County of Lamont No. 30

Part of the North Saskatchewan River Basin
Parts of Tp 051 to 058, R 15 to 20, W4M
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
hydrogeological consultants ltd.
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1 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 creates a solid base for increased economic activity. **This report, even though it is regional in nature, is the first step in fulfilling a commitment by the County toward the management of the groundwater resource, which is a key component toward the well-being of the County, and is a guide for future groundwater-related projects.**

1.1 About This Report

This report provides an overview of (a) the groundwater resources of the County of Lamont No. 30, (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 provided with 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;
2) a table of contents for the Water Well Regulation under the Environmental Protection and Enhancement Act; and
3) additional information.

The Water Well 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.

1.2 The Project

It must be noted that the present project is a regional study and as such the results are to be used only 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 - Covering Report
Module 4 - Groundwater Query
Module 5 - Training Session

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

1.3 Purpose

This project is a regional groundwater assessment of the County of Lamont No. 30. 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 includes:

- identification of the aquifers[1] within the surficial deposits[2] and the upper bedrock;
- spatial definition of the main aquifers;
- quantity and quality of the groundwater associated with each aquifer;
- hydraulic relationship between aquifers; and
- identification of 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.

[1] See glossary
[2] See glossary

2 INTRODUCTION

2.1 Setting

The County of Lamont No. 30 is situated in east-central Alberta. This area is part of the Alberta Plains region. The County exists within the drainage basin of the North Saskatchewan River, the northern boundary of the County. The area includes some or all of townships 051 to 058, ranges 15 to 20, west of the 4th Meridian.

Most of the County boundaries follow township or section lines. The exception is the northern boundary. The ground elevation varies between 590 and 740 metres above mean sea level (AMSL). The topographic surface generally decreases toward the North Saskatchewan River.

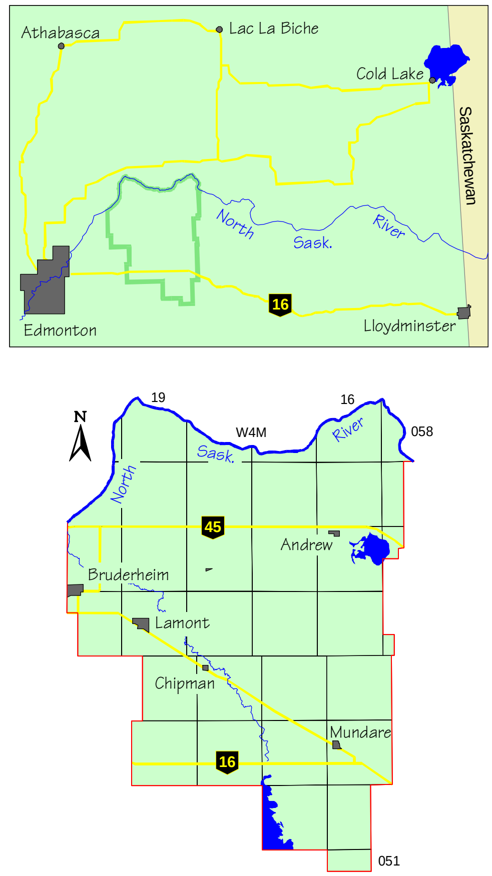

Figure 1. Index Map

2.2 Climate

The County of Lamont lies within the Dfb climate boundary. This classification is based on potential evapotranspiration 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 Legatt, 1981) shows that the County is located in both the Low Boreal Mixedwood region and the Aspen Parkland region. This vegetation change is influenced by increased precipitation and cooler temperatures, resulting in additional moisture availability.

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 four meteorological stations within the County measured 473 millimetres (mm), based on data from 1954 to 1993. The mean annual temperature averaged 2.9 °C, with the mean monthly temperature reaching a high of 16.6 °C in July, and dropping to a low of -11.5 °C in January. The calculated annual potential evapotranspiration is 534 millimetres.

2.3 Background Information

There are currently records for 3,481 water wells in the groundwater database for the County. Of the 3,481 water wells, 1,768 are for domestic/stock purposes. Based on a rural population of 4,200, there are two water wells per family of four. The domestic or stock water wells vary in depth from less than 2 metres to 232.9 metres below ground level. Lithologic details are available for 1,663 water wells.

