Groundwater Availability

Sylvan Lake Area
NE 17-039-01 W5M

Prepared for
ISL Engineering and Land Services Ltd.

Prepared by
hydrogeological consultants ltd. **(HCL)**
1.800.661.7972

April 2009

Our File No.: 09-203.00

PERMIT TO PRACTICE
HYDROGEOLOGICAL CONSULTANTS LTD.
Signature_____
Date_____
PERMIT NUMBER P 385
The Association of Professional Engineers,
Geologists and Geophysicists of Alberta

D R A F T
hydrogeological consultants ltd. (HCL)

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Summary of Approval Conditions

Approval No.
File No.

Legal Location: NE 17-039-01 W5M
Requested Diversion: 120 m³/day 43,800 m³/year)

Condition	Description	Status for Conditions under the direction of HCL
1.	Approval for WTH No. 1-09	Noted - See water well completions, Appx B
2.	Acitivity in accordance with information filed in Department records	Noted
3.	Reclaim disturbed banks and beds of water body and areas accociated with activity.	
4.	Shall not deposit substance that will adversly affect water body.	Noted
5.	Release water into a water body only when water is of similar or better quality than that of receiving body.	Not Applicable
5.	Field-Verified Water Well Survey	
a)	plan	completed - 1000-metre radius - page 12 and Appx D
b)	list noting details of construction of water wells	completed - Appendix D
c)	table summarizing purpose and quantity	completed - Appendix D
7.	Design of Exploration Program	
a)	unreasonably interfere with other water users	no unreasonable interference
b)	negative inmpact on source aquifer or other aquifers	no negative impact
8.	Pumping Test	
a)	flow rate not less than maximum production rate	completed - pages B-18, and C-8 see report text for interpretation
b)	rate variation within 5%	completed - page C-4 rate for AT II was ± 2.4%
c)	pump for long enough to identify boundary conditions	completed - Appendix C
d)	recovery measurements for same length of time as pumping interval	completed - Appendix C
e)	not deposit any substance to adversely affect water body	
9.	Position pump intake above top of aquifer	
10.	AENV disclaimer	noted
11.	Submit report to AENV	
a)	diagrams of diversion site and any obs water wells	completed - page D-1
b)	plans showing:	
i)	physical features	completed - page D-1
ii)	location of diversion site	completed - page D-1
iii)	location, ownership, elevation, water levels of water wells identified during field-verified water well survey	completed - Appendix D
c)	names of drilling contractors	completed - page B-4
d)	lithology	completed - page B-4
e)	drawdown and recovery data and interpretation	completed - Appendix C - text contains interpretation
f)	field-verified survey data	completed - Appendix D
g)	cross section	completed - page 16
h)	calculated cones of depression after 1, 5, and 20 years	completed as graph and table - page 21
i)	table of expected drawdown after 1, 5, and 20 years	completed - page 21
j)	copies of analyses performed on water samples	completed - Appendix B
k)	all other information related to pumping test	completed - Appendix C - text contains interpretation
12.	Alberta government disclaimer	noted
13.	Reclaim any wells not going to be used	not applicable
14.	Retain a copy of approval at site of activity	
15.	Complaint investigation	noted

Executive Summary

This technical report has been prepared for ISL Engineering and Land Services Ltd. (ISL) on behalf of Lance Skinner, the owner of a proposed residential development in NE 17-039-01 W5M, within Lacombe County. The development would require a water supply of up to 43,800 cubic metres per year (m³/year), which is 120 m³/day. The intent is to develop the water supply from a water supply well, licensed for municipal use.

This technical report includes the following:

- review of the local hydrogeology
- results of a water test hole drilling program
- results of chemical analyses of groundwater from the water test hole to be licensed
- data from a field survey
- results of aquifer tests and interpretation
- results of a Phase 1 screen for GWUDI[1]
- predicted impact due to groundwater diversion.

Water Test Hole No. 1-09 is completed in an unconfined sandstone aquifer of the Dalehurst Member of the Paskapoo Formation, in the depth interval between 54.1 and 67.1 metres BGL. The aquifer test data indicate that the entire groundwater supply for the proposed development of at least 120 m³/day is available from the water test hole without adversely affecting any existing groundwater user or the aquifer in which the water test hole is completed. All of the calculations used for the present analysis do not include recharge, but do include the effects of pumping from 26 other water wells in the study area. Therefore, the impact of the diversion can be expected to be less than that calculated.

The chemical analysis of the groundwater from the aquifer in which the water test hole is completed shows that turbidity and the concentration of TDS are above the recommended limits for drinking water. The chemical quality of the groundwater from the water test hole is not expected to change significantly with time.

It is recommended that AENV approve the enclosed application and that groundwater-monitoring requirements should include at least daily water-level and groundwater-production measurements from the water supply well, once the water supply well is put in service.

From the hydrogeological review, it is believed that the groundwater from WTH No. 1-09 is a high-quality groundwater. However, it is recommended that at least one additional sample be collected for MPA in order to gain more confidence that the groundwater is high-quality groundwater rather than GWUDI.

[1] GWUDI is the acronym for *Groundwater Under the Direct Influence of Surface Water*.

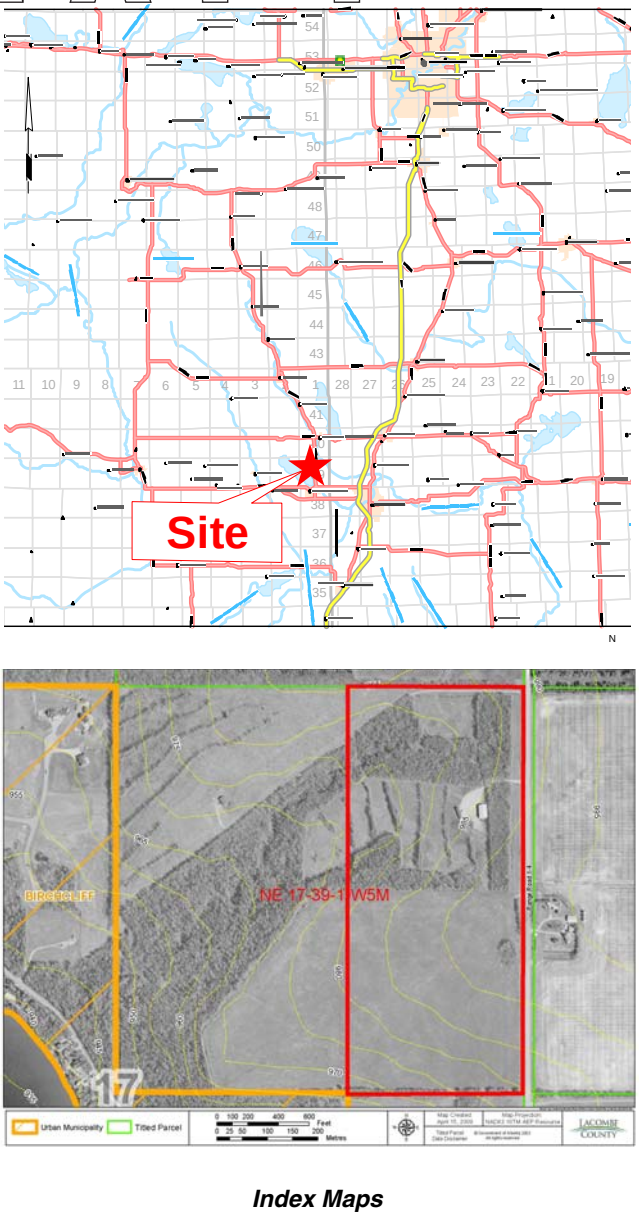
1. Introduction

1.1. Purpose

This technical report has been prepared for ISL Engineering and Land Services Ltd. (ISL) on behalf of Lance Skinner, the owner of a proposed residential development in NE 17-039-01 W5M, within Lacombe County. The development would require a water supply of up to 43,800 cubic metres per year (m³/year), which is 120 m³/day.[1] The intent is to develop the water supply from a water supply well, licensed for municipal use.

The intended groundwater supply is to be from Water Test Hole (WTH) No. 1-09, completed in NE 17 in the depth interval from 54.1 to 67.1 metres below ground level (BGL).

This report was prepared in support of an application by Lance Skinner to Alberta Environment (AENV) to license a total of 43,800 m³/year from WTH No. 1-09 for the required groundwater supply.



Index Maps

1.2. Scope

Hydrogeological Consultants Ltd. (HCL) have been retained to complete a technical report in support of the groundwater application. The technical report includes the following:

- review of the local hydrogeology
- results of a water test hole drilling program
- results of chemical analyses of groundwater from the water test hole to be licensed
- data from a field survey
- results of aquifer tests and interpretation
- results of a Phase 1 screen and Phase 3 microparticulate analysis (MPA) for GWUDI[2]
- predicted impact due to groundwater diversion.

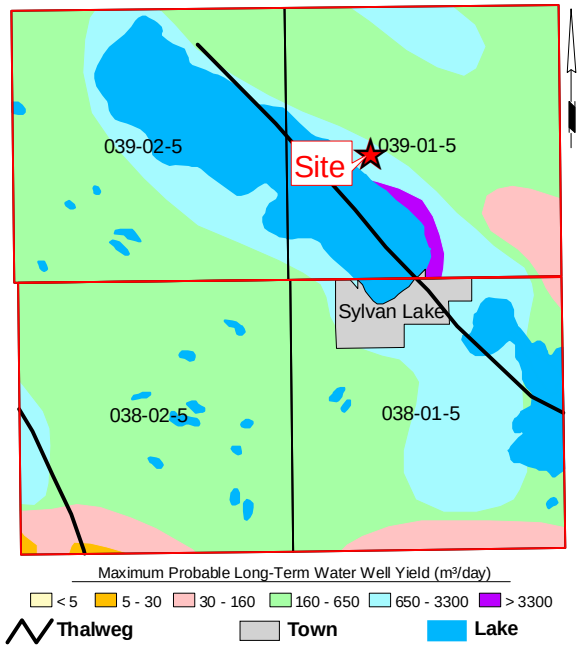
[1] Based on: 49 lots x 3.5 people/lot x 350 litres/person/day = 60 m³/day x a peak factor of 2 = 120 m³/day.
[2] GWUDI is the acronym for *Groundwater Under the Direct Influence of Surface Water*.

The study area for the present investigation is the nine-section area centred on 17-039-01 W5M. The area of interest (AOI) is the area within a 1,000-metre radius of WTH No. 1-09. The present groundwater investigation is submitted under criteria outlined in AENV's Groundwater Evaluation Guideline, available on AENV's website.[3] Schedule 1 of the Guideline and a signed copy of the Application are included in Appendix A.

