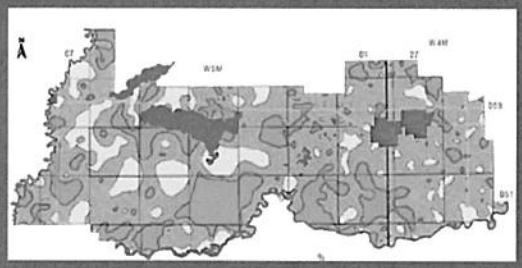

Groundwater Supply Analysis

Fawn Meadows

August 2009 REVISED February 2012

REPORT TO	**NorCan Consulting**
FOR	**Groundwater Supply Analysis**
ON	**Fawn Meadows Development (NC-145)**
PRINCIPAL CONTACT	**Frank Florkewich** **NorCan Consulting Group**

August 2009, REVISED January 2012

SD Consulting Group
796 Cherokee Ave
Saint Paul, MN 55107

Stantec
White Bear Lake, MN 55015

I hereby certify that this report was prepared by me or under my direct supervision and that I am duly Registered Professional Engineer under the laws of the Province of Alberta.

Bryan DeSmet, P. Eng., SD Consulting Group — Alberta Permit to Practice #P10913

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1.0 Introduction

Stantec NAWE was retained by Fawn Meadows Development Corporation through NorCan Consulting as water supply and wastewater consultants. The scope of these services includes the completion of a groundwater supply analysis in support of an application under the *Water Act* for a groundwater diversion license. All revisions to this report were completed by SD Consulting Group.

The purpose of this analysis is to provide information on the capacity of the groundwater aquifer and its ability to meet the potable water demands of the proposed Fawn Meadows Development. This report provides information on site characteristics, locations and ownership of local wells, as well as pump test, water quality and well impact information. Reference materials include the Alberta Environment Water Well Database, The Parkland County Regional Groundwater Assessment other published geology and hydrogeology texts and figures.

The proposed development is located south of Highway 16 and west of Highway 43 in Parkland County. Location maps and property boundaries are provided in **Figure 1.1**.

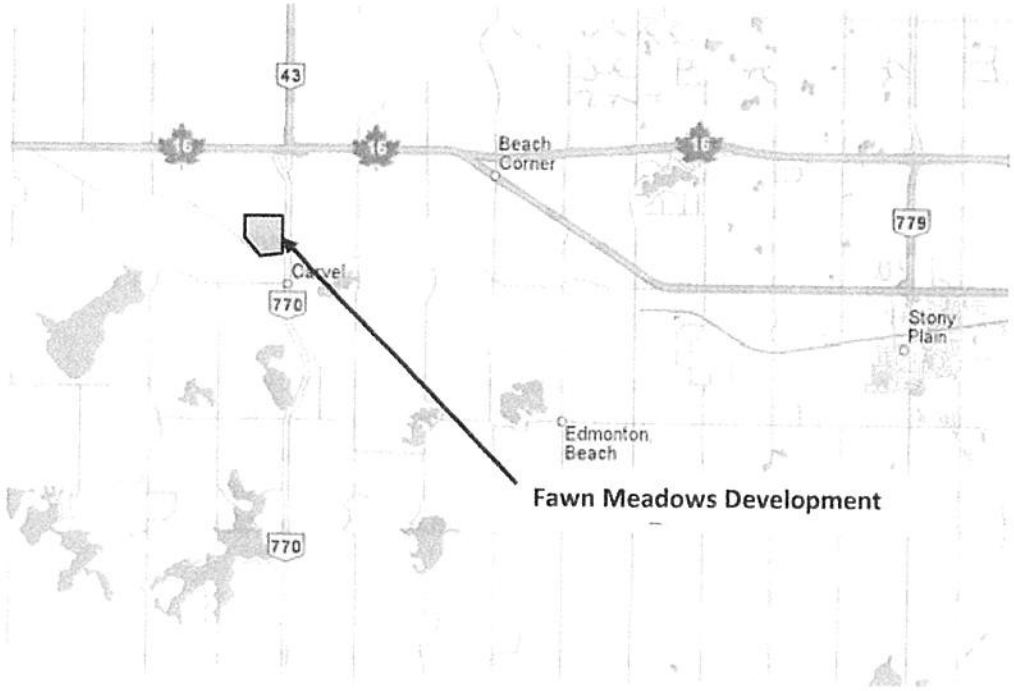

FIGURE 1.1 FAWN MEADOWS LOCATION

1.1 PROPOSED WATER SUPPLY

1.1.1 Water Demands

Current development plans include 36 single family detached dwellings, 24 semi-detached dwellings, 56 villa style dwellings, and 140 apartments. As shown in **Table 1.1**, **this equates to a total flow of 188.23 m^3/day and an average flow of 0.131 m^3/min.** As discussed later in this report, the production well can produce a sustainable yield of 0.46 m^3/min, which is more than enough to meet the demands of the development and not cause negative impacts to neighboring wells.

