steinbach, MB. R5G 1T8 Phone 204-326-2485 Fax 204-326-2483 Toll Free-1-888-794-9355

Introduction 2
Project Background and Scope of Work 2
Description of the Existing Environment in the Project Area 3
Mitigation Measures and Residual Environmental Effects 3
Follow-up Plans, Monitoring, and Reporting 3
Additional Water Supply Details 4
Existing System Use 4
System Conservation 4
Private Water Well Inventory 5
References 5
Limitations 5
Disclaimer 5

Appendix A Municipal Groundwater Supply Investigation Report
Appendix B Status of title – Landmark LUD well sites
Appendix C Correspondence with Manitoba Conservation and Water Stewardship
Appendix D 2012/2013 Landmark LUD Water Consumption Report
Appendix E Private Water Well Inventory – Landmark LUD

Introduction

Friesen Drillers Limited is pleased to submit this environment act proposal for the proposed municipal groundwater supply expansion of the Local Urban District (LUD) of Landmark within the Rural Municipality (RM) of Taché. After many years of gradual progressive growth, the RM and the LUD committee intend to expand the water supply system to allow for future residential and commercial growth within Landmark. The water supply issues have been noted as one of the major limiting factors for additional development within the community.

In August 2012, the RM of Taché retained Friesen Drillers to conduct an extensive hydrogeological assessment of their existing well field to determine if the existing two wells that currently supply Landmark with water, would allow for an expansion of the water supply; which would then allow for a growth of up to 6,000 residents, compared to the current ~1,500 residents. This expansion to 6,000 people would be planned to occur over a 20 year period, allowing for approximately 3.75% growth per year on average.

The hydrogeological assessment to allow for the municipal groundwater supply of up to 6,000 residents resulted in positive outcomes, with the recommendation that the LUD apply for an expansion to their existing license to increase the water use to 537.66 acre feet/year (663.21 dam^3/year). A copy of the hydrogeological report is attached as Appendix A.

On March 4th, 2014, Friesen Drillers held a meeting with Mr. Bruce Webb, P.Eng. of Manitoba Conservation and Water Stewardship (MCWS) – Environmental Approvals Branch. The existing hydrogeological assessment was reviewed, and due to the similarity in the requirements, it was suggested that since the existing document contained much of the required information, a summary letter identifying the location of the required information in the environment act proposal format would be suitable (B. Webb, personal communication, 2014). As such, this report will provide additional details regarding the environment act proposal for Landmark, and highlight the areas in the existing report where the required information may be located.

It should be noted that this environment act proposal will address aspects of pumping the groundwater from the existing wells. The provision of upgraded and expanded treatment plants, water line expansion, waste water treatment, etc. are beyond the scope of this environment act proposal. This proposal will focus on the hydrogeological aspects of the water supply for the community.

Project Background and Scope of Work

The historical development of the community of Landmark, project background, and other details are contained in the hydrogeological assessment, pages 1 to 7. The community location is shown as Figure 1, while the specific well locations within the community are shown as Figure 3.

The lands that the wells are located on are owned by the RM of Taché, a certificate of title for both sites is attached as Appendix B. The RM does not hold the mineral rights for the lands, as these have been retained by the Crown. The lands on which the wells are located are currently zoned as residential for the east well and recreational/light commercial/municipal near the west well.

The development stages for this proposal are straightforward. The RM will simply install larger capacity submersible electrical turbine pumps into the existing two wells for the present. The installation will be planned to take one day per well. In the future, the RM plans to install a third supply well to provide some backup for the water supply system. The existing pump houses will not be modified from the outside. Some interior electrical modifications will likely be undertaken; however these will not be visible from the exterior of the existing pump houses.

The RM is funding this project through municipal tax revenues, and the water use charges for the existing residents within the LUD. There are no other external sources of funding for the project other than general revenues.

The LUD currently holds a water rights license for the existing groundwater supply system. The licence details are contained in Appendix B and C of the overall groundwater report which is attached to this document as Appendix A. The RM has recently applied for a water rights license with MCWS – Groundwater Licensing Section. The groundwater report contained in Appendix A was submitted to the department for review. The department reviewed the document, and provided a commentary letter acknowledging receipt. Further, the RM applied for a groundwater exploration permit, and began the process of obtaining an updated water rights license for the LUD. Copies of the exploration permit and correspondence with MCWS are attached as Appendix C.

The RM of Taché has not undertaken any public consultation on this proposed water supply expansion. The issue has been addressed at local LUD committee meetings, with some public present, during the sessions. Overall, the RM has not experienced a great deal of public interest in the project, and has responded to very few calls and comments from the public in the area.

Description of the Existing Environment in the Project Area

The existing environment is described in the hydrogeology assessment contained in Appendix A. The information is contained in pages 7 through 16.

The nearest surface water body to the site is the Seine River diversion, which is about 1.65 miles north of the site. The Seine River is about 2 miles further north of the site. It is speculated that both surface water features are environments for aquatic life. As there is over 70 feet of glacial/lacustrine deposits, it is speculated that the carbonate aquifer is not interacting with these surface water features in this immediate Landmark area.

Climatic effects are shown on Figure 8 of the attached hydrogeological assessment.

There are no First Nations located within the immediate Landmark area. The nearest First Nation is the Roseau River First Nation, which is located about 50 km to the south. There are no major provincial parks or heritage resources in the immediate Landmark area. This project would not be expected to cause any issues for aboriginal treaty rights, or affect traditional hunting/trapping/farming areas.

The predominant land use around the LUD of Landmark is primarily agricultural.

Mitigation Measures and Residual Environmental Effects

The effects to the carbonate aquifer are described in the hydrogeology report that is attached as Appendix A. The projected impact and long term aquifer response is discussed on pages 22 to 24.

Follow-up Plans, Monitoring, and Reporting

The follow-up plans and long term monitoring is discussed in the hydrogeology report that is attached as Appendix A. The recommendations are shown on page 25.

The RM has committed to the following activities with respect to the monitoring of the carbonate aquifer:

- The RM plans to drill and construct a third backup supply well at as far as can be reasonably set from the current wells. This will likely occur as community growth dictates within the next 5 years.
- Although there are no major surface water bodies or other water supply sources nearby, the RM has committed to undertaking an integrated water supply and watershed planning study within the next 5 years.
- The RM has committed to develop an aquifer/well head protection program for the Landmark LUD supply wells within 5 years, and will develop a contingency plan should the aquifer become impacted in some manner.
- The RM commits to installing at least three additional observation wells in the immediate area around the well field within 2 years.
- The RM have committed to installing automatic data recording pressure transducers in the supply and observation wells within 2 years. This would assist the RM in monitoring pumping water levels.
- A hydrogeologist will be retained as required by the RM to report on any substantive issues with the carbonate aquifer in terms of the LUD municipal water supply.

It is anticipated that some of the recommendations detailed in the hydrogeology report will be reviewed by the staff of the water rights licensing.

Additional Water Supply Details

Existing System Use

The existing system in the Landmark LUD serves a large part of the town site. Some older parts of the town still operate private water wells for individual businesses and homes.

In 2011, Statistics Canada conducted a census within the community of Landmark. Their results revealed a total of 1,326 people. The 2013 water use report reported that the water supply system has 421 individual water use connections and services 1,263 people in the community. The water use report for 2012/2013 is attached as Appendix D. Calculating the per capita/day use consumption for 2013, the average use per person is 326.8 L/person/day.

The RM staff indicates that all connections to the water supply are metered. Up until 2012, the water supply system charge was extremely low, and only relied on a cost collection basis to maintain the system. In 2012, the RM arranged for a hearing and presented a case to the Public Utilities Board for a rate increase. The rate increase was approved by the board, and currently sits at $ 1.50/m^3, which is more in line with the water supply system charges in other municipalities and jurisdictions nearby. The cost increases will also allow for some growth and expansion of the system, while dealing with maintenance and servicing.

The LUD of Landmark system is relatively small and straightforward. The vast majority of the water supply connections are for individual family residences. There are a few businesses, a fire hall, and the community schools which form the larger water supply users. The water supply system is chlorinated, with no further additional treatment undertaken. It is our understanding that the system is operated in accordance with licensing from the Office of Drinking Water – Province of Manitoba.

There is a small bulk truck fill facility present at the west well site. This water use is metered separately, and the RM does not charge for the water supply. This loading station is used primarily for local farmers for chemical mixing and spraying. A suction break is installed on the system.

System Conservation

The RM staff has recently begun to develop a water conservation program for the LUD of Landmark water supply system. Up until recently, the system had not undergone any significant modification or expansion since its original construction. The RM has recently developed a number of programs aimed at water conservation for the municipal system. The following measures have recently been implemented by the RM staff for the LUD system:

- Odd and even residential dwellings are only allowed to water lawns on alternate days during dry periods. This practice is largely monitored by the citizens, and the honor system, with the municipal public works foreman conducting inspections.

- The RM recently began a program to remove older, higher water use, flush type toilets. If private residences install lower flow toilets, the RM offers a cash incentive for the installation. This program is conducted across the RM, within the areas serviced by the municipal water supply systems.

- The RM plans to develop a mail out that will be submitted with the property tax bills on water conservation.

The system has a reasonably high per capita unit consumption prior to 2013, when the water utility rates where extremely low in comparison to nearby municipal centers. The RM staff feels that the per capita water use will decline with the increased rate structure as approved by the Public Utilities Board.

The RM has committed to conducting a water conservation study of the Landmark water supply system within 5 years.

The water supply system piping is well maintained by the RM staff, and very little water loss is noted, which is not accounted for in the metering. Due to the high iron in the groundwater, and lack of treatment, the RM staff flush water lines bi-weekly and a chemical called ClearHIB 5 is used on an ongoing basis pulsed into the lines to improve the water aesthetics. This removes the iron debris from the piping. The water line flushing is not metered at the present time. All other connections and uses of the water supply are metered.

During the past winter, the RM staff noted no frozen water lines, or water service interruptions.

Private Water Well Inventory

In order to detail the type of water wells that have been constructed within the LUD of Landmark, an inventory of private water wells was completed. The specific details of the well inventory are contained in Appendix E, while the discussion of impacts occurs in Appendix A, pages 22 to 25.

References

Webb, Bruce 2013. Personal communication.

Limitations

The scope of this report is limited to the matters expressly covered and is intended solely for the client to whom it is addressed. Friesen Drillers Limited makes no warranties, expressed or implied, including without limitation, as to the marketability of the site, or fitness to a particular use. The assessment was conducted using standard engineering and scientific judgment, principles, and practices, within a practical scope and budget. It is based partially on the observations of the assessor during the site visit in conjunction with archival information obtained from a number of sources, which is assumed to be correct; except as provided, Friesen Drillers Limited has made no independent investigations to verify the accuracy or completeness of the information obtained from secondary sources or personal interviews. Generally, the findings, conclusions, and recommendations are based on a limited amount of data (e.g. number of boreholes drilled or water quality samples submitted for laboratory analysis) interpolated between sampling points and the actual conditions on the site may vary from that described above. Any findings regarding the site conditions different from those described above upon which this report was based will consequently change Friesen Drillers Limited's conclusions and recommendations.

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Appendix A

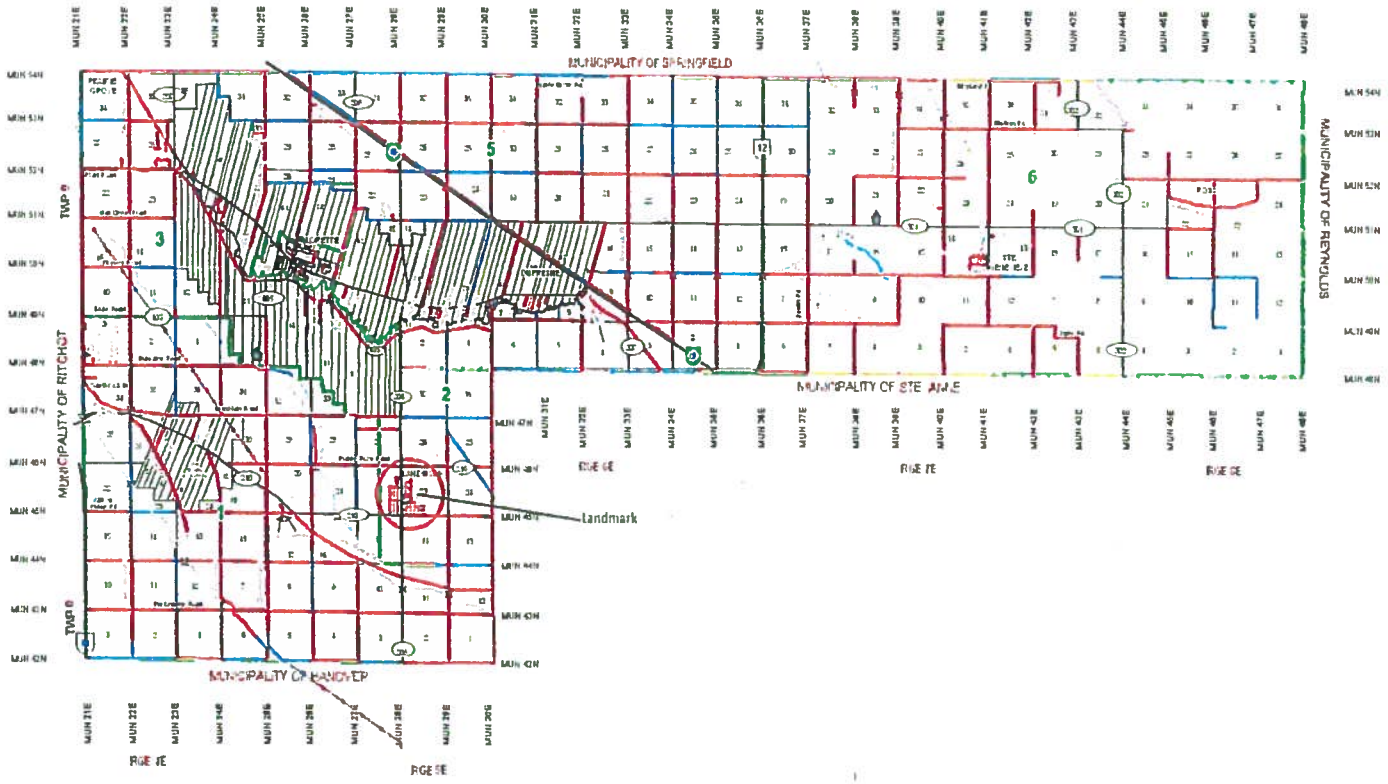
Municipal Groundwater Supply Investigation Report
Friesen Drillers
November, 2013

Friesen Drillers Ltd.
since 1892

Municipal Groundwater Supply Expansion Investigation

Rural Municipality of Tache

Local Urban District of Landmark - Manitoba



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Report to:

RURAL MUNICIPALITY OF
MUNICIPALITÉ RURALE DE TACHÉ

Rural Municipality of Tache
Local Urban District of Landmark

Municipal Groundwater Supply Expansion Investigation

Rural Municipality of Tache

Local Urban District of Landmark - Manitoba

J. J. BELL Member 29321 Nov. 26/2013

APEGM
Certificate of Authorization
Friesen Drillers Limited
No. 4010 Date: Nov. 26/2013

November 26, 2013

Prepared by: J. (Jeff) Bell, B.Sc.(G.E.), P.Eng. Date: Nov 26 /2013

Prepared by: J. Paulynn Estrella-Legal, E.I.T. Date: Nov. 26/2013

Authorized by: John M. Friesen Date: Nov. 26/2013

307 PTH 12 N Steinbach, MB R5G 1T8 Phone 204-326-2485 Fax 204-326-2483 Toll Free 1-888-794-9355

Friesen Drillers Ltd.
307 PTH 12 N Steinbach, MB R5G 1T8 Phone 204-326-2485 Fax 204-326-2483 Toll Free-1-888-794-9355

Introduction 2
Scope of Work 2
Regulatory Requirements for Groundwater Supplies 3
Water Rights Act and Existing Licenses 3
Environment Act License 4
Site Background 5
RM of Tache – Landmark LUD Water Supply System 5
Water Supply Requirements 7
Geology and Hydrogeology of the Landmark Area 7
Bedrock Geology 7
Surficial Geology 8
Hydrogeology 9
Local Hydrograph Review 10
Well Inventory 16
Requested Allocation 16
Aquifer Testing 17
Geochemical Sampling and Results 20
Discussions 22
Long Term Hydrograph Response 22
Aquifer Sustainability 22
Estimated Westward Groundwater Flow in the Bedrock Aquifers 23
Estimated groundwater usage 23
Prediction of Long Term Regional Effects 23
Integrated Water Supply and Watershed Planning Study 25
Recommendations 25
References 26
Limitations 27
Disclaimer 27

Appendix A – Existing Water Rights License (#2005-130)
Appendix B – MWSB Well Report on Well No. 1 (West Well)
Appendix C – MWSB Well Report on Well No. 2 (East Well)
Appendix D – Analytical Laboratory Data

Introduction

Friesen Drillers Limited is pleased to present this report detailing the results of our investigation of a proposed municipal groundwater supply expansion for the Rural Municipality (RM) of Tache – Local Urban District (LUD) of Landmark. The investigation reviewed the background historical information for the area geology, hydrogeology, and investigation results.

This study reviewed the existing water supply capacity of the RM of Tache – Landmark water supply, located at SE22-8-5EPM and SW23-8-5EPM. The system currently consists of two wells. It should be noted that some of the data used in the analysis were collected by others for other purposes. We have assumed that this data is correct, and representative of the actual conditions of the site. The investigation relies on this data and provincial long term monitoring data, along with information collected from within the existing supply wells.

The following report details the results of the groundwater expansion study.

Scope of Work

The RM of Tache – LUD of Landmark currently operates a water supply well field within the town of Landmark. The well field consists of two wells, within the town proper. The first well was constructed in 1990 through the Manitoba Water Services Board (MWSB), with a second well added in 1995. The wells pump water to a small treatment system, which consists of treatment with chlorination. The system does not have any fire protection capability or any reservoir capacity. The wells pump water directly into the distribution lines, and the water within the lines is chlorinated. The system piping apparently acts as the reservoir for the chlorination disinfection of the water supply. Due to the age of the town, many of the residences and businesses within the LUD have their own private wells that pre-date the municipal system. The municipal system apparently services much of the newer housing subdivisions in the LUD.

Along with other chronic issues, the system is known to be critically short of water supplies at various times. The supply well pumps do not appear to have the capacity to supply the required demand. In addition, there are years such as 2011 and 2012, when the total annual water consumption exceeded the license capacity from Manitoba Conservation and Water Stewardship (MCWS).

In order to provide additional water supplies to the system, the LUD committee requested Friesen Drillers undertake an assessment of the existing wells. The purpose of the investigation would be to determine if the existing well field would allow for increased pumpage from the wells to meet the needs of the expanding town. The development plans for the LUD are beyond the scope of this assessment.

The scope of services for this aquifer and well field capacity assessment include the following:

- Undertake a review of the background site history relating to the water supply.
- Review the background geology and hydrogeology.
- Review of all MCWS hydrograph monitoring stations for long term water levels and groundwater chemistry in the area.
- Technical review of previous reports, related literature and studies.
- Undertake a hydraulic capacity assessment of the existing water supply well field for the LUD of Landmark.
- Undertake the installation of a pressure transducer monitoring network to monitor water level response over a long term pumping period.
- Collection of groundwater quality samples for isotope and geochemical analysis.
- Review the capacity of the well field, and calculate the proposed impact from pumping at the proposed higher rate.
- Calculate the radius of influence of the proposed expansion of the system.
- Complete a detailed report of the investigations that is suitable for submission to MCWS.

Scope of Work (cont'd)

The RM of Tache gave approval for the study to commence in August, 2012. It was noted that the work would take up to one year to complete, due to the requirements for long term monitoring that are usually requested by the licensing section of MCWS.

The approximate boundaries and location of the LUD of Landmark is shown below as Figure 1.

