The following changes to the tender documents are effective immediately and will form part of the contract documents:

The following response is to address questions raised by potential bidders for the above noted project. This response will provide both clarification on questions regarding the tender documents and revisions to the design drawings and technical specifications that is to be issued to modify parts of the tender documents for PWGSC.

1.0 CLARIFICATION

The existing 1200 amp distribution panel that requires an 80 amp breaker to be installed was manufactured by J.R. Stephenson Ltd.

All existing equipment that is removed is to be turned over to PWGSC.

All conduit systems for the wastewater treatment plant security system to run back to the existing Maintenance building for interconnection to the existing Silent Knight Regency 4800 series intrusion alarm control panel. New keypads to be Regency 4860C, new motion sensors to be Honeywell DT7450, and new door contacts to be Sentrol 1078 recessed contacts.

Contractor to contact XL Alarms for the supply, installation and commissioning of all security system and devices (204-231-1072).

<u>Drawings C-00, C-01, C-06 and C-09</u>

New 400 KW Generator, pad mount transformer, CSTE and ATS & Distribution Panel are not shown on Civil drawings. Refer to Drawing E-00 for installation location and details.

<u>Drawing M-05</u>

For duct heater controller refer to specifications Section 23 55 01 – Duct Heaters. Departmental Representative cannot control equipment supply and installation.

<u>Drawing E-00</u>

MB Hydro to install the wiring from the new 750kVA transformer to the new side distribution. CSTE to be within 3m of the transformer.

Distribution panels shown on detail B is an outdoor panel and shall be NEMA 3R rated.

<u>Drawing E-01</u>

For the Water Treatment Plant the 75kVA transformer is outside the MCC as shown on drawings E-01.

Contractor to coordinate supply of electrical heating units. Departmental Representative cannot control equipment supply and installation.

Surge Protection Devices (SPDs) for MCC shall be 120 kA and 100 kA for panel boards.

MCC space shall not be reduced and use of compact breakers are unacceptable.

Drawing E-02

For the Water Treatment Plant the 75kVA transformer is outside the MCC as shown on drawings E-02.

For duct heater DH-3 controls refer to drawings M-05.

Fire pump FP-1 controller is to be removed and replaced. Existing fire pump FP-1 to remain.

For beacons refer to drawings E-o6 and E-11 and specifications Section 25 14 23 – Field Equipment Panels.

For HCAV control panel, refer to specifications Section 23 09 13 – Instrumentation and Control Devices for HVAC. Coordinate final mounting location with mechanical trade.

For existing well pump power cable refer to trench detail 6 on drawing E-00 and motor schedule on drawing E-01.

Drawing E-07

For the Wastewater Treatment Plant the 75kVA transformer is inside the MCC as shown on drawings E-07. The reason for this is very limited space in the WWTP electrical room.

The drawing shows 2-30A-3P disconnects feeding SF-2. This should be 1-6P disconnect.

Surge Protection Devices (SPDs) for MCC shall be 120 kA for MCC and 100 kA for panel boards.

Surge Protection Devices (SPDs) for MCC shall be 120 kA and 100 kA for panel boards.

MCC space shall not be reduced and use of compact breakers are unacceptable.

Drawing E-08

For the Wastewater Treatment Plant the 75kVA transformer is inside the MCC as shown on drawings E-08. The reason for this is very limited space in the WWTP electrical room.

For forced flow heaters FF-1 and FF-2 (2kW, 120V, 1 phase) side and controls refer to drawings E-08 and M-10. Two circuit breakers 15A, 1P for forced flow heaters to be replaced with 20A, 1P breakers in Panel A. Departmental Representative cannot control equipment supply and installation.

Section 46 41 00 – Membrane Treatment Equipment

Reference to clause 2.3.6 Clean-in-place (CIP)/permeate flushing

As an alternate, for CIP tank that is already integrally skid mounted with the NF skid package, the 3 HP booster pump can be used to perform CIP function. A dedicated CIP pump will not be required if this option is chosen.

2.0 TECHNICAL SPECIFICATIONS

Section 01 29 00 – Measurement and Payment

Revise Clause 1.3.6.1.1 (Addendum No. 1) to read as follows:

Forcemain: Duplex Grinder Pump System.

Clause 1.3.2.5:

Remove reference to E-one Duplex Grinder Pump System and replace with Duplex Grinder Pump System.

Section 21 30 00 – Fire Pumps

To clarify: Fire pumps does not require VFD

Section 25 90 01 – SCADA System

Delete any references to trending, logging, report generating and remote communication requirements that are beyond the capability of the specified hardware. A full traditional SCADA implementation is not required.

26 32 13 – Back-up Generator

To clarify: The generator output circuit breaker shall be 400 A/3P.

Section 46 41 00 – Membrane Treatment Equipment

Revise clause 2.3.3.3 to read as follows:

The design salt rejection shall be 96% based on 500 PPM water and 739 kPA.

Revise clause 2.3.4.1 to read as follows:

The NF element housing shall be constructed of filament wound epoxy/glass composite for the shell, rated for 300 psi working pressure with side entry feed and concentrate connections.

Revise clause 2.3.8.1 to read as follows:

Concentrate Throttle Valve, Recycle Throttle Valve; In-line globe valve rated for 2068 (300 psi) mimimum.

Section 46 41 45 – IFAS Treatment Equipment

Revise Clause 2.1 to read as follows:

The IFAS Treatment Equipment shall be manufactured by H_2O Innovation or approved equal. Project Contact : Bob Downing, H_2O Innovation, 655 Cathedral Avenue, Winnipeg, MB R2W 0Y7. Tel. No. (204).996.1203, e-mail: bob.downing@h2oinnovation.com.

Refer to Appendix C- Groundwater Quality

The hydrogeological study report is included.

3.0 DESIGN DRAWINGS

Drawing C-02

Note saying “Ex conc. septic tank. Provide E-One pumping system as specified” to be replaced with “Ex conc. septic tank. Provide duplex grinder pump system as specified”

Drawing E-01

Circuit breaker 40A, 600V, 3P in MCC labeled “DH-1” shall be labelled “DH-3”. Wire and connect duct heater with #8 AWG, 3C, 1000V Tech 90 cable. Wire and connect duct heater controls and duct thermostat.

4.0 APPROVED EQUALS

Section 23 34 00 HVAC Fans and Ventilators

Twin City shall be an acceptable manufacturer for fans

Section 23 63 12 Air Cooled Condensing Units

JCI/York shall be an acceptable manufacturer for fan coil unit and condensing unit

END OF ADDENDUM NO. 2

June 3, 2015

Dr. Saibal Basu, Ph.D., P.Eng.
Water/Wastewater Treatment Team Leader/Senior Associate
Stantec Consulting Limited
905 Waverley Street
Winnipeg, MB R3T 5P4

DRAFT

Dear Dr. Basu,

Subject **Lower Fort Garry National Historical Site – Proposed Groundwater Supply**
River Lot 1 – Parish of St. Clements and River Lot 100/131 – Parish of St. Andrews
5925 PTH 9 – Rural Municipality of St. Andrews, Manitoba

Friesen Drillers Limited is pleased to present this report detailing the installation of two groundwater supply wells and one monitoring well, along with the associated testing, at the Lower fort Garry National Historical Site in the Rural Municipality (RM) of St. Andrews, Manitoba. The following report details the project background, site setting, scope of work, geology and hydrogeology, well installations and testing, overall analysis, and geochemical sampling results. This report has been prepared as part of the requirement for a water rights license with Manitoba Conservation and Water Stewardship (MCWS) – Water Use Licensing Section (WULS).

Background and Scope of Work

Lower Fort Garry is a national historical site located on the west banks of the Red River south of the City of Selkirk and north of the community of Lockport. The site was first developed as a Hudson's Bay Company trading post, which operated at the site until 1951, when a country club occupied the site. Water supplies were traditionally obtained from the Red River for the site. Apparently during the 1950's, the irrigation of the site was accomplished with river water. One of the key reasons that the fort was built in this location was the close proximity of limestone bedrock blocks that were used to construct the walls and depot in the fort. Old anecdotes from the site detail how the walls of the fort were built from limestone blocks mined from the banks of the Red River near the fort during times of lower flow on the river. This comment will have important implications later on the local hydrogeology and groundwater supply for the site. Upon development of the site as a national historical site in 1963, a well were drilled in the north part of the site to provide water supplies for the visitor areas, bathrooms, and the gift shop/restaurant in 1965. The water supply was apparently treated with chlorine prior to distribution. This well, which was drilled by Friesen Drillers in 1965, was constructed with 8 inch diameter steel casing, set into the carbonate bedrock at 36 feet below grade. The static water level was noted to be 40 feet below grade, so the water level in the well was below the bedrock/overburden contact. The well was completed within a well pit and piped to the treatment facility.

It is our understanding that the well has not been serviced in a long time, and that the treatment plant no longer meets current standards and regulations. In order to address these concerns, Parks Canada retained Stantec Consulting Limited (Stantec) to complete the design and engineering of a new treatment facility and water supply. Due to the age, condition, and hook up style of the existing well, Stantec suggested a new well completion, along with a backup well, in addition to modifications to the water treatment plant.