Table 1.1: Water Demands

Unit Type	# of Units	Residents/ Dwelling	Total Residents	Water Demand Per Capita (m^3/day)	Total Water Demand (m^3/day)
Detached Dwellings	36	2	72	0.378	27.2
Semi-Detached Dwellings	24	2	48	0.378	18.1
Villa-Style Dwellings	56	2	112	0.378	42.4
Apartment-Style Dwellings	100	2	200	0.378	75.6
	40	1	40	0.378	15.1
Staff – Supportive Living Centre	-	-	10	0.378	3.78
Staff – Café and Gas Bar			2	0.378	0.76
Condominium Maintenance Staff			4	0.378	1.51
Rec Center and Community Hall			10	0.378	3.78
Totals	**256**	-	**498**	-	**188.23**

Water demands were based on a demand per capita of 0.378 m^3/day, or approximately 83 imperial gallons per day and 378 liters/day. According to Environment Canada, the average water usage in Canada is 343 liters/day. Therefore, the estimated water demand of 0.378 m^3/day is a conservative estimate for water usage. In addition, 0.378 m^3/day equals approximately 100 US gallons per day, which is a standard design figure in the water design industry in both the US and Canada.

According to AEW's *Standards and Guidelines for Municipal Waterworks, Wastewater, and Storm Drainage Systems*, peak flow in a water system is equal to the maximum daily design flow plus fire flow. The maximum daily flow is calculated by applying a factor of 1.8 or 2.0 to the average daily flow. Since fire flow is not provided by the groundwater system at Fawn Meadows, the **peak flow will be approximately 376.40 m^3/day or 0.261 m^3/min**

1.1.2 Groundwater Sources

As shown in **Figure 1.2**, two groundwater wells have been installed on the property:

- Observation Well (Well ID #1165411) – Installed on June 12, 2008 to a depth of 73.1 meters, the well has a casing diameter of 18 centimeters. This well installation was exploratory for preliminary water supply determination. The observation well was used

as an observation well during the 2009 pump testing and will be used as a backup domestic supply well in the development.

- Production Well 2 (Well ID# 1165474) – Installed on May 13, 2009 to a depth of 84.4 meters, this well is intended for use as the primary water supply well. This well was installed with a 26 centimeter casing diameter and was test pumped for 72 hours with a 24 hour recovery period.

Both wells are installed into the interlayered sandstone and shale of the Horseshoe Canyon Formation. Five separate sandstone units are discharging into the production well casing. The two wells are 244 meters apart.