Data for casing diameter are available for 1,212 water wells, with 733 indicated as having a diameter of more than 300 mm and 479 having a diameter of less than 300 mm. The casing diameters of less than 300 mm are for drilled water wells, of which 40% were drilled before 1980. The water wells with a diameter of greater than 300 mm are mainly bored water wells.

Before 1980, plastic casing was not used in the water wells in the groundwater database. From the beginning of 1980 to 1995, plastic casing was used in 42% of the water wells.

Water wells not used for domestic needs must be licensed. At the end of 1996, 47 groundwater diversions were licensed in the County. The total maximum authorized diversion from these 47 water wells is 1,453 cubic metres per day (m^3/day); 76% of the authorized groundwater diversion is allotted for agricultural use. The largest licensed groundwater diversion of 845 m^3/day for Sil Silica is for a water well completed in the Buried Beverly Valley. The Village of Bruderheim, and the Towns of Lamont, Chipman and Mundare obtain their water via pipeline from the City of Edmonton.

At many locations within the County, more than one water well is completed at one legal location. Digitally processing this information is difficult. To obtain a better understanding of the completed depths of water wells, a digital surface was prepared representing the minimum depth for water wells and a second digital surface was prepared for the maximum depth. Both of these surfaces are used in the groundwater query on the CD-ROM. When the maximum and minimum water well depths are similar, there is only one aquifer that is being used.

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 2,000 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. Very few chemical analyses indicate a fluoride concentration above 1.0 mg/L.

Alberta Environmental Protection (AEP) 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, the bedrock surface and the Base of Groundwater Protection, a depth to the Base of Groundwater Protection can be determined. This depth, for the most part, would be the maximum drilling depth for a water supply well. Over approximately 40% of the County, the depth to the Base of Groundwater Protection is more than 200 metres. There are only a few areas where the depth to the Base of Groundwater Protection is less than 100 metres, which are areas along the northern boundaries of the County, east of range 18, W4M as shown on the adjacent map.

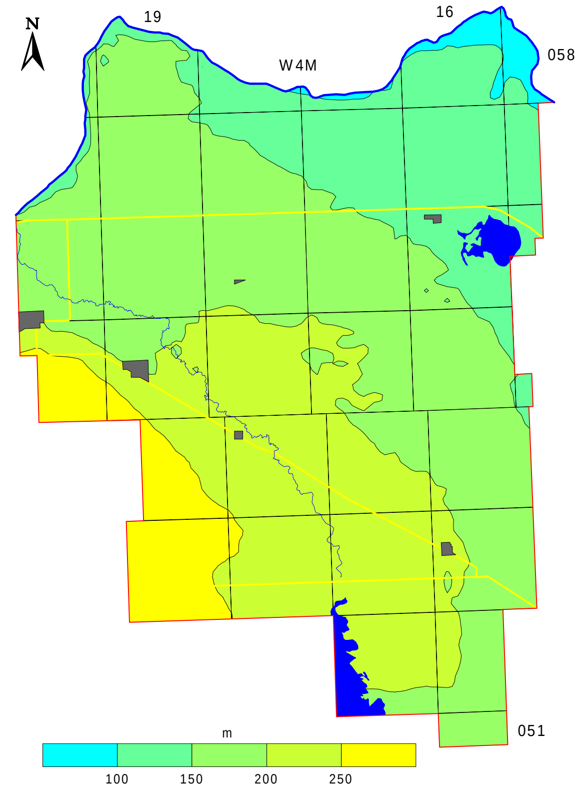

Figure 2. Depth to Base of Groundwater Protection

Proper management of the groundwater resource requires water-level data. These data are often collected from observation water wells. At the present time, these data are available from two observation water wells operated by AEP. Additional data can be obtained from some of the licensed groundwater diversions. In the past, these data have been difficult to obtain from AEP, 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. 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.

