Westlock County

Part of the Athabasca and North Saskatchewan River Basins
Parts of Tp 057 to 064, R 23 to 27, W4M and R 01 to 03, W5M
Regional Groundwater Assessment

Prepared for

In conjunction with

Agriculture and Agri-Food Canada | Agriculture et Agroalimentaire Canada

Prairie Farm Rehabilitation Administration | Administration du rétablisseme agricole des Prairies

Canada

Prepared by
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HYDROGEOLOGICAL CONSULTANTS LTD.

Signature__________________________________

Date_____________________________________

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The Association of Professional Engineers, Geologists and Geophysicists of Alberta

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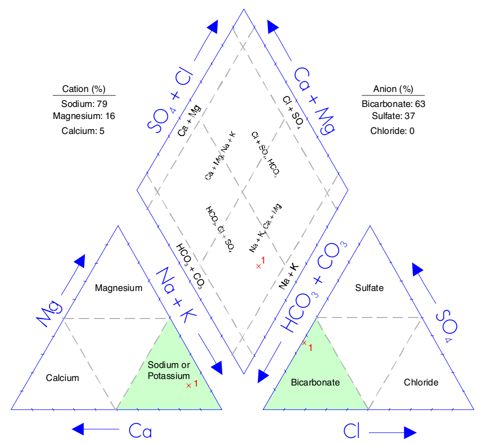
Glossary

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
Aquitard	a confining bed that retards but does not prevent the flow of water to or from an adjacent aquifer
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
Borehole	includes all "work types" except springs
Deltaic	a depositional environment in standing water near the mouth of a river
Dewatering	the removal of groundwater from an aquifer for purposes other than use
Evapotranspiration	a combination of evaporation from open bodies of water, evaporation from soil surfaces, and transpiration from the soil by plants (Freeze and Cherry, 1979)
Facies	the aspect or character of the sediment within beds of one and the same age (Pettijohn, 1957)
Fluvial	produced by the action of a stream or river
Friable	poorly cemented
Hydraulic Conductivity	the rate of flow of water through a unit cross-section under a unit hydraulic gradient; units are length/time
km	kilometre
Kriging	a geo-statistical method for gridding irregularly-spaced data (Cressie, 1990)
Lacustrine	fine-grained sedimentary deposits associated with a lake environment and not including shore-line deposits
Lithology	description of rock material
Lsd	Legal Subdivision
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
Obs WW	Observation Water Well

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



Piper Tri-Linear Diagram

Rock — earth material below the root zone

Surficial Deposits — includes all sediments above the bedrock

Thalweg — the line connecting the lowest points along a stream bed or valley; *longitudinal profile*

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

Water Well — a hole in the ground for the purpose of obtaining groundwater; “work type” includes test hole, chemistry, deepened, well inventory, federal well survey, reconditioned, reconstructed, new, old well-test

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

AE — Alberta Environment

AMSL — above mean sea level

DEM — Digital Elevation Model

DST — drill stem test

EUB	Alberta Energy and Utilities Board
GCDWQ	Guidelines for Canadian Drinking Water Quality
NPWL	non-pumping water level
NSR	North Saskatchewan River
PFRA	Prairie Farm Rehabilitation Administration
TDS	Total Dissolved Solids
WSW	Water Source Well or Water Supply Well

I. PROJECT OVERVIEW

"Water is the lifeblood of the earth." - Anonymous

How a County takes care of one of its most precious resources - groundwater - reflects the future wealth and health of its people. Good environmental practices are not an accident. They must include genuine foresight with knowledgeable planning. Implementation of strong practices not only commits to a better quality of life for future generations, but also creates a solid base for increased economic activity. **Though this report's scope is regional, it is a first step for Westlock County in managing their groundwater. It is also a guide for future groundwater-related projects.**

A. Purpose

This project is a regional groundwater assessment of Westlock County prepared by Hydrogeological Consultants Ltd. (HCL) with financial assistance from Prairie Farm Rehabilitation Administration (PFRA). The regional groundwater assessment provides the information to assist in the management of the groundwater resource within the County. Groundwater resource management involves determining the suitability of various areas in the County for particular activities. These activities can vary from the development of groundwater for agricultural or industrial purposes, to the siting of waste storage. **Proper management ensures protection and utilization of the groundwater resource for the maximum benefit of the people of the County.**

The regional groundwater assessment will:

- identify the aquifers[1] within the surficial deposits[2] and the upper bedrock
- spatially identify the main aquifers
- describe the quantity and quality of the groundwater associated with each aquifer
- identify the hydraulic relationship between aquifers
- identify the first sand and gravel deposits below ground level.