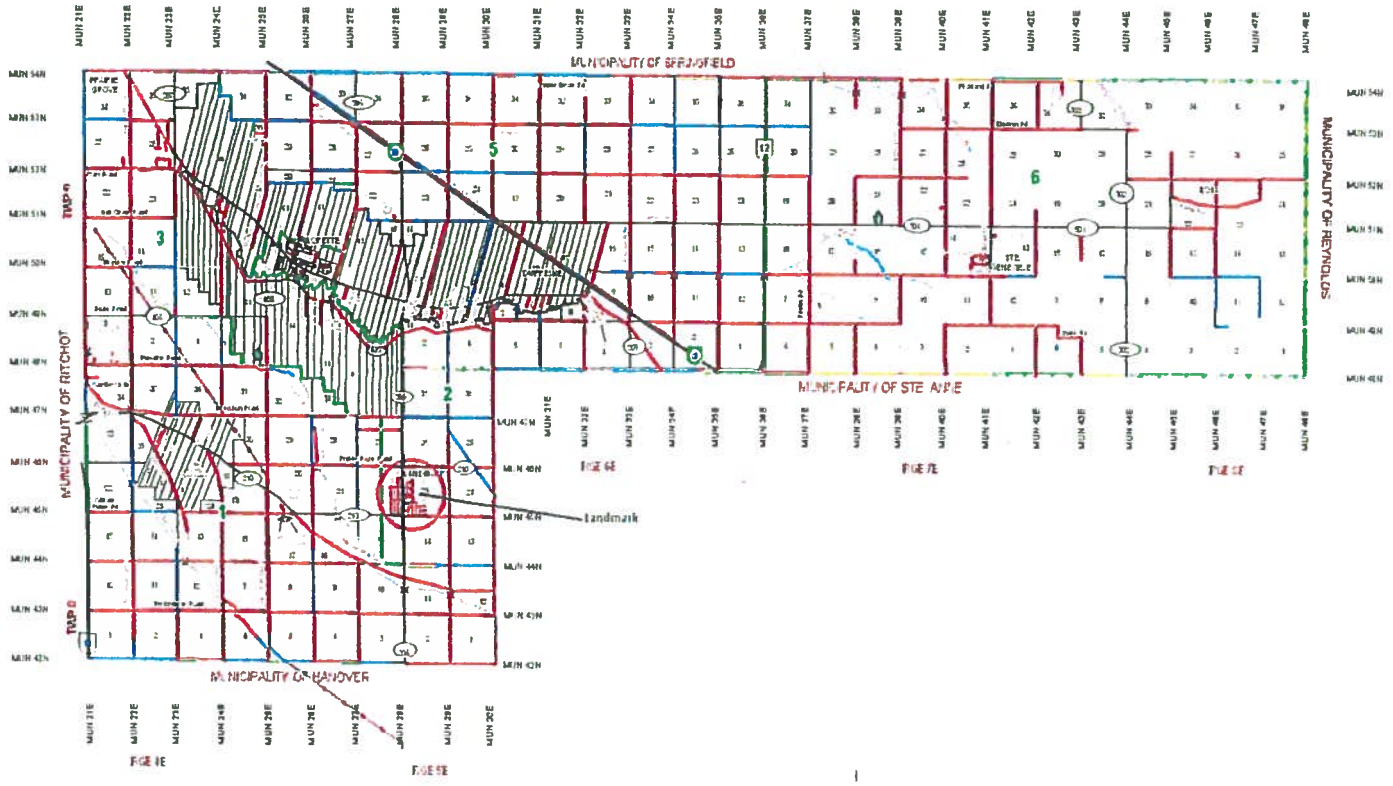

Figure 1 – Location of the LUD of Landmark, Manitoba (source – www.rmoftache.mb.ca)

Regulatory Requirements for Groundwater Supplies

Water Rights Act and Existing Licenses

The Province of Manitoba has the responsibility to distribute water under the Water Rights Act. This act requires that anyone using water exceeding 25,000 L/day for commercial, industrial, agricultural, and municipal use must obtain a license under the act. This is also required for industrial and geothermal heating/cooling applications. Water rights licensing is based on a first in time, first in right procedure. For groundwater projects, an exploration permit is required prior to starting the project. In order to provide approval for the exploration permit, MCWS reviews the available aquifer allocation (if available), to determine if the project is potentially suitable.

Upon completion of the testing of the project, MCWS reviews the proponent's proposal to determine if there are any third party impacts that may result. If these impacts are present, mitigation factors may be required. These includes groundwater interference plans, well repairs, replacements, and pump inspections. These programs are usually undertaken by the proponent of the project. Reports are usually prepared for the project by a consulting engineer or hydrogeologist.

If the application is deemed acceptable and third party impacts are managed or addressed, MCWS will issue a license for the diversion of groundwater. The proponent then has the right, under some conditions, to the water supply. The right is also protected from other use in the area.

For the LUD of Tache water supply, the well field was initially constructed in 1990 and 1995, with an exploration permit not being filed prior to construction. The system was subsequently licensed with MCWS in 2005. This license (#2005-130) is valid for 20 years.

Water Rights Act and Existing Licenses (cont'd)

The following conditions are detailed on license 2005-130, which is the current license:

- The groundwater supply is for municipal purposes.
- The maximum water diversion rate is set at 0.018 m^3/s, of 0.6 c.f.s. (269.3 U.S.G.P.M.).
- The total water diversion in any year shall not exceed 140.0 dam^3 (113.5 acre feet).
- Water shall not be pumped when the water level in the aquifer is deeper than 22.86 m (75 feet) in the east well (No.1) and 25.6 m (84 ft.) below grade in the west well (No.2).

A copy of the current license is attached as Appendix A.

Due to the pump installations in the supply wells, it is not possible to test the Landmark LUD wells at higher rates. Therefore, it was decided to monitor the existing well performance individually using transducers. The LUD was also attempting to determine how much water supply was available from the current wells, prior to submitting an application to MCWS. Therefore, it is recommended that a groundwater exploration permit be obtained before undertaking any modifications to the wells. It will also be discussed in subsequent sections that the annual allocation from the aquifer has been exceeded during the past two years.

Further recommendations will be included in the discussions of the report.

Environment Act License

In the event that a requested groundwater supply project exceeds 200 dam^3/year, an environment act license is also required. This is required under the Environment Act of the Province.

An Environment Act Proposal is prepared by the proponent for a water supply project. This proposal usually involves the identification of any potential environmental effects from the water supply diversion. The proposal usually identifies potential third party impacts and possible effects. Mitigation measures are usually proposed and evaluated. The proposal is usually advertised for public comment and review. Often times, environmental groups and organizations review these proposals to ensure that environmental effects are taken into consideration. In the event that there is a significant amount of public opposition to a potential project, the Minister of Conservation and Water Stewardship may order a Clean Environment Commission to hold public hearings to review the project and the proposed concerns. Although these public hearings are rare, they have been held for water supply projects in Manitoba, in the past.

Copies of environment act proposals are also submitted to various organizations within governments for comments and review. Often, water supply proposals involving groundwater use are reviewed by the provincial groundwater management section. If the environmental impacts are deemed to be minor, or the mitigation proposals are acceptable, the director will issue an environment act license for the development or project.

The requirement for environment act assessments for water supplies was put into force in the in the mid 1990's. As a result of this requirement, several water supply systems that did not originally obtain an environment act license would be requested to undertake this aspect upon a request for additional groundwater use allocation.

The RM of Tache – Landmark LUD water supply system did not originally obtain an environment act license, as the requirement was not enforced at the time as the requested allocation was below 200 dam^3/year. The LUD will not be requested to complete an environment act proposal, if the requested allocation would not be increased or the existing system would be planned to remain the same.

Site Background

RM of Tache – Landmark LUD Water Supply System

The LUD of Landmark developed in the late 1800's with Mennonite settlers in the area. A number of farms were present in the area, and the town site developed as a local service center. Initially, individual private wells were drilled in the area at each house site.

The private wells were initially completed into the overlying carbonate bedrock aquifer. As time went on, it became common knowledge that the Winnipeg Formation sandstone aquifer, which underlies the carbonate aquifer, apparently contained softer groundwater. As a result, many wells from the 1920's on began to be drilled through both aquifer formations to obtain softer groundwater for water supplies. This resulted in head losses between the formations, and geochemical intermixing of the groundwaters from the two formations.

With the growth of the LUD and increased housing in the town site, it became evident that a municipal water supply system was needed. As such, the RM of Tache contacted the MWSB, and the first supply well was drilled at the fire hall, on the west side of Main Street in 1990. This well consisted of a 10 inch diameter steel casing completed into the carbonate aquifer and was then drilled to a depth of 200 feet below grade. The well has 84 feet of casing. Upon completion of the well, the MWSB performed a pumping test for 1.5 hours.

The following results were recorded for the No. 1 (west) well.

- Static water level – 23.0 feet
- Pumping water level – 45.0 feet
- Pumping rate – 571 U.S.G.P.M.
- Duration – 1.5 hours
- Specific capacity – 25.95 U.S.G.P.M./ft.

A small report was prepared by the MWSB at the time of installation. The report is basically a summary of the drilling log, which is attached as Appendix B.

In 1995, the LUD experienced additional growth and a second well was requested through the MWSB. A second well site on the east end of the LUD was chosen. The well was constructed by Friesen Drillers, and consisted of 97 feet of 8 inch diameter steel casing, set into the upper carbonate bedrock. The well was drilled to a depth of 262 feet below grade. Upon completion of the well, MWSB undertook a pumping test for 8 hours.

The following results were recorded for the No. 2 (east) well.

- Static water level – 23.0 feet
- Pumping water level – 27.0 feet
- Pumping rate – 327 U.S.G.P.M.
- Duration – 8.0 hours
- Specific capacity – 81.75 U.S.G.P.M./ft.

A small report was prepared by the MWSB at the time of installation. The report is basically a summary of the drilling log, which is attached as Appendix C.

The wells were mechanized immediately after the completion, and connected to the distribution piping. The mechanization of the wells consisted on installing multiple 5 hp submersible pumps in each well, with the various pumps cycling on and off as needed. The installation is rather unique.

RM of Tache – Landmark LUD Water Supply System (cont'd)

As stated previously, the system operated for many years without holding a valid groundwater license. In 2005, the system was licensed by the department, although discussions with the department have indicated that water use records were submitted in 2010, while records for 2011 and 2012 have not been submitted. In 2010, the licensing staff noted that there was a minor exceedance of the annual allocation limit.

The total annual pumping plots for the wells are shown below as Figure 2. The well locations within the LUD are also shown below as Figure 3.

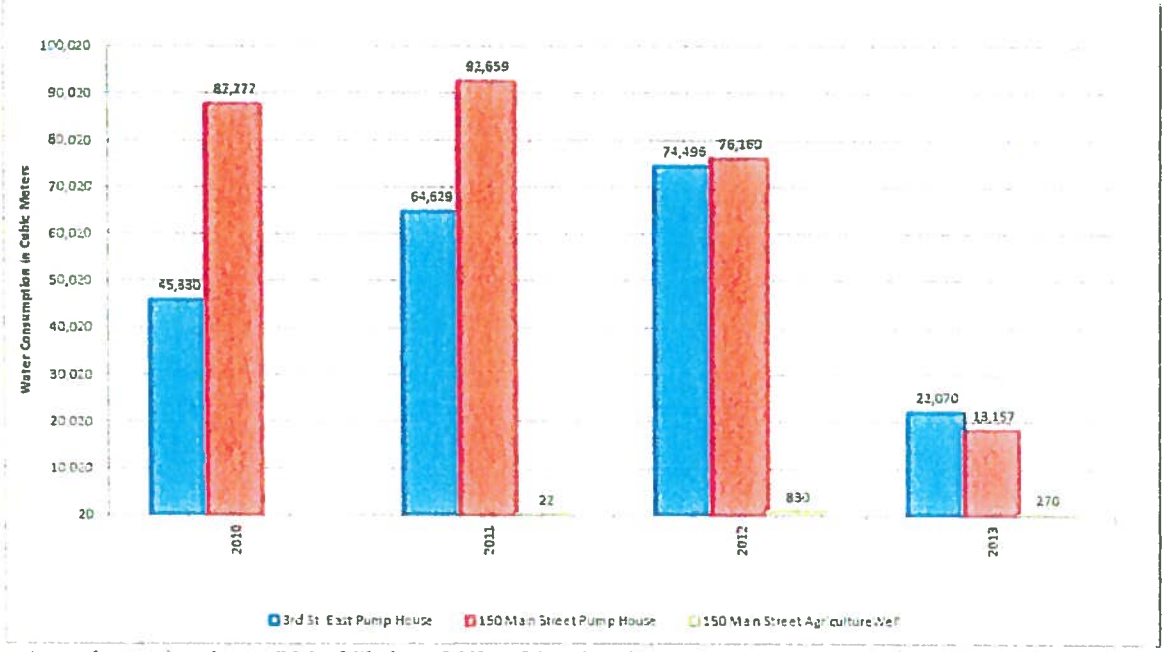

Figure 2 – Annual pumping data – RM of Tache – LUD of Landmark. Note that the "150 Main Street" well is Well No. 1 (West), while the "3rd Street east" well is Well No.2 (East). The 150 Main Street well is a small loading station well that sees occasional use. (Data source – LUD of Landmark, 2012)

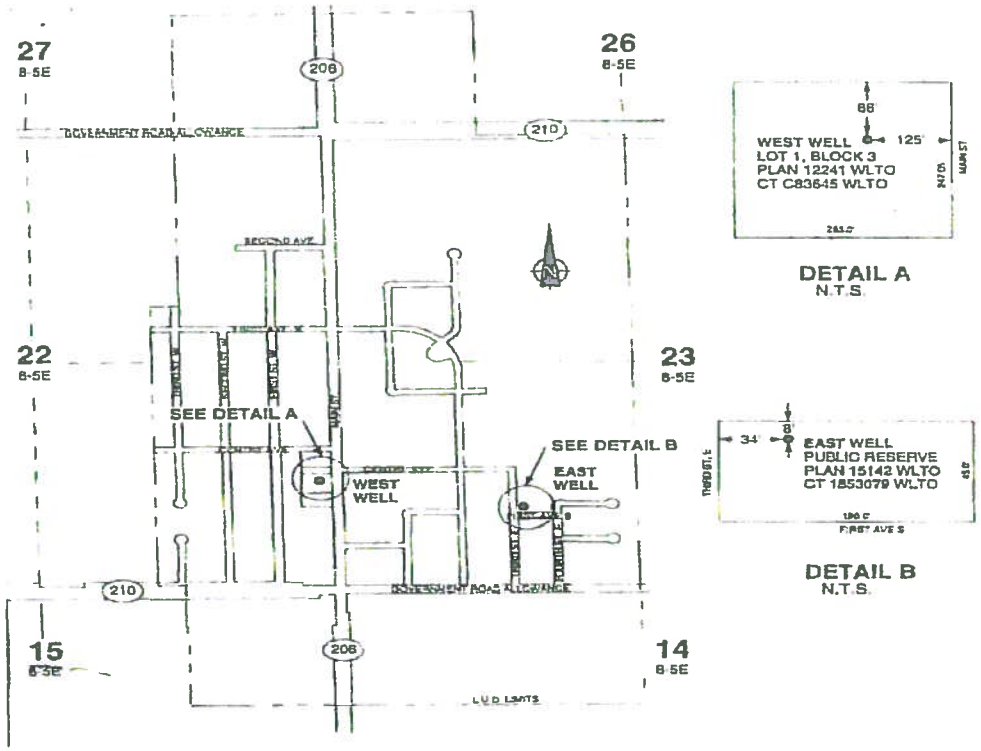

Figure 3 – Well locations within the LUD of Landmark (source – MCWS, 2005)

Water Supply Requirements

As part of the investigations, the RM of Tache provided some indications of their proposed population projections for the LUD. This information was provided to Friesen Drillers based on the calculations and projections undertaken by the RM staff, based on known census data and residential housing subdivisions that have been proposed.

Overall, the study provided the following water supply requirements for the future of the LUD:

- Current population ~ 1,500 people (not all residences are serviced in the LUD)
- Projected population in 2034 ~ 6,000 people (entirely serviced by the LUD water supply system)
- Average daily per capita demand – 300 L/person/day
- Annual consumption – 537.66 acre feet/year (663.21 dam^3/year)
- Projected flow rate – 333 U.S.G.P.M.

The projected water consumption has been estimated assuming the 300 L/person/day. This rate is typical for residential homes of the southeast area, based on the experience of the author.

Geology and Hydrogeology of the Landmark Area

Bedrock Geology

The Landmark area is located within the eastern fringes of the Western Canadian Sedimentary Basin (WCSB), or the Williston Basin. The WCSB is a wide spread wedge shaped sedimentary basin with Precambrian bedrock as the basement feature. Figure 4, shown below, details the extent of the WCSB, and shows the location of the study area.

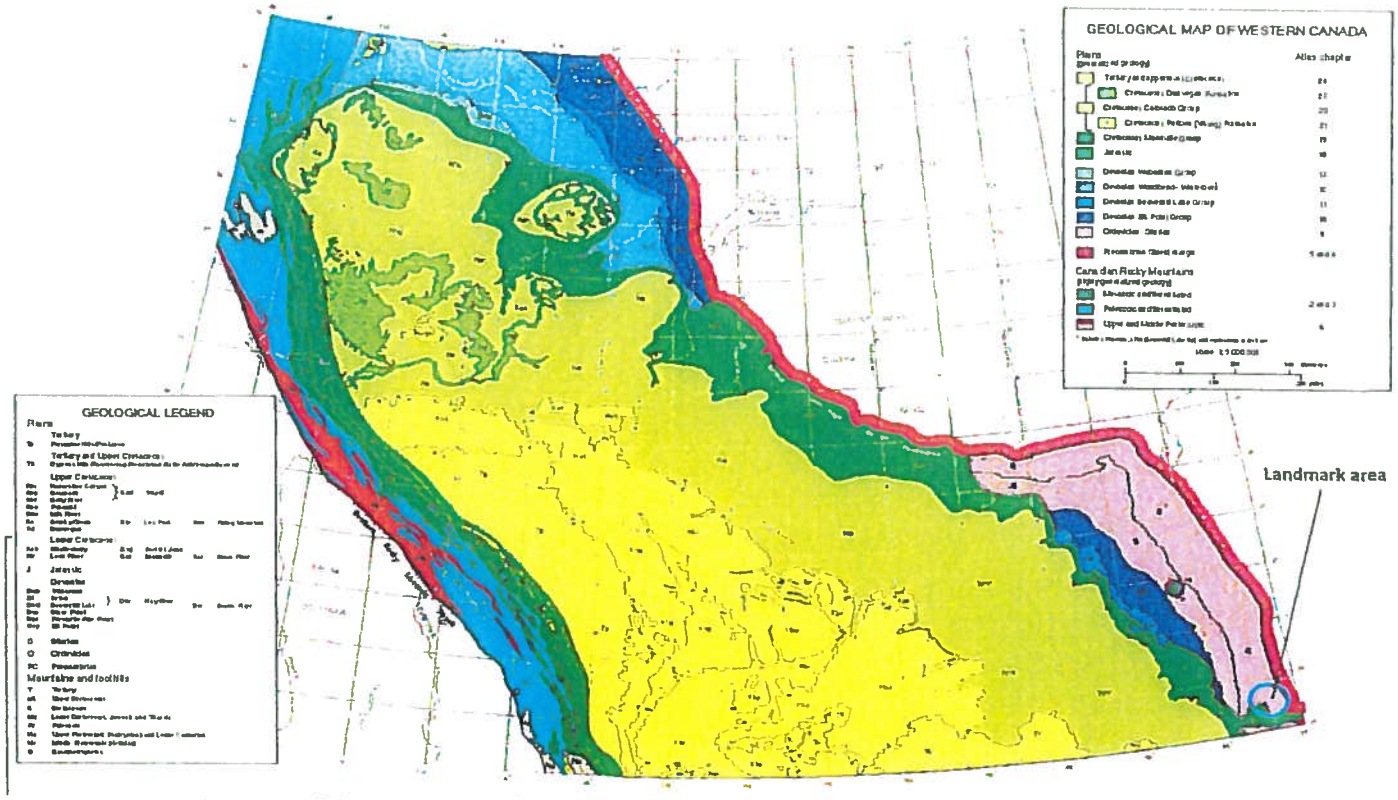

Figure 4 – WCSB showing location of the Landmark area. (source – Alberta Geological Survey, 2009)

Bedrock Geology (cont'd)

The basin extends throughout the central Canadian plains, and underlies about 1.4 million km². The basin extends north into the Northwest Territories, to the eastern fringes of the Rocky Mountains, and westerly, into central Manitoba. A large portion of the basin extends into the northwest United States. Precambrian igneous and metamorphic rocks form the basal geologic unit across the WCSB.

The Precambrian basement bedrock is expected to lie at a depth of approximately 380 to 400 feet below grade within the Landmark area. This is expected to change within the RM of Tache, as the formation typically dips about 5 to 10 feet every mile westward. This follows the dip of the WCSB in the southeastern area of Manitoba. Overlying the Precambrian Surface is the Winnipeg Formation sandstone. The sandstone sequence is thought to be about 80 to 100 feet thick in the area. The Winnipeg Formation consists mainly of layered silica sandstone and marine shales. The sandstone is generally very weakly cemented in the area, which is known locally as the Carmen Sand (Betcher, et. al., 1995). A substantial number of wells have been drilled into this formation in the Landmark area. Overlying the sandstone is a thin (10 to 20 feet in some places) sequence of marine shales. This shale sequence acts as an aquitard overlying the sandstone units.