3 TERMS

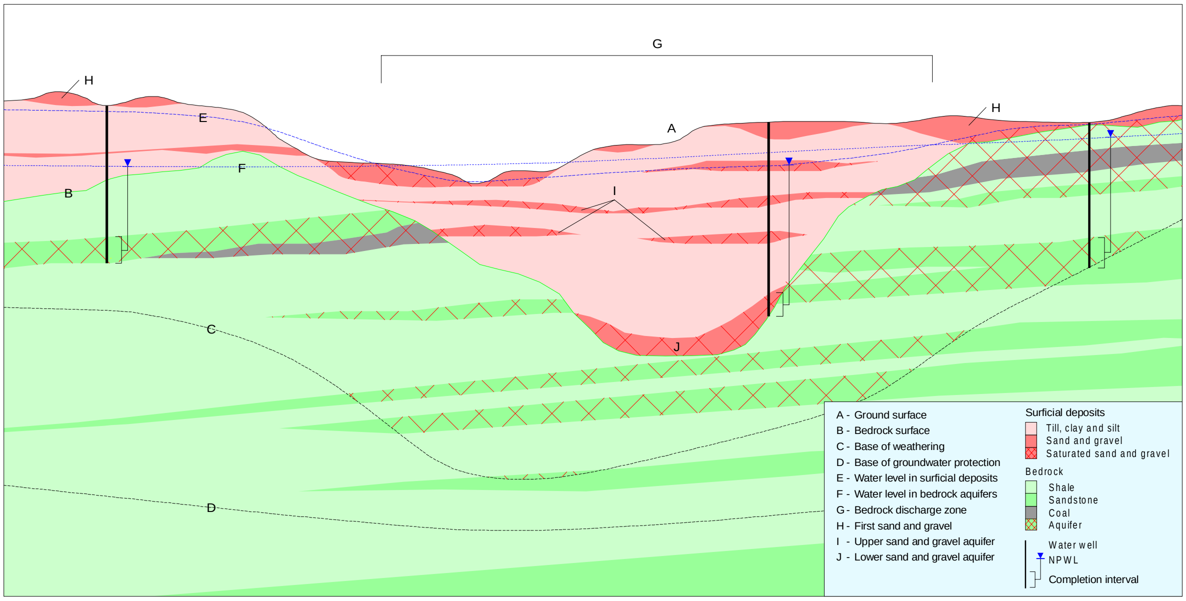

Figure 3. Generalized Cross-Section (for terminology only)

Lithology	Lithologic Description	Group and Formation: Thickness (m)	Group	Group and Formation: Designation	Member: Thickness (m)	Member: Designation	Zone: Thickness (m)	Zone: Designation
	sand, gravel, till, clay, silt	<80		Surficial Deposits	<80	Upper	<30	First Sand and Gravel
					<80	Lower		
	sandstone, siltstone, shale, coal	40-80	Belly River Group	Oldman Formation	<30	Dinosaur Member	<25	Lethbridge Coal Zone
					<20	Upper Siltstone Member		
					8-20	Comrey Member		
	shale, sandstone, coal	10-220		*continental* Foremost Formation			<20	Taber Coal Zone
							<20	McKay Coal Zone
	sandstone, shale	<200		*marine* Foremost Formation (Basal Belly River Sandstone)	<30	Birch Lake Member		Milan Aquifer
					<30	Ribstone Creek Member		
					<30	Victoria Member		
					<30	Brosseau Member		
	shale, siltstone	100-200		Lea Park Formation	50-100	Upper		
					50-100	Lower		

Figure 4. Geologic Column

4 METHODOLOGY

4.1 Data Collection and Synthesis

The AEP groundwater database is the main source of groundwater data. The database includes the following:

1) water well drilling reports;
2) aquifer test results from some water wells;
3) location of some springs;
4) water well locations determined during water well surveys;
5) chemical analyses for some groundwaters;
6) location of flowing shot holes;
7) location of structure test holes; and
8) a variety of data related to the groundwater resource.

The main disadvantage to the database is the absence of quality control. Very little can be done to overcome this lack of quality control in the data collection, other than to assess the usefulness of control points relative to other data during the interpretation. Another disadvantage to the database is the lack of adequate spatial information.