Stantec retained Friesen Drillers Ltd. to undertake the following work for the Lower Fort Garry site:

- Apply for a groundwater exploration permit from MCWS – WULS.
- Install two production wells at the water treatment plant, with the casing set approximately 80 feet below grade in each well. The boreholes would be drilled to a depth of approximately 300 feet below grade. The deeper casing seat was planned to cut off the upper fractured zone in the bedrock, which was thought to contain poor quality groundwater.
- Conduct an aquifer pumping test of 24 hours duration, with water sampling for routine and stable isotopic geochemistry.
- Complete an analysis of the pumping test, along with a determination if the water supply is interacting with surface water.

Background and Scope of Work (cont'd)

- Undertake an inventory of all wells within 1,600 m of the site.

- Submit a technical report to the client, as required by the exploration permit.

Friesen Drillers prepared a groundwater exploration permit, which was submitted to MCWS - WULS on February 20, 2015. MCWS – WULS responded with an exploration permit on February 25, 2015. A copy of the permit is attached.

During the installation of the wells, a municipal water treatment plant was also being re-constructed at the site. This is apparently being designed and supervised by Stantec Consulting Ltd., and is beyond the scope of this hydrogeological assessment of the water supply.

It is important to note that the annual water use for the Lower Fort Garry site will not change above the current system use, which has been taking place since the 1960's. The system will not be expanded in any way. The desired water supply is 15.85 U.S.G.P.M.

Copies of the exploration permit application and completed permit are attached.

Site Setting

Physical Setting

Lower Fort Garry is located on the west side of the Red River, north of the St. Andrews Lock and Dam, and south of the City of Selkirk. The site is mainly a large parkland museum, with the several historical structures, maintenance facilities, and a visitor's center/parking lot. The site is bordered to the east by the Red River. Specifically, the wells are all located on River Lot 1 – Parish of St. Clements and River Lot 100/131 – Parish of St. Andrews in the Parish of St. Clements. The site is specifically located at 5925 PTH 9 in the RM of St. Andrews. The land drainage in the area is generally directed towards ditching, which ultimately ends up in the Red River. The land surface is generally of low relief, with the exception of the banks of the Red River.

The following land uses surround the well site:

- North: Residential homes on larger properties.

- East: Red River.

- South: Residential homes and small businesses.

- West: Residential homes, followed by agricultural lands.

The site location is shown below as Figure 1.

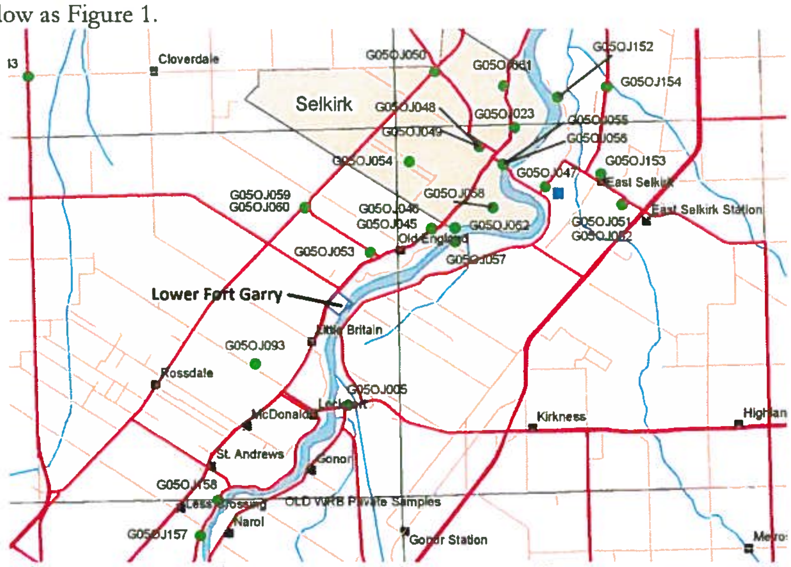

Figure 1 – Site location and surrounding land uses (source – MCWS, 2007)

Geology/Hydrogeology

The subsurface geology at the site consists of silty grey clay, approximately 20 to 25 feet thick, overlying a 10 feet thick unit of calcareous grey clay till with some layers of sand and gravel. Underlying the clay till unit is a highly fractured carbonate rock rubble zone. The thickness of the rubble zone varies up from 10 to 20 feet across the area. The rubble zone gradually changes into the more competent, fractured carbonate rock of the Red River Formation. The Red River formation typically consists of alternating layers of limestone and dolostone with basal shale layers. The Red River Formation is in turn underlain by the Winnipeg Formation clastic (sandstone and shale) unit, and Precambrian basal bedrock (Render, 1970). The sandstone aquifer is thought to lie about 320 to 350 feet below grade, and is expected to be about 60 to 80 feet in thickness. A geological cross section through the Selkirk/Lower Fort Garry area is shown below as Figure 2.

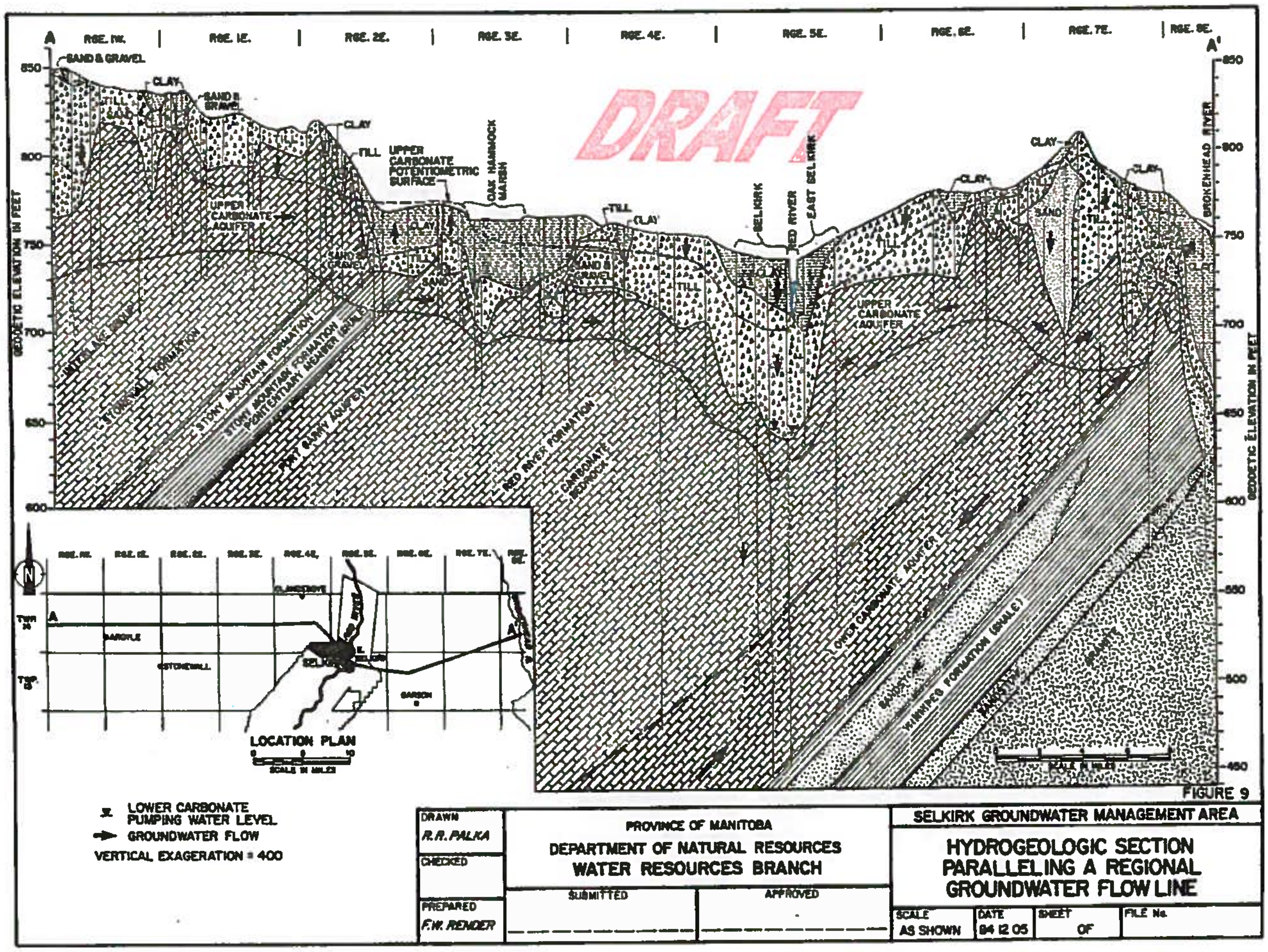

Figure 2 – Geological cross section through Selkirk (source – Render, 1986)

Selkirk is located within a geological depression that is shown above in Figure 2. While the bedrock surface in the center of the City of Selkirk is over 120 feet below grade in places, around the outskirts of the city, bedrock is noted to be as shallow as 30 to 40 feet down. This extends from the east Selkirk area, towards the south near the St. Andrews lock and Dam, which is actually situated on a small river run rapids in the Red River. This small rapids is actually a place where the Red River lies directly on the bedrock surface, and direct interaction with the carbonate aquifer occurs (Render, 1986).

Figure 3, shown below, depicts the depth of the bedrock surface in the Lower Fort Garry area surrounding the Selkirk depression. This situation will have important consequences later on for this investigation.