2. Background

2.1. General Hydrogeology

The upper bedrock in the AOI is the Paskapoo Formation, composed primarily of non-marine sandstone and shale deposits. Tokarsky (1971) identifies the thin tuff and shale beds of the volcanic Kneehills Member as defining the base of the Paskapoo Formation. The geological map accompanying the hydrogeological map for the area (Tokarsky, 1971) indicates that the Kneehills Member at the NE 17 location is at an elevation of approximately 520 metres above mean sea level (AMSL); with a ground surface elevation of approximately 970 metres AMSL, the total thickness of the Paskapoo Formation at the NE 17 site is therefore approximately 450 metres. The non-marine Scollard Formation underlies the Kneehills Member, and is composed of shale, with minor amounts of bentonitic sandstone and coal layers.



***Hydrogeological Map** (after Tokarsky, 1971)*

The hydrogeological map for the area (Tokarsky, 1971) indicates that water wells completed in aquifers within 100 metres of surface in the study area are expected to have long-term yields ranging from 160 to 3,300 m^3/day, as shown in the adjacent map. Tokarsky states that high bedrock water well yields near Sylvan lake may be due to induced infiltration from the lake.

Regional bedrock aquifers are not usually identified in west-central Alberta where the upper bedrock is the Paskapoo Formation. This is because of two factors: the first is the lenticular nature of the sandstone layers; and the second is that the rocks of the Paskapoo Formation become more indurated the closer they are to the mountain front. Therefore, the main permeability in the rocks is not inter-granular permeability but fracture permeability.

Groundwaters from the upper bedrock aquifers are indicated on the regional hydrogeological map as being sodium+potassium-bicarbonate-type waters with total dissolved solids (TDS) of in the order of 500 milligrams per litre (mg/L).

[3] http://www3.gov.ab.ca/env/water/Legislation/Guidelines.html

A groundwater query (gwQuery) was developed by Mow-Tech Ltd. as part of the regional groundwater assessments completed for various counties in Alberta. The results of the groundwater query for NE 17-039-01 W5M provide a summary of expected local hydrogeology. The gwQuery results are based on more than 30 regional maps prepared by HCL, and are provided in the adjacent table. The gwQuery is based on regional data and, therefore, local conditions may vary. The Mow-Tech Ltd. gwQuery is available on the internet: http://www.gwquery.com.

Lacombe County
NE 17-039-01 W5M
MOW-TECH LTD. gwQuery Results

General Results Depth(s)	Top metre	Yield* m³/day	NPWL metre	TDS mg/L	Sulfate mg/L	Chloride mg/L	Fluid Expected
gwQuery Determined Minimum	60	18[2]	41	687	102	2	--
gwQuery Determined Maximum	67	18[2]	41	687	102	2	--

Detailed Results Geologic Unit Encountered	Top metre	Yield* m³/day	NPWL metre	TDS mg/L	Sulfate mg/L	Chloride mg/L	Fluid Expected
Upper Surficial Deposits	--	--	2	555	86	7	--
Bedrock Surface	4						
Dalehurst Member	4	--	13	494	22	10	--
Upper Lacombe Member	28	18[2]	41	687	102	2	--
Lower Lacombe Member	228	4[2]	115	591	--	48	--
Haynes Member	273	1[2]	141	524	35	5	--
Upper Scollard Formation	325	--	137	761	2	60	--
Lower Scollard Formation	420	--	194	946	314	11	--
Upper Horseshoe Canyon Formation	469	--	204	1504	304	99	--
Middle Horseshoe Canyon Formation	570	--	--	--	--	--	Oil

Parameter	metre
Base of Groundwater Protection (Depth)	395
Ground Elevation (AMSL)	971

Legend / Notes
'--' indicates information not available.
Base of Groundwater Protection (BGP; TDS > 4,000 mg/L).
* Yield based on the 'Fluid Encountered' being water.
[2] Results are based on a regional groundwater study by hydrogeological consultants ltd. (HCL)
[3] Results are based on a summary of Drill Stem Test (DST) results.

Contact at least three local licensed water well drillers to get estimates of drilling and water well completion costs in your area. Consult the 'Water wells that Last for Generations' booklet for advice on hiring a water well driller, and for a check list of items that you and the driller should discuss and agree to before starting the work.

The information calculated with the MOW-TECH LTD. gwQuery is meant only as a guide. Actual drilling conditions may vary. MOW-TECH LTD. is not liable for drilling or groundwater problems as a result of using this data.

gwQuery

The adjacent table shows that there is an expected four metres of surficial deposits overlying bedrock; the uppermost bedrock unit is expected to be the partly-eroded Dalehurst Member of the Paskapoo Formation, which is underlain by the Upper Lacombe Member, which extends from a depth of 28 metres BGL to 228 metres BGL.

The gwQuery shows that aquifers within the surficial deposits in NE 17 would not be expected. Groundwater yields from water wells completed in aquifers within the upper bedrock are expected to be less than 20 m³/day. TDS concentrations in groundwaters from upper bedrock aquifers are expected to be in the order of 500 to 700 mg/L.

2.2.

GWUDI

The basis for classification of the water wells is to be carried out in accordance with AENV's *Assessment Guideline for Groundwater Under the Direct Influence of Surface Water (GWUDI)*.[4]

Direct surface-water influence is that influence that may cause the risk of pathogenic organisms such as *Giardia* and *Cryptosporidium* to be transferred from a surface source to a groundwater source. Groundwater sources generally have the following characteristics:

- the initial intake is below ground surface or below the bottom of a surface-water source
- there is natural, undisturbed soil/geologic material completely surrounding the initial source intake (Montana Department of Environmental Quality, 1999).

The scope of work includes a comparison of available data with AENV's Phase 1 screening criteria and a Phase 3 MPA to determine whether the groundwater from the water test hole is classified as supplying high-quality groundwater, or groundwater under the direct influence of surface water (GWUDI). The Phase 3 MPA is used to determine if surface-water organisms are present in groundwater. GWUDI is indicated by the significant occurrence of "insects, algae, or other large-diameter pathogens." (USEPA, 1992). For an MPA to be definitive, two to four analyses must be performed over a 12- to 18-month interval, during times when surface water is most likely to influence groundwater, such as in the spring and fall.

2.3. Previous Work

The Bibliography section of this report includes documents that contain information that could be used in evaluating the groundwater resource in the AOI.

[4] Alberta Environment's assessment guideline is included as Appendix E in the January 2006 "Standards and Guidelines in Municipal Waterworks, Wastewater and Storm Drainage Systems", available at http://environment.gov.ab.ca/info/posting.asp?assetid=6979&subcategoryid=96. Appendix E of these Guidelines is included in Appendix A of this report.

3. Present Program

3.1. Maps, Aerial Photographs

The AOI is situated within the 83/B 1:250,000 National Topographic Series (NTS) map sheet, with local detail available from the 1:50,000 83B/08 map sheet. Digital topographic control is from the 1:20,000 digital elevation model (DEM) prepared by AltaLIS Ltd.

Digital ortho-imagery has been obtained from Valtus Imagery Services (Valtus) for the present program. Otho-imagery is created for a digital image of an aerial photograph when displacements caused by the camera and the terrain have been removed. It combines the image characteristics of a photograph with the geometric qualities of a map. The aerial photographs used in the creation of the ortho-images were flown on 05 Jul 07 at a 1.0-metre resolution.

3.2. Groundwater Database

The Groundwater Centre database, an enhanced version of the AENV groundwater database, includes 262 records for the nine-section study area.[5] Of the 262 groundwater records, 250 are classified as water wells. Of the 250 water wells in the study area, 38 are within the AOI (that is, within 1,000 metres of WTH No. 1-09). Water well classification includes the four categories for "Type of Work" as shown in the adjacent table. The "new well" category, although new at the time the information was filed with AENV, may now be many years old. Information relating to the records in the groundwater database has been used in the preparation of cross-sections, as the starting point for the water well survey, and to determine aquifer parameters.

Type of Work	No. of Records
New Well	209
Chemistry	34
Federal Well Survey	4
Water Test Hole	3
Piezometer	3
Structure Test Hole	3
Water Test Hole - Abandoned	3
Dry Hole - Abandoned	1
New Well - Abandoned	1
Old Well - Abandoned	1
Total Water Well Records	***250***
Total Groundwater-Related Records	***12***
Total:	***262***

Groundwater Database Records

3.3.

[5] The table includes updates to the database made by [illegible] program.

Meteorological Data

Atmospheric pressure data used as part of the aquifer test interpretation were compiled from the Red Deer meteorological station.[6]

3.4. Site Selection

The water test hole drilling location was selected by the client, with guidance provided by HCL to ensure that the location selected is not within set-back distances for municipal water supply wells outlined in Section 46 of AENV's Water (Ministerial) Regulation.[7]

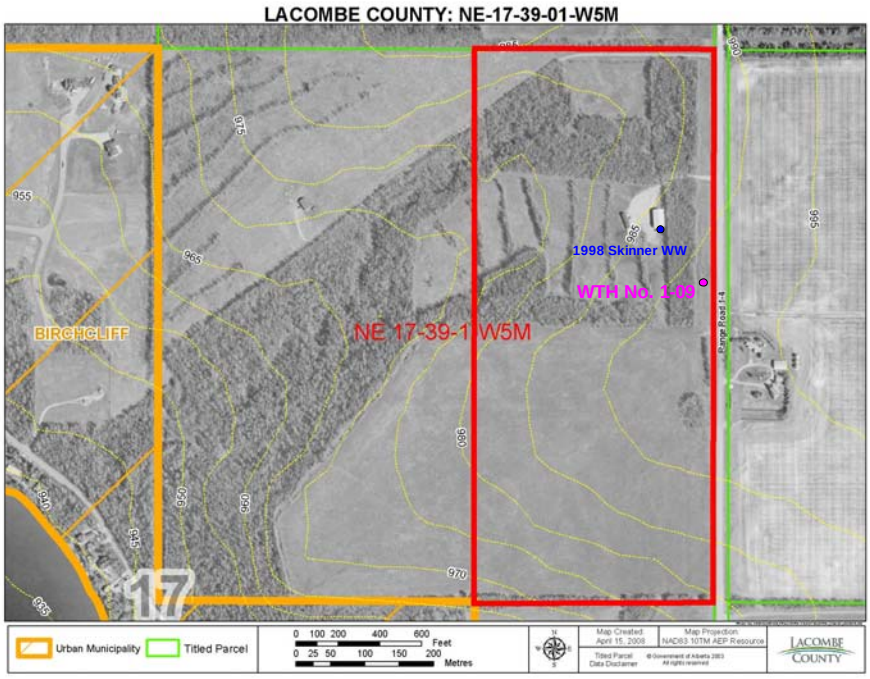
3.5. Field Work

3.5.1. Drilling and Preliminary Aquifer Testing

Water Test Hole No. 1-09 was drilled and completed by Alken Basin Drilling Ltd. on 06 Mar 09 in 16-17-039-01 W5M, as shown on the adjacent site map. The site map also shows the location of the 1998 Skinner Water Well (WW), located 99 metres northwest of WTH No. 1-09, which was used as an observation water well during the extended aquifer test.