Overlying the Winnipeg Formation is the carbonate bedrock of the Red River Formation, which typically consists of alternating layers of limestone and dolostone with very thin basal shale layers. There is a conformable transfer between the two geological units. It is reported that the Selkirk Member of the carbonate sequence is approximately 200 feet in total thickness within the Landmark area (Betcher, 1985). The Red River Formation and the overlying carbonate units are collectively called the carbonate evaporite unit in Manitoba. This unit extends south of the Steinbach area, through the Manitoba Interlake, to The Pas, and beyond. The upper surfaces of the carbonate bedrock have been eroded, worn, and highly damaged by erosional unconformities and Pleistocene glaciations. The surface has also been impacted by some karstic features in the geologic past.

A regional geological cross section approximately includes the LUD of Landmark area is shown below as Figure 5.

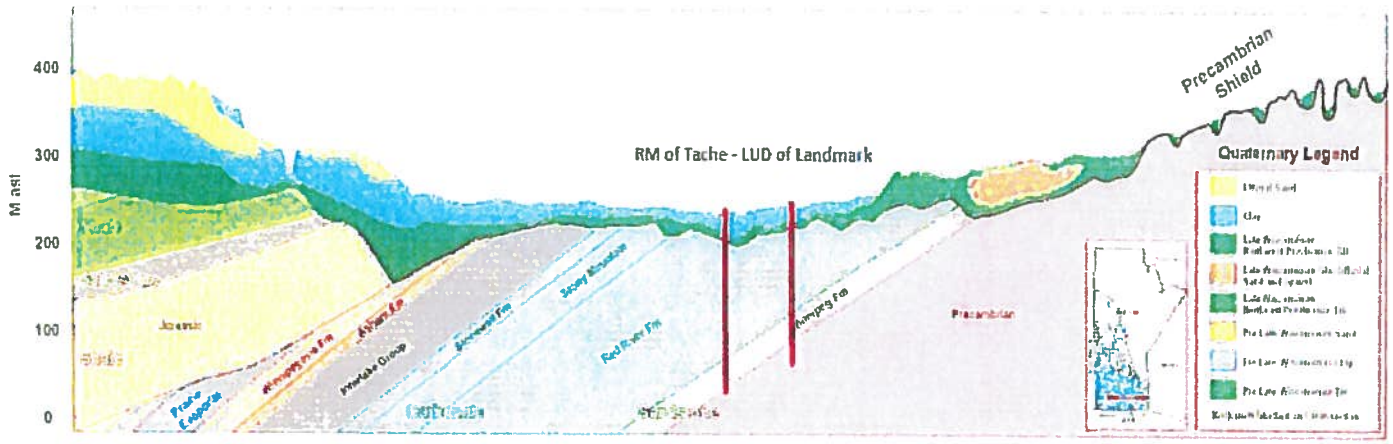

Figure 5 – Geological cross section approximately through the RM of Tache. (source – Matile and Keller, 2007)

Surficial Geology

The carbonate bedrock surface was extensively eroded during the pre-glacial period. This erosion resulted in significant damage to the upper surfaces. Joint sets, fractures, and voids were present, along with an extensive karstic development. Some of these features have been infilled with more recent sediments. A dense basal till unit, with some layers of sand and gravel, was deposited directly on the carbonate bedrock surface during the glaciations. Some of the previous permeable features were infilled during this period.

After the final glacial retreat, a pro glacial lake developed, which resulted in the deposition of water laid tills, and glacio fluvial silty grey clays. The overburden material acts as a confining layer in the southeast of Manitoba. In the Landmark area the overburden clay and glacial till is thought to be about 60 to 80 feet in thickness. The glacial till is typically about 25 to 50 feet thick.

Hydrogeology

Groundwater flow in the carbonate bedrock of the Red River Formation generally occurs in the fracture and joint sets in the rock. The size, extent, and interconnectivity of the fracture system govern horizontal and vertical groundwater movement through the bedrock. Due to this geologic condition, aquifer transmissivity and storativity can vary significantly over a relatively short distance, resulting in substantial variations in well yield (Render, 1970). The Red River Formation is considered to be a significant resource throughout the central portion of Manitoba, being developed for municipal, commercial, and private water supply systems (Betcher et. al, 1995).

Although the aquifer is known locally as a single aquifer, there are numerous fracture sets, joints, bedding planes, and karstic features, which indicate that the aquifer should technically be known as an aquifer system

Groundwater flow in the Winnipeg Formation sandstone is through the weakly cemented, poorly consolidated quartzose sandstone. The thin marine shale sequence acts as an aquitard between the two aquifers.

In some areas of the southeast, there are significant sand and gravel aquifers occurring within the overburden sediments. In the Landmark area, there are some minor sand and gravel sequences within the till, but these appear to be very sporadic in the area, with no major areas forming a regional aquifer.

Groundwater flow is from east to west in both aquifers in the Landmark area. Recharge to the aquifers occurs from a major sand and gravel moraine series that lies to the east. This moraine is known as the Sandilands area. Within the Sandilands, coarse sands, gravels, silts and clays lie directly on the bedrock sub crop of both Paleozoic sequences. These highland moraines accept snow melt run off and rainfall, and impose a high head on the two Paleozoic bedrock aquifers in the area. The exact amount of groundwater recharge to the formation has not been determined by MCWS research.

Groundwater discharge in the area occurs through a variety of means. The carbonate aquifer is known to discharge in the Red River Floodway, and into other creeks, drains and streams in the area. There is thought to be some discharge to the Red River near Winnipeg, and likely discharge into Lake Winnipeg. Further, there is some domestic, farm municipal well consumption on the aquifer, with the largest user in the area being the City of Steinbach. Groundwater discharge in the Winnipeg Formation occurs thorough domestic, farm and municipal well pumping, and basal discharge into Lake Winnipeg.

Groundwater flow in the carbonate and sandstone aquifers within in the Landmark area is shown below as Figure 6. It should be noted that the groundwater flow directions and heads are very similar in both formations, due to similar recharge conditions.

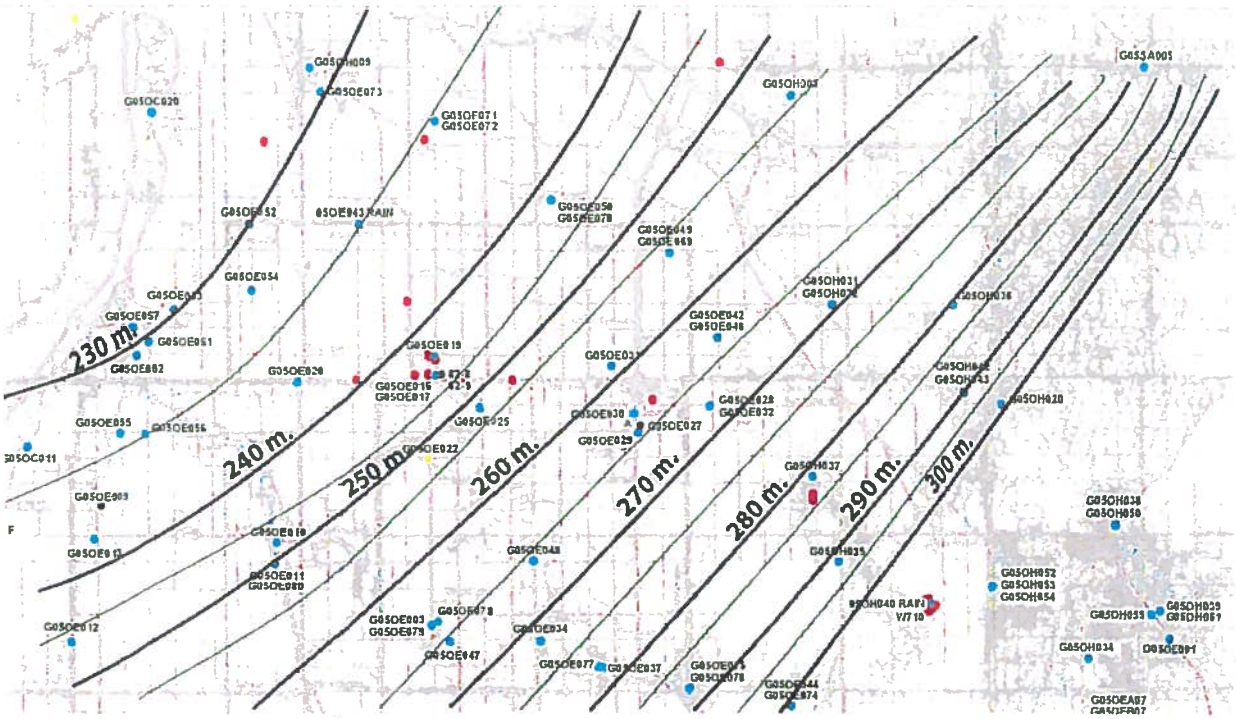

Figure 6 – Groundwater flow in the carbonate and sandstone aquifers – Landmark area (data source – MCWS, 2012)

Hydrogeology (cont'd)

The gradient in the Landmark area was determined to be about 8.23 x 10^{-4}, and a resultant vector of about 312 degrees. The sandstone was determined to be very similar.

The southeastern area of Manitoba generally has high permeability in the carbonate bedrock, with transmissivity values ranging from 30,000 to 150,000 U.S.G.P.D./ft. Due to the fractured rock nature of the aquifer, the permeability varies substantially with distance. In the Winnipeg Formation Sandstone, Wang et. al. (2008) determined the hydraulic conductivity of the Winnipeg Formation Sandstone to be about 2.38 x 10^{-5} m/s. Assuming about 100 feet on average for a formation thickness, the transmissivity was determined to be about 5,000 U.S.G.P.D./ft. on average.

These numbers match well with investigations that have been done into both aquifers in the southeast of Manitoba.

Local Hydrograph Review

In order to review the regional groundwater flow directions and the long term response in the carbonate and sandstone aquifers over the last 50 years across the Landmark site, the following MCWS chart hydrograph stations were accessed for potentiometric elevations:

- G05OH031 – Carbonate Aquifer
- G05OE049 – Carbonate Aquifer
- G05OE072 – Carbonate Aquifer
- G05OH009 – Carbonate Aquifer
- G05OE019 – Carbonate Aquifer
- G05OH008 – Carbonate Aquifer
- G05OH007 – Carbonate Aquifer
- G05OE031 – Carbonate Aquifer
- G05OE073 – Sandstone Aquifer
- G05OE071 – Sandstone Aquifer
- G05OE070 – Sandstone Aquifer
- G05OE069 – Sandstone Aquifer
- G05OE032 – Sandstone Aquifer

Hydrograph data source – MCWS, 2012/2013

The observation (hydrograph) well locations are shown below as Figure 7.

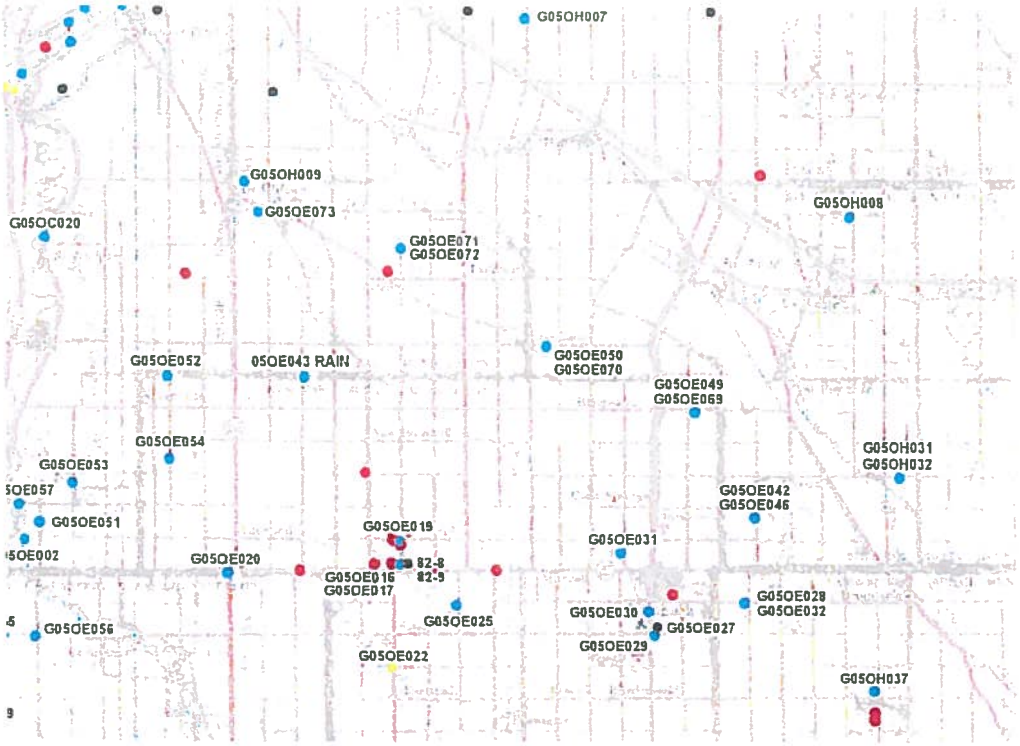

Figure 7 – MCWS Observation Well locations (source – MCWS, 2012)

Local Hydrograph Review (cont'd)

Through a review of the precipitation data and hydrographs, the following comments can be noted. The average annual precipitation in the area is typically around 575 mm/year (1981 to 2010), with typical seasonal and climatic variations. Some years, for example, the precipitation has been higher than 800 mm, with some drier years showing less than 400 mm. The long term groundwater level record is only available for the carbonate aquifer, as the MCWS hydrograph stations in the sandstone aquifer are only a recent addition to the observation well network that was developed as part of the initial floodway construction in the early 1960's. It can be assumed, in the area under discussion that due to numerous interconnecting boreholes that the water levels in the two formations would behave relatively similar.

As can be observed on Figure 8, shown below the long term fluctuations, mostly due to climatic variations are in the 4 meter range. The long term hydrographs were plotted against the total annual precipitation in Figure 8. Although there are fairly major seasonal and climate changes, the long term hydrograph record appears to be stable, with only minor fluctuations and changes.

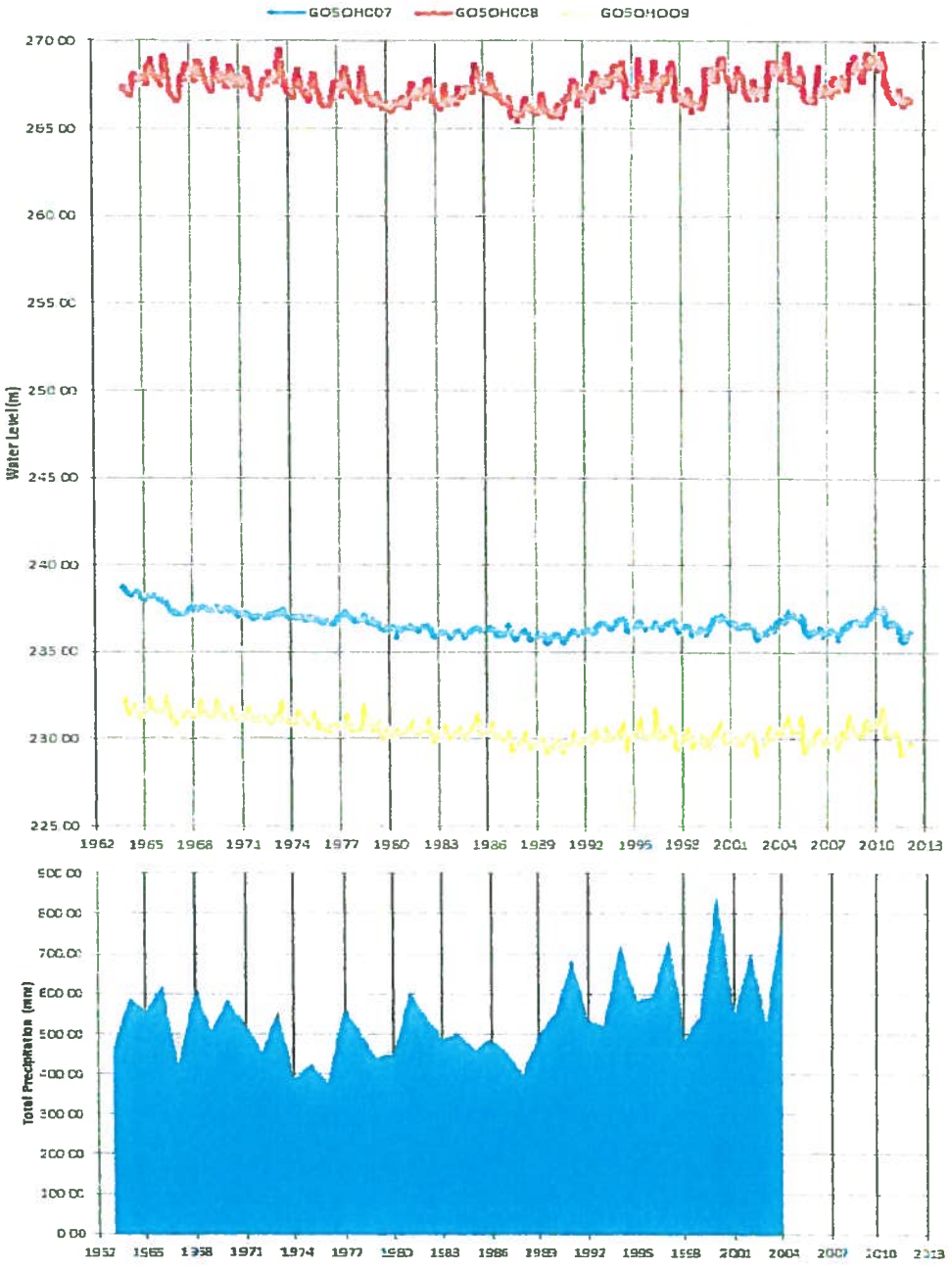

Figure 8 – Long term carbonate aquifer hydrographs in the Landmark area, versus total annual precipitation (data source – MCWS, 2013 and Environment Canada, 2012)

Local Hydrograph Review (cont'd)

The record basically shows a fairly stable hydrograph response, with some minor depressions and rises with seasonal and climatic variations. The dry late 1990's are clearly shown in the four records. There does not appear to be any long term progressive drawdown in the area that is not explainable. There will be more details on this topic discussed below.

In 2006/2007, MCWS began a project to investigate groundwater resources in the southeast. A number of long term hydrograph stations in the carbonate aquifer were twinned with observation well stations completed into the Winnipeg Formation. Although the record is relatively short and a slight head difference is present, the hydrographs appear to be an exact image of each other, with each equally displaying similar change in static water levels. An example station is shown below as Figure 9.

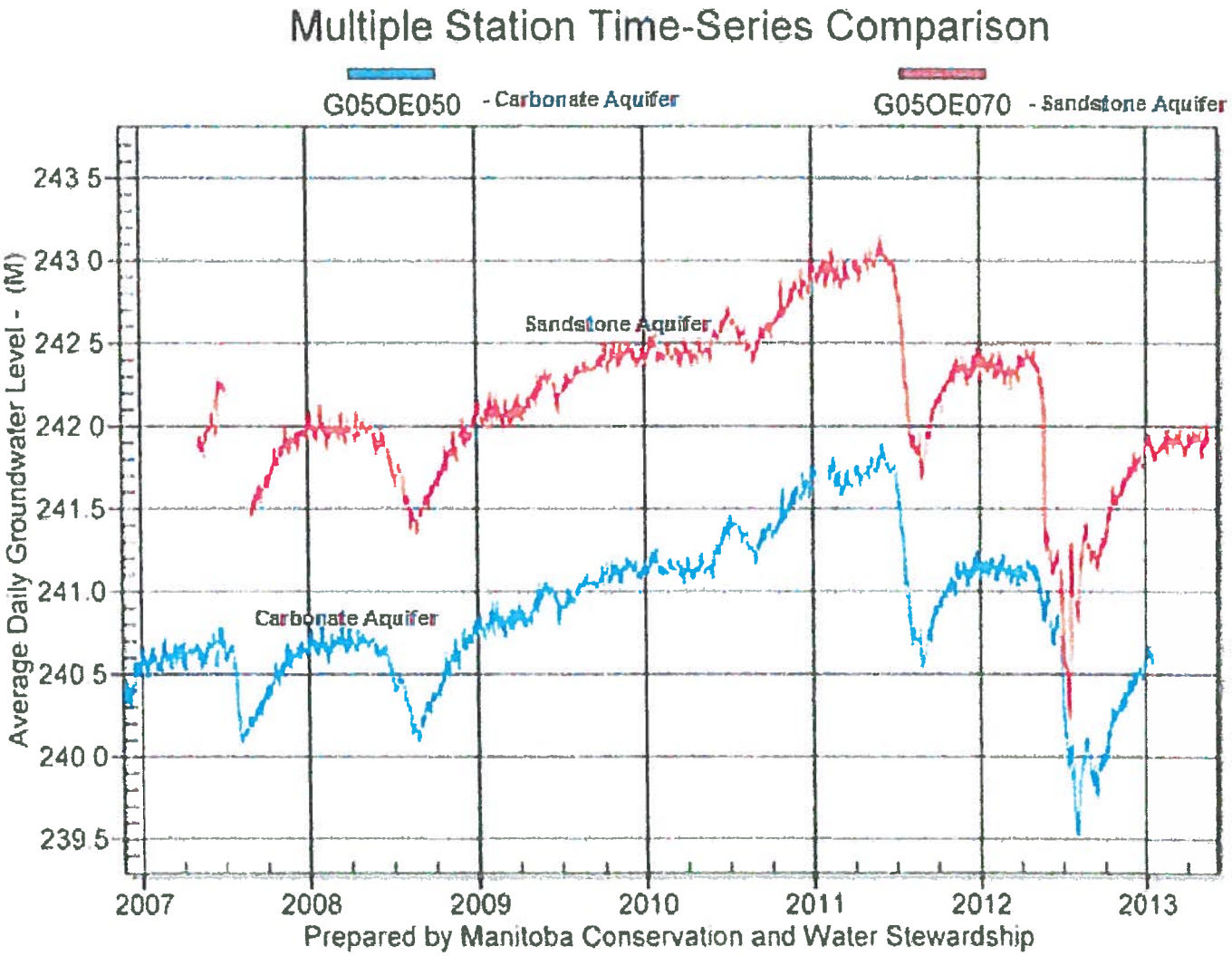

Figure 9 – Multi-station hydrograph comparison. G05OE050 is completed into the carbonate aquifer, while G05OE070 is completed into the sandstone aquifer. (source – MCWS, 2013)

With the exception of the area around the City of Steinbach, the static water levels in the Winnipeg Formation sandstone aquifer appear to be slightly higher than the overlying carbonate aquifer. In the area around Steinbach and Blumenort, the carbonate aquifer is noted to be about 1.5 m higher. This is likely due to the much higher transmissivity in the carbonate aquifer in this area but may be due in part to the large number of boreholes that are interconnecting both aquifers.