Geology/Hydrogeology (cont'd)

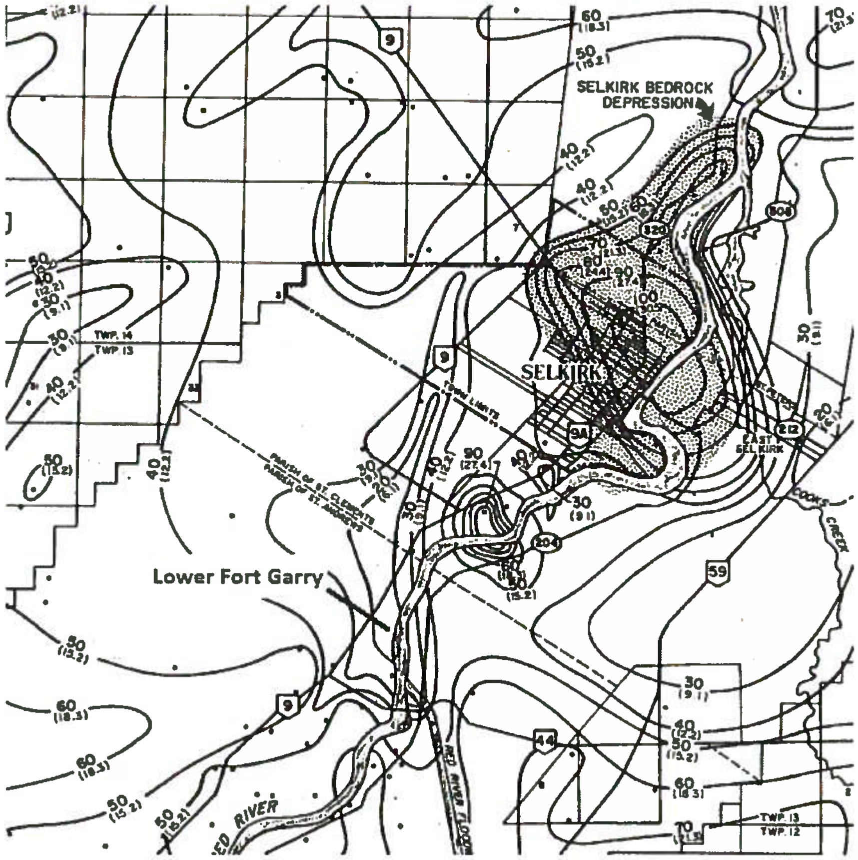

Figure 3 – Depth to bedrock – Selkirk area (source – Render, 1986)

The general hydrogeological conditions of the area were determined from a review of the applicable hydrogeological reports and information available through MCWS. Groundwater Aquifers in the Selkirk area can be found in the overburden till, the Red River Formation carbonate, and the Winnipeg Formation (Betcher et. al, 1995). The inter till sand and gravel aquifers are generally of limited extent in areas of more granular till deposits, and are hydraulically connected to the underlying carbonate bedrock. This unit is therefore considered to have limited development potential, as compared to the more consistent, higher yielding, carbonate bedrock.

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 therefore 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).

With the exception of the carbonate rock surface, which is typically quite irregular due to erosion, fracturing, and karst features, the geology within the study area is fairly uniform and consistent.

Groundwater flow within the City of Selkirk is directed towards the two major aquifer users in the area. These include the City of Selkirk well field, and Gerdau Ameristeel (Manitoba Rolling Mills). Groundwater flow is towards the large drawdown cone that exists. Along the eastern, western, and southern outskirts of the city, static water levels can be 10 to 40 feet below grade or higher. Within the central part of the city, near the City Hall, static water levels are in the 120 to 140 feet below grade level. The groundwater flow direction in Lower Fort Garry area appears to northerly, towards the pumping drawdown cone that surrounds the City of Selkirk/MRM production wells, which are the largest major pumping wells nearest to the site. The average gradient, based on mid summer 2010 groundwater levels appears to be approximately 2.53×10^{-2}, or approximately 2.5%, which is extremely strong towards the centre of the City of Selkirk. Groundwater is recharged to the carbonate aquifer in the Lower Fort Garry area from the Birds Hill Glaciao-Fluvial complex, and the Garson/Tyndall upland areas. Groundwater flow directions in the Selkirk area are shown on the following page as Figure 4.

Geology/Hydrogeology (cont'd)

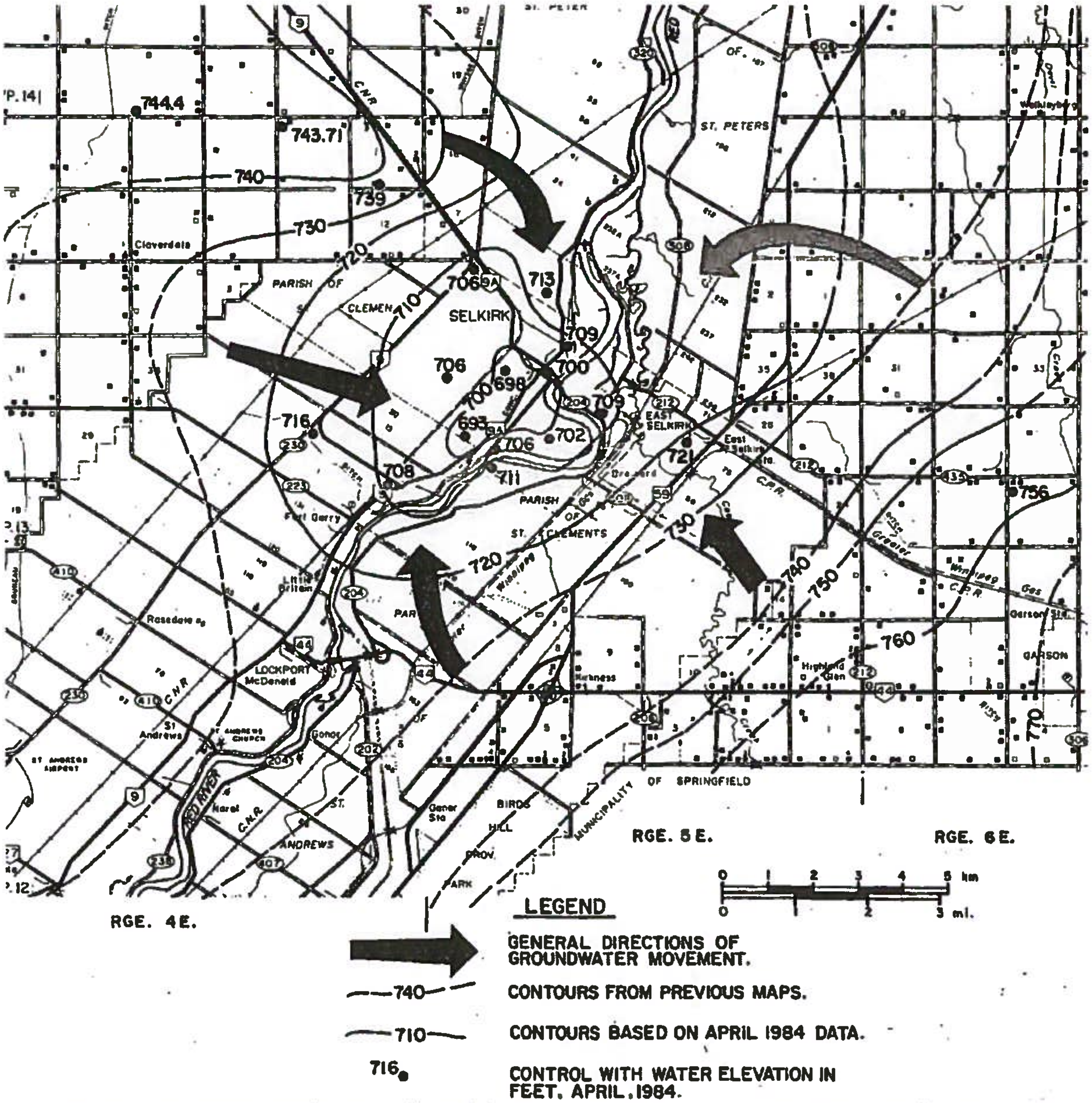

Figure 4 – Groundwater potentiometric surface (in feet) in the carbonate aquifer – City of Selkirk area (source – Render, 1986)

MWS currently maintains several carbonate aquifer hydrograph monitoring wells in the Selkirk area. Some of these wells are shown in Figure 1. The nearest hydrograph monitoring wells to the Lower Fort Garry well site are located about 1.5 miles south and 1.0 miles north of the site. The monitoring wells are constructed to monitor the carbonate aquifer, and no distinction can be made between the zones of completion in both wells. The southerly station is known as G05OJ093, while the northerly station is G05OJ053. Copies of the most recent hydrograph stations are shown on the following page as Figure 5 and 6, respectively.

Through reviewing the hydrographs, the following comments can be made. G05OJ093 appears to show about 2.0 m of annual static water level fluctuation, with the highest levels reported in 2011. G05OJ053 reports a very similar situation to OJ093. Both charts generally show a rising trend since the 1980's forward, with chart record highs occurring in the spring flood period of 2011. The trace of both charts is typical for hydrograph stations from the carbonate aquifer in the Selkirk area, outside of the central drawdown area of the City of Selkirk.