A preliminary aquifer test (AT I) was conducted on 06 Mar 09 by Mow-Tech Ltd., which consisted of 120 minutes of pumping at 113.7 litres per minute (lpm) followed by 120 minutes of recovery.

Water test hole details and preliminary aquifer test results are included in Appendix B, and in the Results section of this report.



Site Map

3.5.2.

[6] Accessed from the website: http://www.wunderground.com/

[7] Sections 44 to 58 are in Appendix A, and at: http://www.qp.alberta.ca/documents/Regs/2003_205.pdf?type=Regs&isbncln=9780779738946

Extended Aquifer Test

Aquifer Test II (AT II) with WTH No. 1-09 was an extended aquifer test conducted by Mow-Tech Ltd. and started on 17 Mar 09, which consisted of 2,890 minutes of pumping at 105.2 lpm followed by 5,460 minutes of recovery. The 1998 Skinner WW was monitored as an observation water well during AT II with WTH No. 1-09.

Water levels during the extended aquifer test were measured with downhole pressure transducers connected to data loggers, which were programmed to record a water level every ten minutes. A turbine and flow analyzer were used to measure groundwater production. Instantaneous flow measurements were recorded every ten minutes with the data logger. Data from the extended aquifer test are in Appendix C.

3.5.3. Groundwater Sampling

Groundwater samples were collected from WTH No. 1-09 on 17 Mar 09 and submitted to Bodycote Testing Group for a municipal suite of chemical analyses that includes routine parameters, and all other parameters for which Health Canada has a maximum acceptable concentration.

The samples collected for a microscopic particulate analysis (MPA) were submitted to Hyperion Research Ltd. (Hyperion) as part of AENV's Phase 3 GWUDI determination. The sampling procedure is described on Hyperion's website,[8] and summarized below:

- Install filter cartridge
- Connect water sampler to water source and install pressure-reducing valve and by-pass loop
- Run at least two m^3 of water through filter at low rate and low pressure
- At the end of sample collection, remove filter cartridge and ship on ice to Hyperion.

The analyses results are included in Appendix B.

3.5.4. Field-Verified Water Well Survey

HCL personnel conducted a field survey within a 1,000-metre radius of WTH No. 1-09 (the AOI) on 17 Mar 09, 23 Mar 09 and 26 Mar 09. Water well records available in the enhanced groundwater database for the AOI were used as a starting point for the field survey. Coordinates for features located in the field were determined with a consumer-grade hand-held GPS unit. When the owner allowed, water levels were measured in water wells. If the residents at a visited location were not home, a letter was left explaining the purpose of the water well survey, and an opportunity was given to the residents to include details from their water well(s) for the survey; a copy of the letter is in Appendix A.

A map and tables of the results of the survey are included in the Results section of this report and in Appendix D.

3.6.

[8] http://www.hyperionlab.ca/

Data Processing

All field observations have been georeferenced using 10-degree Transverse Mercator (10TM) coordinates based on NAD83. Coordinates were determined for features identified in the field using a consumer-grade, hand-held GPS unit.

Transmissivity values from the aquifer test data from the pumped water test hole have been calculated using the following approximation of the Theis non-equilibrium equation:

$$T = \frac{2.3 \cdot Q}{4 \cdot \pi \cdot \Delta s}$$

Where:

T = Transmissivity
Q = Discharge
Δs = Drawdown per log cycle

Transmissivity from specific capacity is calculated based on the following equation:

$$\frac{Q}{s} = \frac{4 \cdot \pi \cdot T}{2.3 \cdot \log_{10}\left(\frac{2.25 \cdot T \cdot t}{S \cdot r^2}\right)}$$

Where:

S = Storativity and is assumed to be 0.0001
t = time since discharge started
r = effective radius of the water well

Drawdowns at various times and distances from the groundwater discharge point are calculated from the following equation:

$$s = \frac{Q \cdot W(u)}{4 \cdot \pi \cdot T}$$

Where:

W(u) is the well function of u

And

$$u = \frac{r^2 \cdot S}{4 \cdot T \cdot t}$$

When multiple groundwater discharge points are involved, the principle of superposition is used. The multiple discharge points can be at various locations or at one location.

Drawdowns at various times and distances are calculated based on approximations of W(u). For values of u greater than 0 and less than one, the following approximation is used:

$$W(u) = - \ln u + (-0.57721556) + (0.99999193)*u + (-0.24991055)*u^2 + (0.05519968)*u^3 + (-0.000976004)*u^4 + (0.00107857)*u^5$$

Where:

ln = natural logarithm

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For values of 1 < u < infinity, the following approximation is used:

W(u) = (1/(u*e^u))*(((0.250621)+(2.334733*u)+u^2))/((1.681534)+(3.330657*u)+u^2))

Theoretical long-term yield is calculated from the Moell Method[9], using the following equation:

$$Q_{20} = \frac{Q(H_A)}{s_{100} + 5\Delta s} \times 0.7$$

Where

H_A	= available drawdown
S_{100}	= the drawdown after 100 minutes of pumping
Q	= pumping rate during the aquifer tests
Q20	= sustainable yield for 20 years
Δs	= drawdown per log cycle
0.7	= safety factor

All gridding uses the Kriging method with a linear variogram model as provided in Golden software Surfer V8.

[9] Groundwater Evaluation Guideline, 05 December 2002. Alberta Environment

4. Results

4.1. Field Work

4.1.1. Drilling and Preliminary Aquifer Testing

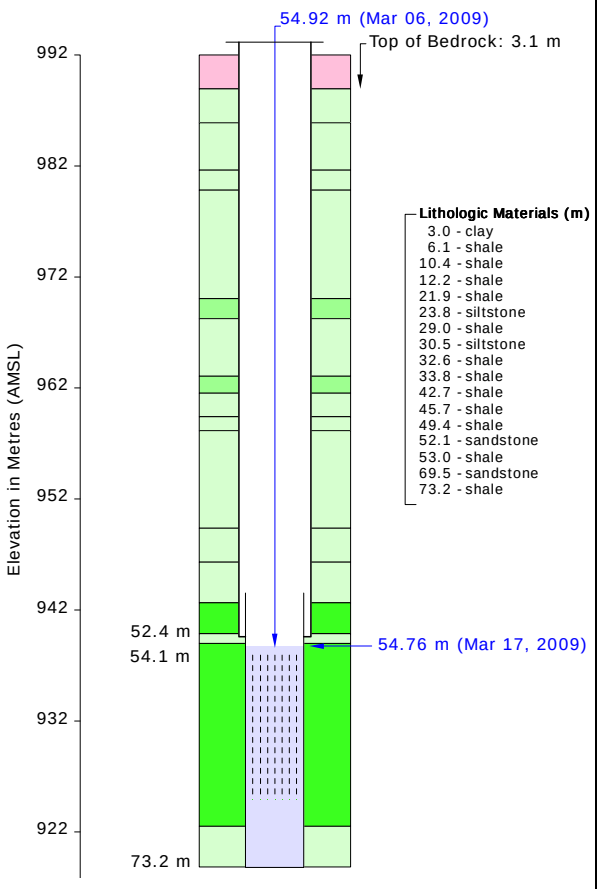
Water Test Hole No. 1-09 was drilled and completed by Alken Basin Drilling Ltd. on 06 Mar 09 to a total depth of 73.2 metres BGL. Lithologic units encountered during drilling included 3.0 metres of clay overlying interbedded sandstone, siltstone and shale units.

The water test hole was completed with 141-millimetre (mm) outside diameter (OD) steel surface casing set to a depth of 52.4 metres BGL. A 114-mm OD plastic (PVC) liner was installed inside the surface casing, and slotted in the depth interval between 54.1 and 67.1 metres BGL, adjacent to a sandstone aquifer, as shown in the adjacent well diagram. The aquifer is considered to be the sandstone unit in the depth interval between 53.0 and 69.5 metres BGL.

The non-pumping water level (NPWL) measured on 06 Mar 09 was 54.92 metres below top of casing (BTOC); the casing stick-up is 1.5 metres above ground level. Because the NPWL is below the top of the sandstone aquifer, the aquifer is considered to be an unconfined aquifer.

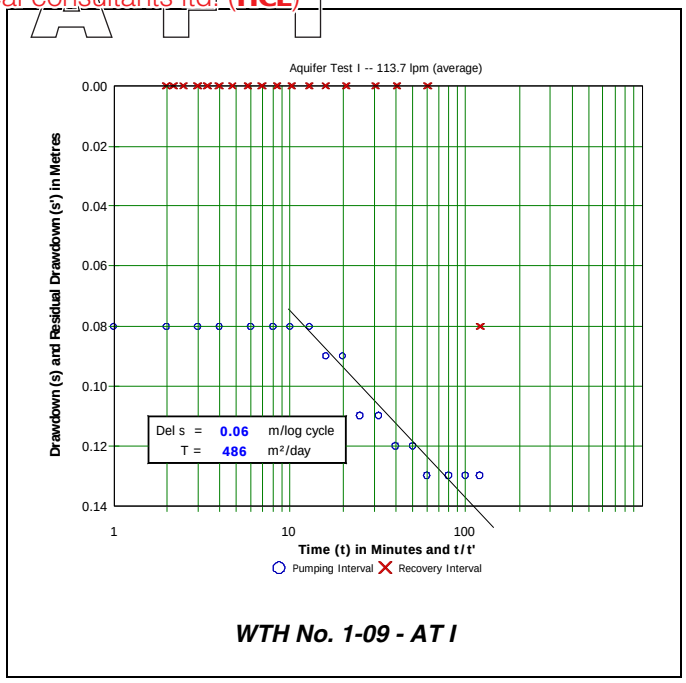
Completion information for WTH No. 1-09 is included in Appendix B.

WTH No. 1-09



WTH No. 1-09 - Well Diagram

Aquifer Test I (AT I) was conducted on 06 Mar 09 by Mow-Tech Ltd., which consisted of 120 minutes of pumping at 113.7 lpm followed by 120 minutes of recovery. The adjacent graph shows that there was a drawdown of 0.08 metres within the first minute of pumping, after which there was no water-level change for 11 minutes. The measured drawdown from 12 minutes to 120 minutes of pumping indicates an aquifer transmissivity of 486 metres squared per day (m²/day). The water level recovered to the pre-test water level by the second minute of recovery.