Around the Landmark area, the Sandstone aquifer is thought to have about 1.5 m of head above the carbonate aquifer level. This level rises somewhat towards the west, as in Ile des Chenes, the Sandstone hydrograph is about 3.5 m higher than the overlying carbonate aquifer. This is logical, as there are more opportunities for discharge on the carbonate aquifer than there would be for the Winnipeg Formation Sandstone aquifer. It is known that pumping either of the formations separately will cause a similar pressure decline in the non-pumping formation.

Local Hydrograph Review (cont'd)

As part of the MCWS investigations into the aquifers in the southeast, Wang et. al. (2008), noted that most hydrograph records recovered after the 1991 dry period, with the exception of an area located west of Steinbach. Wang et. al. (2008) concluded that this was the result of development pressure, as it was in a negative drawdown condition. The area is shown below as Figure 10.

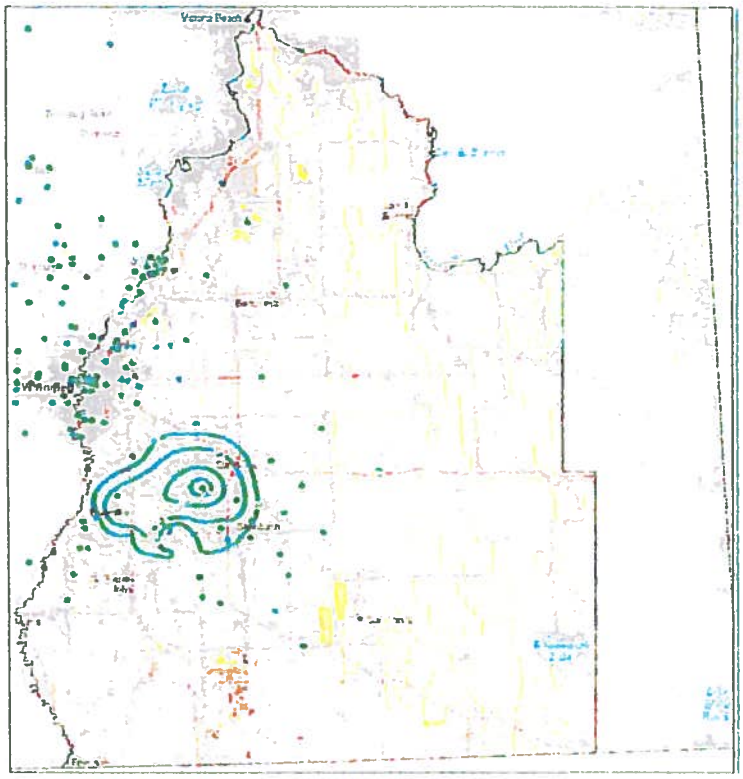

Figure 10 – Negative drawdown in the carbonate aquifer (source – Wang, et. al , 2008)

Figure 10 shows a negative drawdown of about -7 in the area around the LUD of Landmark. The units are not depicted on the map; although the remainder of the paper utilizes metric units. Therefore, it can be assumed that the unit used is meters.

This concept is somewhat difficult to accept, as there are no major production wells or consumptive groundwater users in the area, other than the LUD of Landmark, which was put into service, at about 60 U.S.G.P.M., in 1991. It is also speculated by Wang et. al, (2008) that this section of the carbonate aquifer may take longer to come to equilibrium from climatic changes and pumping stress. It was noted in the paper that the remainder of the southeast did not show any development stress, even around the well established drawdown cone around the City of Steinbach supply wells. In effect, what the authors (Wang, et. al., 2008) were discussing was a potentiometric area in the aquifer that did not respond to increased groundwater recharge and in effect, was a constant head discharge area. There are zones similar to this along the mid part of the Red River Floodway Channel.

It is speculated that the situation (Wang et. al., 2008) refers to is drawdown and an area of constant head that has resulted from a project conducted by MCWS in the 1970's, when the Seine River diversion channel was excavated through the area. In an area west of Steinbach, the drain base, of what is called the Manning Canal continued to blow out from the high artesian carbonate aquifer conditions that were present. In order to lower the heads in the area, four large diameter relief wells were constructed, and were allowed to drain through a pipeline to the Red River. Eventually this water was collected at the Towns of Ste. Agathe and Ile des Chenes, and is still currently used for water supply in the area. The four wells apparently discharge over 500 U.S.G.P.M. per well upon original construction. Since the installation, the static water levels have declined somewhat to the point that the flow rate is considerably less. According to some local residents in the area, the drawdown in the aquifer has been noted several miles to the north near Landmark and New Bothwell.

It is speculated that the "negative drawdown" discussed by Wang et. al. (2008) is a result of the MCWS artificial head lowering and constant carbonate aquifer conditions caused by the south lateral drain head lowering project. Thus, the current water levels in the area are the new "state of equilibrium" for the area.

Regional Groundwater Geochemistry

The geochemistry of the two aquifers in the southeast of Manitoba is complex. In the geologic past, prior to the start of the Pleistocene glaciations, it was highly likely that both aquifers were saline or brackish. Due to the subcrop recharge dynamics of the moraines present to the east, the aquifer receives a large amount of freshwater recharge annually. This has resulted in a large freshwater presence in both the carbonate and Winnipeg Formation Aquifers. This freshwater has formed a distinctive "wedge" in the southeast of the province. Figure 11 and 12, shown below; depict the freshwater portions of the carbonate and Winnipeg Formation aquifers, respectively.

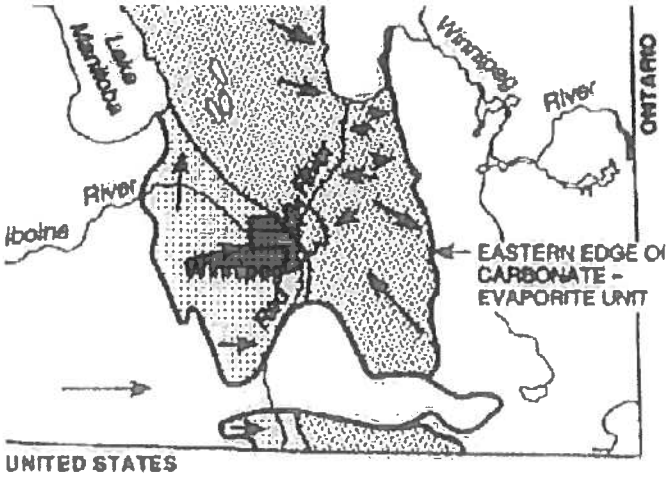

Figure 11 – Carbonate aquifer freshwater areas (saline areas are shown as to the west of the River) source – Betcher et. al, 1995.

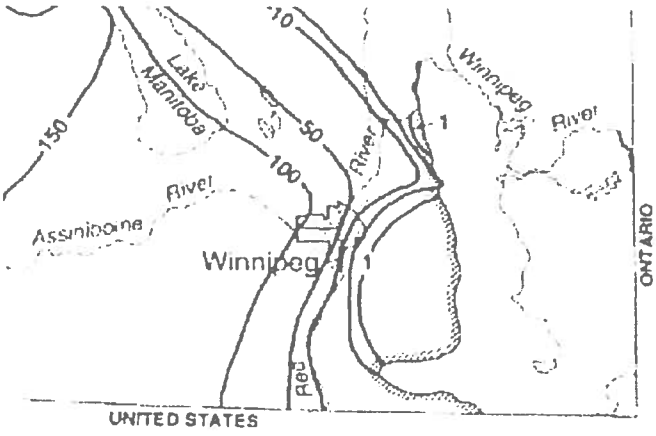

Figure 12 – Winnipeg Formation chemistry (> 1 g/L is fresh) Source – Betcher, et. al., 1995.

In order to determine the background groundwater geochemistry across the Landmark area, the following MCWS hydrograph station sampling results were reviewed.

- G05OH031 – Carbonate Aquifer
- G05OE049 – Carbonate Aquifer
- G05OE072 – Carbonate Aquifer
- G05OH009 – Carbonate Aquifer
- G05OE019 – Carbonate Aquifer
- G05OH008 – Carbonate Aquifer
- G05OH007 – Carbonate Aquifer
- G05OE031 – Carbonate Aquifer
- G05OE073 – Sandstone Aquifer
- G05OE071 – Sandstone Aquifer
- G05OE070 – Sandstone Aquifer
- G05OE069 – Sandstone Aquifer
- G05OE032 – Sandstone Aquifer

Observation well chemistry data source – MCWS, 2012/2013

The results from the MCWS observation wells were plotted on a Piper plot for comparison purposes. The results are shown on the following page as Figure 13.

Generally, the groundwater quality declines towards the west. Moving further west from the recharge area results in rising concentrations of major ions and total dissolved solids. In both aquifers, the groundwater quality is mostly Calcium/Magnesium/Bicarbonate type. However particularly in the carbonate aquifer there are zones of Calcium/Magnesium/Chloride waters. In both aquifers, this recent freshwater is actively flushing through the residual sodium chloride groundwater towards the west.

This flushing action of recent recharge through the area also acts as a natural softening of the groundwater from the Winnipeg Formation. The freshwater is not moving uniformly through the aquifer, as shown by Phipps et. al, 2008. In addition, the change in chemistry between the sandstone and overlying carbonate aquifer is shown on the following page as Table 1.

In the Landmark area, the sandstone aquifer is expected to have slightly better quality than the overlying carbonate aquifer.

Regional Geochemistry (cont'd)

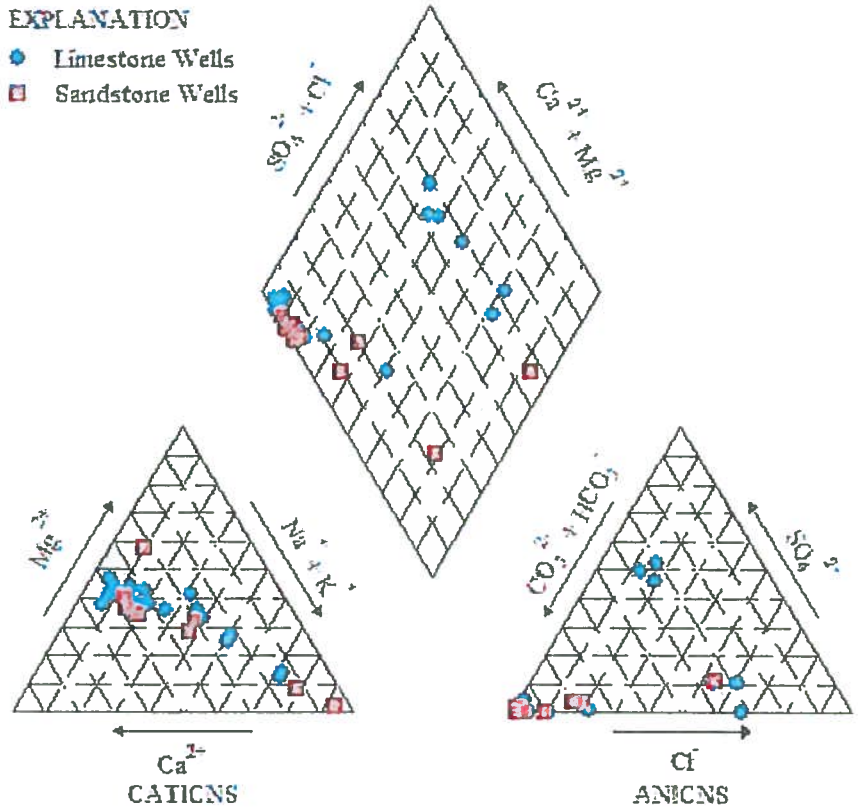

Figure 13 – Piper plot (data source – MCWS, 2012)

Table 1
RM of Tache – LUD of Landmark
MCWS Observation Wells
Comparison of Carbonate and Sandstone Aquifers in the Landmark area

Parameter (mg/L)	G05OE071 – Sandstone Aquifer	G05OE072 – Carbonate Aquifer
Calcium	14.2	87.6
Magnesium	5.75	63.6
Sodium	101	143
Potassium	10.4	8.57
Carbonate	< 0.5	< 0.5
Bicarbonate	286	348
Chloride	40.9	115
Sulphate	10.5	368
Total Dissolved Solids	324	1010

Table 1 – Comparison of sandstone and carbonate aquifer basic routine geochemistry. (data source – MCWS, 2012)

Well Inventory

A review of the MCWS GWDRILL database shows a large number of private, commercial, industrial, and agricultural wells in the area surrounding the Town. A large number of domestic wells are also present in the town site. Many of these wells were completed only in the carbonate aquifer, while some were completed into the sandstone aquifer. In the 1970's, it became commonplace to install a well through both aquifers in an effort to obtain "softer" groundwater in the well. This has resulted in inter aquifer mixing in many cases.

A large number of the private wells in Landmark were drilled by homebuilders, as part of residential subdivisions constructed in the area prior to the municipal water supply being developed. It is not known if these wells are still in use, or are supplemental to the municipal water supply.

The RM of Tache should undertake a program to identify and seal the old, unused water supply wells within the area of municipal service. Many of these wells may be located in parts of the town constructed prior to 1990. These wells should be checked prior to sealing to confirm if multiple aquifer penetration has occurred. There should be an effort made to educate the public about the interconnection of both aquifers, and the benefits of proper sealing of unused wells in the community.

Investigation Methodology and Results

Requested Allocation

As discussed previously, MCWS had issued a license to the RM of Tache (License No. 2005-130) which allowed for the use of the two wells for municipal water supply. The following significant conditions were part of the license:

- The groundwater supply is for municipal purposes
- The maximum water diversion rate is set at 0.018 m^3/s, of 0.6 c.f.s. (269.3 U.S.G.P.M.).
- The total water diversion in any year shall not exceed 140.0 dam^3 (113.5 acre feet).
- Water shall not be pumped when the water level in the aquifer is deeper than 22.86 m (75 feet) in the east well (No.1) and 25.6 m (84 ft.) below grade in the west well (No.2)

In order for the RM of Tache to supply the LUD of Landmark with the projected growth of the town with a municipal water supply, an increase to the existing license would be requested from MCWS. The rate would include the following:

- Projected population in 2034 ~ 6,000 people (entirely serviced by the LUD water supply system)
- Average daily per capita demand – 300 L/person/day
- Annual consumption – 537.66 acre feet/year (663.21 dam^3/year)
- Projected flow rate – 333 U.S.G.P.M.
- The maximum water diversion rate is set at 0.028 m^3/s, of 1.0 c.f.s. (450 U.S.G.P.M.).

The projected water consumption has been estimated assuming the 300 L/person/day. This rate could be refined with additional civil engineering investigations into the LUD water supply.

It is not known what the per capita consumption of the residences in the LUD of Landmark is at the present time, or if any water conservation practices are in place.

The LUD of Landmark has not undertaken a comprehensive water supply sourcing study, or an integrated water supply management study, that the authors are aware of.

Aquifer Testing

In order to obtain preliminary aquifer parameters and to determine how the well responds to pumping, a long term well monitoring program was initiated. Several automatic, data recording pressure transducers were placed in two supply wells of the municipal well field to monitor the daily static water levels. The pressure transducers were set to record water levels every 10 minutes, and were deployed in the well field for several months. During the operation, staff from the RM also recorded their daily flow rates and water consumption record. The transducer records for both wells are shown below as Figure 14 and 15.

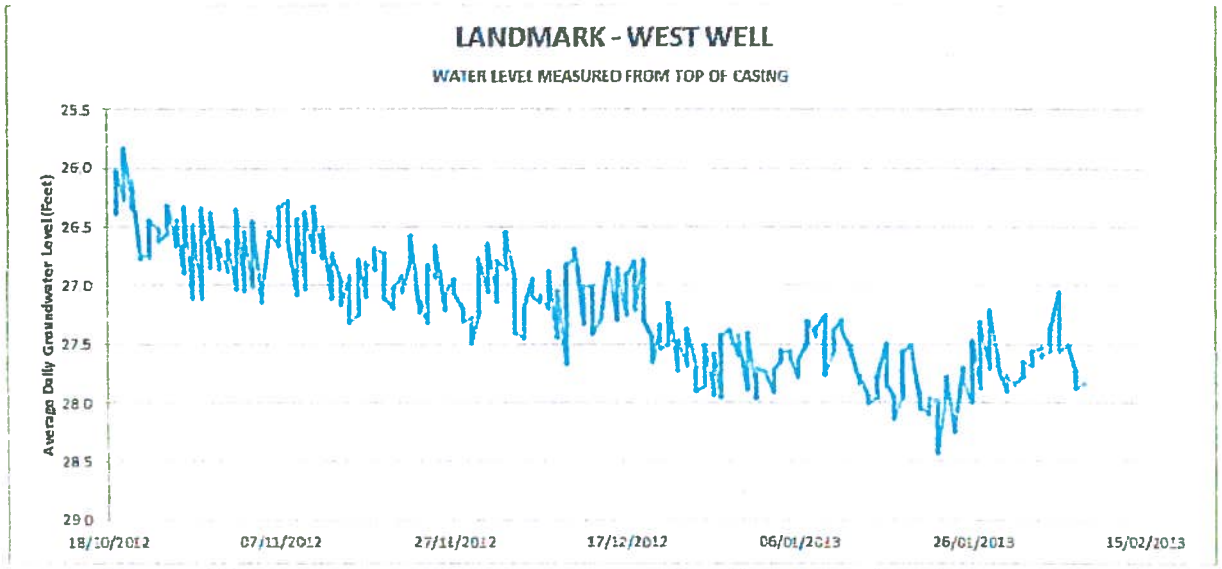

Figure 14 – Transducer record – LUD of Landmark – West (Well No. 1) 10 inch diameter supply well.

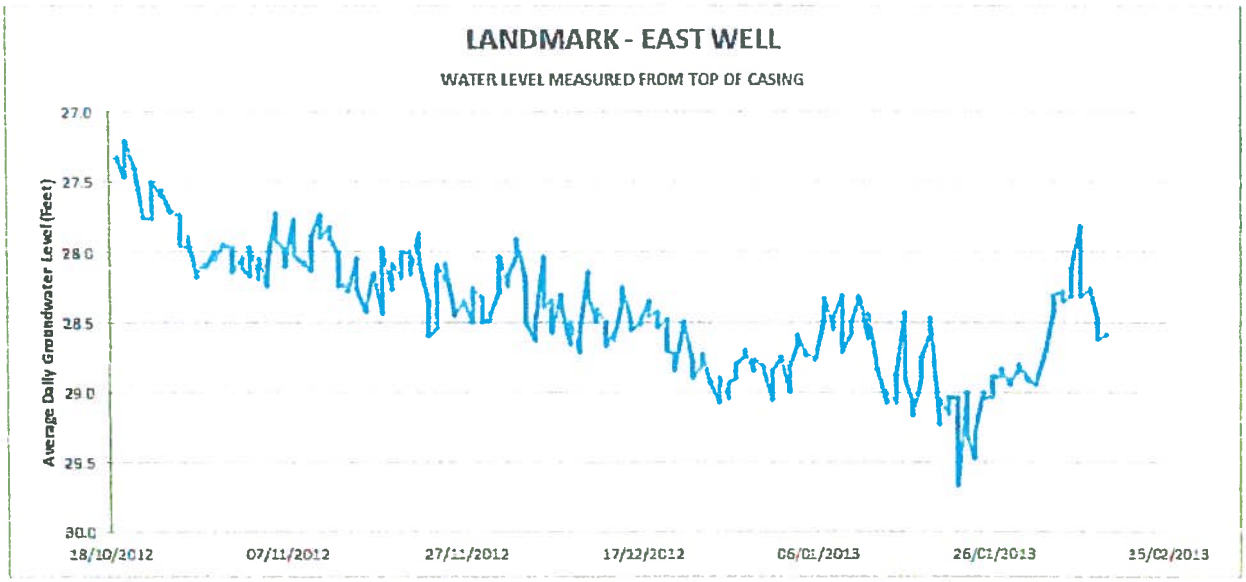

Figure 15 – Transducer record – LUD of Landmark – East (Well No. 2) 8 inch diameter supply well.