The AEP groundwater database uses a land-based system with only a limited number of records having a value for ground elevation. The locations for records usually include a quarter section description; a few records also have a land description that includes a Legal Subdivision (Lsd). For digital processing, a record location requires a horizontal coordinate system. In the absence of an actual location for a record, the record is given the coordinates for the centre of the land description.

The present project uses the 10TM coordinate system. This means that a record for the SE ¼ of section 24, township 055, range 19, W4M, would have a horizontal coordinate with an Easting 152619 and a Northing 5957080, the centre of the quarter section. Once the horizontal coordinates are determined, a ground elevation is obtained from the 1:20,000 Digital Elevation Model (DEM) from the Resource Data Division of AEP.

After assigning spatial control to the records in the groundwater database, the data are processed to determine values for hydrogeological parameters. As part of the processing, obvious keying errors in the database are corrected.

Where possible, determinations are made from individual records for the following:

1) depth to bedrock;
2) total thickness of sand and gravel;
3) thickness of first sand and gravel when present within one metre of ground surface;
4) total thickness of saturated sand and gravel; and
5) depth to the top and bottom of completion intervals.

Also, where sufficient information is available, values for apparent transmissivity[3] and apparent yield[4] are calculated, based on the aquifer test summary data supplied on the water well drilling reports. The apparent transmissivity results are then used to estimate a value for hydraulic conductivity[5]. The conductivity values are obtained by dividing the apparent transmissivity by the completion interval. To obtain a value for regional transmissivity of the aquifer, the hydraulic conductivity is multiplied by the effective thickness of the aquifer based on nearby e-log information. Where valid detailed aquifer test results exist, the interpreted data provide values for aquifer transmissivity and effective transmissivity.

The Alberta Energy and Utilities Board (EUB) well database includes records for all of the wells drilled by the oil and gas industry. The information from this source includes:

1) spatial control for each well site;
2) depth to the top of various geological units;
3) type and intervals for various down-hole geophysical logs; and
4) drill stem test (DST) summaries.

Unfortunately, the EUB database contains very little information from above the Base of Groundwater Protection. Because the main interest for a groundwater study comes from data above the Base of Groundwater Protection, the data from the EUB database have limited use.

Values for apparent transmissivity and hydraulic conductivity are calculated from the DST summaries.

Published and unpublished reports and maps provide the final source of information to be included in the new groundwater database. The reference section of this report lists the available reports. The only digital data from publications are from the Geological Atlas of the Western Canada Sedimentary Basin (Mossop and Shetsen, 1994). These data are used to verify the geological interpretation of geophysical logs but cannot be distributed because of a licensing agreement.

4.2 Spatial Distribution of Aquifers

Determination of the spatial distribution of the aquifers is based on:

1) lithologs provided by the water well drillers;
2) geophysical logs from structure test holes;
3) wells drilled by the oil and gas industry; and
4) data from existing cross-sections.

The identification of aquifers becomes a two-step process: first, mapping the tops and bottoms of individual geological units; and second, identifying the porous and permeable parts of each geological unit in which the aquifer is present.

After obtaining values for the elevation of the top and bottom of individual geological units at specific locations, the spatial distribution of the individual surfaces can be determined. Digitally, establishment of the distribution of a surface requires the preparation of a grid. The inconsistent quality of the data

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[3] For definitions of Transmissivity, see glossary
[4] For definitions of Yield, see glossary
[5] See glossary

necessitates creating a representative sample set obtained from the entire data set. If the data set is large enough, it can be treated as a normal population and the removal of extreme values can be done statistically. When data sets are small, the process of data reduction involves a more direct assessment of the quality of individual points. Because of the uneven distribution of the data, all data sets are gridded using the Kriging[6] method.

The final definition of the individual surfaces becomes an iterative process involving the plotting of the surfaces on cross-sections and the adjusting of control points to fit with the surrounding data.

The porous and permeable parts of the individual geological units have been mainly determined from geophysical logs.