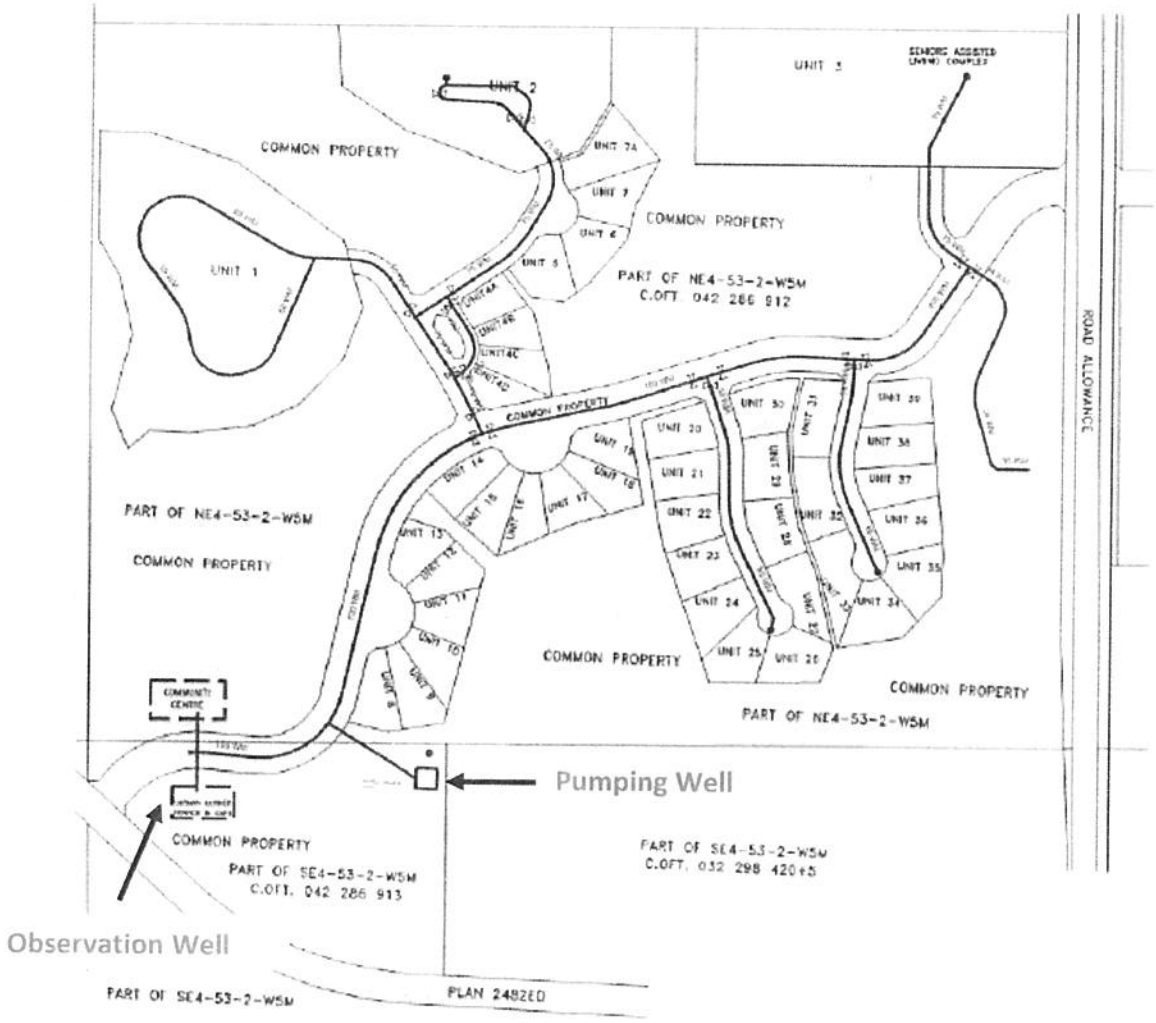

FIGURE 1.2 FAWN MEADOWS WELL LOCATIONS

2.0 Site Geology and Hydrogeology

2.1 SITE GEOLOGY

2.1.1 Local Surficial Geology

Fawn Meadows is located on the western edge of the Alberta Plains in a landscape characterized by rolling hills, river terraces, hummocky moraines, and numerous lakes/wetlands. Surficial geology is dominated by glacial till, lacustrine and outwash deposits from the Wisconsin Glaciation. Locally, the Fawn Meadows site is on the western edge of a large outwash deposit. Therefore, surficial materials consist of silt, sand and gravel. Approximately 10-50% of the surficial deposits consist of sand and gravel. Surficial deposits at Fawn Meadows have an average thickness of 20 meters over bedrock. **Figure 2.1** shows the amount of sand and gravel in surficial deposits throughout the county; the location of the proposed Fawn Meadows development is noted.