The transducers were left in place for 4 months throughout the winter. During this period, the static water levels in both wells declined about 1.5 feet. This was a period of mostly winter conditions, when the carbonate aquifer is typically not recharging. This overall decline in water levels was also noted on the regional hydrographs during this period.

During the monitoring, it was hoped that a long enough pumping duration would be present to enable predictions of aquifer capacity. Due to the relatively low pumping rates, and little drawdown produced by the supply wells, it was not possible to determine effective aquifer parameters for the individual supply wells. The drawdown from the existing wells after almost 20 years has not produced a detectable drawdown cone in the area around the LUD of Landmark. Other methods will be employed to determine effective aquifer parameters.

Aquifer Parameter Estimation

In order to estimate the aquifer parameters around the LUD of Landmark, alternate means had to be employed. The on-site wells cannot be shut down for even short term periods without interrupting the town water supply. Therefore, it was decided to utilize the specific capacity testing as the basis for determining aquifer parameters.

Table 2
Specific Capacity Determinations
LUD of Landmark Supply Wells

	West Well (No.1)	East Well (No.2)
Drawdown	21.45 ft @ 572 U.S.GPM – 1 hour	4.00 ft @ 326 U.S.G.P.M. – 8 hours
Static Water Level	23.30 ft from top of casing	23.00 ft from top of casing
Specific Capacity	26.67 U.S.GPM/ft	81.50 U.S.G.P.M./ft.

Table 2 – Specific capacity – RM of Tache – LUD of Landmark

Since an accurate, instrumented pumping test was not possible to perform on the system due to the operational requirements of the LUD water supply, alternative means of obtaining reasonable aquifer parameters had to be utilized. The installation of the 1990 well included a specific capacity test of only one hour duration. During this test, the MCWS GWDRILL (2012) log shows a transmissivity estimate of 44,000 U.S.G.P.D./ft. In 1995, the second well was installed, and an 8 hour test was conducted. The MCWS log does not show an estimate of the transmissivity. Friesen Drillers files on the well installation show an estimate of about 70,000 U.S.G.P.D./ft., which was apparently calculated on the site by the Water Services Board field engineer. However, the East Well only drew down from 23.00 feet to 27.00 feet during the eight hour test. Therefore the drawdown was 4 feet. The pumping rate was 327 U.S.G.P.M.. Thus the specific capacity was 81.5 U.S.G.P.M. over the test period. This is a substantial indication of a high transmissivity zone. Using the Theim equation (Walton, 1970) one derives a transmissivity of 190,000 U.S.G.P.D./ft.. As this number is from a pumping well it is likely a conservative number for that particular site. It appears that an observation well was used during the test and the value of 70,000 U.S.G.P.D./ft. was obtained from analyzing that data.

Wang et. al. (2008) provided a map, shown on the following page as Figure 16, and paper showing the log of the hydraulic conductivity for the area to show the variability of the regional transmissivity. However, the authors (Wang, et. al., 2008) did not provide the true carbonate aquifer thicknesses at the test sites. The data are based on short time single well pumping tests. Therefore, their data was reviewed but determined to be more of a provincial scale evaluation of the aquifer and was not included in this project.

In order to provide a range of the regional transmissivity of the carbonate aquifer, different methods were used, as shown below in Table 3.

Table 3
Range of Transmissivity – Carbonate Aquifer – Landmark area

Source	Method	Result
Specific Capacity East Well Specific Capacity East Well	Theim (1906), (Walton, 1970) Cooper Jacob (1946)	*190,000 U.S.G.P.D./ft.* *147,000 U.S.G.P.D./ft.*
Pedersen, 1990 and 1995	Cooper Jacob (1946) analysis of single well pumping tests.	*44,000 to 76,000 U.S.G.P.D./ft.*
Kennedy, 2000	Regional mapping of GWDRILL airlift testing.	*30,000 to 80,000 U.S.G.P.D./ft.*
Bell, 2009	Regional analysis of the City of Steinbach drawdown cone.	*~ 75,000 U.S.G.P.D./ft.*

Table 3 – Range of regional transmissivities in the Landmark area. (source – various authors)

Through the review discussed above it was determined that an approximate regional transmissivity of about 76,000 U.S.G.P.D./ft. would be reasonable for use in the carbonate aquifer at in the Landmark site. The results appear to be fairly conservative on the basis of the 8 hour pumping test performed on the east well in the Landmark LUD. Without the testing of the supply wells, it was thought that the above review would provide the best possible estimate of the site transmissivity case, shutting down the supply wells for testing was not possible, as both wells are critical to the water supply for the LUD. The long term monitoring did not produce an acceptable amount of drawdown to allow for the proper analysis of a pumping test at the site.

Aquifer Parameter Estimation (cont'd)

The storage coefficient was estimated to be about 1.0 x 10 $^{-1}$, which is fairly typical for the area, based on the regional assessment of the carbonate aquifer area. A number of long term large capacity pumping tests in the carbonate aquifer have been conducted in the area, and these results are typical.

It is stressed that long term, fully instrumented aquifer pumping tests are obviously superior for obtaining aquifer parameters. In this case, shutting down the supply wells for testing was not possible, as both wells are critical to the water supply for the LUD. The long term monitoring did not produce an acceptable amount of drawdown to allow for the proper analysis of a pumping test at the site.

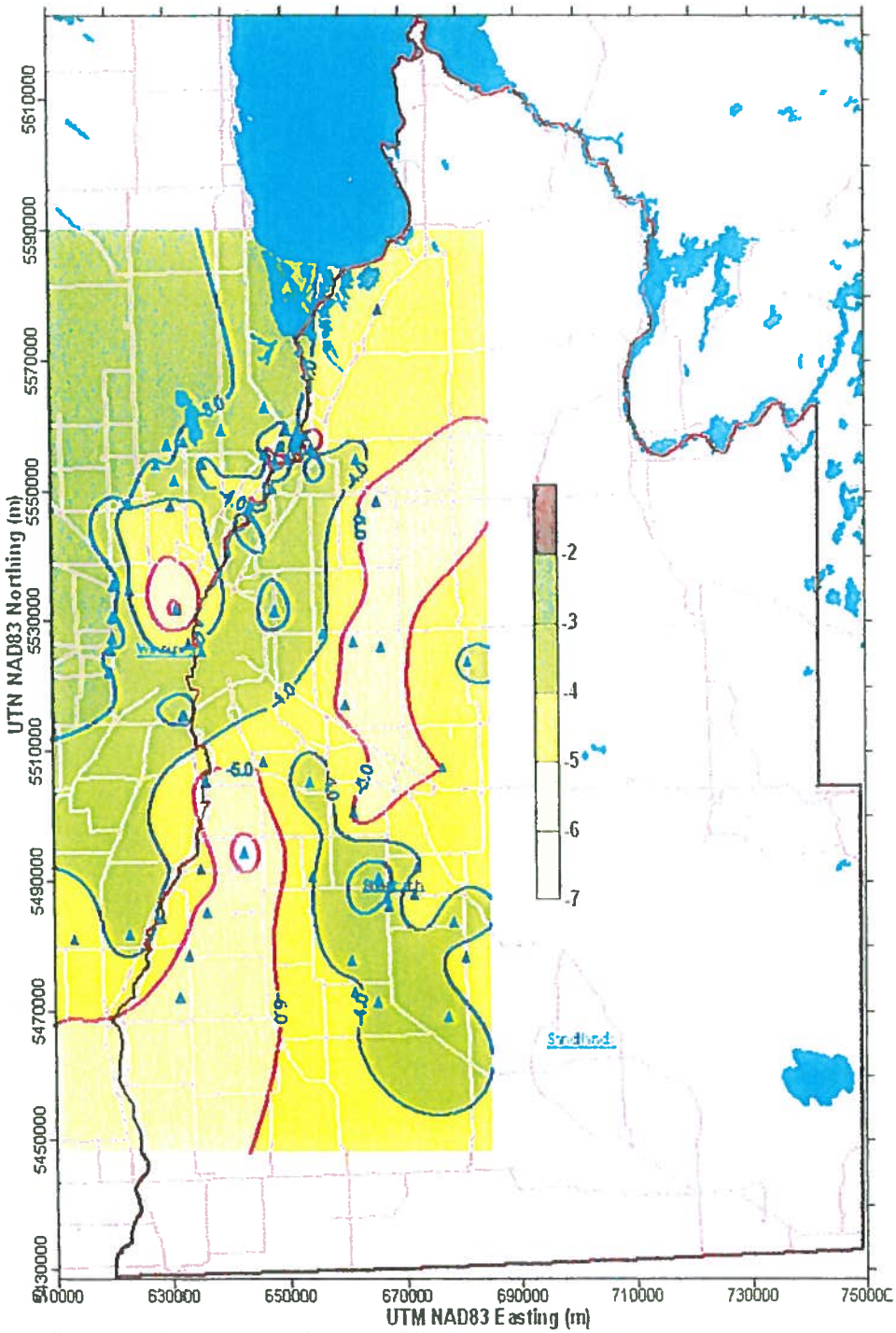

Figure 16 – Regional mapping of hydraulic conductivity in the southeast of Manitoba. (source – Wang, et. al, 2008)

Geochemical Sampling and Results

During the regular operation of the LUD water plant, several water samples were collected for geochemical analysis from both wells. The samples were collected at the well head, prior to any treatment by the RM system by Friesen Drillers staff.

The water samples were collected in laboratory supplied sample bottles. Upon collection, the sample was kept cool for delivery to the analytical laboratory. All samples were analyzed by ALS Laboratories in Winnipeg (L1238931). A formal copy of the laboratory analytical results is attached as Appendix D.

The major results are shown below as Table 4. Figure 17, shown below, depicts the Piper plot comparing the on site results with the MCWS observation wells in the southeast of Manitoba.

Table 4
RM of Tache – LUD of Landmark
Groundwater Sampling Results

Well Name	Total Dissolved Solids	Chloride	Nitrate	Conductivity	Sodium	Iron	Hardness
Well No. 1 (West)	686 mg/L	112 mg/L	<0.050 mg/L	1,130 umhos/cm	148 mg/L	0.50 mg/L	281 mg/L
Well No. 2 (East)	888 mg/L	130 mg/L	<0.050 mg/L	1,400 umhos/cm	147 mg/L	0.82 mg/L	459 mg/L

Table 4 – Groundwater analytical results (source - ALS L1238931)

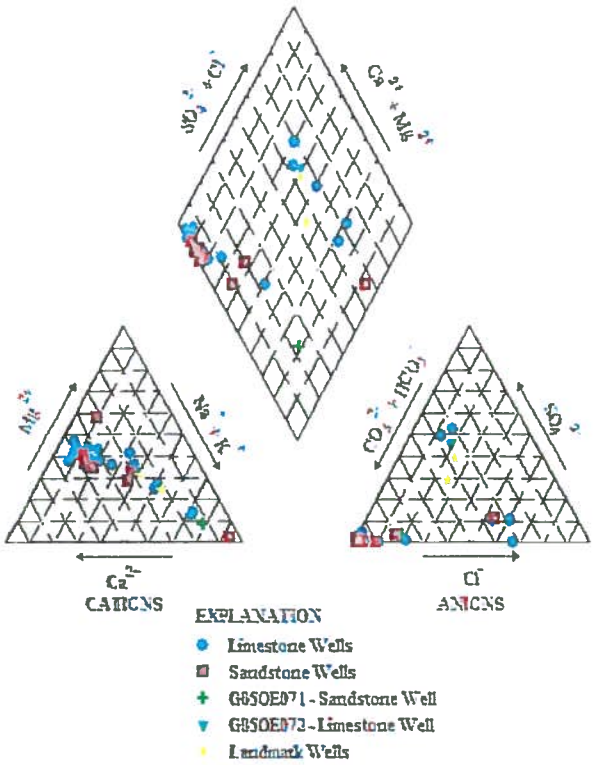

Figure 17 – Piper plot comparing local water qualities with LUD of Landmark sample results.

The results in general compare very well with the regional water quality in the area. The samples plot reasonably close to the middle of the Piper plot, which is reasonable with the changing water quality in the carbonate aquifer. The west well appears to provide slightly better quality than the eastern well, based on the sampling conducted. This type of variation is normal in the carbonate aquifer

The groundwater is a Calcium/Magnesium/Bicarbonate type, which is expected for the carbonate aquifer in the area. Overall, the groundwater is very hard, with lower levels of sodium and iron. The nitrates show non-detectable levels, which is expected. This is not the case in other areas where carbonate bedrock is shallower to surface.

Geochemical Sampling and Results (cont'd)

During field investigations by the MCWS in the Southeast, samples were collected for the analysis of isotopes of oxygen. The ratios of the main isotopes that comprise the water molecule ($^{18}O/^{16}O$) and $^{2}H/^{1}H$ are important for hydrogeological investigations (Freeze and Cherry, 1979). The units are presented in delta (δ) units as parts per thousand or ‰ (Freeze and Cherry, 1979) relative to standard mean oceanic water (SMOW). The two isotopes of water have different freezing and vapour points, which leads to different concentrations as a result of freezing, condensation, melting, and evaporation (Freeze and Cherry, 1979). As water is evaporated from the ocean, there is a decline in the ^{18}O concentration by a specific amount. As the vapor condenses, the precipitation has a higher ^{18}O concentration. This process continues as the vapor moves inland, and undergoes many cycles of condensation and evaporation. This fact makes deuterium and oxygen^{18} very useful for hydrogeological investigations, as the origin and mixing of different waters can be determined. In order to determine the changes from local precipitation, deuterium and oxygen^{18} results are plotted to determine the local meteoric water line, which would be expected to be the typical concentrations in recent precipitation events in the southeast.

Phipps et. al., conducted sampling of approximately 50 MCWS observation and monitoring wells in 2008, as part of the southeast groundwater study. These results were plotted against a local meteoric water line, which was determined to be $\delta^{2}H = 7.6 \cdot \delta^{18}O + 2.2$, which is the virtually the same as the local meteoric water line for the Gimli area (IAEA, 2006).

In order to provide a comparison, stable isotope samples were collected from the LUD of Landmark supply wells and were plotted on Phipps et. al., 2008 plot. This plot is shown below as Figure 18. The various aquifers are also shown.

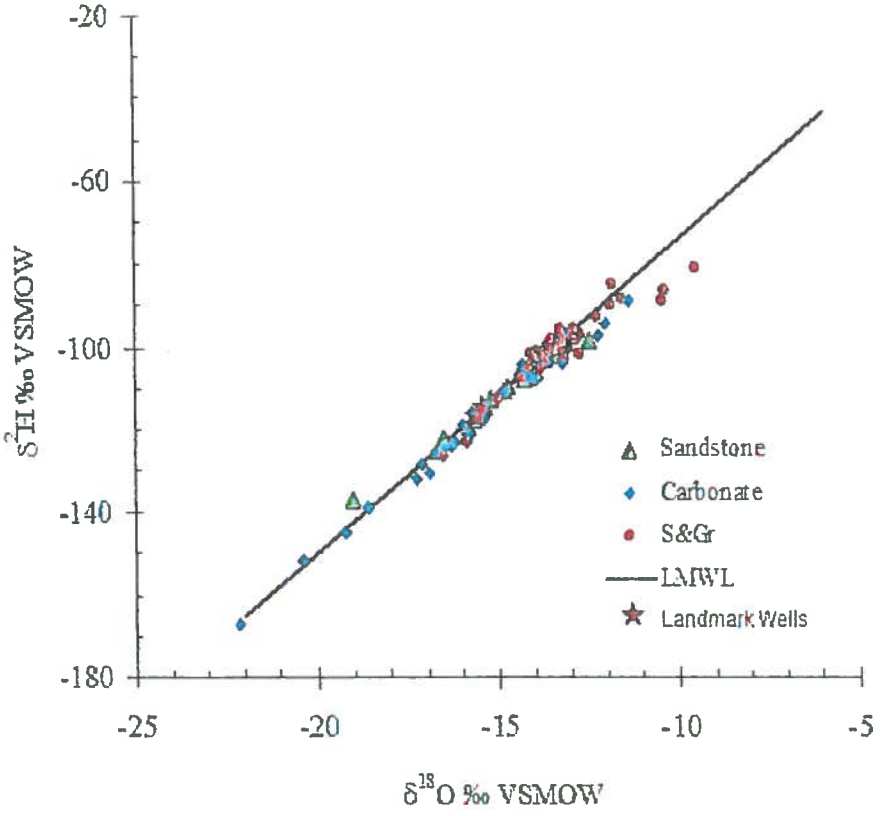

Figure 18 – Local isotopes comparing with the LN006 result.

The values indicate that the groundwater is modern precipitation. The results are typical for fairly recent recharge, and there is a slight indication of a slope change resulting from snow melt infiltration. Groundwater from the supply wells is slightly older than the overlying sand and gravel aquifer isotope samples obtained from the recharge moraine area. It should be noted that highly depleted samples are shown to the left on the local meteoric water line, which indicate recharge under very different climatic conditions. This is likely from the Pleistocene glaciations

The groundwater from the LUD of Landmark wells is fairly recent, and indicates a fairly recent movement through the aquifer towards the town wells. There is also not a marked change in the values in the sandstone aquifer from the overlying carbonate aquifer in the Landmark area.

Discussions

Long Term Hydrograph Response

The RM of Tache Landmark LUD is located fairly near to a major recharge area in the carbonate and sandstone aquifers in the southeast of Manitoba. Through reviewing all of the regional hydrograph data, the following comments can be made:

- The existing operation of the LUD of Landmark wells has not produced a major drawdown cone that has been detected by the regional hydrograph network operated by MCWS. Drawdown cones would typically be expected around major pumping centers, similar to what has developed around the City of Steinbach and Granny's Poultry. The fact that the LUD of Landmark has been pumping since the 1990's, though at relatively low pumping rates and no detectable cone has developed around the well field, indicates that the aquifer is highly transmissive, which is also reflected in the regional potentiometric surface mapping.

- The aquifer is highly responsive to seasonal and climatic variations. Water levels in the carbonate aquifer appear to decline very rapidly during prolonged dry periods. The aquifer appears to be very similar to an open reservoir and pipe analogy. When the water level in the reservoir falls, the potential in the pipe declines very rapidly. This means that during prolonged dry periods, static water levels in the area will respond very rapidly, and decline accordingly.

- During periods of recharge, the aquifer also responds quickly.

- The hydrograph record is relatively short for the sandstone aquifer. However, as previously noted, the carbonate and sandstone aquifers appear to respond in a very similar manner. The longest term record near the Landmark site is G05OH008, with the hydrograph shown below as Figure 19. The long term hydrograph record follows normal seasonal and climatic variations.

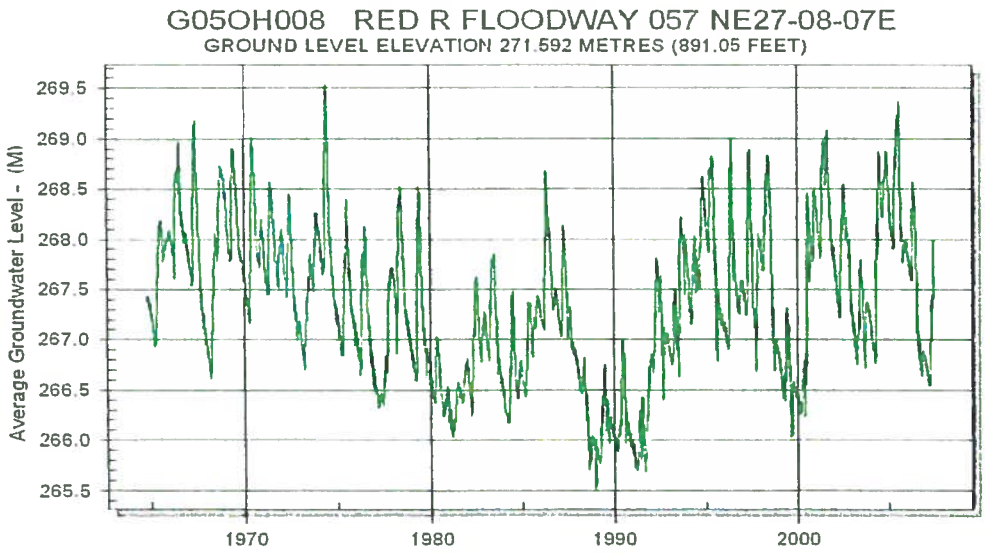

Figure 19 – G05OH008 (1964 – present) – (source – MCWS, 2010)

Aquifer Sustainability

As discussed above the Sandilands area lying up gradient east of the Landmark site is a recharge area for the bedrock aquifer system lying to the west. This recharge area covers approximately 400 square miles. The following is an attempt to determine the long term average groundwater sustainability for this area.