4.3 Hydrogeological Parameters

Water well records that indicate the depths to the top and bottom of their completion interval are compared digitally to the spatial distribution of the various geological surfaces. This procedure allows for the determination of the aquifer in which individual water wells are completed. When the completion interval of a water well cannot be established unequivocally, the data from that water well are not used in determining the distribution of hydraulic parameters.

After the water wells are assigned to a specific aquifer, the parameters from the water well records are assigned to the individual aquifers. The parameters include non-pumping (static) water level (NPWL), transmissivity and projected water well yield. The total dissolved solids, chloride and sulfate concentrations from the chemical analysis of the groundwater are also assigned to applicable aquifers.

Once the values for the various parameters of the individual aquifers are established, the spatial distribution of these parameters must be determined. The distribution of individual parameters involves the same process as the distribution of geological surfaces. This means establishing a representative data set and then preparing a grid.

4.3.1 Risk Criteria

Surface Permeability	Sand or Gravel Present To Within One Metre Of Ground Surface	Groundwater Contamination Risk
Low	No	Low
Moderate	No	Moderate
High	No	High
Low	Yes	High
Moderate	Yes	High
High	Yes	Very High

Table 1. Risk of Groundwater Contamination Criteria

The main source of groundwater contamination involves activities on or near the land surface. The risk is high when the near-surface materials are porous and permeable and low when the materials are less porous and less permeable. The two sources of data for the risk analysis include (a) a determination of when sand and gravel is or is not present within one metre of the ground surface, and (b) the surficial geology map. The presence or absence of sand and gravel within one metre of the land surface is based on a geological surface prepared from the data supplied on the water well drilling reports. The information available on the surficial geology map is categorized based on relative permeability. The information from these two sources is combined to form the risk assessment map. The criteria used in the classification of risk are given in the table above.

6 See glossary

4.4 Maps and Cross-Sections

Once grids for geological surfaces have been prepared, various grids need to be combined to establish the extent and thickness of individual geological units. For example, the relationship between an upper bedrock unit and the bedrock surface must be determined. This process provides both the aquifer outline and the aquifer thickness. The aquifer thickness is used to determine the aquifer transmissivity by multiplying the hydraulic conductivity by the thickness.

Grids must also be combined to allow the calculation of projected long-term yields for individual water wells. The grids related to the elevation of the NPWL and the elevation of the top of the aquifer are combined to determine the available drawdown[7]. The available drawdown data and the transmissivity values are used to calculate values for projected long-term yields for individual water wells, completed in a specific aquifer.

Once the appropriate grids are available, the maps are prepared by contouring the grids. The areal extent of individual parameters is outlined by masks to delineate individual aquifers. Appendix A includes page-size maps from the text, plus additional page-size maps and figures that support the discussion in the text. A list of maps and figures that are included on the CD-ROM is given in Appendix B.

Cross-sections are prepared by first choosing control points from the database along preferred lines of section. Data from these control points are then obtained from the database and placed in an AutoCAD drawing with an appropriate vertical exaggeration. The data placed in the AutoCAD drawing include the geo-referenced lithology, completion intervals and NPWLs. Data from individual geological units are then transferred to the cross-section from the digitally prepared surfaces.

Once the technical details of a cross-section are correct, the drawing file is moved to the software package CorelDRAW! for simplification and presentation in a hard-copy form. These cross-sections are presented in this report and in Appendix A, are included on the CD-ROM, and are in Appendix D in a page-size format.

4.5 Software

The files on the CD-ROM have been generated from the following software:

- Microsoft Professional Office 97
- Surfer 6.04
- ArcView 3.1
- AutoCAD 14.01
- CorelDRAW! 8.0
- Acrobat 3.0

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[7] See glossary

5 AQUIFERS

5.1 Background

An aquifer is a porous and permeable rock that is saturated. If the NPWL is above the top of the rock unit, this type of aquifer is an artesian aquifer. If the rock unit is not entirely saturated and the water level is below the top of the unit, this type of aquifer is a water-table aquifer. These types of aquifers occur in one of two general geological settings in the County. The first geological setting is the sediments that overlie the bedrock surface. In this report, these are referred to as the surficial deposits. The second geological setting includes aquifers in the upper bedrock. The geological settings, the nature of the deposits making up the aquifers within each setting, the expected yield of water wells completed in different aquifers, and the general chemical quality of the groundwater associated with each setting are reviewed separately.