Under the present program, the groundwater-related data for the County have been assembled. Where practical, the data have been digitized. These data are then being used in the regional groundwater assessment for the County.

B. The Project

This regional study should only be used as a guide. Detailed local studies are required to verify hydrogeological conditions at given locations.

The present project is made up of five parts as follows:

Module 1 - Data Collection and Synthesis
Module 2 - Hydrogeological Maps
Module 3 - Report
Module 4 - Groundwater Query
Module 5 - Familiarization Session

This report and the accompanying maps represent Modules 2 and 3.

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1 See glossary
2 See glossary

C. About This Report

This report provides an overview of (a) the groundwater resources of Westlock County, (b) the processes used for the present project, and (c) the groundwater characteristics in the County.

Additional technical details are available from files on the CD-ROM to be provided with the final version of this report. The files include the geo-referenced electronic groundwater database, maps showing distribution of various hydrogeological parameters, the groundwater query, and ArcView files. Likewise, all of the illustrations and maps from the present report, plus additional maps, figures and cross-sections, are available on the CD-ROM. For convenience, poster-size maps and cross-sections have been prepared as a visual summary of the results presented in this report. Copies of these poster-size drawings have been forwarded with this report, and are included as page-size drawings in Appendix D.

Appendix A features page-size copies of the figures within the report plus additional maps and cross-sections. An index of the page-size maps and figures is given at the beginning of Appendix A.

Appendix B provides a complete list of maps and figures included on the CD-ROM.

Appendix C includes the following:

1) a procedure for conducting aquifer tests with water wells[3]
2) a table of contents for the Water (Ministerial) Regulation under the new Water Act
3) a flow chart showing the licensing of a groundwater diversion under the new Water Act
4) additional information.

The Water (Ministerial) Regulation deals with the wellhead completion requirement (no more water-well pits), the proper procedure for abandoning unused water wells and the correct procedure for installing a pump in a water well. The new Water Act was proclaimed 10 Jan 1999.

Appendix E provides a list of water wells recommended for field verification.

[3] See glossary

II. INTRODUCTION

A. Setting

Westlock County is situated in central Alberta. This area is part of the Alberta Plains region. The County is within the Athabasca and North Saskatchewan river basins; a part of the County's northwestern boundary is the Athabasca River. The other County boundaries follow township or section lines. The area includes parts of the area bounded by township 057, range 3, W5M in the southwest and township 064, range 23, W4M in the northeast.

Regionally, the topographic surface varies between 600 and 740 metres above mean sea level (AMSL). The lowest elevations occur in the Pembina River Valley and the highest are in the southern and northeastern parts of the County as shown on Figure 1 and page A-2.