The only area known to the author where the aquifer recharge has been determined in Manitoba is the Upper Pine Creek Basin of the Assiniboine Delta Aquifer (Render, 1986). Render determined that the average precipitation for the area during the time of evaluation was 482.82 mm (17.04 in). Render calculated that the average annual groundwater discharge from the basin over 17 years was 34.29 mm (1.35 in). This value was considered the sustainable yield of the aquifer in that area. Due to the importance of the determination for agricultural activities over the Assiniboine Delta Aquifer this work was reviewed by a committee chaired by R.N. Farvolden from the University of Waterloo.

Aquifer Sustainability (cont'd)

While the Sandilands area is not a perfect replica of the Upper Pine Creek Basin, there are quite a few similarities. The author considered that if the Upper Pine Creek recharge value was adjusted for the current climatic precipitation average in the Sandilands area it would produce a reasonable estimate of the Sandilands sustainability. The current climatic average for precipitation provided by Environment Canada (2012) from 1981 to 2010 shows an average annual value of precipitation of 575 mm (22.64 in) for the Sandilands area. This value was used to adjust the Upper Pine Creek recharge rate to an approximate rate for the Sandilands area.

If this value is used for the long term average annual recharge, then the 400 square miles of the Sandilands would produce 1,666,814,197 cubic feet (47,198,921 cubic meters) of water per annum. This amount of water is considerably above the amount of water flowing westward through the carbonate and Winnipeg Sandstone aquifers. Which, from the view point of those aquifers, means that if there is a decline in water level in the carbonate aquifer due to an addition in withdrawals, the recharge area can likely supply the requested allocation.

Estimated Westward Groundwater Flow in the Bedrock Aquifers

The Potentiometric Surface for the area involving Landmark is illustrated on page 9 as Figure 6. The flow of groundwater moving out of the Sandilands area can be estimated using the groundwater gradient on the east side of the map; of 1.24×10^{3}, and average transmissivity of 50,000 U.S.G.P.D./ft. for the carbonate aquifer and transmissivity of 5,000 U.S.G.P.D./ft. for the Winnipeg Sandstone Aquifer. As shown on the map the flow front is about 40 miles wide. Using these numbers one obtains a westward flow of about 711,848,649 cubic feet (20,172,798 cubic meters) per annum. These figures are less than half the recharge estimate. Therefore if there is some additional stress put on the flow system, there, appears to be ample groundwater to make up the difference.

Estimated groundwater usage

Due to the lack of monitoring, it is virtually impossible to determine the total average annual groundwater usage in the area being studied. However, this value must be in the order of the groundwater flow to the west from the Sandilands. It is recognized that there is some discharge to river, creeks and swamps in the upper section of Figure 6. Also there may be some groundwater discharge to the Red River, springs in streams and drains and the southern end of the Red River Floodway. While it is close to pure conjecture the authors have made the following gross estimate of usage – City of Steinbach 201,612 cubic feet per day, remainder of area farms and acreages 500,000 cubic feet per day, Grannies Poultry 232,258 cubic feet per day and the Manning Canal Relief wells 232,258 cubic feet per day for a total very rough estimate of 1,166,128 cubic feet per day or 425,000,000 cubic feet (12,000,000 cubic meters) per annum. As this estimate is considerably below the estimated flow in the aquifers, it is probably low. However it does indicate that the system still has considerable amounts of water that is available for use. That is, the current usage is well below the groundwater flow in the aquifer and more importantly, the sustainable yield.

Prediction of Long Term Regional Effects

In order to determine the long term effects of operating the RM of Tache – LUD of Landmark well field at the proposed pumping rate, the drawdown was calculated at a distance using the Theis (1935) equation at an average pumping rate of 333 U.S.G.P.M., after one year of operation for the site. The 333 U.S.G.P.M corresponds to the requested allocation of 537 acre feet per year. In order to calculate the effects regionally, the well field was assumed to consist of one large pumping well. Therefore the regional analysis will not attempt to predict water levels within the immediate area of the supply wells. Though from the fact the drawdown in the East Well was only 4 feet after 8 hours of steady pumping at 327 U.S.G.P.M the local drawdown is not expected to be more than eight feet. The calculated drawdowns follow all the assumptions of the Theis method. Drawdowns were calculated using Walton's B8.BAS Fortran code (Walton, 1979).

The drawdown at a radial distance of 5,280 feet was determined to be approximately 3.2 feet after pumping one year continuously at a rate of 333 U.S.G.P.M.. In order to provide a conservative estimation, the local aquifer transmissivity was assumed to be uniform across the area at 76,000 U.S.GPD/ft, with an assumed storage coefficient of 1.0×10^{-4}. It is expected that the levels will also decline similarly in the Winnipeg Formation Sandstone.

The Tache area is well populated, and to a large extent, the aquifer is well utilized by both industry and private residences. In reviewing the local static water levels, it can be assumed that most private well systems in the area have taken current conditions as static for the area. In order to provide the expected additional drawdown from the proposed expansion, the water levels were also predicted based on the current pumping rate. Table 5, shown on the following page compares the expected drawdowns at current levels, versus the

Prediction of Long Term Regional Effects (cont'd)

expected drawdown resulting from the requested pumping rate. The predicted additional drawdown is also shown as Figure 20, below. It should be noted that the drawdown plotted in Figure 20 includes estimated drawdown without natural gradients and the effects of other unknown pumping wells that may be present.

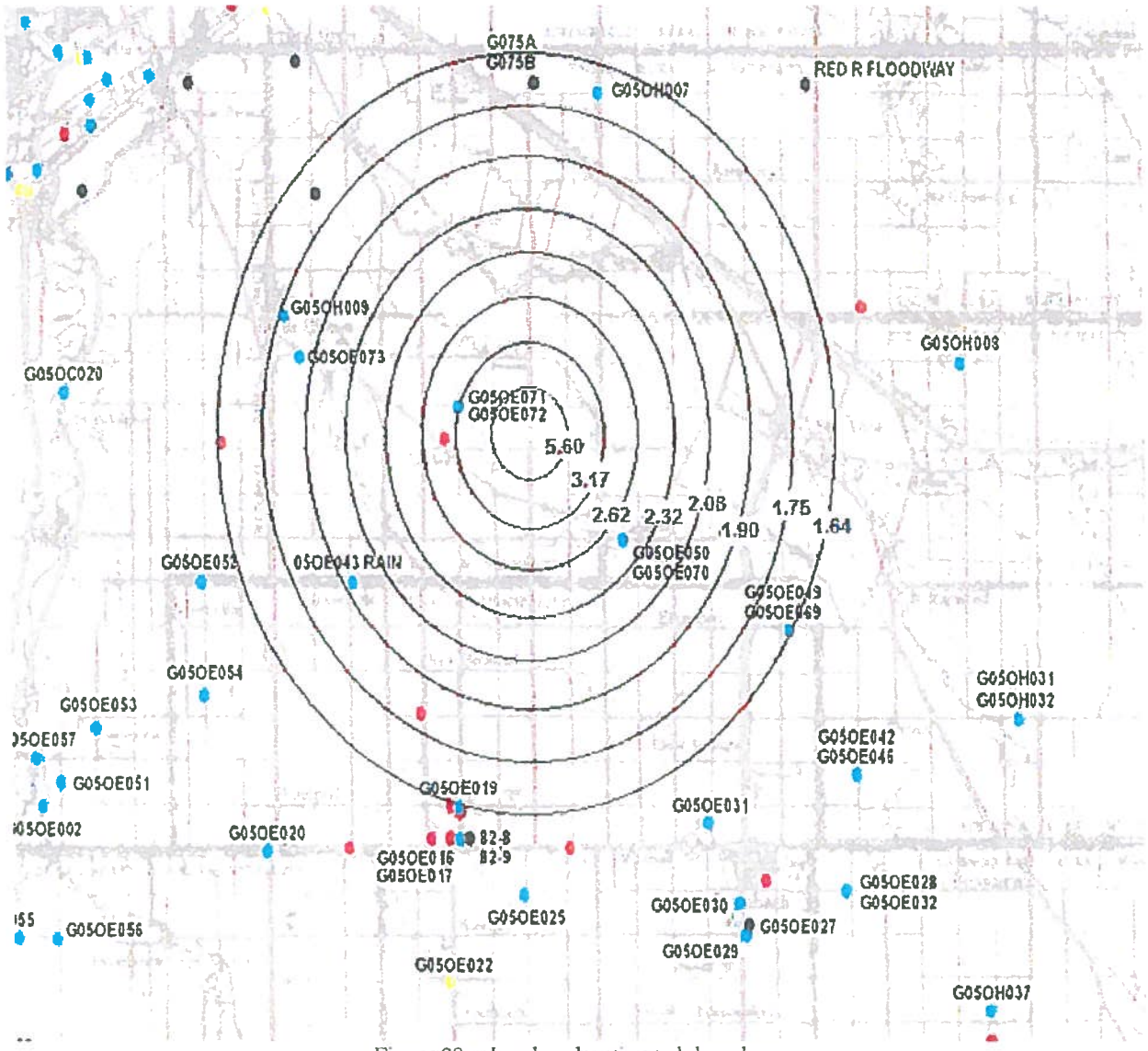

Figure 20 – Landmark estimated drawdown.

Table 5
Drawdown Comparison at Distance – Requested Rate of Pumping vs. Existing Pumping Rate and Expected Additional Drawdown
RM of Tache – LUD of Landmark Well Field
All calculations following the Theis (1935) equation and assumptions

	Distance							
Pumping Rate	**Well**	**1 mile**	**2 miles**	**3 miles**	**4 miles**	**5 miles**	**6 miles**	**7 miles**
Proposed rate	7.00 ft.	4.02 ft.	3.32 ft.	2.92 ft.	2.63 ft.	2.40 ft.	2.22 ft.	2.07 ft.
Current rate	1.40 ft.	0.85 ft.	0.70 ft.	0.60 ft.	0.55 ft.	0.50 ft.	0.47 ft.	0.43 ft.
Additional Drawdown	5.60 ft.	3.17 ft.	2.62 ft.	2.32 ft.	2.08 ft.	1.90 ft.	1.75 ft.	1.64 ft.

Table 5 – Expected drawdowns resulting from requested yields versus expected drawdown at distance from existing licensed after one year – LUD of Landmark well field.

Integrated Water Supply and Watershed Planning Study

A water supply investigation and development of this size requires careful planning and assessment. Although it is assumed that groundwater supplies are the best option, an integrated water supply and watershed planning study is an important tool in the evaluation process.

An integrated planning study for water supply would identify future and prospective water supply sources, and the relative availability. This would document and address items such as river supplies, allocations, and other water supply alternatives. This is important for future water supply licensing and environment act licensing.

Integrated water supply and watershed planning studies are often required in obtaining environment act licensing for new proposed water supplies in the province.

Recommendations

Based on our review of the RM of Tache – LUD of Landmark proposed expanded water supply expansion, we offer the following recommendations:

- The municipality of Tache should apply to the Department of Conservation and Water Stewardship for an increase Water Rights License to 537.66 acre feet. An Environmental Act Proposal will also be required to accompany the said application.

- The municipality should plan, as a part of the water supply expansion to drill a third backup supply well at as far as can be reasonably set from the current wells.

- Through a review of the background geology and hydrogeology at the site, it can be readily seen that a suitable clay/overburden cover exists in the well field area to provide aquifer/well head protection. Even though the protection is relatively thick, there are other wells near the RM wells which could become contaminated in some unknown fashion. Should this occur, all of the wells within the well field would likely be impacted due to their close proximity with each other, combined with the gradient towards the pumping wells. The RM should develop an aquifer/well head protection program for the wells, and develop a contingency plan should the aquifer become impacted in some manner.

- According to our analysis and data collection, it appears the LUD of Landmark well field is capable of providing the requested additional allocation, under normal seasonal and climatic conditions. The analysis indicates that the requested allocation will not result in a significant (greater than 4.00 feet) amount of additional drawdown one mile from the pumping wells. At least three additional observation wells are needed in the immediate area around the well field.

- While the two pumping wells appear to be operating in a satisfactory manner. The pumping systems in each well are not quite industry standard, and should be reviewed.

- In the event of considerably lower regional static water levels in the carbonate aquifer, water levels in the pumping wells should be monitored daily.

- We recommend that each pumping well be equipped with an automatic data recording pressure transducer. This would assist the RM in monitoring pumping water levels.

- We recommend that additional monitoring wells be installed in the carbonate aquifer at various distances to monitor the regional impacts. A hydrogeologist/hydrogeological engineer should review the data collected from these wells ever few years to determine regional impacts, yearly.

- Each well should be closely monitored for well performance. The RM should continue performing a regular servicing/maintenance program for each well.

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Limitations

The scope of this report is limited to the matters expressly covered and is intended solely for the client to whom it is addressed. Friesen Drillers Limited makes no warranties, expressed or implied, including without limitation, as to the marketability of the site, or fitness to a particular use. The assessment was conducted using standard engineering and scientific judgment, principles, and practices, within a practical scope and budget. It is based partially on the observations of the assessor during the site visit in conjunction with archival information obtained from a number of sources, which is assumed to be correct. Except as provided, Friesen Drillers Limited has made no independent investigations to verify the accuracy or completeness of the information obtained from secondary sources or personal interviews. Generally, the findings, conclusions, and recommendations are based on a limited amount of data (e.g. number of boreholes drilled or water quality samples submitted for laboratory analysis) interpolated between sampling points and the actual conditions on the site may vary from that described above. Any findings regarding the site conditions different from those described above upon which this report was based will consequently change Friesen Drillers Limited's conclusions and recommendations.

Disclaimer

This Friesen Drillers Limited report has been prepared in response to the specific requests for services from the client to whom it is addressed. The content of this document is not intended to be relied upon by any person, firm, or corporation, other than the client of Friesen Drillers Limited, to who it is addressed. Friesen Drillers Limited denies any liability whatsoever to other parties who may obtain access to this document by them, without express prior written authority of Friesen Drillers Limited and the client who has commissioned this document.

Appendix A

Existing Water Rights License (#2005-130)

Licence to Use Water for Municipal-Distribution System Purposes

Manitoba Water Stewardship
Infrastructure and Operations Division
200 Saulteaux Cresc.
Winnipeg, Manitoba
R3J 3W3

Project Village of Landmark

Issued in accordance with the provisions of
The Water Rights Act and regulations made thereunder.

Licence No.: **2005-130**

U.T.M.: Zone 14 656774 E
5503966 N

Know all men by these presents that in consideration of and subject to the provisos, conditions and restrictions hereinafter contained, the Minister of Water Stewardship for the Province of Manitoba does by these presents give full right and liberty, leave and licence to **The Rural Municipality of Tache** in the Province of Manitoba (hereinafter called "the LICENSEE") to divert water from a **fractured limestone** aquifer by means of two water wells, pumps, pipeline(s) and other appurtenances (hereinafter called "the WORKS"), located on the following described lands

the Southeast Quarter of Section 22 and the Southwest Quarter of Section 23, both in Township 8 and Range 5, East of the Principal Meridian in Manitoba, more particularly described on Certificates of Title No. C83645 and No. 1853079 WLTO, respectfully,

and more particularly shown on a plan filed in the office of the Executive Director, Infrastructure and Operations Division, a copy of which plan is hereto attached and marked Exhibit "A" for **municipal-distribution system** purposes on the following described lands

the East Half of Section 22 and the West Half of Section 23, in Township 8 and Range 5, East of the Principal Meridian in Manitoba

This licence is issued upon the express condition that it shall be subject to the provisions of The Water Rights Act and Regulations and all amendments thereto and, without limiting the generality of the aforesaid, to the following terms and conditions, namely:

1 The water shall be used solely for **municipal-distribution system** purposes.

2 The WORKS shall be operated in accordance with the terms herein contained.

3 a) The maximum rate at which water may be diverted pursuant hereto shall not exceed **0.018 cubic metres per second (0.6 cubic feet per second)**.

b) The total quantity of water diverted in any one year shall not exceed **140.0 cubic decametres (113.50 acre feet)**.

4 Water shall not be diverted during any period when the water level in the aquifer as measured at

a) the West well is more than 25.6 metres (84 feet) beneath the surface of the ground.
b) the East well is more than 22.86 metres (75 feet) beneath the surface of the ground.

5 The LICENSEE does hereby remise, release and forever discharge Her Majesty the Queen in Right of the Province of Manitoba, of and from all manner of action, causes of action, claims and demands whatsoever which against Her Majesty the LICENSEE ever had, now has or may hereafter have, resulting from the use of water for **municipal-distribution system** purposes.

6 In the event that the rights of others are infringed upon and/or damage to the property of others is sustained as a result of the operation or maintenance of the WORKS and the rights herein granted, the LICENSEE shall be solely responsible and shall save harmless and fully indemnify Her Majesty the Queen in Right of the Province of Manitoba, from and against any liability to which Her Majesty may become liable by virtue of the issue of this Licence and anything done pursuant hereto.

7 This Licence is not assignable or transferable by the LICENSEE and when no longer required by the LICENSEE this Licence shall be returned to the Executive Director, Infrastructure and Operations Division, for cancellation on behalf of the Minister.

8 Upon the execution of this Licence the LICENSEE hereby grants the Minister or the Minister's agents the right of ingress and egress to and from the lands on which the WORKS are located for the purpose of inspection of the WORKS and the LICENSEE shall at all times comply with such directions and/or orders that may be given by the Minister or the Minister's agents in writing from time to time with regard to the operation and maintenance of the WORKS.

9 If for any reason whatsoever the Minister deems it advisable to cancel this Licence, he may do so by letter addressed to the LICENSEE at **Box 100, Lorette, MB, R0A 0Y0, Canada** and thereafter this Licence shall be determined to be at an end.

10 Notwithstanding anything preceding in this Licence, the LICENSEE must have legal control, by ownership or by rental, lease, or other agreement, of the lands on which the WORKS shall be placed.

11 The term of this Licence shall be **twenty (20) years** and this Licence shall become effective only on the date of execution hereof by a person so authorized in the Department of Water Stewardship. The LICENSEE may apply for renewal of this Licence not more than 365 days and not less than 90 days prior to the expiry date.

12. This Licence expires automatically upon the loss of the legal control of any of the lands on which the WORKS are located unless the Licence is transferred or amended by the Minister upon application for Licence transfer or amendment.

13. The LICENSEE shall keep records of daily and annual water use and shall provide a copy of such records to the Executive Director, Infrastructure and Operations Division, not later than February 1st of the following year.

14. A flow meter must be installed, positioned to accurately measure instantaneous pumping rate and accumulative withdrawals from the water source.

A COMMISSIONER FOR OATHS
in and for the Province of Manitoba

Witness

My Commission expires _____

Issued at the City of Winnipeg, in the Province of Manitoba, this 22 day of March A.D. 20 06.