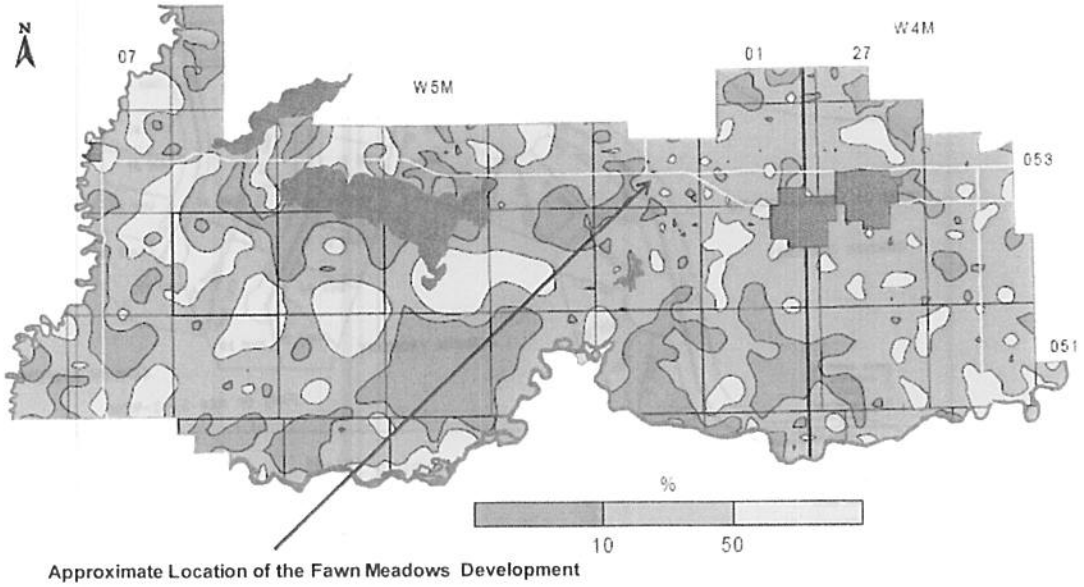

FIGURE 2.1 PARKLAND COUNTY SAND AND GRAVEL DEPOSITS IN SURFICIAL DEPOSITS
FIGURE SOURCE: PARKLAND COUNTY REGIONAL GROUNDWATER ASSESSMENT

2.1.2 Local Bedrock Geology

According to the Parkland County Regional Groundwater Assessment and the Research Council of Alberta's "Hydrogeology of the Wabamun Lake Area", Fawn Meadows is underlain by the Edmonton Group, a series of bedrock units consisting of alternating sandstone, siltstone and shale layers. The first bedrock unit, the Upper Horseshoe Canyon Formation is encountered at a depth of 20 meters and is approximately 80 meters at its thickest point. Below the Upper Horseshoe Canyon Formation, the Middle and Lower Horseshoe Canyon formations are encountered to a depth of approximately 300-500 meters below ground surface. The Bearspaw Formation is encountered below the Horseshoe Canyon and is the lowest bedrock unit typically studied in the area. A Parkland County bedrock map is provided in **Figure 2.2.**