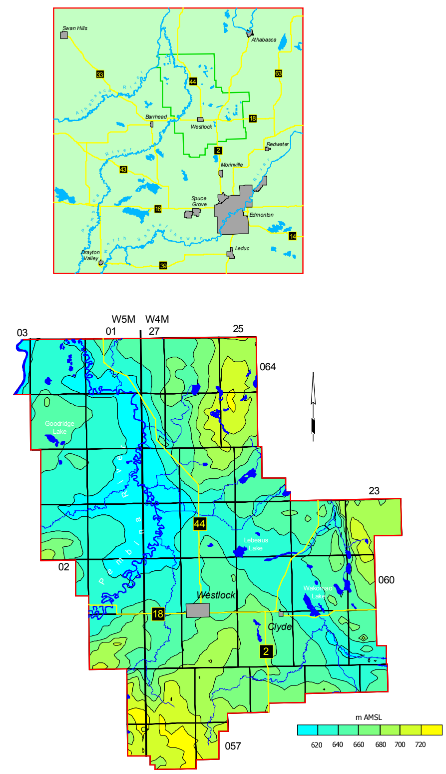

Figure 1. Index Map

B. Climate

Westlock County lies within the Dfb climate boundary. This classification is based on potential evapotranspiration[4] values determined using the Thornthwaite method (Thornthwaite and Mather, 1957), combined with the distribution of natural ecoregions in the area. The ecoregions map (Strong and Leggatt, 1981) shows that the County is located in both the Low Boreal Mixedwood region and the Aspen Parkland region. Increased precipitation and cooler temperatures, resulting in additional moisture availability, influence this vegetation change.

A Dfb climate consists of long, cool summers and severe winters. The mean monthly temperature drops below -3° C in the coolest month, and exceeds 10° C in the warmest month.

The mean annual precipitation averaged from one meteorological station within the County measured 468 millimetres (mm), based on data from 1980 to 1990. The mean annual temperature averaged 1.9° C, with the mean monthly temperature reaching a high of 16.8° C in July, and dropping to a low of -11.4° C in January. The calculated annual potential evapotranspiration is 528 millimetres.

[4] See glossary

C. Background Information

1) Numbers, Types and Depths of Water Wells

There are currently records for 3,677 water wells in the groundwater database for the County. Of the 3,677 water wells, 3,241 are for domestic/stock purposes. The remaining 436 water wells were completed for a variety of uses, including municipal, industrial, irrigation, investigation and observation. Based on a rural population of 6,958 (Phinney, 1999), there are 1.9 domestic/stock water wells per family of four. The domestic or stock water wells vary in depth from 1.2 metres to 365 metres below ground level. Details for lithology[5] are available for 1,924 water wells.

2) Numbers of Water Wells in Surficial and Bedrock Aquifers

There are 1,568 water well records with sufficient information to identify the aquifer in which the water wells are completed. The water wells that were not drilled deep enough to encounter the bedrock plus water wells that have the bottom of their completion interval above the top of the bedrock are water wells completed in surficial aquifers. Of the 1,568 water wells for which aquifers could be defined, 451 are completed in surficial aquifers, with 55% having a completion depth of more than 30 metres. The adjacent map shows that the water wells completed in the surficial deposits occur throughout the County, frequently in the vicinity of linear bedrock lows.