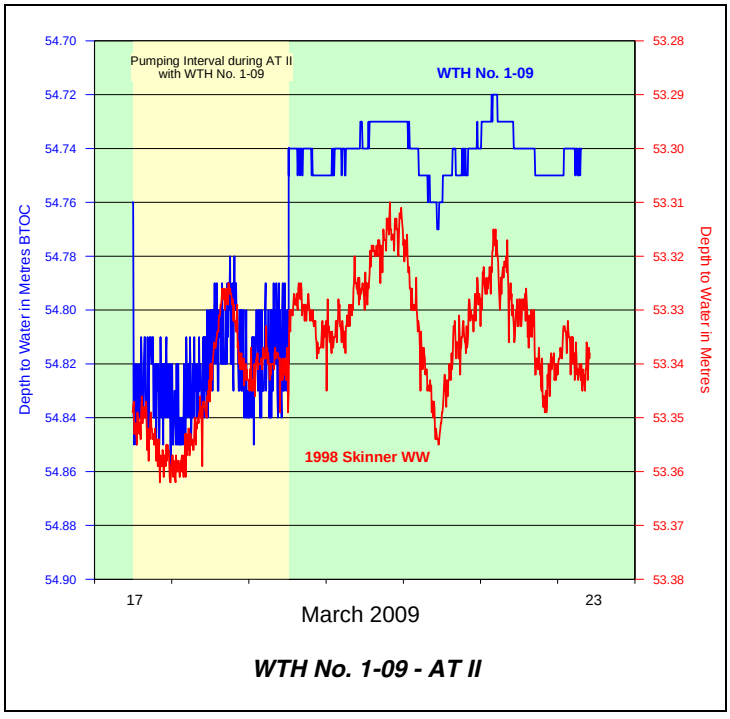


WTH No. 1-09 - AT I

4.1.2. Extended Aquifer Test

Aquifer Test II (AT II) with WTH No. 1-09 was an extended pumping-and-recovery-type aquifer test that was started on 17 Mar 09, and consisted of 2,890 minutes of pumping at 105.2 lpm followed by 5,460 minutes of recovery. The 1998 Skinner WW was used as an observation water well during AT II with WTH No. 1-09. The graph below shows the measured water levels in WTH No. 1-09 and the 1998 Skinner WW. Some significant features shown by the graph include:

- the water level in WTH No. 1-09 drew down from an NPWL of 54.76 to 54.84 metres during the first ten minutes of pumping
- the water level in WTH No. 1-09 showed an overall rise in water level during the pumping interval



WTH No. 1-09 - AT II

- the water level in WTH No. 1-09 recovered to a water level 0.02 metres above the pre-test level within the first ten minutes of recovery; full recovery was achieved within these first ten minutes, although the water level fluctuated by ± 0.02 metres for the remainder of the recovery interval
- the water level in the 1998 Skinner WW showed the same characteristics of water-level fluctuation as in WTH No. 1-09, although the depth to water was generally about 1.5 metres higher than in WTH No. 1-09.

AT II results for WTH No. 1-09 are in Appendix C.

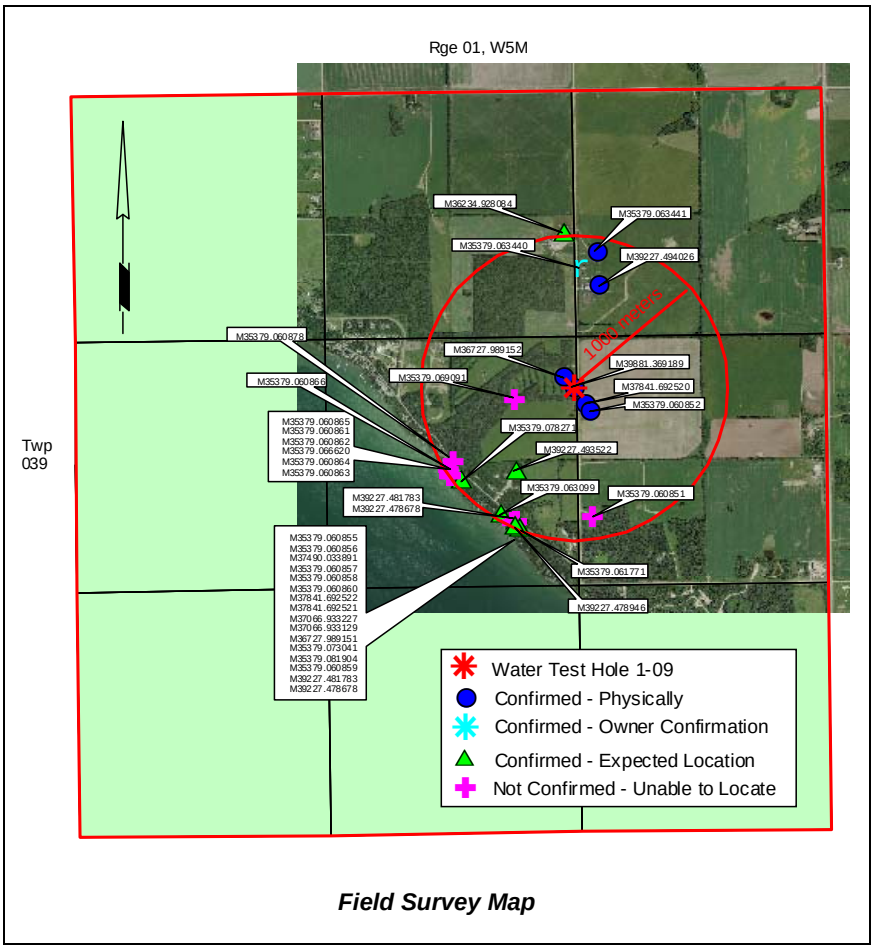
4.1.3.

Water Well Survey

HCL personnel conducted a water well survey within the AOI on 17, 23 and 26 Mar 09. The purpose of the field-verified water well survey was to locate as many of the 38 water wells in the database for the AOI as practical, and to update records accordingly. A field survey includes seven criteria for identification of a feature:

1. Physically confirmed - this means the feature was observed, and horizontal coordinates were obtained after receiving authorization to do so by the owner/user.
2. The feature is confirmed by the owner/user, and horizontal coordinates were obtained based on information provided.
3. The feature could be expected based on information that is not provided by the owner/user.
4. No evidence of the feature could be observed in the field.
5. The location of the feature is confirmed, but not located in the field.
6. The location of the feature is confirmed, and there is a chemical analysis associated with the feature.
7. The location of the feature is confirmed, and there is a measured water level associated with the feature.

The map below shows the spatial distribution of 39 water wells within the AOI. Of these 39[10] water wells:



Field Survey Map

- one is WTH No. 1-09 (identified with ✹)
- five additional water wells were physically confirmed in the field (identified with ●)
- one water well was confirmed based on information provided by the owner (identified with ✳)
- seven water wells were not located, but their location was moved from the centre of the legal location to the most likely site in the land location (identified with ▲)
- 25 water wells were not located in the field and no evidence of the feature could be observed in the field (identified with ✚)

A larger version of the field survey map is in Appendix D. Water well details for the water wells within the AOI are also included in Appendix D.

[10] There are actually 38 water wells in the AOI; however, because Water Well No. M36234.928084 (located in SE 20 just over 1,000 metres from WTH No. 1-09) is owned by a concerned resident, it was included in the field survey.

4.2.

Groundwater Database

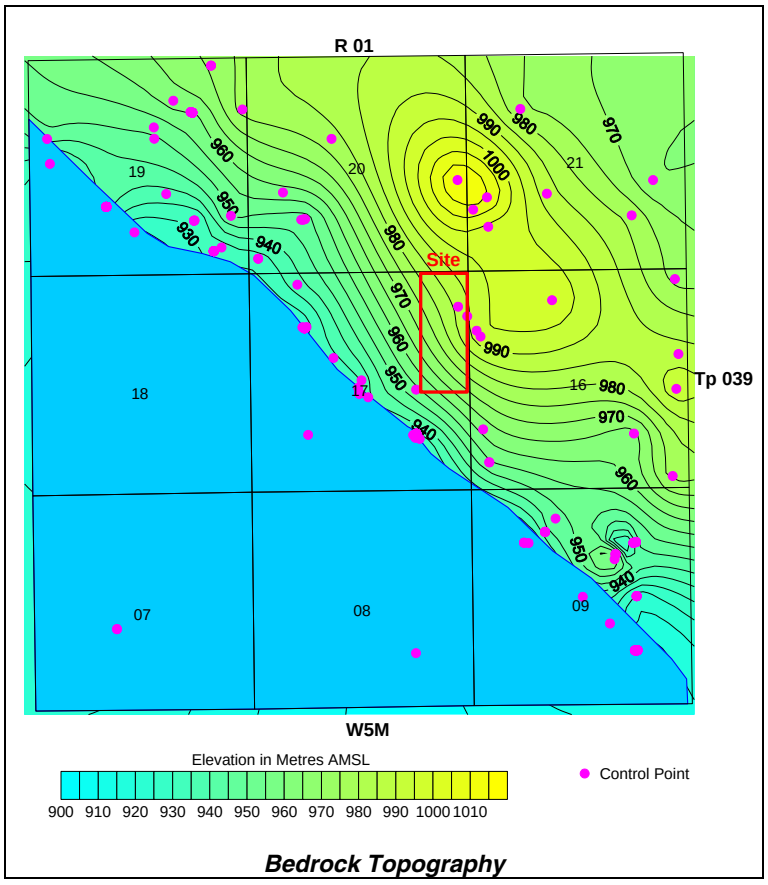
The AENV licensing database indicates that there are eight authorized groundwater diversions in the study area, comprising four licensed diversions and four groundwater registrations. The total allocated volume of these eight authorizations is 623,191 m³/year, which is 1,707 m³/day, as shown in the adjacent table.

Groundwater Authorizations

Applicant	AENV File No.	Legal Location (039-01, W5M)	Approximate Distance from WTH No. 1-09 (m)	Water Well Identifier	Authorized Diversion (m³/year)	Specific Purpose	Authorization Date
Gillian Skinner	203562	NE 17	400	M36727.989152	345	Registration	12-Dec-03
EBOR Enterprises Ltd.	180433	SW 21	700	M39227.494026	6,250	Registration	07-Jan-04
Frank Wilson	170554	SE 20	1,000	M36234.928084	442	Registration	28-May-02
Sunnyside Pentecostal Camp	81195	NW 17	1,200	M35379.060869	12,412	Schools	19-Apr-07
Sunnyside Pentecostal Camp	81195	NW 17	1,200	M36234.928477	0	Schools	19-Apr-07
Frank Wilson	170554	SW 20	1,500		745	Registration	28-May-02
Town of Sylvan Lake	19727	NE 09	2,200		215,860	Urban	04-Jun-96
Town of Sylvan Lake	19727	NE 09	2,200		387,137	Urban	21-Mar-06
				Total:	623,191		

Authorized Groundwater Diversions in Study Area

Information from the water well survey was used to update the groundwater database. Of the 262 records in the groundwater database for the study area, 214 records included a determination of the top of bedrock, which was used to create the bedrock topography map to the left. The map shows the presence of a northwest-southeasterly-trending linear bedrock high in the northeastern part of the study area, approximately parallel to the shoreline of Sylvan Lake. The bedrock underlying the development site is at an elevation of 955 to 990 metres AMSL, and slopes to the southwest at a gradient of about 0.04.