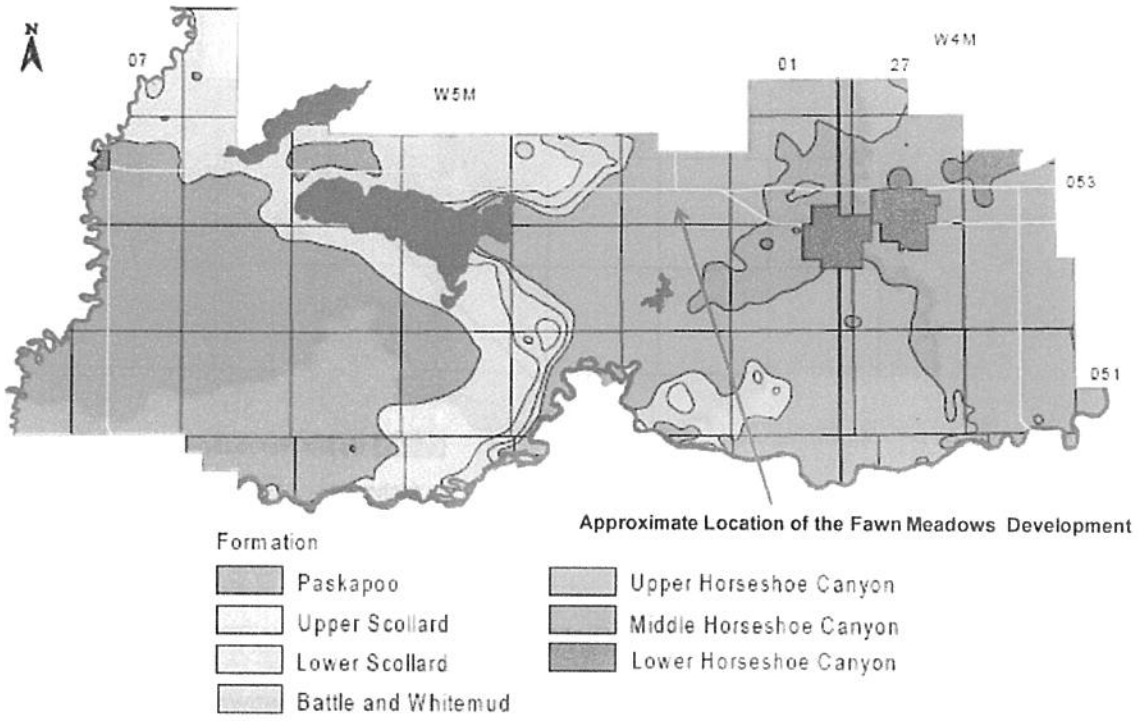

FIGURE 2.2 PARKLAND COUNTY BEDROCK GEOLOGY
FIGURE SOURCE: PARKLAND COUNTY REGIONAL GROUNDWATER ASSESSMENT

2.2 SITE HYDROGEOLOGY

Drinking water at Fawn Meadows will be provided by the Horseshoe Canyon Aquifer, which consists of three distinct bedrock formations. The upper, middle and lower Horseshoe Canyon Aquifers are the porous and permeable parts of the formation. The source aquifer consists of alternating layers of porous sandstone and impermeably shale/siltstone. Well casings typically intersect several sandstone layers that provide potable water and the entire system functions as a leaky confined aquifer. These aquifers are encountered at depths between 20-300 meters

below ground surface and this aquifer is the most common bedrock aquifer in this region of Parkland County.

According to the Parkland County Regional Groundwater Assessment, the aquifer recharge/discharge for the Horseshoe Canyon formations, and the surficial deposits, discharge from the bedrock occurs over and area smaller than 10% of the County. **Figure 2.3** shows the recharge and discharge areas for the Upper Horseshoe Canyon Aquifer.

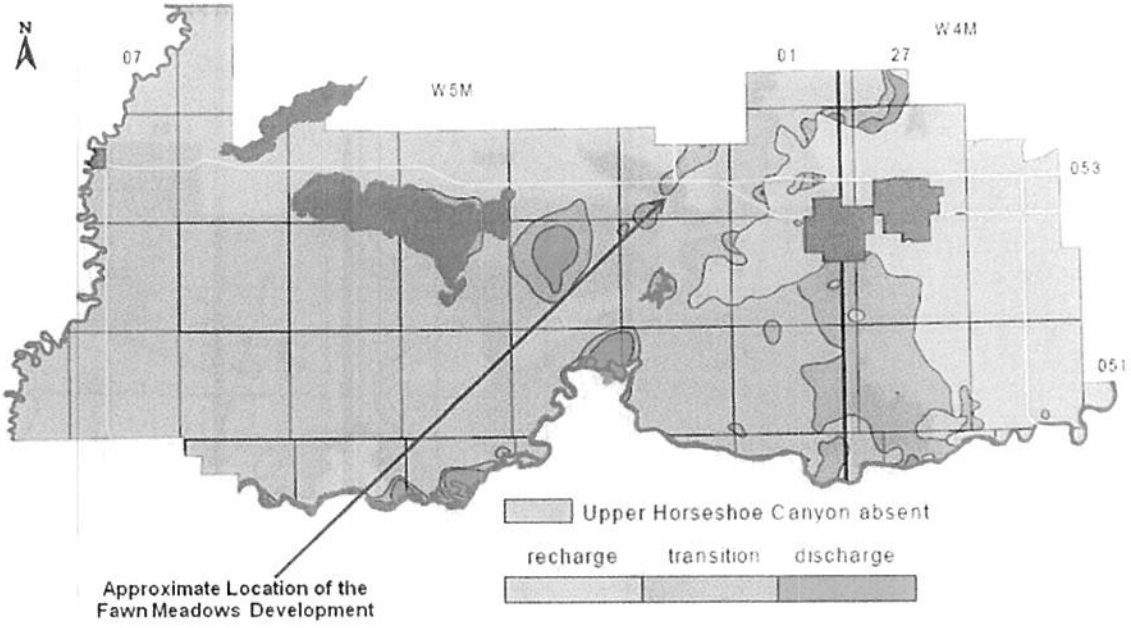

FIGURE 2.3 RECHARGE/DISCHARGE AREAS BETWEEN SURFICIAL DEPOSITS AND UPPER HORSESHOE CANYON AQUIFER

FIGURE SOURCE: PARKLAND COUNTY REGIONAL GROUNDWATER ASSESSMENT

3.0 Well Survey

According to the Parkland County Regional Groundwater Assessment, of the 3,107 recorded water wells in the county, 1,617 were defined as being constructed in the bedrock aquifer. Of these bedrock wells, 640 are located in the Upper Horseshoe Canyon Aquifer, 485 in the Middle Horseshoe Canyon Aquifer and 79 in the Lower Horseshoe Canyon Aquifer.