5.1.1 Surficial Aquifers

Surficial deposits in the County are mainly less than 20 metres, except in areas of linear bedrock lows where the thickness of surficial deposits can exceed 50 metres. The Buried Beverly Valley is the main linear bedrock low. The Buried Beverly Valley is present in the northern part of the County and trends generally from southwest to northeast. Cross-section A-A’ passes across the Buried Beverly Valley, and shows the thickness of the surficial deposits to be approximately 60 metres.

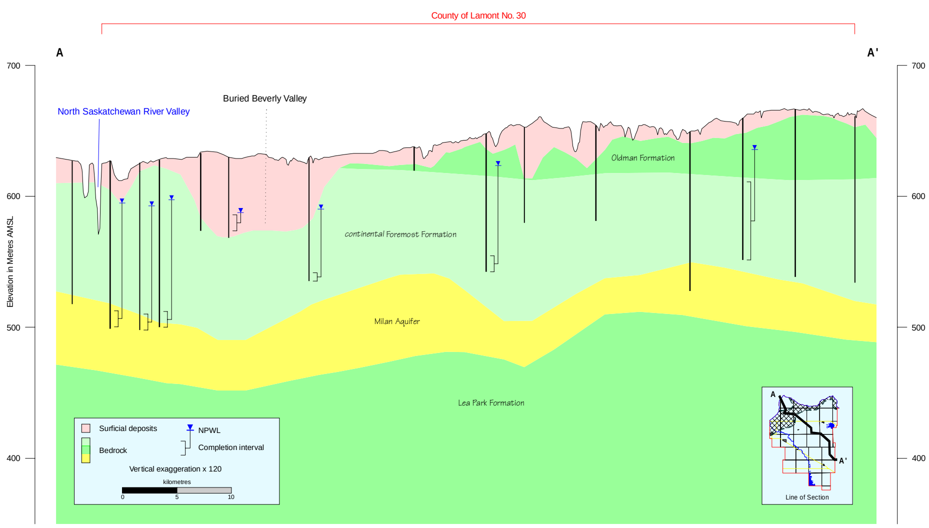

Figure 5. Cross-Section A - A'

The main aquifers in the surficial materials are sand and gravel deposits. In order for a sand and gravel deposit to be an aquifer, it must be saturated; if not saturated, a sand and gravel deposit is not an aquifer. The top of the surficial aquifers has been determined from the NPWL in water wells less than 15 metres deep. The base of the surficial aquifers is the bedrock surface.

For a water well with a small-diameter casing to be effective in surficial deposits and to provide sand-free groundwater, the water well must be completed with a water well screen. Many of the water wells completed in the surficial deposits are completed in low-permeability aquifers and have a large-diameter casing. The large-diameter water wells may have been hand dug or bored and because they are completed in very low permeability aquifers, most of these water wells would not benefit from water well screens. The groundwater from an aquifer in the surficial deposits usually has a chemical hardness of at least a few hundred mg/L and a dissolved iron concentration such that the groundwater is usually treated before being used for domestic needs. Within the County, 60% of the water wells completed in the surficial deposits have a casing diameter of greater than 300 millimetres or no reported diameter for the surface casing, and are assumed to be dug or bored water wells.

5.1.2 Bedrock Aquifers

The upper bedrock includes rocks that are less than 200 metres below the bedrock surface. Some of this bedrock contains porous, permeable and saturated rocks that are permeable enough to transmit groundwater for a specific need. Water wells completed in bedrock aquifers usually do not require water well screens, though some of the sandstones are friable[8] and water well screens are a necessity. The groundwater from the bedrock aquifers is usually chemically soft. The majority of the water wells completed in bedrock aquifers within the County have casing diameters of less than 300 millimetres.

The upper bedrock includes the Bearpaw Formation and part of the Belly River Group. The Belly River Group has a maximum thickness of 250 metres and includes the Oldman Formation and both the *continental* and *marine* facies[9] of the Foremost Formation (Figure 6).