Bedrock Topography

Within the study area, there are aquifer test summary data for 100 records that allow for a calculation of apparent transmissivity. The 100 apparent transmissivity records range from 1.7 to 1,164 m²/day, with an average of 38.8 m²/day and a median of 13 m²/day. Ninety-eight percent of the values are less than 200 m²/day, and only one value exceeds 225 m²/day. Ninety-four of the 100 apparent transmissivity records have water well completion information that allows for a calculation of apparent long-term yield. The 94 apparent long-term yields range from 4.8 to 6,048 m³/day, with an average of 219 m³/day, and a median of 58 m³/day; 93% of the records are less than 500 m³/day, and 3% exceed 1,000 m³/day.

Groundwater Quality

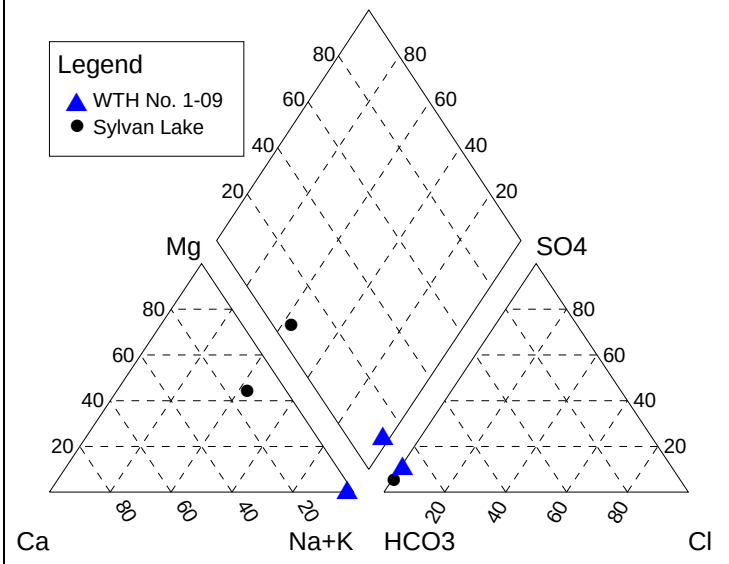
Groundwater samples were collected from WTH No. 1-09 on 17 Mar 09 and submitted to Bodycote Testing Group for a municipal suite and routine chemical analyses. In the adjacent table, the routine chemical analysis results are compared to the Summary of Guidelines for Canadian Drinking Water Quality (Federal-Provincial-Territorial Committee on Drinking Water of the Federal-Provincial-Territorial Committee on Health and the Environment. 2008). The table shows that turbidity and the concentration of TDS in the groundwater exceed the recommended SGCDWQ limits for potable water; the concentrations exceeding the limits have been highlighted in the table in red. The TDS concentration exceeded the recommended aesthetic limits, and the turbidity exceeded the maximum acceptable concentration (MAC).[11] Copies of the complete chemical analyses are in Appendix B. The additional analyses results show that concentrations of all parameters in the municipal suite of analyses are either below detection limits, or below drinking water guidelines.

Comparison Between Recommended Limits For Concentrations of Chemical Constituents in Potable Water and in Groundwater from WTH No. 1-09

Constituent	WTH No. 1-09 17 Mar 09 mg/L	SGCDWQ Recommended Maximum Concentration AO	SGCDWQ Recommended Maximum Concentration MAC
pH	8.2	6.5-8.5	---
Conductivity (µS/cm)	797	---	---
Total Dissolved Solids	512	500	---
Sodium	197	200	---
Potassium	1.1	---	---
Calcium	{2.9}	---	---
Magnesium	{1}	---	---
Total Hardness	12	---	---
Carbonate	19	---	---
Bicarbonate	489	---	---
Total Alkalinity	432	---	---
Sulfate	{49.2}	500	---
Hydroxide	< 5		
Chloride	1.6	250	---
Fluoride	1.15	---	1.5
Iron	0.01	0.3	
Manganese	< 0.005	0.05	
Nitrate + Nitrite (as N)	0.08	---	10
Colour (colour units)	< 5	15	
Turbidity (NTU)	1.2	5	1
Ionic Balance (%)	91	---	---

Concentrations are in milligrams per litre unless otherwise stated.
AO - Aesthetic Objective
MAC - Maximum Acceptable Concentration
SGCDWQ - Summary of Guidelines for Canadian Drinking Water Quality, Federal–Provincial–Territorial Committee on Drinking Water, 2008

Groundwater Quality Results



Piper Tri-Linear Diagram

A Piper tri-linear diagram of the analysis for the groundwater sample collected from WTH No. 1-09 is shown in the adjacent figure.[12] The diagram also includes the chemical quality of water from Sylvan Lake.[13] The diagram shows that, chemically, the groundwater from WTH No. 1-09 is classified as a sodium+potassium-bicarbonate-type water, and the water from Sylvan Lake has a significantly different chemical quality.

One filtered sample from WTH No. 1-09 was collected on 18 Mar 09 and submitted to Hyperion Research Ltd. for MPA as part of the present program. The sample did not contain any Giardia or Cryptosporidium cysts or any primary or secondary indicators. A copy of the MPA is in Appendix B.

[11] The MAC guideline for turbidity refers to treated water.
[12] There were no chemical analyses results in the database for any other water wells in the nine section study area.
[13] Average concentrations reported by Mitchell and Lapalme

4.3.1.

GWUDI

The purpose of AENV's Phase 1 screening criteria is to "rapidly identify non-GWUDI sources that do not require a detailed assessment" (Appendix A). Should the water source not meet any of the screening criteria, the source should be flagged as potentially GWUDI, and the assessment can either proceed to Phase 2a, or the source can be declared GWUDI.

The wellhead protection component of a site inspection by HCL personnel was made to determine whether the proposed water supply well satisfies the Water (Ministerial) Regulations 44 to 58, which have to do with water well construction and site specifications (Appendix A). Water Test Hole No. 1-09 is constructed with a cap and casing stick-up that exceeds the 0.2-metre requirement.[14] The water test hole is also not located within the setback distances of any items listed in Table 1 of Regulation 46.

A comparison of WTH No. 1-09 with AENV's GWUDI Phase 1 screening criteria is discussed below.

1. *Sensitivity Setting* **Fail**
   WTH No. 1-09 is completed in an unconfined bedrock aquifer with a top of completion at 54.1 metres BGL. Although the water test hole has a top of completion that is below 15 metres BGL, the aquifer is considered to be unconfined, and therefore fails the GWUDI sensitivity setting.

2. *Proximity to Surface Water* **Pass**
   Water Test Hole No. 1-09 is more than 100 metres from the nearest permanent, intermittent or seasonal surface-water body. The elevation of the completion interval of WTH No. 1-09 is approximately equivalent to the elevation interval spanning the Sylvan Lake water level and the Lake bottom.

3. *Water Well Construction* **Pass**
   Water Test Hole No. 1-09 was drilled and completed by a licensed water well driller. The water test hole is constructed with steel casing set to a depth of 52.4 metres BGL, and sealed with bentonite in the borehole annulus. The result is an effective seal against vertical migration of water and/or contaminants. The water test hole has a casing stick-up that is 1.5 metres above ground level, which exceeds the 0.2-metre guideline, and is equipped with a well cap.

4. *Water Quality* **Pass**
   The groundwater quality from WTH No. 1-09 does not show any evidence of surface-water contamination, although the concentration of nitrate of 0.08 mg/L does raise a small level of concern.

The groundwater source for WTH No. 1-09 fails one of the four AENV Phase 1 screening criteria because the water test hole is completed in an unconfined aquifer. However, although the bedrock aquifer is considered to be unconfined, the guideline is meant to assess shallow water-table type aquifers that may be under the direct influence of surface water. For this reason, the "failure" of the sensitivity setting criterion is not considered to be of great consequence.

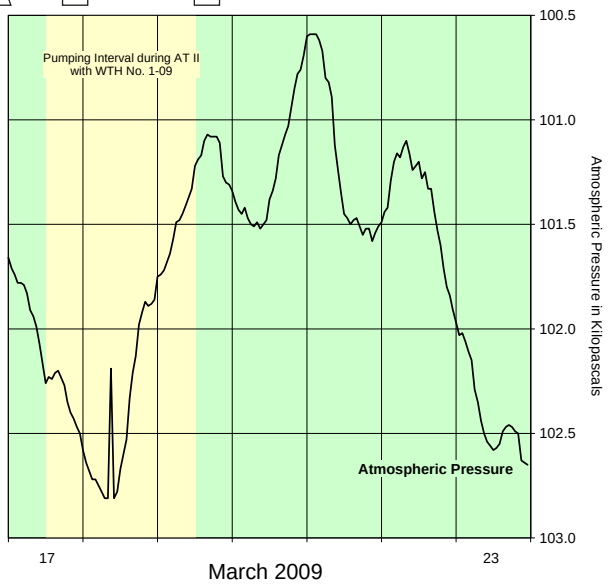
Hyperion's review of the Phase 3 MPA results of the sample from WTH No. 1-09 concluded that the risk of surface-water contamination is judged to be low, and the risk factor is zero.

[14] The regulation requires a casing stick-up of at least 0.2 metres above the established ground surface, and at least 0.6 metres above the highest flood record in the area if the water well is not equipped with a [illegible]

4.4.

Barometric Pressure

The adjacent graph shows the hourly-recorded barometric pressure at the Red Deer meteorological station from 17 to 23 Mar 09. The graph shows that the pressure during this time interval fluctuated from a low of 100.59 to a high of 102.81 kilopascals (kpa).