Geology/Hydrogeology (cont'd)

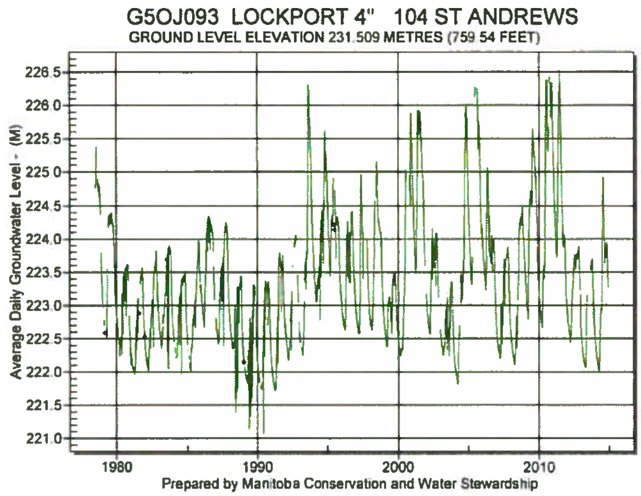

Figure 5 – G05OJ093 (source – MCWS, 2014)

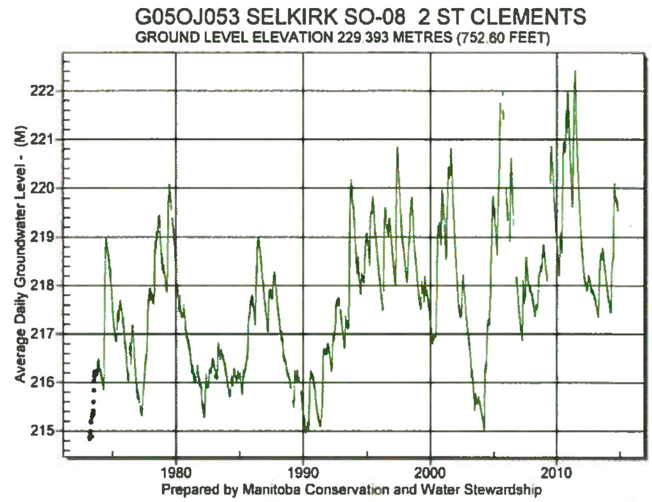

Figure 6 – G05OJ053 (source – MCWS, 2014)

The hydrograph data plots a generally smooth uniform potentiometric surface across the area, as depicted in Figure 4, shown on the previous page.

Recent sampling by MCWS indicates the following basic water quality parameters:

- G05OJ093 (Carbonate Aquifer – unknown completion)
  - Total dissolved solids – 838 mg/L
  - Electrical conductivity – 1,240 umhos/cm
  - Chloride – 64 mg/L
  - Nitrate – 2.93 mg/L
- G05OJ053 (Carbonate Aquifer – unknown completion)
  - Total dissolved solids – 797 mg/L
  - Electrical conductivity – 1,410 umhos/cm
  - Chloride – 117 mg/L
  - Nitrate – 0.11 mg/L

It is interesting to note that the nitrate levels are still present in both observation wells, indicating that some surface activities have impacted the aquifer by some means. Figure 7, shown below, provides a map of Render's nitrate levels in 1986

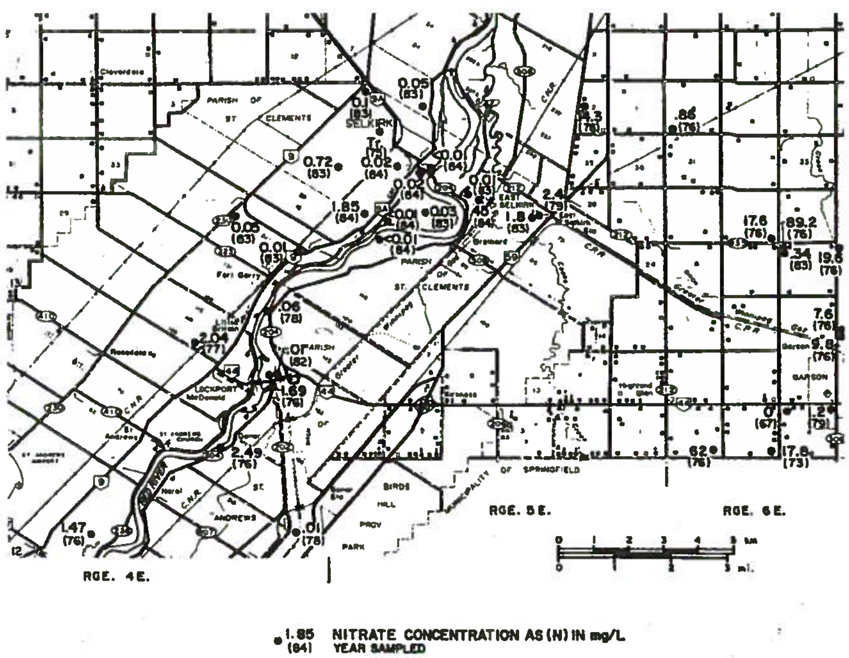

Figure 7 – Nitrate levels in the Selkirk area, 1986 (source – Render, 1986)

Geology/ Hydrogeology (cont'd)

Render (1986) noted the presence of saline water in the deeper areas of the carbonate aquifer near the Lower Fort Garry site. The origin of these deeper waters is unknown, although it is speculated to be the result of some wells in the area penetrating the Winnipeg Formation sandstone aquifer.

In the Lower Fort Garry area, the groundwater quality is a difficult factor. The upper aquifer appears to be impacted with nitrates, and the shallow bedrock conditions appear to indicate that groundwater would be under the direct influence of surface water from the Red River. The deeper portions of the carbonate aquifer appear to have some poorer quality groundwater resulting from the impacts of boreholes drilled into the Winnipeg Formation sandstone aquifer.

Through a review of the existing well log from the site, the following comments can be noted:

- The existing well log shows the well on the site had the 8 inch diameter steel casing set to 36 feet below grade.

- The well is drilled to 311.8 feet below grade, and is completed as open hole in the carbonate bedrock.

It is evident that this well likely was fairly low yielding from the upper portion of the bedrock, hence the reason to drill the well deeper into the bedrock. It is likely that this well provided a blended mix of groundwater from the upper and lower portions of the bedrock aquifer. Hydraulic data, or groundwater samples were not available for review from the existing well.

A particularly interesting aspect of the geochemistry of the area is presented in Render (1986). During the extensive investigations in the Selkirk area conducted by Render, stable Environmental Isotope sampling of the water supply at the MRM site revealed evaporitic water in their supply wells. Render had concluded that this evaporitic water entered the aquifer through the connection with the Red River to the south and east of the MRM drawdown cone. Render concluded that the aquifer was interacting with the Red River in the area, and the groundwater was likely under the influence of surface water.

These aspects have led to the interesting investigations and deeper well constructions of the on-site investigations at the lower Fort Garry site.

Investigations

Well Inventory

A review of the hydrogeological information specific to the area around the East Selkirk site involved the use of air photos and the MCWS water well database (GWDRILL, May 2012 edition).

As part of the licensing requirements, a water well inventory of known groundwater users was conducted in an area within a 1.6 km radius of the Lower Fort Garry well field site. Approximately 53 private wells were located in the area, with the oldest wells reported as having been drilled in the mid 1960's. There is a wide spectrum of well ages in the area, with the newest wells being located within the residential subdivisions to the west of the Lower Fort Garry site.

Most of the wells appear to have shallow casing settings, with depths ranging from 62 feet to 320 feet in depth. There appears to be little control over the average well depth in the area, with fairly broad differences in well depths located close together. The static water levels in many wells appears to be below the casing set in the bedrock. Due to the static water levels ranging from 25 to 45 feet below grade, single line suction pumps would not likely be feasible. It is therefore anticipated that two line jetmatic systems, or submersible turbine pumps. The water level changes in the area also indicate that the pumping systems must be able to address the static water level changes that occur.

Due to the wide variety of well ages, it is speculated that a number of well pit style hook ups, and multiple house connections to a single private well are present. The more modern homes, constructed from the 1980's onwards, likely have conventional residential pitless unit type connections. There is no public sewage system present for the area at the present time, so individual homes typically employ septic fields for private waste disposal. It is known from a number of reports that the break out of septic fields and such has been an issue in the area (Wardrop, 1995).

Lower Fort Garry apparently operates a small wastewater plant on the site, with discharge to the Red River.

Well Constructions

Friesen Drillers Limited mobilized to the East Selkirk area in early March, 2015. A Foremost DR-12W dual rotary drill rig was used to construct the two wells on the site. The supply wells were constructed using 6 inch diameter steel casing, set to a depth of 80 feet below grade. The casing was extended to this depth in both wells to cut off and seal the upper fractures from the open hole sections. The first test hole encountered some fracturing at 200 feet, and a few minor ones down to 277 feet. The second borehole yield appeared to be much less, and was drilled to 332 feet below grade, which is a similar depth to the existing well

Both wells were developed with compressed air until the sample was visibly clean. Both wells were noted to clean up very quickly with compressed air developing, and produced little fines. The well details are presented below in Table 1.

Complete geologic and borehole construction logs are attached.