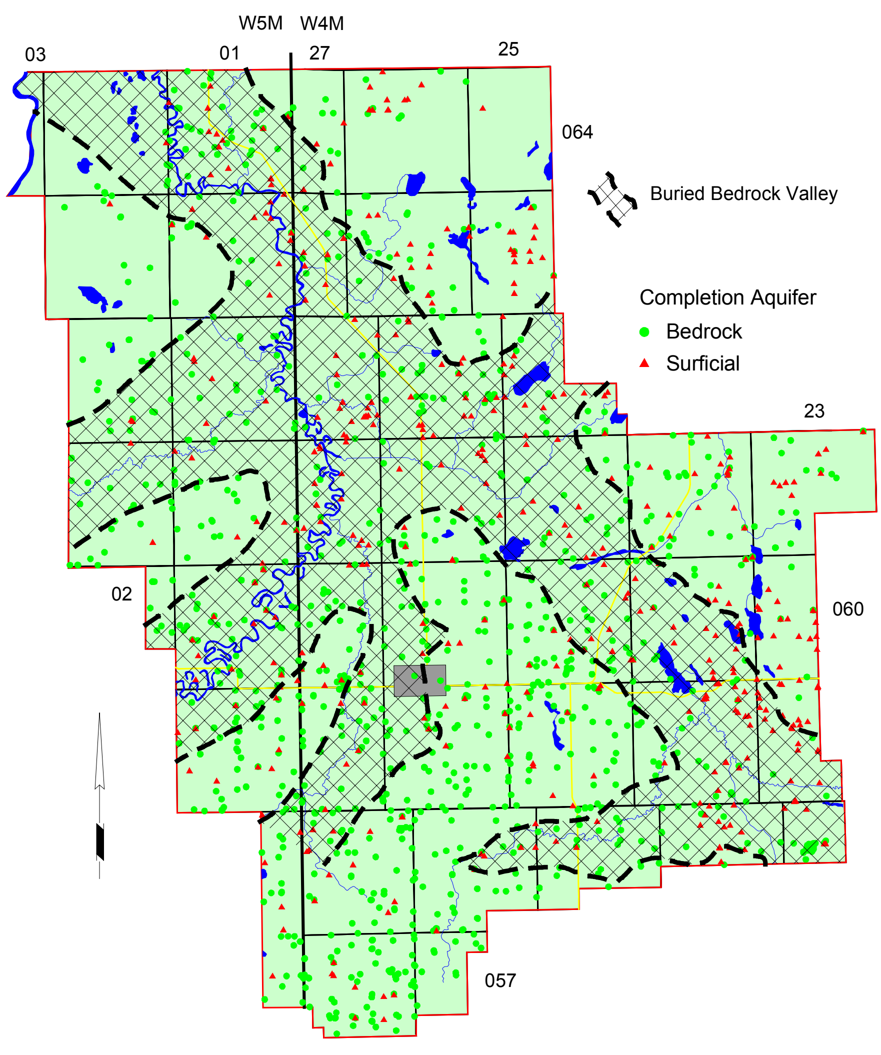

Figure 2. Location of Water Wells

The 1,117 water wells that have the top of their completion interval deeper than the top of the bedrock are referred to as bedrock water wells. From Figure 2, it can be seen that water wells completed in bedrock aquifers also occur throughout the County.

[5] See glossary

3) Casing Diameter and Types

Data for casing diameters are available for 1,660 water wells, with 1,497 (90%) indicated as having a diameter of less than 300 mm and 163 having a diameter of more than 300 mm. The casing diameters of greater than 300 mm are mainly bored or dug water wells and those with a surface-casing diameter of less than 300 mm are drilled water wells. Large-diameter water wells are mainly in the areas where significant linear bedrock lows are present.

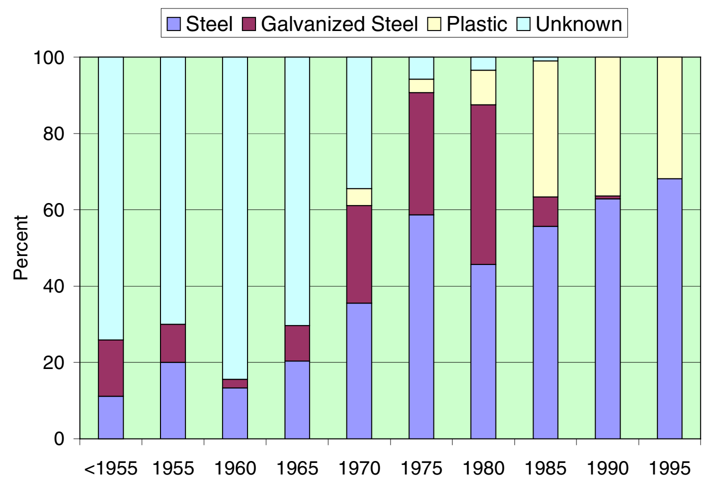

Figure 3. Surface Casing Types used in Drilled Water Wells

In the County, steel, galvanized steel and plastic represent 99% of the materials that have been used for surface casing in drilled water wells over the last 40 years. Until the 1960s, the type of surface casing used in drilled water wells was mainly undocumented. Steel casing was in use in the 1950s and is still used in 70% of the water wells being drilled in the County in the 1990s. Steel and galvanized steel were the main casing types until the start of the 1980s, at which time plastic casing started to replace the use of galvanized steel casing.

Galvanized steel surface casing was used in a maximum of 42% of the new water wells from the 1950s to the early 1990s. Galvanized steel was last used in January 1990.