The Honourable the Minister of Water Stewardship

Appendix B

MWSB Well Report on Well No. 1 (West Well)

Driller's Report

Manitoba Natural Resources

WELL LOCATION

QTR S.E SEC 22 TWP 8 RGE 5 E ☒ W ☐

R LOT ____ PARISH ____

REMARKS ____

WELL OWNER

NAME MWSB Landmark

ADDRESS 150 MAIN ST WELL #1 PHONE ____

WELL IDENTIFICATION (NO., NAME) Well No. 1

WELL USE: PRODUCTION ☒ TEST WELL ☐ RECHARGE ☐ OBSERVATION WELL ☐

WATER USE: DOMESTIC ☐ LIVESTOCK ☐ MUNICIPAL ☒ INDUSTRIAL ☐ IRRIGATION ☐ AIR-CONDITIONING ☐ OTHER ☐ (Specify) ____

DATE WELL COMPLETED DAY ____ MONTH July 19 90

LOCATION SKETCH OF WELL

DEPTH BELOW GROUND IN FEET FROM	TO	DESCRIPTION	WATER RECORD (KIND OF WATER)
0	28	Light brown clay	
28	33	Grey clay	
33	39	Grey till	
39	64	Gravel, till + boulders	
64	72	Till	
72	78	Brown + white carbonate rock	
78	79	Yellow Lis ; Lots of water (Sand in Lis)	
79	84	White Carb. rock	
84	138	Yellow + biege Carb. Rock; Fractures @ 137 + 138	EC - 1100
138	186	Yellow, brown, mauve Carb Rock; Fract. 153 + 172	
186	198	Grey, biege, white, brown Carb. rock	
198	228	Red + brown carb. rock; Fracture @ 201; more water	EC-1100
228	235	Dark brown carb. rock w streaks dark brown shale	
235	238	Light brown + grey carb. rock	
238	240	Dark brown carb. rock; clay streaks; lot more water	EC-1100
240	246	Brown + red carb. rock	
246	261	Dark Brown carb. rock with clay streaks	

DEPTH BELOW GROUND LEVEL IN FEET FROM	TO	CASING	OPEN HOLE	PERFORATIONS	GRAVEL PACK	CASING GROUT	PITLESS UNIT	INSIDE DIAMETER INCHES	OUTSIDE DIAMETER INCHES	SCREEN SLOT SIZE NO OR INCH	TYPE	MATERIAL	MAKE
0	84	X						10			Black	Steel	Plain end
0	84					X		10	15		Neat	Cement	
84	261		X					8 3/4					

TOP OF CASING OR PITLESS UNIT 1½ FEET ABOVE ☒ BELOW ☐ GROUND LEVEL

REMARKS Field Analysis

EC - 1200 mmhos

Hard - 18 gpg

Na⁺ - 250 mg/l

Iron - 0.8 mg/l

T = 44,000 usgpd/ft

PUMPING TEST

DATE OF TEST DAY ____ MONTH ____ 19 ____

PUMPING ☒ FLOWING ☐ RATE 57.2 IGPM

WATER LEVEL BEFORE PUMPING 23.3 FT ABOVE ☐ BELOW ☒ GRD LEVEL

PUMPING LEVEL AT END OF TEST 44.75 FT ABOVE ☐ BELOW ☒ GRD LEVEL

DURATION OF TEST ____ HOURS 80 MINUTES

WATER TEMPERATURE ____ °F SC = 26 us @ 80 min

RECOMMENDED PUMPING RATE 500 us plus G.P.M.

WITH PUMP INTAKE AT 50 to 60 FEET BELOW GROUND LEVEL.

CONTRACTOR

LICENCE NO ____

NAME Friesen Drillers Ltd

ADDRESS Dugald

DRILL OPERATOR James

L. Hopper

Signature of Contractor

Appendix C

MWSB Well Report on Well No. 2 (East Well)

LOCATION: SW23-8-5E

Well_PID: 81034
Owner: RM OF TACHE
Driller: Friesen Drillers Ltd.
Well Name: TOWN WELL NO. 2
Well Use: PRODUCTION
Water Use: Municipal
UTMX: 657728
UTMY: 5503854
Accuracy XY: 1 EXACT [<5M] [GPS]
UTMZ:
Accuracy Z: UNKNOWN
Date Completed: 1995 Sep 13

WELL LOG

From (ft.)	To (ft.)	Log
0	56.0	CLAY
56.0	63.0	TILL
63.0	91.9	SAND AND GRAVEL
91.9	261.8	LIMESTONE

WELL CONSTRUCTION

From (ft.)	To (ft.)	Casing Type	Inside Dia.(in)	Outside Dia.(in)	Slot Size(in)	Type	Material
0	96.9	casing	8.00			WELDED	STEEL
96.9	261.8	open hole	7.90				

Top of Casing: 1.5 ft. above ground

PUMPING TEST

Date: 1995 Sep 13
Pumping Rate: 271.9 Imp. gallons/minute
Water level before pumping: 23.0 ft. below ground
Pumping level at end of test: 27.0 ft. below ground
Test duration: 8 hours, minutes
Water temperature: ?? degrees F

REMARKS

LANDMARK - PUBLIC WATER SYSTEM WELL (COMMUNITY CODE 108.00). WELL LOCATED INSIDE EAST PUMP HOUSE NEAR CORNER OF 3RD STREET EAST AND 1ST AVENUE SOUTH. WELL INVENTORY/GPS COMPLETED BY WRB IN JUNE 2006. PREVIOUS WELL NAME - TOWN WELL #1.

Appendix D

Analytical Laboratory Data

FRIESEN DRILLERS LTD
ATTN: JEFF BELL
307 PTH 12 N
STEINBACH MB R5G 1L9

Date Received: 17-NOV-12
Report Date: 12-FEB-13 08:23 (MT)
Version: FINAL REV. 2

Client Phone: 204-326-2485

Certificate of Analysis

Lab Work Order #: L1238931
Project P.O. #: NOT SUBMITTED
Job Reference: RM OF TACHE
C of C Numbers:
Legal Site Desc:

Comments:

12-FEB-13: Sublet final report

Chantal Graham

CHANTAL GRAHAM
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L1238931-1 EASTWELL							
Sampled By: C WILSON on 16-NOV-12 @ 15:00							
Matrix: WATER							
Miscellaneous Parameters							
Special Request	See Attached				11-DEC-12	11-DEC-12	R2495924
ROU4W total							
Alkalinity							
Alkalinity, Total (as CaCO3)	269		20	mg/L		19-NOV-12	R2477702
Bicarbonate (HCO3)	329		24	mg/L		19-NOV-12	R2477702
Carbonate (CO3)	<12		12	mg/L		19-NOV-12	R2477702
Hydroxide (OH)	<6.8		6.8	mg/L		19-NOV-12	R2477702
Chloride by Ion Chromatography							
Chloride	130		0.50	mg/L		17-NOV-12	R2475875
Conductivity							
Conductivity	1400		20	umhos/cm		19-NOV-12	R2477702
Fluoride by Ion Chromatography							
Fluoride	0.64		0.10	mg/L		17-NOV-12	R2475875
Hardness Calculated							
Hardness (as CaCO3)	459		0.30	mg/L		21-NOV-12	
Nitrate as N by Ion Chromatography							
Nitrate-N	<0.050		0.050	mg/L		17-NOV-12	R2475875
Nitrate+Nitrite							
Nitrate and Nitrite as N	<0.071		0.071	mg/L		19-NOV-12	
Nitrite as N by Ion Chromatography							
Nitrite-N	<0.050		0.050	mg/L		17-NOV-12	R2475875
Sulfate by Ion Chromatography							
Sulfate	294		0.50	mg/L		17-NOV-12	R2475875
TDS calculated							
TDS (Calculated)	888		5.0	mg/L		21-NOV-12	
Total Metals by ICP-MS							
Calcium (Ca)-Total	86.2		0.20	mg/L	20-NOV-12	20-NOV-12	R2478768
Iron (Fe)-Total	0.82		0.10	mg/L	20-NOV-12	20-NOV-12	R2478768
Magnesium (Mg)-Total	59.2		0.050	mg/L	20-NOV-12	20-NOV-12	R2478768
Manganese (Mn)-Total	0.0247		0.0010	mg/L	20-NOV-12	20-NOV-12	R2478768
Potassium (K)-Total	9.67		0.10	mg/L	20-NOV-12	20-NOV-12	R2478768
Sodium (Na)-Total	147		0.050	mg/L	20-NOV-12	20-NOV-12	R2478768
Turbidity							
Turbidity	11.5		0.10	NTU		19-NOV-12	R2477824
pH							
pH	7.81		0.10	pH units		19-NOV-12	R2477702
L1238931-2 FIREHALL WELL							
Sampled By: C WILSON on 16-NOV-12 @ 15:20							
Matrix: WATER							
Miscellaneous Parameters							
Special Request	See Attached				11-DEC-12	11-DEC-12	R2495924
ROU4W total							
Alkalinity							
Alkalinity, Total (as CaCO3)	258		20	mg/L		19-NOV-12	R2477702
Bicarbonate (HCO3)	315		24	mg/L		19-NOV-12	R2477702
Carbonate (CO3)	<12		12	mg/L		19-NOV-12	R2477702
Hydroxide (OH)	<6.8		6.8	mg/L		19-NOV-12	R2477702
Chloride by Ion Chromatography							
Chloride	112		0.50	mg/L		17-NOV-12	R2475875
Conductivity							
Conductivity	1130		20	umhos/cm		19-NOV-12	R2477702
Fluoride by Ion Chromatography							

* Refer to Referenced Information for Qualifiers (if any) and Methodology

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L1238931-2 FIREHALL WELL							
Sampled By: C WILSON on 16-NOV-12 @ 15:20							
Matrix: WATER							
Fluoride by Ion Chromatography							
Fluoride	1.01		0.10	mg/L		17-NOV-12	R2475875
Hardness Calculated							
Hardness (as CaCO3)	281		0.30	mg/L		21-NOV-12	
Nitrate as N by Ion Chromatography							
Nitrate-N	<0.050		0.050	mg/L		17-NOV-12	R2475875
Nitrate+Nitrite							
Nitrate and Nitrite as N	<0.071		0.071	mg/L		19-NOV-12	
Nitrite as N by Ion Chromatography							
Nitrite-N	<0.050		0.050	mg/L		17-NOV-12	R2475875
Sulfate by Ion Chromatography							
Sulfate	171		0.50	mg/L		17-NOV-12	R2475875
TDS calculated							
TDS (Calculated)	686		5.0	mg/L		21-NOV-12	
Total Metals by ICP-MS							
Calcium (Ca)-Total	54.1		0.20	mg/L	20-NOV-12	20-NOV-12	R2478768
Iron (Fe)-Total	0.50		0.10	mg/L	20-NOV-12	20-NOV-12	R2478768
Magnesium (Mg)-Total	35.4		0.050	mg/L	20-NOV-12	20-NOV-12	R2478768
Manganese (Mn)-Total	0.0122		0.0010	mg/L	20-NOV-12	20-NOV-12	R2478768
Potassium (K)-Total	10.5		0.10	mg/L	20-NOV-12	20-NOV-12	R2478768
Sodium (Na)-Total	148		0.050	mg/L	20-NOV-12	20-NOV-12	R2478768
Turbidity							
Turbidity	2.60		0.10	NTU		19-NOV-12	R2477824
pH							
pH	8.01		0.10	pH units		19-NOV-12	R2477702

* Refer to Referenced Information for Qualifiers (if any) and Methodology

Reference Information

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ALK-TOT-WP	Water	Alkalinity	APHA 2320B

Alkalinity of water is a measure of its acid neutralizing capacity. Alkalinity is imparted by bicarbonate, carbonate and hydroxide components of water. It is determined by titration with a standard solution of strong mineral acid to the successive HCO3- and H2CO3 endpoints indicated electrometrically.

CL-IC-WP	Water	Chloride by Ion Chromatography	EPA 300.1 (modified)

Anions in aqueous matrices are analyzed using ion chromatography with conductivity and/or UV absorbance detectors.

EC-WP	Water	Conductivity	APHA 2510B

Conductivity of an aqueous solution refers to its ability to carry an electric current. Conductance of a solution is measured between two spatially fixed and chemically inert electrodes.

ETL-HARDNESS-TOT-WP	Water	Hardness Calculated	HARDNESS CALCULATED
ETL-SOLIDS-CALC-WP	Water	TDS calculated	CALCULATION
F-IC-WP	Water	Fluoride by Ion Chromatography	EPA 300.1 (modified)

Anions in aqueous matrices are analyzed using ion chromatography with conductivity and/or UV absorbance detectors.

IONBALANCE-OP05-WP	Water	Ion Balance Calculation No Reporting	APHA 1030E
MET-T-MS-WP	Water	Total Metals by ICP-MS	U.S. EPA 200.8-T

Total Metals by ICP-MS: This analysis is carried out using sample preparation procedures adapted from Standard Methods for the examination of Water and Wastewater Method 3030E and analytical procedures adapted from U.S. EPA Method 200.8 for analyis of metals by inductively coupled-mass spectrometery.

NO2+NO3-CALC-WP	Water	Nitrate+Nitrite	CALCULATION
NO2-IC-WP	Water	Nitrite as N by Ion Chromatography	EPA 300.1 (modified)

Anions in aqueous matrices are analyzed using ion chromatography with conductivity and/or UV absorbance detectors.

NO3-IC-WP	Water	Nitrate as N by Ion Chromatography	EPA 300.1 (modified)

Anions in aqueous matrices are analyzed using ion chromatography with conductivity and/or UV absorbance detectors.

PH-WP	Water	pH	APHA 4500H

The pH of a sample is the determination of the activity of the hydrogen ions by potentiometric measurement using a standard hydrogen electrode and a reference electrode.

SO4-IC-WP	Water	Sulfate by Ion Chromatography	EPA 300.1 (modified)

Anions in aqueous matrices are analyzed using ion chromatography with conductivity and/or UV absorbance detectors.

SPECIAL REQUEST-UW	Misc	Special Request University of Waterloo	SEE SUBLET LAB RESULTS
TURBIDITY-WP	Water	Turbidity	APHA 2130B (modified)

Turbidity in aqueous matrices is determined by the nephelometric method.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
UW	UNIVERSITY OF WATERLOO
WP	ALS ENVIRONMENTAL - WINNIPEG, MANITOBA, CANADA

Chain of Custody Numbers:

Reference Information

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**

GLOSSARY OF REPORT TERMS

Surrogates are compounds that are similar in behaviour to target analyte(s), but that do not normally occur in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery. In reports that display the D.L. column, laboratory objectives for surrogates are listed there.
mg/kg - milligrams per kilogram based on dry weight of sample
mg/kg wwt - milligrams per kilogram based on wet weight of sample
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight
mg/L - unit of concentration based on volume, parts per million.
< - Less than.
D.L - The reporting limit.
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

Client: Dalmaijer
ALS Environmental
PO#: L1238931

ISO# 2012598
Location:
2 for 18O, 2H, 3H

Environmental Isotope Lab
11/12/2012

#	Sample	Lab#	$\delta^{18}O$	Result	Repeat	$\delta^{2}H$	Result	Repeat	3H	Result	± 1σ	Repeat	± 1σ
			H_2O	VSMOW		H_2O	VSMOW						
1	L1238931-1	295093	X			X			X	<6.0	8.0		
2	L1238931-2	295094	X			X			X	<6.0	8.0		

pH	Conductivity	AZD

Tritium is reported in Tritium Units.
1TU = 3.221 Picocuries/L per IAEA, 2000 Report.
1TU = 0.11919 Becquerels/L per IAEA, 2000 Report.

To Contact uwEILAB:
519 888 4732

Rick Heemskerk
uwEILAB Manager
rkhmskrk@uwaterloo.ca
519 888 4567 ext 35838

Client: Dalmaijer
ALS Environmental
PO#: L1238931

ISO# 2012598
Location:
2 for 18O, 2H, 3H

Environmental Isotope Lab
12/02/2013

#	Sample	Lab#	$\delta^{18}O$	Result	Repeat	$\delta^{2}H$	Result	Repeat	3H	Result	± 1σ	Repeat	± 1σ
			H_2O	VSMOW		H_2O	VSMOW						
1	L1238931-1	295093	X	-15.22	-15.15	X	-114.00	-113.89	X	<6.0	8.0		
2	L1238931-2	295094	X	-15.12	-15.23	X	-115.65	-115.50	X	<6.0	8.0		

pH	Conductivity	AZD

Tritium is reported in Tritium Units.
1TU = 3.221 Picocurries/L per IAEA, 2000 Report.
1TU = 0.11919 Becquerels/L per IAEA, 2000 Report.

To Contact uwEILAB:
519 888 4732

Rick Heemskerk
uwEILAB Manager
rkhmskrk@uwaterloo.ca
519 888 4567 ext 35838

Appendix B

Status of Title – Landmark LUD Well Sites

MANITOBA

Certificate of Tit[le]

UNDER "THE REAL PROPERTY ACT"

THE RURAL MUNICIPALITY OF TACHE

is now seized of an estate in fee simple in possession subject to such interests as are notified by memorandum underwritten (or endorsed hereon) of land known and described as follows,

Lot One, in Block Three, which lot is sh[own]

part of the East half of Section 22-8-5 East, in Manitoba, registered in the Winnip[eg]

12,241. Subject to the reservations and provisoes contained in the ~~Grant from the~~ Crown Lan[ds]

NB
[illegible]
[illegible]

29.3.77

###

[IN] WITNESS WHEREOF I have hereunto signed my name and affixed m[y seal] of office this Nineteenth day of March One thous[and n]ine hundred and seventy - five

Signed in [p]resence of

Deputy District Registrar

for Winnipeg,

The land mentioned in a certificate of title shall by implication and without special mention in the certificate, unless the contrary be expressly declared, be deemed to be subject to:

(a) Any subsisting reservation contained in the original grant of the land from the Crown.
(b) Any municipal charge, rate, or assessment, existing at the date of the certificate, or subsequently imposed on the land;
(c) Any right-of-way or other easement, howsoever created, upon, over or in respect of the land;
(d) Any subsisting lease or agreement for a lease for a period not exceeding three years, where there is actual occupation of the land thereunder;
(e) Any drainage levy or mechanics' lien affecting the land.
(f) Any order of attachment, judgment, or order for the payment of money, against the registered owner of the land, registered since the date of the certificate of title, and which has been maintained in force under the provisions of any Act of the province relating thereto;
(g) Any certificate of lis pendens issued out of a court in the province and registered since the date of the certificate of title.
(h) Any right of expropriation by statute.
(i) The title of a person adversely in actual occupation, of and rightly entitled, to the land at the time it was brought under the Act, and who continues in such occupation;
(j) Caveats affecting the land registered since the date of the certificate, and
(k) Any town planning scheme or by-law authorized under The Town Planning Act or under the provisi[ons of th]e charter of any city and any by-law passed by any municipal corporation under "The Municipal Act" or the [cha]rter of any city relating to residential areas or zoning.
(l) Any zoning regulation as that expression is defined in the Aeron[autics Act] (CANADA) made under that act and deposited in the Land Titles Office.
(m) Any limitation or restriction under The [Highways Pr]otection Act or a permit issued under The Highways Protection Act.

Public highways embraced [...] of the land included in a certificate shall be deemed to be excluded unless the certificate is to the [...]ipality.

Form No. AG-Y-4

From No. B 80806
E.R. Dyck & Co., Steinbach, Man.

~~Request~~ Application
Request M 68863

	REGISTERED		
Mortgage for $	The day of 19 at	TO Deputy District Registrar	No.
Mortgage for $	The day of 19 at	TO Deputy District Registrar	No.
Mortgage for $	The day of 19 at	TO Deputy District Registrar	No.
Mortgage for $	The day of 19 at	TO Deputy District Registrar	No.
Mortgage for $	The day of 19 at	TO Deputy District Registrar	No.

DATE: 2014/01/30
TIME: 14:50

MANITOBA

STATUS OF TITLE

TITLE NO: 1853079/1

STATUS OF TITLE..... ACCEPTED
ORIGINATING OFFICE... WINNIPEG
REGISTERING OFFICE... WINNIPEG
REGISTRATION DATE.... 2002/01/29
COMPLETION DATE..... 2002/02/14

PRODUCED FOR.. R.M. OF TACHE
ADDRESS..... BOX 100
LORETTE, MB R0A 0Y0

CLIENT FILE... NA
PRODUCED BY... B. SOROKOWSKI

LEGAL DESCRIPTION:

THE RURAL MUNICIPALITY OF TACHE

IS REGISTERED OWNER SUBJECT TO SUCH ENTRIES RECORDED HEREON IN THE FOLLOWING DESCRIBED LAND:

ALL THAT PORTION OF THE SW 1/4 23-8-5 EPM
TAKEN FOR PUBLIC RESERVE CONTAINED WITHIN THE LIMITS
BORDERED PINK ON PLAN NO. 15142 WLTO

ACTIVE TITLE CHARGE(S):

80-43150/1 ACCEPTED CAVEAT REG'D: 1980/07/14
FROM/BY: MANITOBA TELEPHONE SYSTEM
TO:
CONSIDERATION: NOTES: AFF: E7' PERP

ADDRESS(ES) FOR SERVICE:

EFFECT	NAME AND ADDRESS	POSTAL CODE
ACTIVE	THE R.M. OF TACHE X	

ORIGINATING INSTRUMENT(S):

REGISTRATION NUMBER	TYPE	REG. DATE	CONSIDERATION	SWORN VALUE
2683637/1	EREQ	2002/01/29	$0.00	$0.00

PRESENTED BY: WLTO CONVERSION
FROM: WINNIPEG LAND TITLES OFFICE - CONVERSION
TO:

FROM TITLE NUMBER(S):

G53365/1 ALL

LAND INDEX:

LOT	QUARTER SECTION	SECTION	TOWNSHIP	RANGE
	SW	23	8	5E

NOTE: PT PUB RESERVE WTN LTS PL 15142

CERTIFIED TRUE EXTRACT PRODUCED FROM THE LAND TITLES DATA
STORAGE SYSTEM ON 2014/01/30 OF TITLE NUMBER 1853079/1

********** STATUS OF TITLE 1853079/1 CONTINUED ON NEXT PAGE **********

STATUS OF TITLE.....	ACCEPTED	PRODUCED FOR..	R.M. OF TACHE
ORIGINATING OFFICE...	WINNIPEG	ADDRESS.....	BOX 100
REGISTERING OFFICE...	WINNIPEG		LORETTE, MB ROA OYO
REGISTRATION DATE....	2002/01/29		
COMPLETION DATE.....	2002/02/14		
		CLIENT FILE...	NA
		PRODUCED BY...	B. SOROKOWSKI

ACCEPTED THIS 29TH DAY OF JANUARY, 2002
BY W.KNIGHT FOR THE DISTRICT REGISTRAR OF
THE LAND TITLES DISTRICT OF WINNIPEG.