Following the site clean up, the well site was located using a portable GPS unit. The readings were recorded in latitude and longitude, along with vertical elevations above sea level. It should be noted that all GPS readings are subject to the normal error (+/- 5 meters both horizontally and vertically). The location is shown on the construction and geologic log.

Temporary caps were installed on the main wells. The former supply well should be sealed.

Table 1
Well Specific Construction Details
Lower Fort Garry National Historical Site – Proposed Groundwater Supply
River Lot 1 – Parish of St. Clements and River Lot 100/131 – Parish of St. Andrews
5925 PTH 9 – Rural Municipality of St. Andrews, Manitoba

Well	Date Drilled	Latitude	Longitude	Casing Depth	Diameter	Casing Type	Total Depth	Open Hole Diameter
North #1	Mar.17/2015	N50.11392°	W96.92867°	80 ft.	6 inch	Steel	277 ft.	5.5 inch
South #2	Mar.19/2015	N50.11388°	W96.92880°	80 ft.	6 inch	Steel	323 ft.	5.5 inch

Table 1– Well details – Lower Fort Garry site

Pumping Test

In order to obtain preliminary aquifer parameters, determine the well responds to pumping, and determine groundwater under the influence of surface water conditions, one 24 hour pumping test was conducted on North Well #1 at the site. It should be noted that it is not planned to have both wells running at the same time. The second well will only be used as a backup. A short term, one hour long specific capacity test was undertaken on the second supply well. The desired flow rate is 15.85 U.S.G.P.M.

A 2 hp Berkeley submersible pump and motor was installed in the North Well (#1) at a depth of 80 feet below grade. The initial pumping rate was set at 35 U.S.G.P.M., which was above the requirement flow rate for the project set by Stantec and the client. The flow rate was maintained through each test by timing known volumes. Water levels were monitored using a Powers M-scope well sounder in the pumping well and the south well (monitoring well). In addition, two water samples were collected from the pumping discharge in laboratory supplied analytical sample bottles. The samples were submitted to ALS Laboratories for routine analysis. The results will be discussed in the data analysis section. In addition to the routine analysis, two environmental isotope samples were collected for the analysis of Oxygen^{18} and Deuterium isotopes.

The specifics of the pumping test are shown in Table 2, below.

Table 2
Well Specific Construction Details
Lower Fort Garry National Historical Site – Proposed Groundwater Supply
River Lot 1 – Parish of St. Clements and River Lot 100/131 – Parish of St. Andrews
5925 PTH 9 – Rural Municipality of St. Andrews, Manitoba

Well	Date Drilled	Latitude	Longitude	Function	Pumping Rate	Static Water Level	Pumping Water Level	Drawdown
North #1	Mar.17/2015	N50.11392°	W96.92867°	Pumping	35 US GPM	39.42 ft.	67.86 ft.	28.44 ft.
South #2	Mar.19/2015	N50.11388°	W96.92880°	Monitor	N.A.	40.90 ft.	48.41 ft.	7.51 ft.

Table 2 – Pumping test details – Lower Fort Garry site

Data Analysis

Aquifer Testing Analysis - Single Well Constant Rate 24 Hour Pumping Test

The Theis method (1935) method is the most common method for analyzing the results from aquifer pumping tests. Some critical assumptions of the method were noted during the development. They are detailed as follows:

- Darcy's law is valid
- The aquifer is horizontal and constant thickness
- The aquifer is infinite in areal extent
- The aquifer is bounded by impermeable strata above and below
- Uniform hydraulic conductivity
- Isotropic hydraulic conductivity
- Head always remains above the top of the pumped aquifer
- There are no water level changes that are not due to the pumping.
- Infinitesimal diameter of well
- Fully penetrating the aquifer formation
- Perfectly efficient well
- Single pumping well
- Constant pumping rate
- Constant storage properties through time
- The head is known everywhere prior to pumping.

Through a review of the assumptions, it can be seen that some of the conditions for the analysis of the pumping tests conducted at the on the Lower Fort Garry site are invalid for the Theis (1935) approach. The Theis (1935) approach is highly idealized to the assessment of the aquifer, and represents the state of the art for the determination of aquifer parameters. The conditions are also not being violated overly severely, so this approach will be used for the analysis.

The pumping test data from the 24 hour pumping test/recovery test on the North Well #1 was entered into Waterloo Hydrogeologic's AquiferTest Professional v4.20, for analysis of aquifer parameters. The data was analyzed using the Theis (1935), Cooper-Jacob (1946) and Theis (1935) Recovery methods, although the exact same result should be expected, as the Cooper -Jacob (1946) method is simply a straight line approximation of the Theis (1935) method. In order to determine the acceptability of the results, a derivative analysis was used, which is also shown on the attached plot (Bourdet, et. al., 1989). Well efficiency was determined to be about 69%. In general, the hydraulic parameters that were determined are shown in Table 3, below:

Table 3
Aquifer Parameters
Lower Fort Garry National Historical Site – Proposed Groundwater Supply
River Lot 1 – Parish of St. Clements and River Lot 100/131 – Parish of St. Andrews
5925 PTH 9 – Rural Municipality of St. Andrews, Manitoba

	North Well #1	
Drawdown	28.44 ft @ 35 U.S.GPM – 24 hours	
Static Water Level	39.42 ft from top of casing	
Specific Capacity	0.896 U.S.GPM/ft	
Method	**Transmissivity**	**Storativity**
Theis Method[1]	4,500 U.S.G./day/ft	1.00×10^{-5}
Cooper - Jacob Method[2]	4,500 U.S.G./day/ft	1.00×10^{-5}
Theis Recovery[3]	4,500 U.S.G./day/ft	1.00×10^{-5}

Notes [1] Theis (1935) method using Waterloo Hydrogeologic Limited – Aquifer Test Professional v4.20
[2] Cooper - Jacob (1946) method using Waterloo Hydrogeologic Limited – Aquifer Test Professional v4.20
[3] Theis Recovery (1935) method using Waterloo Hydrogeologic Limited – Aquifer Test Professional v4.20

Table 3 – Aquifer Parameters – Lower Fort Garry site

In general, the aquifer was determined to have an estimated transmissivity of less than 5,000 U.S.G./day/ft., based on the results of the 24 hour single well test. This estimation appears to be fairly low from the Transmissivity mapping that was undertaken by Render, in 1986 for the area. Render's mapping showed levels of about 20,000 U.S.G./day/ft., although there did not appear to be an abundance of data points within the Lower Fort Garry area, as the primary focus of his investigations was the City of Selkirk.

During the analysis, the $t_{critical}$ was assumed to be less than approximately 30 minutes for casing storage; therefore, the data previous to 30 minutes was not used in the analysis. The Cooper-Jacob (1946) method was used, since emphasis is not placed on early time measurements. The pumping well configuration was fully penetrating. The aquifer is not continuous, or isotropic, and displays a strong spatial variability. These conditions indicate a fundamental breech in the conditions of Theis (1935). Due to amount of data present

Aquifer Testing Analysis - Single Well Constant Rate 24 Hour Pumping Test (cont'd)

the aquifer was assumed to be Theissian, although this may or may not be totally correct in this instance. This approach will be used for comparison purposes only in this evaluation. It was assumed that skin effects for the supply well would be minimal since the well is an open hole style of construction.

Through a review the analysis plots, no deviations from the Cooper-Jacob (1946) plot could be located. Boundary conditions did not appear to be encountered during the testing at the site.

The drawdown versus time, Theis (1935) method, Cooper – Jacob method (1946), and Theis (1935) recovery results are shown below and on the following pages as Figure 8, 9, 10, and 11. Render's 1986 Transmissivity map for the Selkirk area is shown as Figure 12.

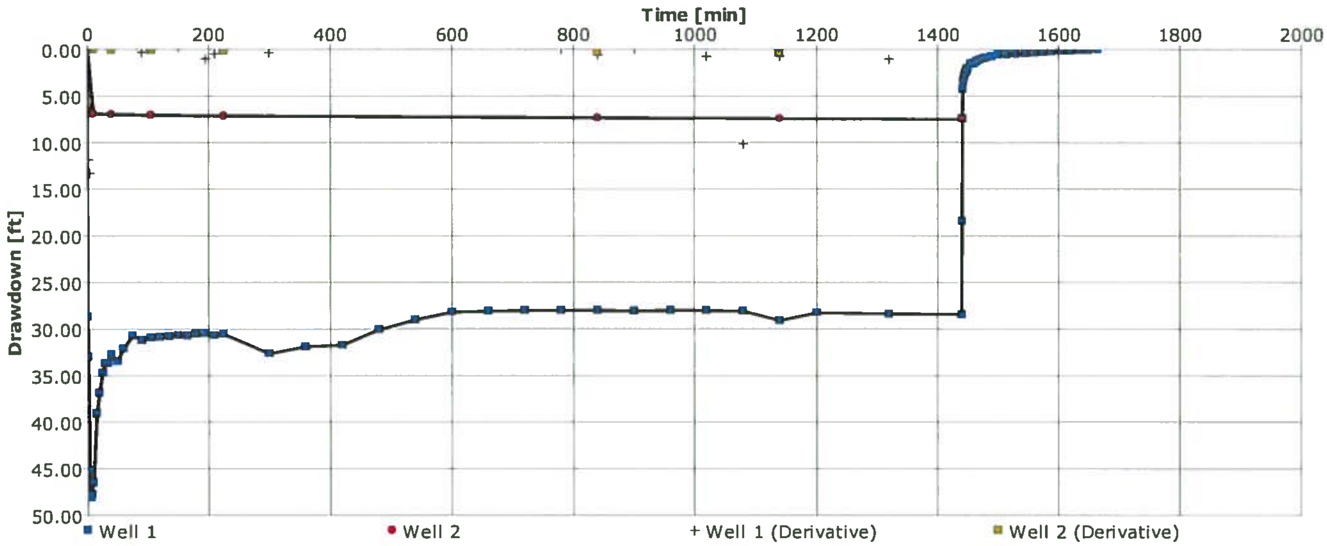

Figure 8 – Drawdown vs. Time with derivative analysis shown. The constant pumping rate from the North Well #1 is 35 U.S.G.P.M.