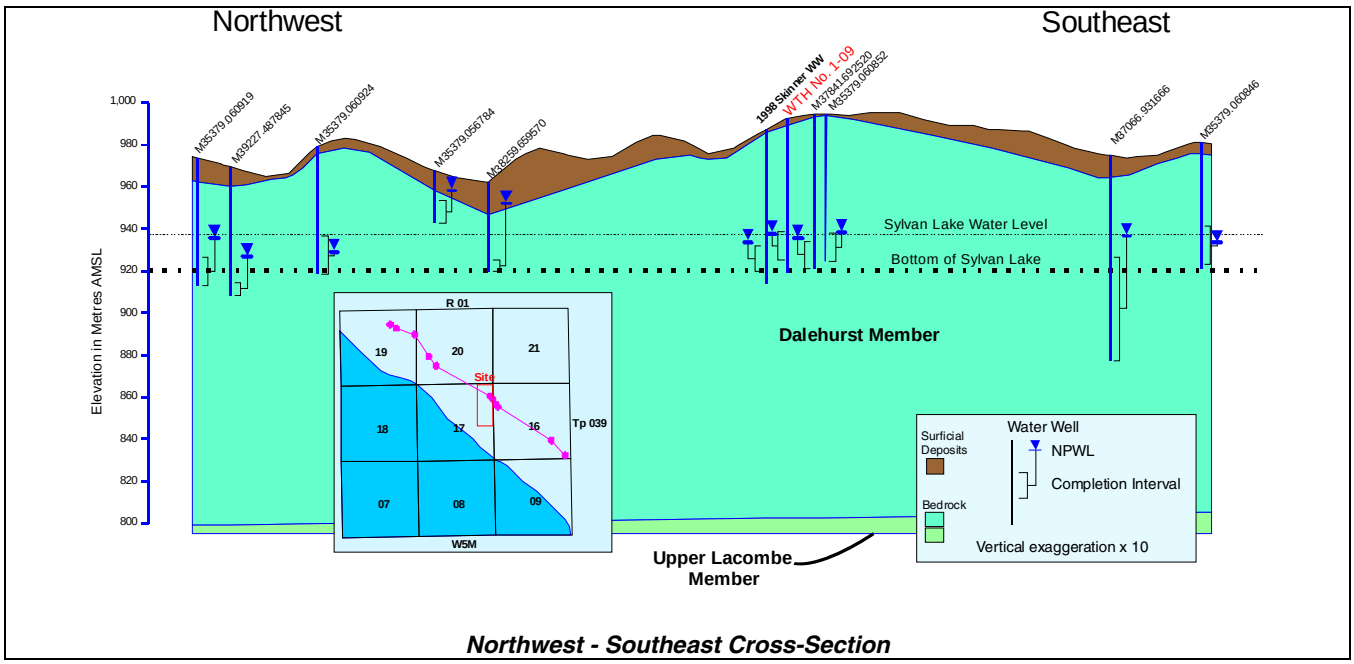


Barometric Pressure Recorded at Red Deer Meteorological Station

5. Interpretation

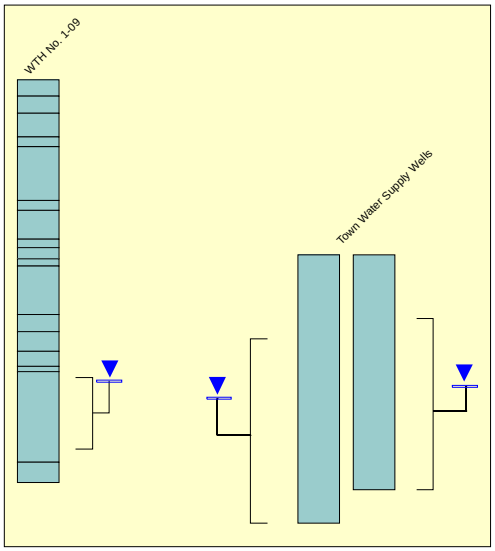
5.1. Geometry of Aquifers

The northwest-southeast cross-section below shows the relationship between WTH No. 1-09 and ten other water wells in the study area. The cross-section includes the relative positions of the two upper members of the Paskapoo Formation, based on regional stratigraphic picks. The cross-section shows that WTH No. 1-09 is completed in the elevation interval between approximately 925 and 938 metres AMSL, which is in the Dalehurst Member of the Paskapoo Formation. The elevation of the NPWL of WTH No. 1-09 is approximately 935 metres AMSL, which is similar to the water level in Sylvan Lake.[15]



Northwest - Southeast Cross-Section

The schematic diagram to the right shows the vertical relationship between WTH No. 1-09 and the Town of Sylvan Lake's WSW Nos. 10 and 11, which are located approximately two kilometres southeast of the water test hole, in NE 09. Discussion with the Town's operator indicates that both WSW Nos. 10 and 11 are considered to be providing high-quality groundwater that is not GWUDI. Because WTH No. 1-09 is completed in an aquifer with similar elevations of completion interval and NPWL as the Town's water supply wells, the three water wells may be completed in the same aquifer, which suggests that the aquifer in which WTH No. 1-09 is completed is not GWUDI.



Schematic Cross-Section

[15] The water-level graph in the Atlas of Alberta Lakes (Mitchell and Prepas, 1990) shows that the water level from 1955 to 1987 in Sylvan Lake has fluctuated between 936.0 and 937.2 metres AMSL.

Additional significant information shown on the cross-section includes:

- the completion interval of WTH No. 1-09 and eight other water wells is within the elevation interval spanning the Sylvan Lake water level and the Lake bottom
- the elevation of the NPWL of WTH No. 1-09 and eight other water wells is similar to the elevation of Sylvan Lake's water level
- the elevations of the completion interval and the NPWL of WTH No. 1-09 are similar to those for the 1998 Skinner WW
- the NPWL of WTH No. 1-09 is at about the same elevation as the top of its completion interval.

The 1998 Skinner WW and WTH No. 1-09 are considered to be completed in the same aquifer because:

- of the similarities in the elevation of their completion intervals
- of the similarities in the elevation of their NPWLs
- they are completed in close proximity to each other
- the water level in the 1998 Skinner WW drew down due to pumping from WTH No. 1-09.

The table below summarizes completion elevations and elevations of NPWLs for the 38 water wells that are within the AOI; water wells highlighted in red may be completed in the same aquifer as the aquifer in which WTH No. 1-09 is completed.

Water Well GCID	Water Well Name	Legal Location (042-04 W5M)	Field Action	Proposed Use	Owner	Elevation (m AMSL)				Distance from WTH No. 1-09 (m)	Authorized Allocation (m³/day)	Protected Allocation (m³/day)
						Top of Completion	Bottom of Completion	Drilled Depth	NPWL			
M39881.369189	Water Test Hole No. 1-09	16-17	1	Municipal	Lance Skinner	938	925	919	937	0		
M36727.989152	1998 Skinner Water Well	16-17	1	Domestic	Skinner, Lance & Gil	932	920	914	934	99	0.9	0.9
M37841.692520	2002 Holm Water Well	NW 16	1	Domestic	Holm, Elmer H.	934	921	921	935	128		3.4
M35379.060852	1976 Holm Water Well	NW 16	1	Domestic & Stock	Holm, Elmer H	938	924	924	938	181		17.1
M35379.069091		NE 17	4	Domestic	Lynn-White, Virginia			939		399		3.4
M39227.493522	2006 Simpson Water Well	SE 17	3	Domestic	Simpson, Andrew & Sharon	933	928	928	936	666		3.4
M39227.494026	2006 Skinner Water Well	04-21	1	Stock	E-Bor Enterprises (Lance)	930	920	919	935	684	17.1	17.1
M35379.063440	1980 Skinner Water Well	SW 21	2	Domestic	Skinner, Lance	961	932	932	942	794		3.4
M35379.060851	Rig Well (Kenting 39)	05-16	4	Industrial	Suncor Energy Inc.	925	883	883	925	850		
M35379.063441	1985 Skinner Water Well	05-21	1	Domestic	Skinner, Lance	938	926	926	935	897		3.4
M35379.060878	1971 Warden Water Well	Sec 17	4	Domestic	Warden, A. S.	920	915	915	939	923		3.4
M35379.063099		SE 17	3	Domestic	Yaworski, Brian			903		950		3.4
M35379.060860	1964 Hancock Water Well	SE 17	4	Domestic	Hancock	930	925	925	935	953		3.4
M35379.060859	1966 Manning Water Well	SE 17	4	Domestic	Manning	929	924	924	937	953		3.4
M35379.060858	1977 Arthur Water Well	SE 17	4	Domestic	Arthur, Collin	913	904	904	936	953		3.4
M35379.060857	1989 Bast Water Well	SE 17	4	Domestic	Bast, Joann	909	903	903	938	953		3.4
M35379.073041	1993 Densmore Water Well	SE 17	4	Domestic	Densmore, Art	930	927	927	936	953		3.4
M35379.081904	1995 Walters Water Well	SE 17	4	Domestic	Walters, Ralphs	931	922	922	941	953		3.4
M36727.989151	1998 Himes Water Well	SE 17	4	Domestic	Hines, Denis & Marie	938	935	935	941	953		3.4
M37066.933129	2000 Furguson Water Well	SE 17	4	Domestic	Ferguson, Cindy	910	904	904	939	953		3.4
M37066.933227	2000 Wilson Water Well	SE 17	4	Domestic	Wilson, Frank & Delta Res	917	915	910	938	953		3.4
M37841.692521	2002 Chris Wilson Water Well	SE 17	4	Domestic	Wilson, Chris	880	874	867	927	953		3.4
M37841.692522	2002 Des Wilson Water Well	SE 17	4	Domestic	Wilson, Des	898	886	867	922	953		3.4
M35379.060855		SE 17	4	Domestic	Mccaffery, Terrence			909		953		3.4
M35379.060856		SE 17	3	Domestic	Park, Lavern			913		953		3.4
M37490.033891		SE 17	4	Domestic	Delta Land Corporation	904	898	892	938	953		3.4
M35379.078271	1994 Brand Water Well	SE 17	3	Stock	Brand, Bruce & Ann	914	906	906	935	955		17.1
M39227.478678	2005 Handel Water Well	SE 17	4	Domestic	Handel, Brad	925	922	921	943	972		3.4
M39227.481783		SE 17	4	Domestic	Beluk, Scott	925	922	921	938	972		3.4
M35379.060866	1964 Finn Water Well	06-17	4	Domestic	Finn, G.N.	928	922	922	937	973		3.4
M35379.061771	1991 Macsween Water Well	SE 17	3	Domestic	Macsween, Ian	908	904	904	937	979		3.4
M39227.478946	2004 Burnand Water Well	SE 17	3	Domestic	Burnand, Bernard & Jean	920	908	908	930	985		3.4
M35379.060863	1973 Charman Water Well	SW 17	4	Domestic	Charman, H.G.	929	925	925	934	990		3.4
M35379.060862	1973 Mathen Water Well	SW 17	4	Domestic	Mathen, L.J.	922	916	916	931	990		3.4
M35379.060861	1974 Marlin Wolfe Water Well	SW 17	4	Domestic	Wolfe, Marlin	926	922	922	936	990		3.4
M35379.060864	1974 Wolfe Water Well	SW 17	4	Domestic	Wolfe	926	922	922	937	990		3.4
M35379.060865	1987 Turnbull Water Well	SW 17	4	Domestic	Turnbull, Michiel	901	893	892	923	990		3.4
M35379.066620	1991 Reid Water Well	SW 17	4	Domestic	Reid, Allan	902	898	898	937	990		3.4

A water well is considered to possibly be in the same aquifer as WTH No. 1-09 if the water well meets the following criteria:

- If the elevation of the NPWL of the water well is within five metres of the elevation of the NPWL of WTH No. 1-09.
- If the elevation of the completion interval of the water well is within five metres of the elevation of the completion interval of WTH No. 1-09.
- In the absence of a completion interval or NPWL, if the drilled depth is below the elevation or within five metres of the elevation of the top of the completion interval of WTH No. 1-09.
- If there is no information on drilled depth, completion interval or a reported NPWL.