4) Requirements for Licensing

Water wells used for household needs in excess of 1,250 cubic metres per year and providing groundwater with total dissolved solids (TDS) of less than 4,000 milligrams per litre (mg/L) must be licensed. At the end of 1999, 200 groundwater allocations were licensed in the County. Of the 200 licensed groundwater users, 165 are for agricultural purposes, and the remaining 35 are for power, municipal, dewatering, recreation and commercial purposes. The total maximum authorized diversion from the water wells associated with these licences is 3,098 cubic metres per day (m^3/day), of which 57% is allotted for agricultural use, and 25% is allotted for municipal use. The remaining 18% has been licensed for power, dewatering, recreation and commercial use as shown in Table 1 on the following page.

The largest potable groundwater allocation within the County is for the Village of Clyde, having a diversion of 243 m^3/day. The water supply well, used for municipal purposes, is completed in the Oldman Aquifer.

The following table shows a breakdown of the 200 licensed groundwater allocations by the aquifer in which the water well is completed. The largest total licensed allocations are in the Oldman Aquifer; the majority of the groundwater is used for agricultural and municipal purposes.

Aquifer **	Licensed Groundwater Users* (m³/day) Agricultural	Power	Municipal	Dewatering	Recreation	Commercial	Total	Percentage
Upper Sand and Gravel	247	0	0	176	0	132	555	18
Lower Horseshoe Canyon	90	0	115	0	0	0	205	6
Bearpaw	52	0	0	0	0	0	52	2
Oldman	1,205	45	544	0	0	7	1,801	58
Birch Lake	142	0	108	0	203	2	455	15
Ribstone	24	0	0	0	0	0	24	1
Victoria	7	0	0	0	0	0	7	0
Unknown	0	0	0	0	0	0	0	0
Total	1,767	45	767	176	203	141	3,099	100
Percentage	57	1	25	6	6	5	100	

* - data from AE ** - identification of Aquifer by HCL

Table 1. Licensed Groundwater Diversions

Based on the 1996 Agriculture Census, the water requirement for livestock for the County is in the order of 12,149 m³/day. Of the 12,149 m³/day required for livestock use, groundwater provides 1,767 m³/day (14%) and surface water provides 2,107 m³/day (17%) for a total of 31% licensed by Alberta Environment.

5) Groundwater Chemistry and Base of Groundwater Protection

Groundwaters from the surficial deposits can be expected to be chemically hard with a high dissolved iron content. The total dissolved solids (TDS) concentrations in the groundwaters from the upper bedrock in the County are generally less than 1,500 milligrams per litre (mg/L). Groundwaters from the bedrock aquifers frequently are chemically soft with generally low concentrations of dissolved iron. The chemically soft groundwater is high in sodium concentration. Less than 1% of the chemical analyses indicate a fluoride concentration above 1.0 mg/L.

The minimum, maximum and average concentrations of TDS, sodium, sulfate, chloride and fluoride in the groundwaters from water wells completed in the upper bedrock in the County have been compared to the Guidelines for Canadian Drinking Water Quality (GCDWQ) in Table 2. Of the five constituents compared to the GCDWQ, only average values of TDS and sodium concentrations exceed the guidelines.

Constituent	Range for County in mg/L Minimum	Maximum	Average	Recommended Maximum Concentration GCDWQ
Total Dissolved Solids	222	4834	1250	500
Sodium	0	1775	454	200
Sulfate	0	1994	109	500
Chloride	<1	4875	195	250
Fluoride	0	13	1.0	1.5

Concentration in milligrams per litre unless otherwise stated
Note: indicated concentrations are for Aesthetic Objectives

GCDWQ - Guidelines for Canadian Drinking Water Quality, Sixth Edition
Minister of Supply and Services Canada, 1996

Table 2. Concentrations of Constituents in Groundwaters from Upper Bedrock Aquifer(s)

Alberta Environment (AE) defines the Base of Groundwater Protection as the elevation below which the groundwater is expected to have more than 4,000 mg/L of total dissolved solids. By using the ground elevation, and the elevation of the Base of Groundwater Protection provided by the Alberta Energy and Utilities Board (EUB), a depth to the Base of Groundwater Protection can be determined. These values are gridded using the Kriging[6] method to prepare a depth to the Base of Groundwater Protection surface. This depth, for the most part, would be the maximum drilling depth for a water well for agricultural purposes or for a potable water supply. If a water well is completed below the Base of Groundwater Protection with the total dissolved solids of the groundwater exceeding 4,000 mg/L, the groundwater use does not require licensing by AE.