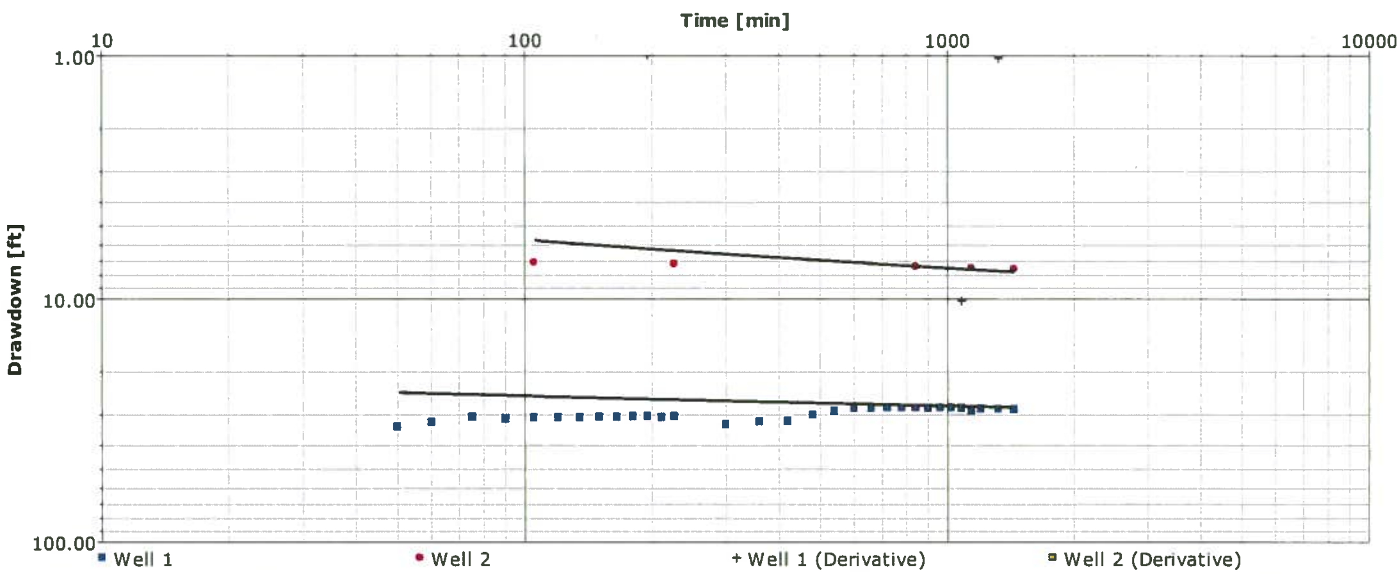

Figure 9 - The Theis (1935) plot with derivative analysis for the Lower Fort Garry North Well #1, which was pumping at 35 U.S.G.P.M. for 24 hours duration. There are some small fluctuations in the water levels that appear to be the result of pumping changes at the MRM site.

Aquifer Testing Analysis - Single Well Constant Rate 24 Hour Pumping Test (cont'd)

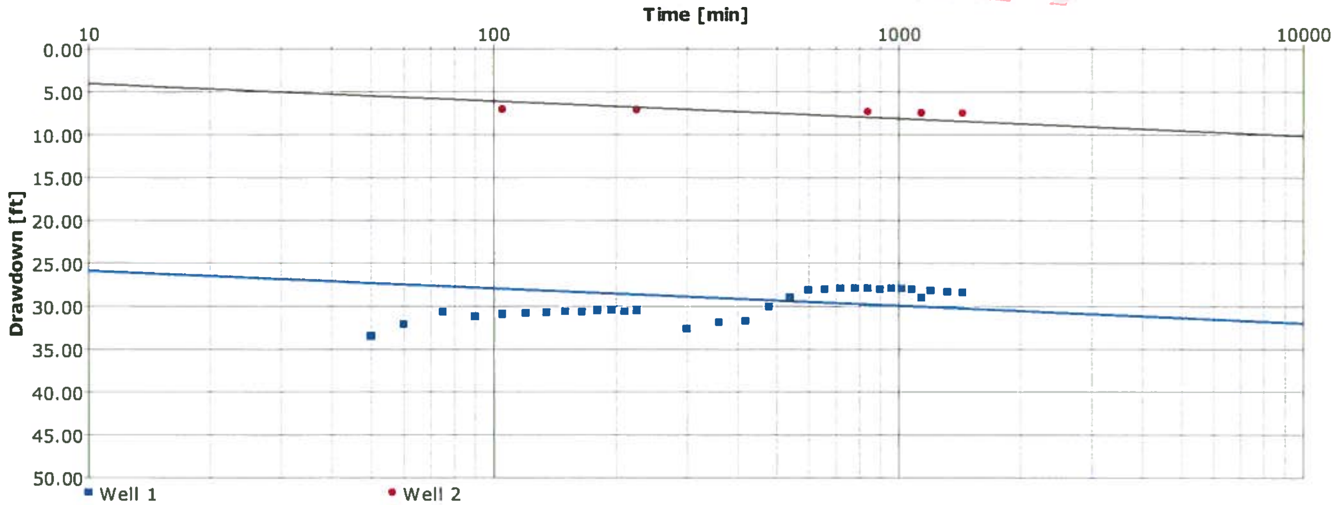

Figure 10 – The Cooper – Jacob (1946) plot for the Lower Fort Garry site. There are some small fluctuations in the water levels that appear to be the result of pumping changes at the MRM site. The flow rate was noted to be 35 U.S.G.P.M.

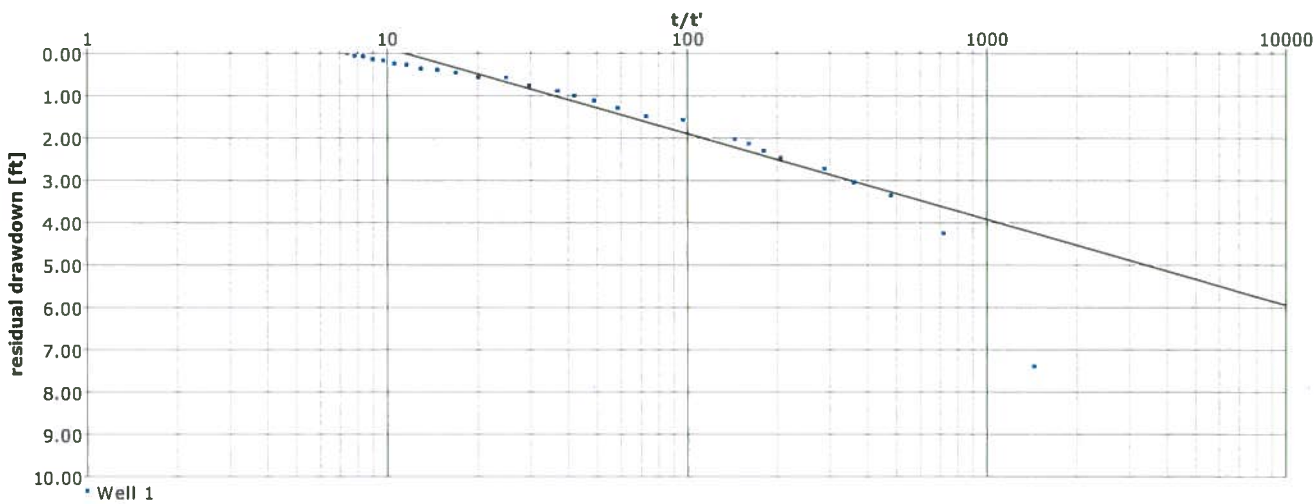

Figure 11 - The Theis (1935) Recovery plot for the Lower Fort Garry North Well #1.

During the testing, it was noted that there were a few changes and fluctuations in the water levels. The pumping test was conducted for 24 hours duration, and noted a slight increase in water levels after 6 pm in the evening. This change in water levels in the area is speculated to be part of the MRM well shut down at the end of the day's shifts. It is speculated that their well use decreases during the evenings, and steadily increases during the working shift during the day.