The Alberta Environment Well Database has been utilized to identify wells drilled within a 1 km radius of the well for the proposed Fawn Meadows Development. **Table 3.1** summarizes the data on the known wells within this area and individual water well drilling reports are located in **Appendix A** of this report. A field verified survey will verify these well locations during the AEW approval process.

TABLE 3.1 NEIGHBORING WELL LOCATION DATA

Owner's Name	Well ID	Legal Land Location	Date (DD MM YY)	Well Depth	Original Non-Pumping Water Level
			18 05 1990	210	36
			02 08 1990	280	60
			12 09 1990	260	65
			15 05 1989	215	60
			11 06 1992	260	59
			17 07 1992	205	48
			18 08 1992	242	43
			13 11 1992	240	63
			14 03 1994	240	70
			04 10 1995	319	99
			25 06 1979	220	65.4
			30 03 1971	190	54
			11 06 1980	256	75
			28 11 1989	285	55
			07 12 1983	120	15
			18 08 1983	220	40
			23 08 1985	198	75
			17 08 1981	240	147
			26 05 1967	170	18
			26 09 1976	120	19
			17 08 1963	124	32
			10 08 1994	260	65
			26 09 1995	240	40
			06 05 1999	220	85
			13 10 1999	220	42.1
			14 07 2000	265	42.2
			21 02 2002	240	77.7
			18 05 2003	140	32.48
			21 06 2005	320	72.08
			26 02 2003	195	20.013

1. Standard units are used as they are specified on all well logs

4.0 Pumping Test and Water Level Monitoring

4.1 TESTING PROCEDURES

Two pump tests have been completed at the Fawn Meadows Development. The first test occurred in the Observation Well on June 24th, 2008 and the well was pumped for 26 hours until steady state conditions were reached. Recovery in the well was monitored over an 18 hour period before monitoring equipment was removed from the well. Only one well had been installed at this time, so this test was completed as a single well aquifer test.

Following the installation of the Production Well in May of 2009, a second pump test was completed on May 21, 2009. The production well was pumped for 72 hours and the first well was monitored as an observation well. Recovery was monitored in both wells over a 24 hour period. The water well drilling report for both wells is provided in **Appendix B**, and the pump testing field reports are located in **Appendix C** of this report. All test monitoring was completed at intervals specified in the *Alberta Groundwater Evaluation Guidelines*.

4.2 AQUIFER PARAMETERS

Table 4.1 summarizes the results of the tests performed. All hydraulic parameters have been calculated utilizing the computer software AQTESOLV v4.5.

TABLE 4.1 AQUIFER PARAMETERS

Well	Length of Test (hrs)	Discharge Rate (m^3/min)	Analytical Procedure	Transmissivity(m^2/d)	Storativity	Observation Well?
Observation	26	0.113	Hantush	14.67	NA[1]	No
Production	72	0.227	Hantush	26.05	.0008714	Yes
			Theis	26.05	.0008712	Yes

1 – Unable to calculate storativity without observation wells

Using the equation T = KB, the hydraulic conductivity of the groundwater aquifer was calculated. Using a T value of 26.05 and a saturated thickness of 72 meters, the hydraulic conductivity is calculated to be 0.361 m/day, or 0.000004183 m/sec. This is consistent with textbook values for sandstone aquifers (3 x10-10 – 6 x 10-10), so it appears to be appropriate for this analysis.

4.2.1 Sustainable Yield

The theoretical long-term safe yield (Q_{20}) of the production well has been calculated using the Farvolden Method and the results of the aquifer testing. The equations and calculations using this method are shown below.

Equation 4.1 Farvolden Method

$$Q_{20} = (0.68) \times T \times H \times (0.7)$$

T = Transmissivity *H = Distance from top of aquifer to the pre pumping water level*

Using the Farvolden Method, a Q_{20} of 0.460 m^3/min is calculated as the safe yield. As mentioned previously, the new development will require an average flow of approximately 0.131 m^3/min and a peak flow 0.261 m^3/min Based upon the results of this analysis, **the production well has the ability (with adequate pump capacity) to support a flow of 0.460 m^3/min and meet the peak and average demands of the new development.** If additional water supply is needed, the observation well will serve as the backup production well.

4.2.2 Radius of Influence Modeling (Well Impact Assessment)

The radius of influence of the production well was modeled using the Theis Distance Drawdown Method. Pumping rate, transmissivity, and storativity were all utilized in the software to estimate the extent of the affected area. Using this data, the predicted radius of influence is 1038 meters from the Production well. However, past a distance of 234 meters, drawdown is minimal (<1.5 meters) and will not unreasonably interfere with neighboring groundwater supplies.