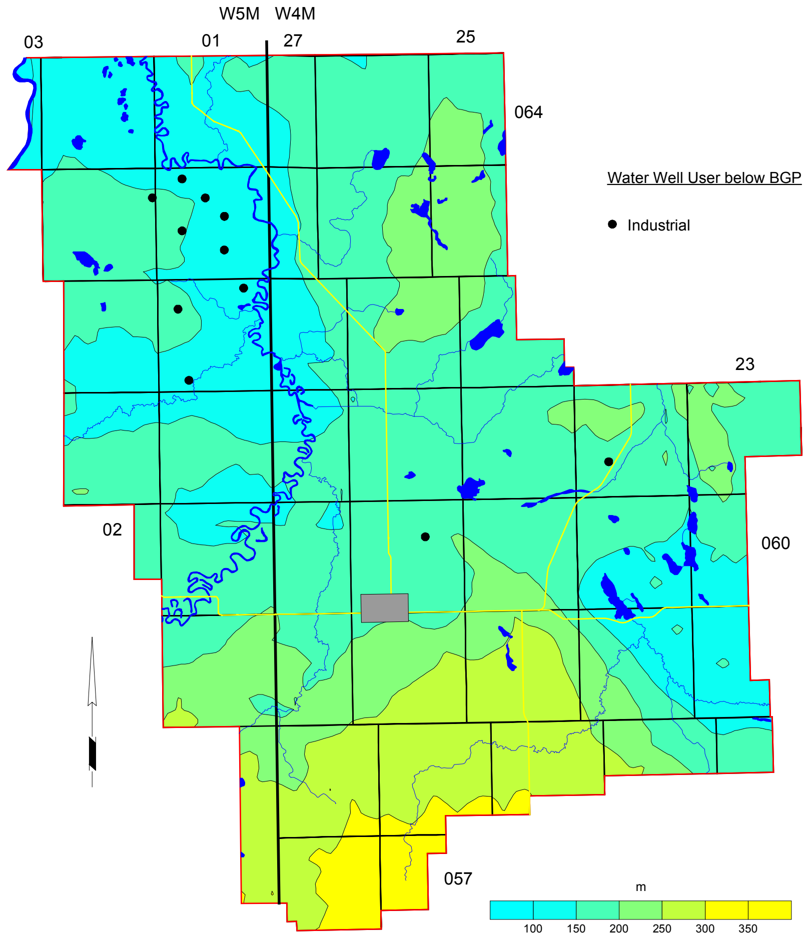

Figure 4. Depth to Base of Groundwater Protection (after EUB, 1995)

Of the 3,535 water wells with completed depth data, 11 are completed below the Base of Groundwater Protection. Most of these water wells are located within a few kilometres of the Pembina River and in other areas where the depth to Base of Groundwater Protection ranges from less than 50 to 200 metres. All 11 water wells are used for industrial purposes; chemistry data are available for one water well, which provides groundwater with TDS of 3,195 mg/L.

Proper management of the groundwater resource requires water-level data. These data are often collected from observation water wells. At the present time, there are no AE-operated observation water wells within the County. Additional data can be obtained from some of the licensed groundwater diversions. In the past, the data for licensed diversions have been difficult to obtain from AE, in part because of the failure of the licensee to provide the data.

However, even with the available sources of data, the number of water-level data points relative to the size of the County is too few to provide a reliable groundwater budget (see section 6.0). The most cost-efficient method to collect additional groundwater monitoring data would be to have the water well owners measuring the water level in their own water well on a regular basis.