The table indicates that the closest water well that was located during the water well survey (with a Field Action of 1 or 2) is the 1998 Skinner WW, located 99 metres northwest of WTH No. 1-09.

None of the water wells in the above table are indicated as having a licensed groundwater diversion from AENV, but two are Registered for a total groundwater diversion of 18.0 m³/day. Unlicensed water wells would be protected by AENV for 3.4 m³/day for a domestic supply, or 17.1 m³/day for a stock supply. The 37 water wells in the preceding table (which excludes WTH No. 1-09) are therefore protected for a maximum of 161.1 m³/day, of which 99.8 m³/day is protected for water wells that may be in the same aquifer as WTH No. 1-09.

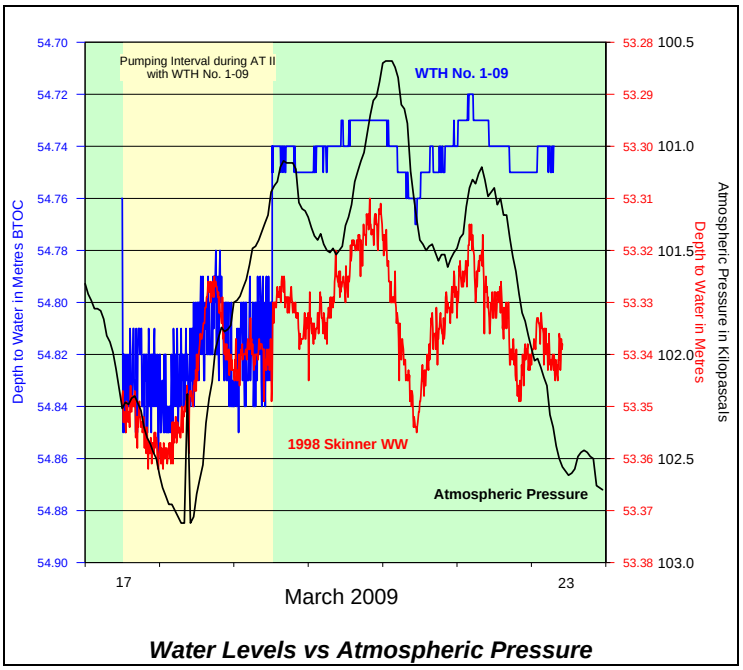
5.2. Aquifer Test Analysis

The long-term yield is based on an aquifer that is homogeneous, isotropic and of infinite areal extent. To determine a long-term yield, a safety factor is used that limits the drawdown over 20 years to 70% of the available drawdown.

5.2.1. AT II with WTH No. 1-09

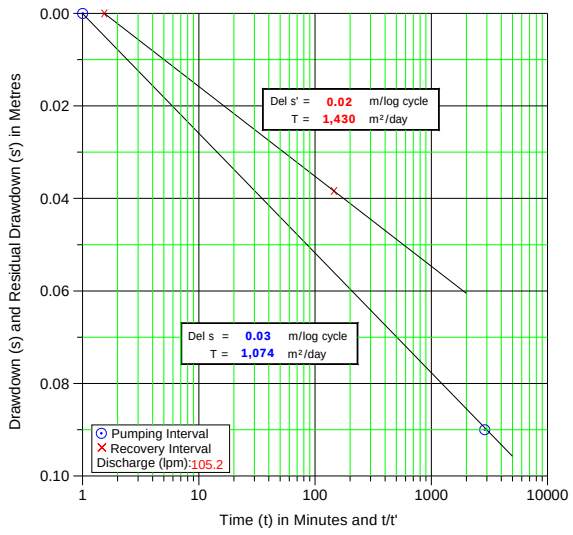
Initial analysis of the aquifer test data in the Results section of this report indicated that the water-level drawdown and recovery data could not be analyzed in order to obtain reliable parameters of transmissivity or storativity because of water-level fluctuations.

The adjacent graph shows that there is a correlation between the measured water-level fluctuations and atmospheric-pressure fluctuations measured at the Red Deer meteorological station. In general, an increase in pressure of 1.0 kpa results in a corresponding water-level decline of 0.04 metres in WTH No. 1-09 and the 1998 Skinner WW.



Water Levels vs Atmospheric Pressure

The graph below shows the pressure-adjusted drawdown and recovery in WTH No. 1-09. The two data points making up the drawdown data include the NPWL used for time t = 1 minute, and the pressure-adjusted water level at the end of the pumping interval.[16] The two data points making up the recovery interval include the pressure-adjusted water level at time t/t1 = 20,[17] and the NPWL at the end of the recovery interval.



AT II with WTH No. 1-09 (Pressure-Adjusted Data)

The graph shows that the adjusted pumping data indicate an effective transmissivity of 1,074 m²/day, and the adjusted recovery data indicate an effective transmissivity of 1,430 m³/day. The calculated transmissivity based on specific capacity is in the order of 2,500 m²/day.

The large values of effective transmissivity may be a result of induced infiltration from Sylvan Lake, as mentioned by Tokarsky (1971). Data supporting this interpretation include an NPWL elevation in WTH No. 1-09 that is similar to the Lake level, and a completion interval that is similar to the elevation of the water column in the Lake.

5.2.2.

[16] Which has been adjusted downward by 0.04 metres due to atmospheric pressure being less at the end of the pumping interval than at the start of the pumping interval.

[17] Which has been adjusted downward by 0.04 metres due to atmospheric pressure being less at the start of the recovery interval than at the start of the pumping interval.

Long-Term Yield

Based on an aquifer that is homogeneous, isotropic and of infinite areal extent and a safety factor that limits the drawdown over 20 years to 70% of the available drawdown, and the following parameters, WTH No. 1-09 has a projected theoretical long-term yield of 5,150 m^3/day, using the Moell Method of analysis:

Available drawdown:	9.2 metres
Specific capacity:	1,169 lpm/metre of drawdown after 10 minutes of pumping
Aquifer transmissivity	1,074 m^2/day
Effective transmissivity:	1,074 m^2/day
Percent of available drawdown used:	70%

The available drawdown of 9.2 metres in WTH No. 1-09 is based on an NPWL of 54.76 metres BTOC, the bottom of the aquifer at a depth of 67.1 metres BGL, and a casing stick-up of 1.5 metres; these values indicate a saturated thickness of 13.8 metres, two-thirds of which is 9.2 metres. The aquifer transmissivity and effective transmissivity are based on the pressure-adjusted drawdown data from AT II.

AENV will not license a water supply well for a volume in excess of the maximum pumping rate during aquifer testing. The pumping rate from WTH No. 1-09 was 164 m^3/day during AT I, and 151 m^3/day during AT II, both of which are significantly less than the projected theoretical long-term yield, and more than the required peak diversion of 120 m^3/day.

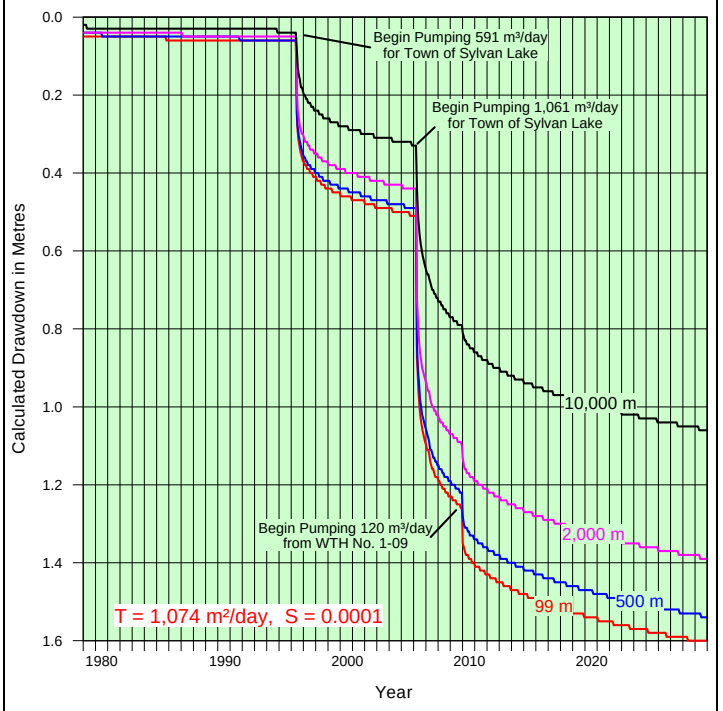
5.3.

Predicted Impact

The adjacent graph and table show the predicted drawdown at various times and various distances from WTH No. 1-09, based on pumping the required 120 m³/day, an effective transmissivity of 1,074 m²/day and a storativity of 0.0001.[18] The calculated drawdowns also assume interference from pumping the following:

- the protected 99.8 m³/day from domestic and stock water wells in the AOI that may be completed in the same aquifer as WTH No. 1-09,
- the 1,688 m³/day from licensed water wells that are outside the AOI, but within the nine-section study area.

It is assumed that the interfering water wells are being pumped at their maximum protected or licensed allocations, and that these groundwater diversions are from aquifers that are hydraulically connected to the aquifer in which WTH No. 1-09 is completed. The start of pumping for interfering diversions is the licensed date for the licensed water wells, and the water well completion date for the domestic and stock water wells; for those water wells with no completion date, a date of 01 Jan 70 is assumed.