On **Figure 4.1**, the radius of influence has been broken down into three zones: major, minor and minimal impact areas. The major impact area consist of drawdown greater than 1.5 meters is **contained within the property boundaries to a distance of 234 meters from the production well**. The minor impact area shows an estimated drawdown of 1.5 meters or less and the minimal impact area consists of impact less than 0.2 meters and extends to a distance of 1038.15 meters, and which aquifer impact is predicted. Graphically, this is shown as a circle in **Figure 4.1**. Realistically, the radius of impact is an elongated circle in the direction of groundwater flow, which is generally northwest to southeast in the Horseshoe Canyon Aquifer.

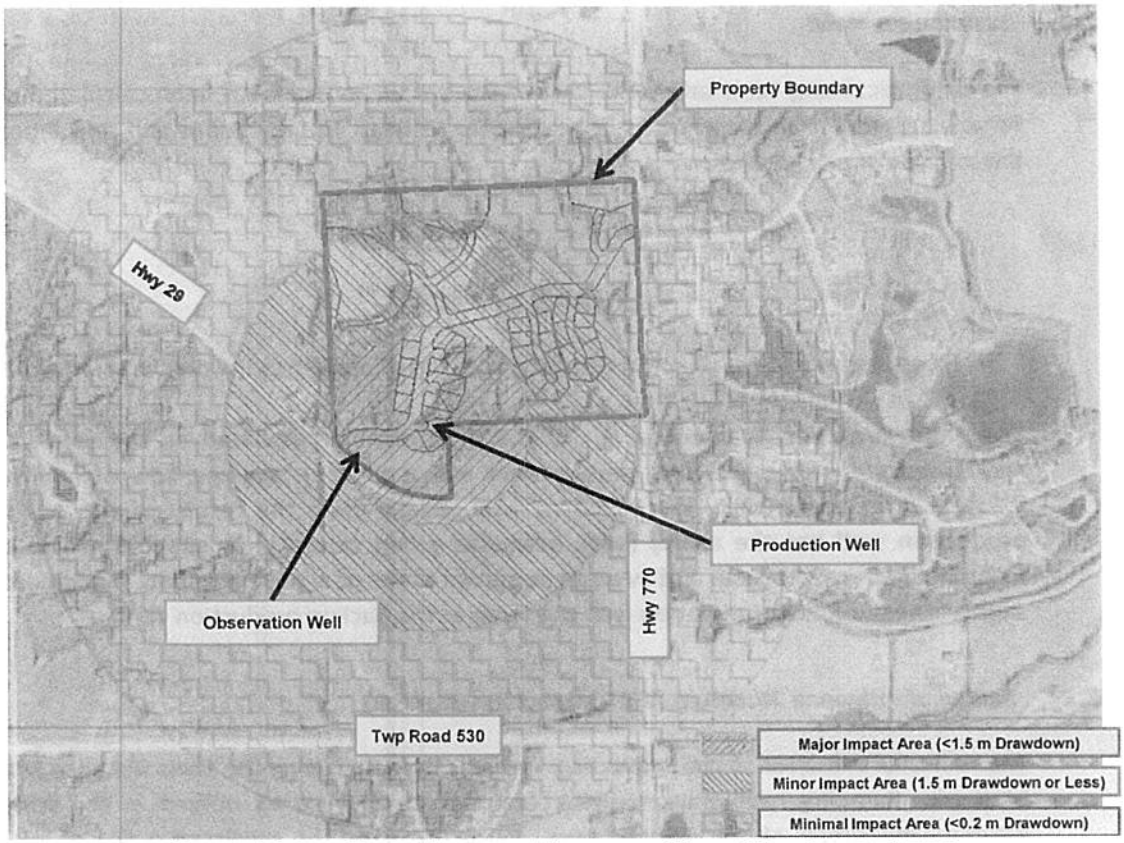

FIGURE 4.1 FAWN MEADOWS MAJOR AND MINOR WELL IMPACT AREAS

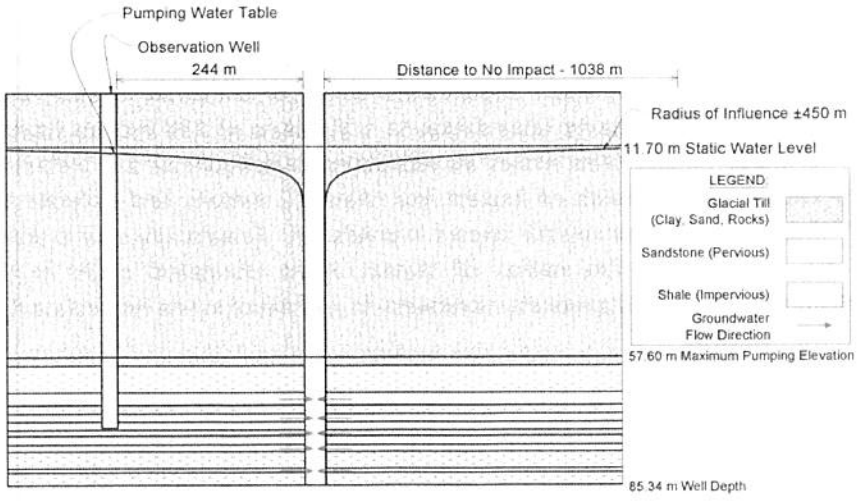

FIGURE 4.2 FAWN MEADOWS WELL CROSS SECTION

5.0 Water Quality Assessment

Water samples were taken from the production wells immediately before completion of the pump test at 72 hours. These samples were analyzed by Kaizen Labs for routine heavy metals and bacterial content. Lab reports are provided in **Appendix D** of this report. Groundwater quality from the production well is consistent with the Horseshoe Canyon Formation.

Water quality results indicate levels of sodium and total dissolved soils (TDS) that exceed Canadian Drinking Water Quality Standards. Groundwater is classified as sodium- bicarbonate water with high levels of sodium, TDS, and in some cases (not for this project), sulfate. Water treatment will likely be necessary to bring TDS levels down to potable standards.

6.0 Conclusions

Two wells have been installed and pump tested at the proposed Fawn Meadows Development. The following conclusions summarize the results of the well installation and pump testing:

- The new development will require a flow of approximately 0.131 m^3/min and according to this study, well #2 has the ability to support a flow of 0.46 m^3/min and meet the demands of the development.

- The predicted radius of influence is 1038 meters from the production well. However, past a distance of 244 meters, drawdown is minimal (<1.5 m). **For example, the maximum impact predicted for the nearest wells east of Highway 770 is less than 0.2 meters of drawdown.**