CERTIFIED TRUE EXTRACT PRODUCED FROM THE LAND TITLES DATA
STORAGE SYSTEM ON 2014/01/30 OF TITLE NUMBER 1853079/1.

********** END OF STATUS OF TITLE 1853079/1 **********

Appendix C

Correspondence with Manitoba Conservation and Water Stewardship

Manitoba
Conservation and Water Stewardship

Water Use Licensing Section
Box 16, 200 Saulteaux Crescent
Winnipeg, Manitoba, Canada R3J 3W3
T 204-945-6009 F 204-945-7419
Kristina.Anderson@gov.mb.ca

February 7, 2014

File: Tache, The Rural Municipality of -6

Dan Poersch
Rural Municipality of Tache
Box 100, 1294 Dawson Road
Lorette, MB R0A 0Y0

Dear Mr. Poersch:

This letter acknowledges receipt of the 2013 municipal groundwater supply expansion investigation report for the Rural Municipality of Tache – Local Urban District of Landmark from your consultant Friesen Drillers Ltd., in which several recommendations were made to support the proposed water supply expansion.

Below is a brief summary of each of the recommendations made by the consultant and a disposition on where Water Rights Use Licensing stands.

First, it was recommended that the RM apply to the Water Use Licensing Section for an increase in allocation; as well as submit an Environment Act Proposal.

- We agree with this recommendation and have received the application for the allocation increase. I understand that you have retained a consultant to prepare an Environment Act Proposal.

Second, it was recommended that a third backup supply well be installed.

- We agree with the recommendation and we will be issuing a Groundwater Exploration Permit in due course.

Third, it was recommended that the RM develop an aquifer/well head protection program for their wells and develop a contingency plan should the aquifer become impacted in some manner.

- This recommendation is outside the scope of Groundwater Use Licensing, but the recommendation appears to have merit.

Fourth, it was recommended that at least three additional observation wells are needed in the immediate area around the well field to monitor drawdown levels to ensure that the well field is capable of providing the requested additional allocation under normal seasonal and climatic conditions.

- We agree with this recommendation, but we feel only two additional observation wells are needed for the forthcoming pump test. Monitoring drawdown associated with increased allocation is addressed in a subsequent bullet on regional impacts.

Fifth, it was recommended that the pumping system in each well should be reviewed since they are not industry standard.

- This recommendation is outside the normal scope of Groundwater Use Licensing.

Sixth, it was recommended that water levels in the pumping wells should be monitored daily in the event of considerably lowered regional static water levels in the carbonate aquifer.

- This recommendation is outside the scope of Groundwater Use Licensing, but the recommendation appears to have merit.

Seventh, it was recommended that each pumping well be equipped with an automatic data recording pressure transducer to assist in monitoring pumping water levels.

- This recommendation is out of the scope of Groundwater Use Licensing, but the recommendation appears to have merit.

Eighth, it was recommended that additional monitoring wells be installed in the carbonate aquifer at various distances to monitor the regional impacts; for which a hydrogeologist/hydrogeological engineer should review the data every few years.

- We agree with this recommendation, but the final number and configuration will depend upon where the third well is situated and its response to aquifer pump testing.

Ninth, it was recommended that the RM should continue performing a regular servicing/maintenance program for each well to closely monitor well performance.

- This recommendation is outside the scope of Groundwater Use Licensing.

We believe that the above agreed upon recommendations are compatible with the anticipated request for more water; therefore, we feel it is in the RM of Tache's best interest to incorporate them into your Environment Act Proposal.

If you have any questions regarding the recommendations outlined in this letter or the water rights licensing aspects of this project, please contact the undersigned at 204-945-6009.

Yours truly,

Kristina Anderson

Kristina Anderson, P.Geo.
Head of Groundwater Licensing

C: J. Bell, Friesen Drillers Ltd.
K. Wiseman, Water Use Licensing Section
B. Webb, Environment Act Licensing
K. Phillp, Office of Drinking Water
Manager, Seine-Rat River Conservation District
G. Phipps, Groundwater Management
R. Matthews, Water Use Licensing Section

Manitoba
Conservation and Water Stewardship

Water Use Licensing Section
Box 16, 200 Saulteaux Crescent
Winnipeg, Manitoba, Canada R3J 3W3
T 204-945-6118 F 204-945-7419
Rob.Matthews@gov.mb.ca

February 11, 2014

Dan Poersch
Rural Municipality of Taché
Box 100, 1294 Dawson Road
Lorette, MB, R0A 0Y0

Dear Mr. Poersch:

Attached herewith is a **Groundwater Exploration Permit** issued in response to an application dated January 30, 2014 to construct well(s) and divert groundwater on SE 22-8-5 EPM and SW 23-8-5 EPM for municipal purposes (a back-up well).

The Groundwater Exploration Permit authorizes the RM of Taché to construct a supply well, and conduct aquifer pump testing. The purpose of the pump testing is to determine if sufficient water is available from the well and the aquifer to support the project and to determine water level impacts on existing local wells and/or registered projects with earlier precedence dates than the proposed project. Please note that during testing, pumping must cease if any local water supplies are negatively impacted as a result of testing. The RM of Taché would further be responsible to correct any water supply problems or provide temporary water supply to anyone whose water supplies are negatively impacted as a result of testing. Please familiarize yourself with the terms and conditions of the Groundwater Exploration Permit.

A licensing decision on this project will be held pending submission of the required information. Please note that diversion of water without a Water Rights Licence or written authorization would constitute a violation of *The Water Rights Act* and may be subject to enforcement.

One important condition of any licence that may be issued for this project, in due course, is that a flow meter must be installed on the pipeline from the supply well(s), positioned to accurately measure instantaneous pumping rate and accumulative withdrawals.

Please contact Kylene Wiseman directly at 204-945-7424 should you have any questions regarding the requirements outlined in this letter and the attached permit or the water rights licensing aspects of this project.

Yours truly,

Rob Matthews
Manager
Water Use Licensing Section

Attachment - Form H / Permit

cc P. Estrella-Legal, Friesen Drillers Ltd.
K. Wiseman, Water Use Licensing
Manager, Seine-Rat River Conservation District
B. Webb, Environment Act Licensing

Manitoba
Manitoba Conservation & Water Stewardship
Water Use Licensing Section

FORM F

200 Saulteaux Crescent
Winnipeg, Manitoba
R3J 3W3

Groundwater Exploration Permit

Pursuant to The Water Rights Act

The Rural Municipality of Taché (Local Urban District of Landmark)

is hereby permitted to construct a water well or wells on the following described lands to explore for groundwater in **SE 22-8-5 EPM and SW 23-8-5 EPM** for **municipal** purposes, subject, however, to the following conditions:

1. The permittee must have legal access to the site where the exploration work and project wells are to be located.

2. This Authorization is not transferable or assignable to any other party.

3. Prior to undertaking any work or construction of any works authorized by this permit the permittee is required to retain the services of a hydrogeologist registered with Association of Professional Engineers and Geoscientists of Manitoba, who would be required to:
   - Plan and supervise the drilling of boreholes, test wells, production wells, observation wells and well pump testing as authorized by this permit.
   - Plan and supervise the installation of at least two (2) observation wells as authorized by this permit.
   - Conduct a 24-hour constant rate pumping test on proposed production well(s) in accordance with Form H (http://www.gov.mb.ca/conservation/waterstewardship/licensing/wlb/pdf/form_h_july_2013.pdf).
   - Conduct a recovery test for a period equal to pump test or 90% recovery.
   - Carry out an inventory of private and commercial wells within an 800 m radius of the project well site. The inventory may need to be expanded based on the assessment of the expected area of water level drawdown impact resulting from future pumping.
   - Prepare and submit to the Water Use Licensing Section a technical report on drilling of boreholes and wells, pump testing of well, well inventory and water quality sampling. The report would contain, but not limited to, such things as: well driller's reports for test wells, production wells and observation wells; a plan showing the location of these wells on the property and/or GPS locations of the wells; an analysis of aquifer pumping tests; calculations of storativity and transmissivity; and a description of the amount of water level interference that would be expected to occur at existing local wells that are located within an 800 m radius of the project well site. The report would also indicate if any local wells are expected to be adversely affected by the proposed use of water and where these wells are located. Two copies of the report shall be submitted, one hardcopy and one digital copy.

4. During any pumping tests that may be conducted, pumping must cease immediately if any local water supplies are negatively impacted as a result of the tests. The permittee is also responsible to correct any water supply problems or provide temporary water supply to anyone whose water supplies are negatively impacted as a result of the tests.

5. This permit expires within twenty-four (24) months of the date of issuance.

6. Please note that diversion of water without a Water Rights Licence or written authorization would constitute a violation of The Water Rights Act and may be subject to enforcement.

Issued at the City of Winnipeg in the Province of Manitoba, this 10th day of February, A.D. 2014

for The Honourable Minister of Water Stewardship

Appendix D

2012/2013 Landmark LUD Water Use Report

Rm of Tache

Communtiy of Landmark

Annual Water Report 2013

3rd St. East Pump House — **Licence No. 2005-130**

Month	Total Monthly Hours	Pumping Rate/Hr in cubic meters	Total consumption measured in cubic meters
January	744	8.46	6294
February	672	8.71	5853
March	744	6.626	4930
April	720	6.935	4993
May	744	7.347	5466
June	720	9.76	7027
July	744	10.2	7589
August	744	9.308	6925
September	720	9.008	6486
October	744	8.659	6442
November	720	6.926	4987
December	744	7.497	5578
	8760	8.286333333	72570

150 Main Street Pump House — **Licence No. 2005-130**

Month	Total Monthly Hours	Pumping Rate/Hr in cubic meters	Total consumption measured in cubic meters
January	744	6.374	4742
February	672	6.819	3928
March	744	7.085	5271
April	720	5.856	4216
May	744	4.923	3663
June	720	7.989	5742
July	744	5.534	4117
August	744	4.829	3593
September	720	6.469	4658
October	744	4.884	3634
November	720	7.24	5213
December	744	6.108	4544
Total	8760	6.175833333	53321

Total Treated Water Produced (cubic meters)	125891

Rm of Tache

Communtiy of Landmark

Annual Water Report 2013

150 Main Street AgricultureWell

Licence No. 2005-114

Month	Total Monthly Hours	Pumping Rate/Hr in cubic meters	Current Water Meter Reading	Total Consumption Measured in Cubic Meters
January	744	0	969	0
February	672	0.013393	978	9
March	744	0.018817	992	14
April	720	0.005556	996	4
May	744	0.061828	1042	46
June	720	0.334722	1283	241
July	744	0.038978	1312	29
August	744	0.02957	1334	22
September	720	0.027778	1354	20
October	744	0.048387	1390	36
November	720	0.028	1410	20
December	744	0.04	1440	30
	8760	0.053919		471

Rm of Tache

Communtiy of Landmark

Annual Water Report 2012

3rd St. East Pump House — **Licence No. 2005-130**

Month	Total Monthly Hours	Pumping Rate/Hr in cubic meters	Total consumption measured in cubic meters
January	744	8.144	6059
February	696	6.246	4347
March	744	6.308	4694
April	720	6.832	4919
May	744	8.346	6209
June	720	8.563	6164
July	744	13.79	10260
August	744	10.202	7590
September	720	10.626	7651
October	744	7.673	5709
November	720	7.446	5361
December	744	7.437	5533
	8784	8.46775	74496

150 Main Street Pump House — **Licence No. 2005-130**

Month	Total Monthly Hours	Pumping Rate/Hr in cubic meters	Total consumption measured in cubic meters
January	744	5.472	4071
February	696	8.104	5640
March	744	9.075	6752
April	720	8.886	6398
May	744	8.079	6012
June	720	10.065	7247
July	744	8.996	6693
August	744	7.874	5858
September	720	11.033	7944
October	744	8.27	6153
November	720	9.004	6483
December	744	9.286	6909
Total	8784	8.678666667	76160

Total Treated Water Produced (cubic meters)	150656

Rm of Tache

Communtiy of Landmark

Annual Water Report 2012

150 Main Street AgricultureWell

Licence No. 2005-114

Month	Total Monthly Hours	Pumping Rate/Hr in cubic meters	Current Water Meter Reading	Total Consumption Measured in Cubic Meters
January	744	0.081	22.6	60
February	696	0.014	22.7	10
March	744	0.013	22.8	10
April	720	0.014	22.9	10
May	744	0.220	39.3	164
June	720	0.185	52.6	133
July	744	0.122	61.7	91
August	744	0.226	78.5	168
September	720	0.151	89.4	109
October	744	0.024	91.2	18
November	720	0.010	91.9	7
December	744	0.067	96.9	50
	8784	0.094		830

Appendix E

Well Inventory

Appendix E
Water Well Inventory
RM of Tache – LUD of Landmark
800 m Radius

Well I.D.	Location	Owner	Year	Driller	Depth of Casing	Total Depth	Aquifer	Grout Type	Static Water Level	Pumping Water Level	Pumping Rate
1	NE22-8-5E	R. and R. Dirks	2004	Echo	75 ft.	162 ft.	L	C	25 ft.	70 ft.	70 IGPM
2	NE22-8-5E	R. and R. Dirks	2004	Echo	70 ft.	147 ft.	L	B	25 ft.	70 ft.	60 IGPM
3	NE22-8-5E	J. Plett	1982	Friesen	82.9 ft.	314.8 ft.	L	NA	15 ft.	55 ft.	25 IGPM
4	NE22-8-5E	J. Hiebert	1967	Friesen	80.4 ft.	304.8 ft.	L	NA	NA	NA	15 IGPM
5	NE22-8-5E	R. Reimer	1966	Mankey	77.9 ft.	301.8 ft.	L	NA	12 ft.	13 ft.	20 IGPM
6	NE22-8-5E	D. Hoeher	1977	Guys	109.9 ft.	116.9 ft.		NA	20 ft.	NA	20 IGPM
7	NE22-8-5E	B. Koop	2005	Echo	86 ft.	147 ft.	L	B	14 ft.	55 ft.	75 IGPM
8	NE22-8-5E	S D. Reimer	1965	Mankey	79.9 ft.	299.8 ft.	L	NA	10 ft.	15 ft.	6 IGPM
9	NW22-8-5E	Poplar Grove Farms	1994	Echo	80.9 ft.	137.9 ft.	L	NA	20 ft.	NA	15 IGPM
10	NW22-8-5E	R D. Reimer	1977	Mankey	78.9 ft.	141.9 ft.	L	NA	NA	NA	30 IGPM
11	NE22-8-5E	Harry Friesen	1900	NA	NA	NA	NA	NA	NA	NA	NA
12	SE22-8-5E	Hanover School Div.	2006	Friesen	87 ft.	280 ft.	L	NA	30.1 ft.	37.2 ft.	360 IGPM
13	SE22-8-5E	Hanover School Div.	1990	Friesen	76 ft.	282.8 ft.	L	C	23 ft.	28 ft.	349 IGPM
14	SE22-8-5E	Hanover School Div.	1990	Echo	76 ft.	279.8 ft.	L	NA	20 ft.	22 ft.	98 IGPM
15	SE22-8-5E	Roser Wiebe	2006	Echo	74 ft.	158 ft.	L	NA	23 ft.	65 ft.	75 IGPM
16	SE22-8-5E	Philip Reimer	2004	Echo	75 ft.	147 ft.	L	B	22 ft.	70 ft.	30 IGPM
17	SE22-8-5E	W. Plett	1987	Echo	77.9 ft.	314.8 ft.	L	NA	NA	NA	25 IGPM
18	SE22-8-5E	E. Reimer	1983	Guys	80.9 ft.	89.9 ft.	L	NA	NA	NA	30 IGPM
19	SE22-8-5E	P. Reimer	1976	Friesen	72 ft.	97.9 ft.	L	NA	14 ft.	35 ft.	20 IGPM
20	SE22-8-5E	Hanover School Div.	1999	Echo	78 ft.	277 ft.	L	C	20 ft.	22 ft.	98 IGPM
21	SE22-8-5E	RM Tache	1900	NA	NA	NA	NA	NA	NA	NA	NA
22	SE22-8-5E	RM Tache	1979	Friesen	75 ft.	159.9 ft.	L	C	16 ft.	17 ft.	25 IGPM
23	SE22-8-5E	RM Tache	1990	Friesen	83.9 ft.	260.8 ft.	L	C	23 ft.	45 ft.	476 IGPM
24	SW22-8-5E	Steve Plett	2006	Echo	73 ft.	335 ft.	L	NA	16 ft.	60 ft.	30 IGPM
25	SW22-8-5E	Prairie Rose Church	1990	Echo	73 ft.	319.8 ft.	L	NA	29 ft.	70 ft.	40 IGPM
26	23-8-5E	J G. Reimer	1971	Friesen	101.9 ft.	324.8 ft.	L	NA	17 ft.	20 ft.	10 IGPM
27	23-8-5E	N. Kinstscher	1993	Echo	67 ft.	317.8 ft.	NA	NA	20 ft.	40 ft.	25 IGPM
28	23-8-5E	B. Schmidke	1985	Friesen	77.9 ft.	134.9 ft.	L	NA	22 ft.	35 ft.	20 IGPM
29	23-8-5E	Landmark Collegiate	1972	Friesen	72 ft.	324.8 ft.	L	NA	14 ft.	16 ft.	15 IGPM
30	NE23-8-5E	N. Kinstscher	1996	Echo	83 ft.	318 ft.	L	B	20 ft.	50 ft.	50 IGPM
31	NE23-8-5E	G. McGregor	1991	Echo	89.9 ft.	319.8 ft.	L	NA	30 ft.	50 ft.	50 IGPM
32	NE23-8-5E	P. Hilderbrant	1977	Friesen	85.9 ft.	114.9 ft.	L	NA	21 ft.	35 ft.	15 IGPM
33	NE23-8-5E	D. Penner	1973	Friesen	94.9 ft.	289.8 ft.	L	NA	12 ft.	13 ft.	40 IGPM
34	NE23-8-5E	PTL Construction	1977	Friesen	85.9 ft.	114.9 ft.	L	NA	21 ft.	35 ft.	15 IGPM
35	NW23-8-5E	N. Krocker	1973	Friesen	87.9 ft.	324.8 ft.	L	NA	10 ft.	12 ft.	50 IGPM

Appendix E
Water Well Inventory (cont'd)
RM of Tache – LUD of Landmark
800 m Radius

Well I.D.	Location	Owner	Year	Driller	Depth of Casing	Total Depth	Aquifer	Grout Type	Static Water Level	Pumping Water Level	Pumping Rate
36	NW23-8-5E	Heartwork Homes	1996	Echo	78 ft.	318 ft.	L	B	22 ft.	50 ft.	50 IGPM
37	NW23-8-5E	Landmark Feeds	1998	Echo	82 ft.	320 ft.	L	B	21 ft.	75 ft.	100 IGPM
38	SE23-8-5E	F P. Reimer	1971	Friesen	94.6 ft.	324.8 ft.	L	NA	18 ft.	21 ft.	10 IGPM
39	SE23-8-5E	Jason Krahn	1999	Echo	94 ft.	157 ft.	L	B	23 ft.	80 ft.	50 IGPM
40	SE23-8-5E	W. Penner	1973	Mankey	119.9 ft.	287.8 ft.	L	NA	20 ft.	25 ft.	15 IGPM
41	SE23-8-5E	Landen Farms	1988	Echo	87.9 ft.	317.8 ft.	L	NA	21 ft.	50 ft.	100 IGPM
42	SW23-8-5E	G. Reimer	1979	Mankey	NA	296.8 ft.	NA	NA	16 ft.	18 ft.	30 IGPM
43	SW23-8-5E	Plett Trucking	1999	Echo	80 ft.	135 ft.	L	B	16 ft.	50 ft.	50 IGPM
44	SW23-8-5E	Brant	1975	Mankey	108.9 ft.	288.8 ft.	L	NA	18 ft.	24 ft.	10 IGPM
45	SW23-8-5E	RM Tache	1995	Friesen	96.9 ft.	261.8 ft.	L	NA	23 ft.	27 ft.	272 IGPM

Notes All data contained in table as presented in Manitoba Water Stewardship GWDRILL database – 2008 Edition.
Friesen Drillers Limited has not verified or field confirmed any data present in this table. All yields and static water levels are as reported and have not been verified by Friesen Drillers Limited. Current well use or operations are unknown for all wells listed.
L = carbonate aquifer Till = Glacial inter till aquifer (sand and gravel) SS = Winnipeg Formation sandstone aquifer Comb. = SS/Carbonate
N.A. = Not available or not provided in reference Grout type: C = Cement B = Bentonite + = Flowing condition at surface