Distance from WTH No. 1-09 (metres)	Projected Drawdown in Metres				
	1 month	1 year	5 years	10 years	20 years
99	0.1	0.2	0.2	0.3	0.3
500	0.1	0.1	0.2	0.3	0.3
2,000	0.0	0.1	0.2	0.2	0.3
10,000	0.0	0.1	0.2	0.2	0.3

Calculated Drawdown

The graph and table show that a drawdown of 0.3 metres can be expected at the location of the 1998 Skinner WW after 20 years of pumping 120 m³/day from WTH No. 1-09 and a combined 1,788 m³/day from the 26 interfering water wells. A drawdown of 0.3 metres represents 3% of the available drawdown of 9.7 metres in the 1998 Skinner WW;[19] a drawdown of this magnitude is not considered to represent an adverse effect. Because the Skinner WW is the closest water well to WTH No. 1-09, at a distance of 99 metres, the impact on any other water well due to diverting the required 120 m³/day from WTH No. 1-09 would be less.

5.4.

[18] The storativity of 0.0001 is a reasonable value for bedrock aquifers in Alberta.
[19] The available drawdown is based on an NPWL of 53.34 metres BTOC, a casing stick-up of 0.8 metres, and the completion bottom of 67.1 metres; two-thirds of this saturated interval of 14.6 metres is 9.7 metres.

GWUDI

From the hydrogeological review, it is believed that the groundwater from WTH No. 1-09 is a high-quality groundwater. However, it is important to note that the information collected to date does not indicate that the groundwater is definitely not GWUDI. Areas of concern that need to be addressed to increase the level of confidence are as follows:

1. limited results of microbiological and nitrate analyses of groundwater collected at wellhead
2. limited data related to turbidity of groundwater collected at wellhead
3. no WQA and only one MPA result (see below).

The water quality assessment (WQA) involves frequent and simultaneous measurement of water-quality parameters in groundwater and nearby surface water to determine similar variation patterns if the two are in hydraulic connection. For MPA results to be definitive, two to four MPA analyses must be performed over a 12- to 18-month interval, during times when surface water is most likely to influence groundwater, such as in the spring and fall.

6. Conclusions

Water Test Hole No. 1-09 is completed in an unconfined sandstone aquifer within the Dalehurst Member of the Paskapoo Formation, in the depth interval between 54.1 and 67.1 metres BGL. The aquifer test data indicate that the required groundwater supply of 120 m³/day is available from the water test hole without adversely affecting any existing groundwater user or the aquifer in which the water test hole is completed. All of the calculations used for the present analysis do not include recharge, but do include the effects of pumping from 26 other water wells in the study area. Therefore, the impact of the diversion can be expected to be less than that calculated.

The chemical analysis of the groundwater from the aquifer in which the water test hole is completed shows that turbidity and the concentration of TDS are above the recommended limits for drinking water. The chemical quality of the groundwater from the water test hole is not expected to change significantly with time.

From the hydrogeological review, it is believed that the groundwater from WTH No. 1-09 is a high-quality groundwater. However, this determination is not made with complete confidence because:

- the water test hole fails one of the Phase 1 screening criteria for GWUDI, and
- there is an indication that there may be hydraulic connection between WTH No. 1-09 and Sylvan Lake, and
- there is no data record consisting of many years of negative GWUDI results with respect to water quality, and
- the proposed water supply well is to be used as a municipal drinking water supply.

7. Recommendations

It is recommended that WTH No. 1-09 be renamed Water Supply Well (WSW) No. 1-09, and that AENV approve the enclosed application by Lance Skinner to divert and use a total of 43,800 m^3/year of groundwater from the proposed WSW No. 1-09.

When WSW No. 1-09 is put into service as a municipal water supply well, it is recommended that groundwater-monitoring requirements should include at least daily water-level and groundwater-production measurements from the water supply well. The groundwater-monitoring data must be reviewed annually to ensure that parameters calculated from the aquifer tests continue to be representative of the actual hydrogeological conditions. Water levels are to be recorded to the nearest 0.01 metres and groundwater production is to be recorded to the nearest 0.1 cubic metres.

The available data indicate that the groundwater from WTH No. 1-09 is supplying high-quality groundwater rather than GWUDI. However, because:

- the water test hole fails one of the Phase 1 screening criteria for GWUDI, and
- there is an indication that there may be hydraulic connection between WTH No. 1-09 and Sylvan Lake, and
- there is no data record consisting of many years of negative GWUDI results with respect to water quality, and
- the proposed water supply well is to be used as a municipal drinking water supply,

it is recommended that at least one additional sample be collected for MPA in the spring; if the MPA result supports the 18 Mar 09 result that the risk factor is zero, the water test hole should be considered to be providing high-quality groundwater rather than GWUDI at this time.

It is also recommended that a groundwater-sampling program be initiated to ensure that the groundwater quality remains suitable for public consumption. Samples should include turbidity, nitrate, and total and fecal coliforms to confirm compliance with Canadian Drinking Water Quality Guidelines.

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9. Glossary

AENV	Alberta Environment
AMSL	above mean sea level
AO	Aesthetic Objectives
AOI	Area of Interest
Aquifer	a formation, group of formations, or part of a formation that contains saturated permeable rocks capable of transmitting groundwater to water wells or springs in economical quantities
Available Drawdown	in a confined aquifer, the distance between the non-pumping water level and the top of the aquifer in an unconfined aquifer (water table aquifer), two thirds of the saturated thickness of the aquifer
BGL	Below Ground Level
BTOC	Below Top of Casing
Kriging	a geo-statistical method for gridding irregularly-spaced data (Cressie, 1990)
MAC	Maximum Acceptable Concentration
m	metres
mm	millimetres
m^2/day	metres squared per day
m^3	cubic metres
m^3/day	cubic metres per day
mg/L	milligrams per litre
NPWL	non-pumping water level
Obs WW	Observation Water Well

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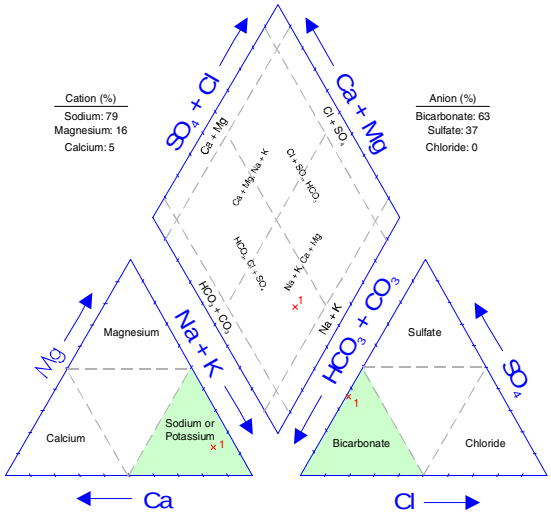
Piper tri-linear diagram	a method that permits the major cation and anion compositions of single or multiple samples to be represented on a single graph. This presentation allows groupings or trends in the data to be identified. From the Piper tri-linear diagram, it can be seen that the groundwater from this sample water well is a sodium-bicarbonate-type. The chemical type has been determined by graphically calculating the dominant cation and anion. For a more detailed explanation, please refer to Freeze and Cherry, 1979
SGCDWQ	Summary of Guidelines for Canadian Drinking Water Quality
Surficial Deposits	includes all sediments above the bedrock
TDS	Total Dissolved Solids
Till	a sediment deposited directly by a glacier that is unsorted and consisting of any grain size ranging from clay to boulders
Transmissivity	the rate at which water is transmitted through a unit width of an aquifer under a unit hydraulic gradient: a measure of the ease with which groundwater can move through the aquifer
	Apparent Transmissivity: the value determined from a summary of aquifer test data, usually involving only two water-level readings
	Effective Transmissivity: the value determined from late pumping and/or late recovery water-level data from an aquifer test
	Aquifer Transmissivity: the value determined by multiplying the hydraulic conductivity of an aquifer by the thickness of the aquifer
WSW	Water Source Well or Water Supply Well
WTH	Water Test Hole
WW	Water Well
VE	Vertical Exaggeration
Yield	a regional analysis term referring to the rate a properly completed water well could be pumped, if fully penetrating the aquifer
	Apparent Yield: based mainly on apparent transmissivity
	Long-Term Yield: based on effective transmissivity



Piper Tri-Linear Diagram

Stratigraphy of the "Undisturbed" Geology of Alberta as used by Hydrogeological Consultants Ltd.

- upper surficial
- lower surficial
- Cypress Hills Fm
- Dalehurst Member
- upper part of Lacombe Member
- lower part of Lacombe Member
- Haynes Member
- upper part of Scollard Fm
- lower part of Scollard Fm
- Battle/Whitemud Fms
- upper part of Horseshoe Canyon Fm
- middle part of Horseshoe Canyon Fm
- lower part of Horseshoe Canyon Fm
- Bearpaw Fm
- Oldman Fm
- Foremost Fm
- Lea Park Fm
- Milk River Fm
- Colorado shale
- Cardium Fm
- Kaskapau Fm
- Dunvegan Fm
- Shaftesbury Fm
- Viking Fm
- Joli Fou Fm
- upper part of Mannville Grp
- middle part of Mannville Grp
- lower part of Mannville Grp
- Jurrassic
- Triassic
- upper part of Paleozoic
- Banff Fm
- Wabamun Group
- Winterburn Group
- Woodbend Group
- Beaverhill Lake Group
- Elk Point Group
- Precambrian

10. Conversions

Multiply	by	To Obtain
Length/Area		
feet	0.304 785	metres
metres	3.281 000	feet
hectares	2.471 054	acres
centimetre	0.032 808	feet
centimetre	0.393 701	inches
acres	0.404 686	hectares
inches	25.400 000	millimetres
miles	1.609 344	kilometres
kilometre	0.621 370	miles (statute)
square feet (ft^2)	0.092 903	metres (m^2)
metres (m^2)	10.763 910	square feet (ft^2)
metres (m^2)	0.000 001	kilometres (km^2)
Concentration		
grains/gallon (UK)	14.270 050	ppm
ppm	0.998 859	mg/L
mg/L	1.001 142	ppm
Volume (capacity)		
acre feet	1233.481 838	cubic metres
cubic feet	0.028 317	cubic metres
cubic metres	35.314 667	cubic feet
cubic metres	219.969 248	gallons (UK)
cubic metres	264.172 050	gallons (US liquid)
cubic metres	1000.000 000	litres
gallons (UK)	0.004 546	cubic metres
imperial gallons	4.546 000	litres
Rate		
litres per minute	0.219 974	ipgm
litres per minute	1.440 000	cubic metres/day (m^3/day)
igpm	6.546 300	cubic metres/day (m^3/day)
cubic metres/day (m^3/day)	0.152 759	igpm
Pressure		
psi	6.894 757	kpa
kpa	0.145 038	psi
Miscellaneous		
Celsius	F° = 9/5 (C° + 32)	Fahrenheit
Fahrenheit	C° = (F°- 32) * 5/9	Celsius
degrees	0.017 453	radians