- The average flow from the development will be approximately 0.131 m^3/min (29 igpm). Considering that the pump test was completed at a rate of 0.22 m^3/min (49 ipgm), the average pumping rate will have considerably less impact than observed in **Figure 4.1**. It is likely that at low pumping rates, the impact will be limited to the boundaries of the project. In addition, all modeling assumed consistent pumping conditions. In reality, the well will be pumped intermittently to feed water storage and treatment facilities. The pumps will not consistently run as they did during the pump testing.

- Groundwater usage will be further limited by the reuse of stormwater for domestic irrigation and fire protection.

- Aquifer testing and analysis indicate that a diversion of 188.23 m^3/day (0.131 m^3/min) is sustainable and will not unreasonably interfere with neighboring groundwater supplies.

- The peak flow is estimated at 0.261 m^3/min (calculated per AEW criteria). Considering the well has the ability to support a flow of 0.460 m^3/min and peak flows do not occur on a regular basis,

no additional impact is predicted than what is shown in **Figure 4.1.** In addition, peak flows will be offset by water storage, which will allow the well to pump at a consistent rate based on the average flow.

- Water quality results indicate values of sodium and total dissolved solids in exceedance of Canadian Drinking Water Quality Standards. Water treatment will be necessary before use as potable water.

- The Fawn Meadows development will adhere to all requirements of *Alberta's Water Act*. These requirements specify a maximum amount of 1,250 cubic meters of freshwater per year to be provided for household uses. Groundwater will be provided for potable water only at Fawn Meadows and the maximum water usage per household is estimated at **268.4 cubic meters per year**. This includes all staff members and a contingency of 3,650 full day visitors or guests every year.

7.0 Closure

This report presents results of the Hydrogeologic Investigation at the Fawn Meadows Development and is intended for presentation to Parkland County and Alberta Environment for a groundwater diversion license pursuant to the Alberta *Water Act*.

This report also incorporates field data collected by others and this information is assumed to be accurate for the purposes of this report. This work was carried out using commonly accepted hydrogeologic practices and no other warranty is made as to these professional services. Any third party use of this report, or decisions made based upon it, are the responsibility of such third parties. SD Consulting accepts no responsibility for damages, if any, suffered by third parties as a result of decisions made based on this report.