Aquifer Testing Analysis - Single Well Constant Rate 24 Hour Pumping Test (cont'd)

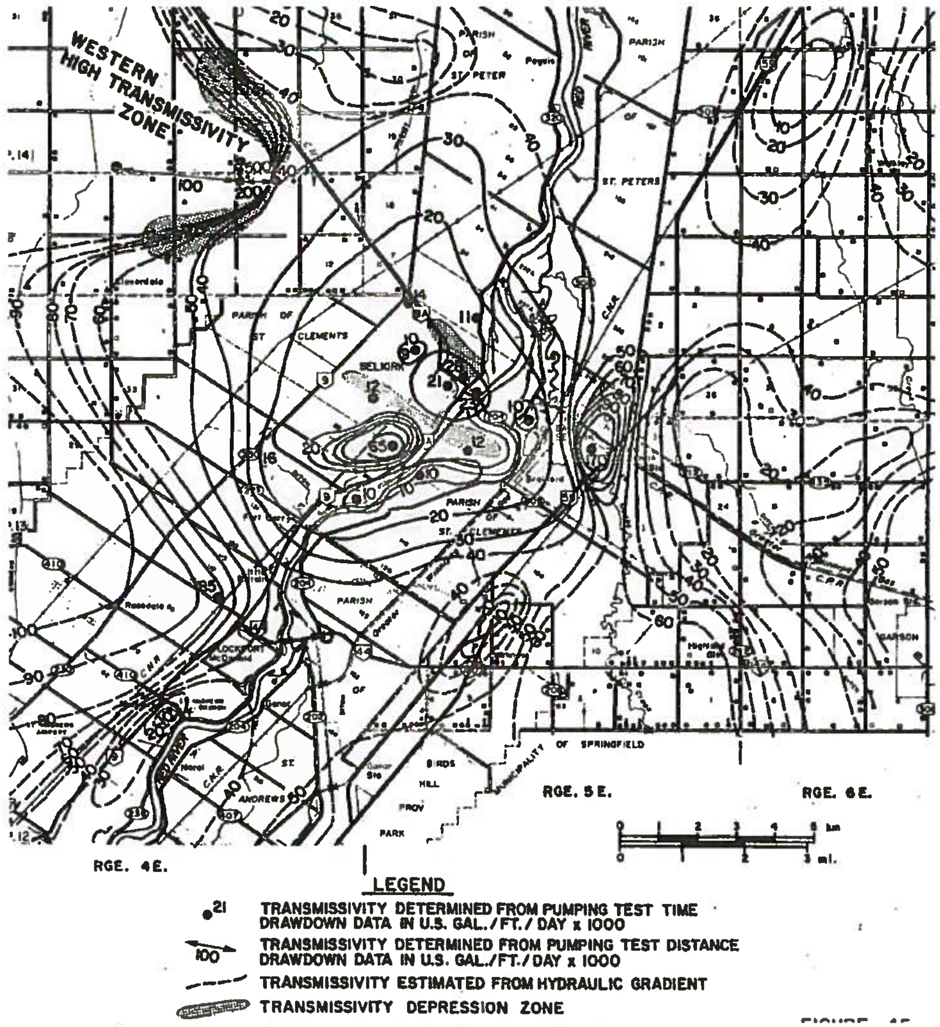

Figure 12 – Selkirk area transmissivity mapping (source – Render, 1986)

Groundwater Analytical Sampling and Stable Environmental Isotopic Results

Groundwater samples were collected from the pump discharge from the 24 hour pumping test on the North Well #1, in laboratory supplied sample bottles. These samples were submitted to ALS Laboratories in Winnipeg for analysis, with the results attached. One sample was collected at 12 hours, with the second collected immediately before shut down at 24 hours. The significant results (L1593224) are shown below:

- North Well #1 Pumping Test - 12 Hours
  - Total dissolved solids – 1,760 mg/L
  - Electrical conductivity – 3,030 umhos/cm
  - Chloride – 665 mg/L
  - Nitrate – Non Detect
  - Bicarbonate – 413 mg/L
  - Hardness – 753 mg/L
- North Well #1 Pumping Test – 24 Hours
  - Total dissolved solids – 1,740 mg/L
  - Electrical conductivity – 3,060 umhos/cm
  - Chloride – 642 mg/L
  - Nitrate – Non Detect
  - Bicarbonate – 416 mg/L
  - Hardness – 765 mg/L

Overall, the water quality is very poor and is brackish. This is expected for the deeper aquifers south of the City of Selkirk (Render, 1986). The turbidity is reported to be less than 10.0 NTU at the end of the testing, based on field analysis. Nitrates were not detected in the sample. Generally speaking, the results remained very stable throughout the duration of the testing.

Groundwater Analytical Sampling and Stable Environmental Isotopic Results (cont'd)

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The groundwater quality is defined as a Chloride/Sulphate/Bicarbonate. The results were plotted on a Tri-linear (Piper) diagram, which is shown below as Figure 13. Render noted that the presence of brackish water in this area in 1986, and speculated that deeper wells drilled into the Winnipeg formation sandstone may be leaking into the overlying carbonate aquifer regionally. In order to provide some additional protection, we recommend that the lower 20 foot section of the South Well #2 be cemented off with Sulphate resistant cement.

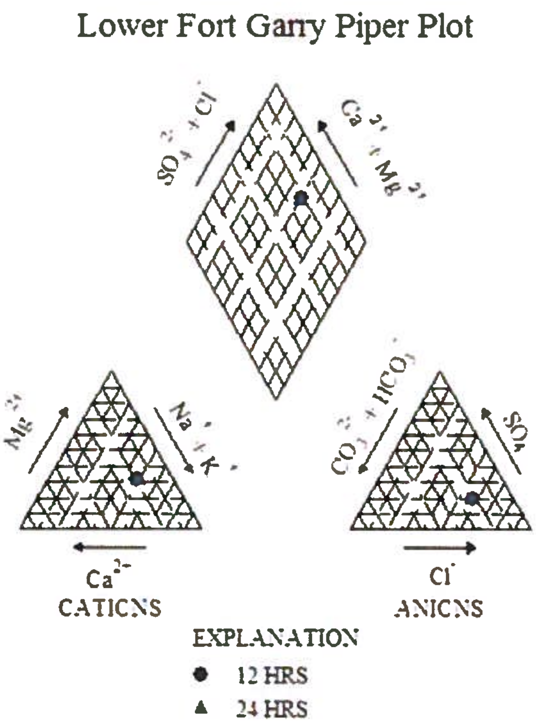

Figure 13 – Tri-Linear diagram – Lower Fort Garry site. (data source – ALS Laboratories (L1593224), 2013)

In addition to the routine geochemistry, samples were collected for the Stable Environmental Isotope analysis. The purpose of this analysis is to determine the origin and provenance of groundwater at the site, and to determine relative ages, and possible interactions that could modify groundwater on the site.

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 area.

Within Manitoba, glacial water (~ 10,000 years ago), typically shows oxygen 18 concentrations of -19 to -23 ‰. Waters that are mixing with older glacial waters typically indicate about -17 to -19 ‰, while recent water is -14 to -16 ‰ (Freeze and Cherry, 1979).

Another important occurrence in water in the hydrological cycle is the measurement of Tritium. Although tritium is known to occur naturally in groundwater, the quantities are thought to be less than 2 to 4 TU (Tritium Units). Increases in tritium were noted as a result of the extensive testing of nuclear weapons by the Union of Soviet Socialist Republics and the United States in the 1950's and into the early 1960's. Since the cessation of nuclear testing the levels of Tritium have been monitored extensively in Canada. Since tritium has a half life of 12.3 years, groundwater that was recharged at surface before 1953 is expected to have a tritium level less than 2 to 4 TU (Freeze and Cherry, 1979).

Groundwater Analytical Sampling and Stable Environmental Isotopic Results (cont'd)

Following Fritz and Clark (1997), for continental regions, the following interpretations can be made regarding Tritium concentrations:

- < 0.8 T.U. Sub-modern groundwater – recharged to the aquifer prior to 1953
- 0.8 to ~ 4 T.U. Mixture of sub-modern and recent recharge
- 5 to 15 T.U. Modern recharge (5 to 10 years)
- 15 to 30 T.U. Considerable recharge from the 1960's (peak bomb water)

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At the Lower Fort Garry site, the results indicate that the groundwater is meteoric in nature, and has undergone little enrichment or modification from the Local Meteoric water line for the area (Gimli, Manitoba). Further, the results do not appear to show the presence of any evaporitic water present. The groundwater appears to be a slight blend of primarily glaciogenic groundwater, and more recent meteoric water. The plot of the results agains the local meteoric water line is shown below as Figure 14. The Tritium results are non-detect, indicating that the groundwater has not been exposed to atmospheric conditions after 1953.