6 See glossary

III. TERMS

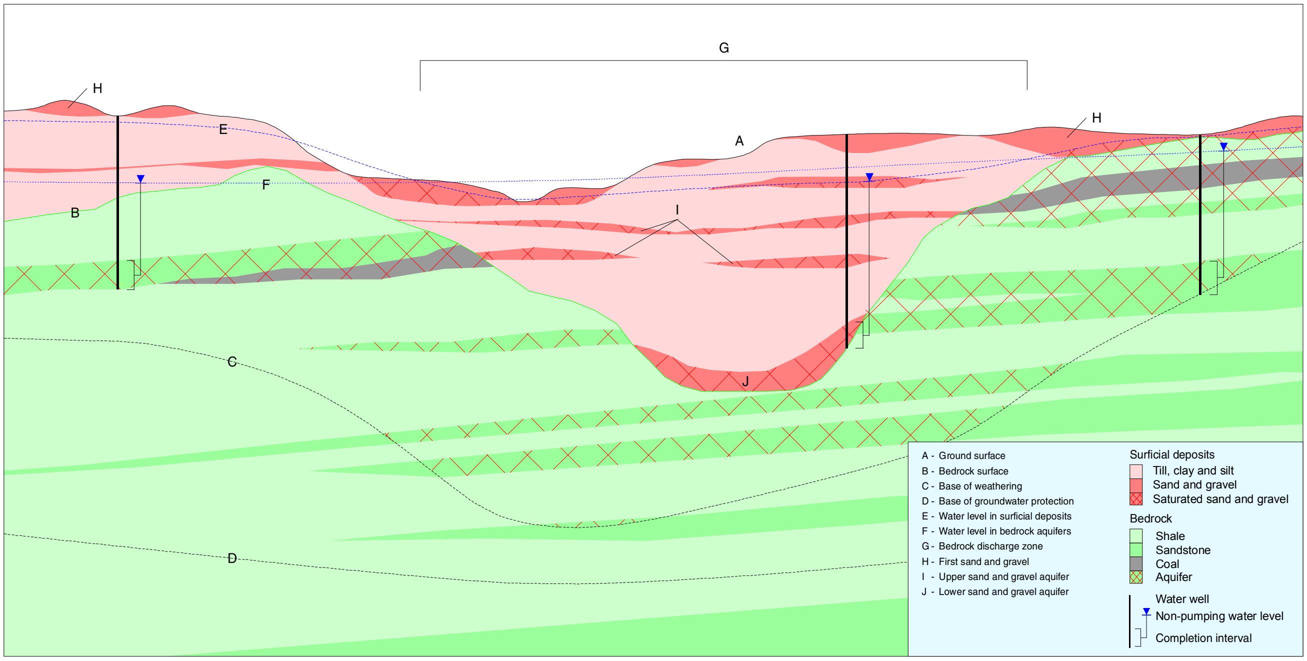

Figure 5. Generalized Cross-Section (for terminology only)

Lithologic Description	Group and Formation: Average Thickness (m)	Group	Formation Thickness (m)	Group and Formation: Designation	Member: Average Thickness (m)	Member: Designation	Zone: Average Thickness (m)	Zone: Designation
sand, gravel, till, clay, silt	<140			Surficial Deposits	<140	Upper	<30	First Sand and Gravel
					<50	Lower		
shale, sandstone, coal, bentonite, limestone, ironstone	300-380	Edmonton Group		Horseshoe Canyon Formation	~100	Upper		
					~100	Middle		
					~170	Lower		
shale, sandstone, siltstone	60-120			Bearpaw Formation				
sandstone, siltstone, shale, coal	<300	Belly River Group	40-130	Oldman Formation		Dinosaur Member	<25	Lethbridge Coal Zone
						Upper Siltstone Member		
						Comrey Member		
sandstone, shale			<200	Foremost Formation	<70	Birch Lake Member		Taber Coal Zone
					<60	Ribstone Creek Member		
					<70	Victoria Member		McKay Coal Zone
					0-30	Brosseau Member		
shale, siltstone				Lea Park Formation	100-200			

Figure 6. Geologic Column