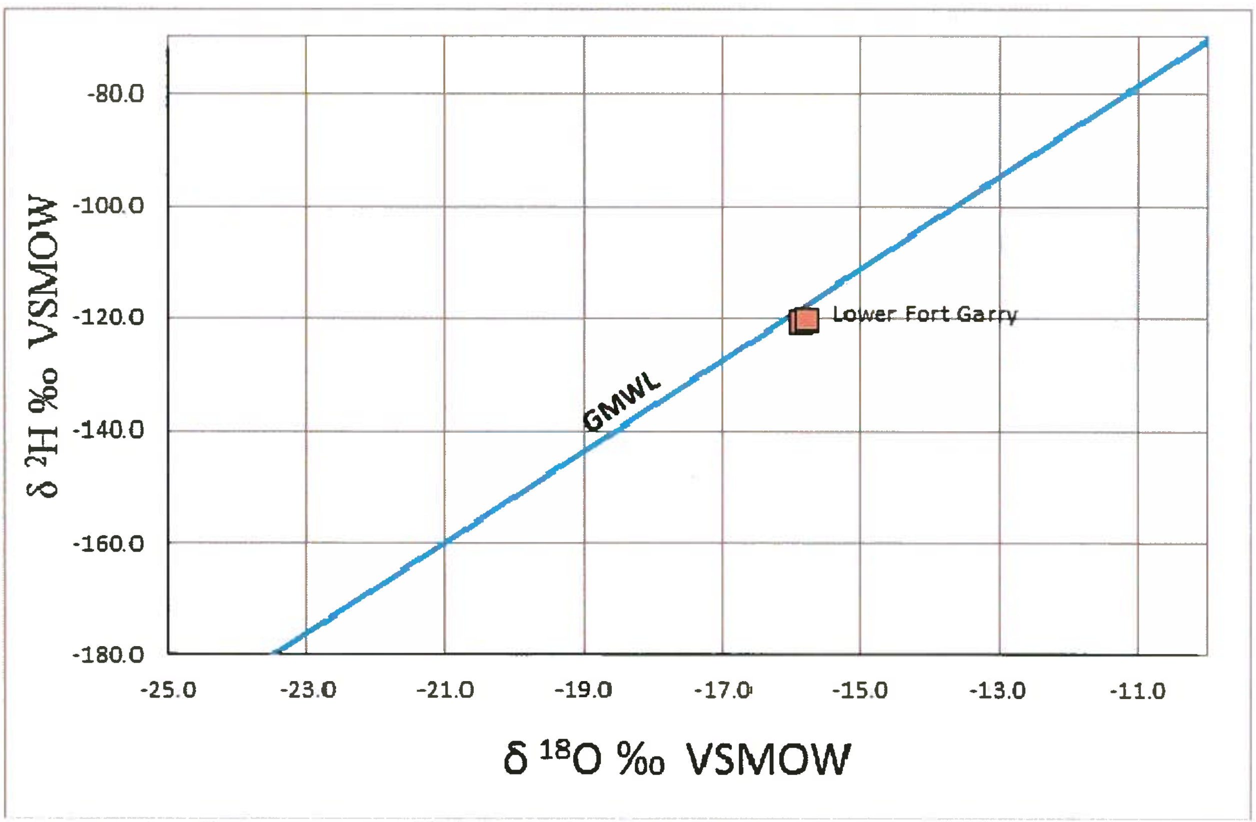

Figure 14 — Deuterium (^{2}H) and Oxygen 18 (^{18}O) plot of samples from the Lower Fort Garry site. (data source – ALS Laboratories (L1593224), 2013)

Water Supply Requirements and Estimated Drawdown

It is important to stress that Lower Fort Garry is not expanding, and the site is not planning to utilize more water than currently used from the existing well. It is speculated that the water levels that have already been created in the area will not change considerably. According to information provided by the Stantec Consulting Limited, only one well on the Lower Fort Garry site would be used at any give time for water supply. The second well will be maintained a cycling back up well. The maximum pumping rate that was requested for the study would be 15.85 U.S.G.P.M. continuous, with a maximum instantaneous rate of 20 U.S.G.P.M required. Further, the site typically operates for about 200 days per year, and is closed in the winter. Overall, the annual consumption of for current and future requirements was determined to be approximately 20 acre-feet per year (24.5 dam^3/year), pumping for about 200 days per year.

Long Term Aquifer Capacity

In order to determine the long term effects of the water supply system, the drawdown was calculated at distance using the Theis equation at an average pumping rate of 20 U.S.G.P.M., after one year of operation for the site, assuming 200 days of pumping per year. These drawdowns follow all the assumptions of the Theis method. Drawdowns were calculated using Walton's B8.BAS Fortran code (Walton, 1983). The drawdowns at various distances are shown below in Table 4.

Table 4
Predicted Drawdown at Radial Distance After One Year of Operations (200 days)
Lower Fort Garry National Historical Site – Proposed Groundwater Supply
River Lot 1 – Parish of St. Clements and River Lot 100/131 – Parish of St. Andrews
5925 PTH 9 – Rural Municipality of St. Andrews, Manitoba

Well	200 ft.	300 ft.	400 ft.	500 ft.	600 ft.	700 ft.	800 ft.	900 ft.
6.47 ft.	5.73 ft.	5.30 ft.	5.00 ft.	4.77 ft.	4.59 ft.	4.43 ft.	4.30 ft.	4.19 ft.

Table 4 – Predicted drawdown at various distances after one year at 20 U.S.G.P.M. – Lower Fort Garry site

The drawdown at a radial distance of 1,000 feet was determined to be approximately 4.00 feet after pumping one year continuously at a rate of 20 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 5,000 U.S.G./day/ft, with an assumed storage coefficient of 1.0×10^{-5}. It is difficult to predict the exact amount of drawdown from the Lower Fort Garry site, as Render's map shows, the Transmissivity changes considerably in the area. Around the well field, it is expected to have Transmissivity in the 20 to 30,000 U.S.G./day/ft range. The well field impact is also likely well developed from the existing well on the site. Based on this fact, it is not expected that any change in water level conditions on the site will be experienced.

Discussions

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The Lower Fort Garry site is a very interesting groundwater supply development. Due to the shallow bedrock on the site, it is speculated by many authors that the Red River and the carbonate aquifer are interacting with each other. Further, since the bedrock is also shallow in the area, impacts from human activities at surface also appear to be having an effect in the area. The presence of nitrates in the area provides a strong indication of this. It is speculated that large a larger withdraw of groundwater near the river from the shallow carbonate aquifer could result in the intrusion of surface water into the aquifer. This has occurred at the MRM site nearby, as detailed in Render, 1986. Therefore, it is speculated that this condition could occur elsewhere in the area of the Selkirk drawdown cone.

The lower bedrock aquifer appears to be less transmissive than the upper, with poorer quality brackish water present. Render (1986) speculated that this water is from deeper wells drilled into the Winnipeg Formation in the area, although specific evidence could not be found.

Since the site requires a new treatment facility, it was suggested that isolating the upper aquifer would provide the best means to avoid dealing with the possible water quality changes of the upper aquifer groundwater. As a result, deeper wells were constructed to develop the lower aquifer. As noted in the well inventory, few wells in the area have been constructed in this manner, and many have long open hole sections that likely interconnect both zones. Although the testing does not indicate a departure from meteoric conditions, changes could occur over time with pumping. Careful monitoring of long term water quality is extremely important in this site. Although the second well did not penetrate the Winnipeg Formation sandstone, we do suggest that the lower 20 feet be sealed with cement as an addition assurance protection.

Through a review of the historical reports, it is evident that the Selkirk area responds very quickly to seasonal and climatic changes. In the event of a prolonged dry period, water levels in the area appear to decline rapidly. Render (1986) noted that the aquifer in Selkirk behaves like a pipeline and open reservoir. During dry periods when the water levels in the reservoir decline, the potential, or water level in the pipeline declines significantly. Water levels should be monitored closely at all times during operation. Render also noted that significant recharge is occurring to the east of Selkirk from the Birds Hill and Garson area. Water levels should be monitored in the supply well weekly for static water levels. Lower Fort Garry should consider installing instrumentation in the wells to undertake this.

A hydrogeologist/hydrogeological engineer should prepare a monitoring and water quality report for this water supply system on an annual basis.

Recommendations

Based on review at the supply well at the Lower Fort Garry site, we recommend the following activities with respect to the activities with respect to the use to the wells for groundwater supply:

- This report should be submitted to MCWS-WULS for their review and possible issuance of a license.
- The lower portion (20 feet) of South Well#2 should be sealed with sulphate resistant cement under the supervision of a hydrogeologist/hydrogeological engineer. A licensed well driller should undertake the work.
- Flow meters should be installed and maintained in the supply piping.
- The existing well should be sealed with sulphate resistant cement under the supervision of a hydrogeologist/hydrogeological engineer. A licensed well driller should undertake the work.
- An annual report should be prepared by a hydrogeologist/hydrogeological engineer for the well field. The water quality results and static water levels should be reviewed. Stable isotopes should be collected.
- The well should be equipped with a spool type pitless unit.
- The static water levels should be monitored regularly in the well, along with the water consumption and flow rate.
- The well should be permanently vented and remain vented at all times.
- Water quality samples should be taken annually during operation. These samples should be analyzed for routine water quality and isotopic results.
- The wells may require air lifting/cleaning/servicing from time to time. A licensed drilling contractor should perform this service work.

We thank you for the opportunity to be of service to Stantec. We thank you for the opportunity to work with you on this project.

Should you require anything further, please call me at (204) 326-2485.

Sincerely

Friesen Drillers Limited

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J.J.(Jeff) Bell, B.Sc.(G.E.), P.Eng.
Hydrogeological Engineer

Reviewed by

Friesen Drillers Limited

DRAFT

Jason D. Friesen
Operations Manager

JJB

Attachments

Friesen Drillers Ltd. – February 20, 2015 – Groundwater exploration permit application
MCWS - WULS – February 25, 2015 – Groundwater exploration permit
Friesen Drillers Ltd. – March, 2015 – Well logs, pumping test data, and field notes
ALS Laboratories – L1593224 Analytical results

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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.

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