The Lea Park Formation underlies the Belly River Group and is a regional aquitard[10].

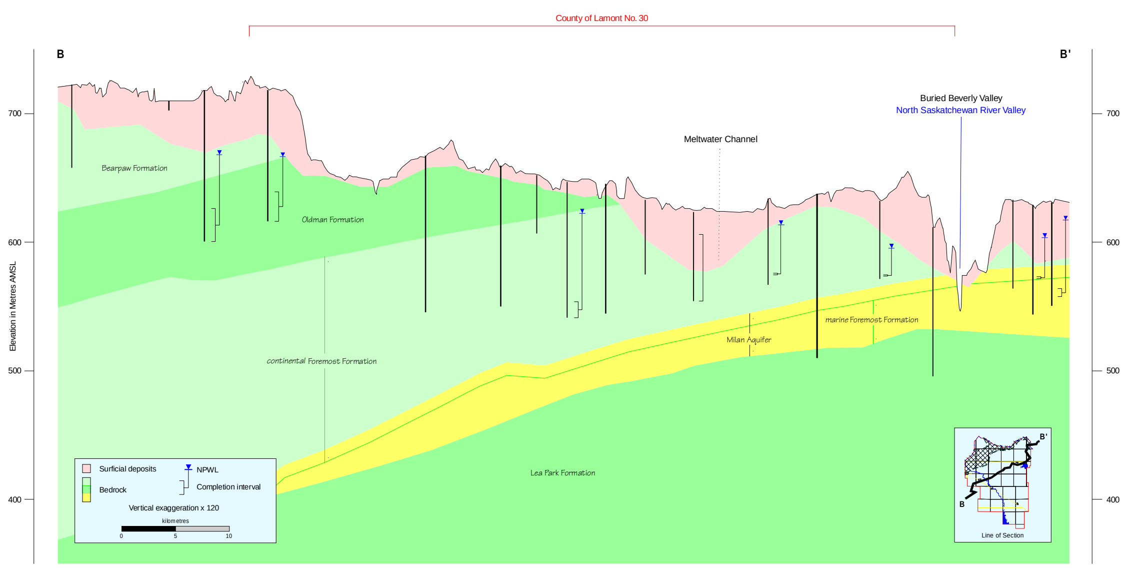

Figure 6. Cross-Section B - B'

8 See glossary
9 See glossary
10 See glossary

5.2 Aquifers in Surficial Deposits

The surficial deposits are the sediments above the bedrock surface. This includes pre-glacial materials, which were deposited before glaciation, and materials deposited directly or indirectly by glaciation. The lower surficial deposits include pre-glacial fluvial[11] and lacustrine[12] deposits. The lacustrine deposits include clay, silt and fine-grained sand. The upper surficial deposits include the more traditional glacial deposits of till and meltwater deposits. In the southeastern part of the County, there are narrow meltwater channels. These meltwater channels cannot be identified on a regional basis, but could be significant local aquifers.

5.2.1 Geological Characteristics of Surficial Deposits

While the surficial deposits are treated as one hydrogeological unit, they consist of three hydraulic parts. The first is the sand and gravel deposits of the lower surficial deposits, the second is the saturated sand and gravel deposits of the upper surficial deposits and the third is the sand and gravel close to ground level, which is usually unsaturated. The sand and gravel deposits in the upper part of the surficial deposits can extend above the upper limit of the saturation zone and because they are not saturated, they are not an aquifer. However, these sand and gravel deposits are significant since they provide a pathway for liquid contaminants to move downward into the groundwater. Because of the significance of the shallow sand and gravel deposits, they have been mapped where they are present within one metre of the ground surface and are referred to as the “first sand and gravel”.

Over the majority of the County, the surficial deposits are less than 20 metres thick. The maximum thickness occurs in association with the Buried Beverly Valley, which is north of the Village of Bruderheim. In the Buried Beverly Valley, surficial deposits can be up to 60 metres thick.

The lower surficial deposits are composed mostly of fluvial and lacustrine deposits. The total thickness of the lower surficial deposits can be up to 30 metres. If the elevation of the top of the lower surficial deposits is approximately 600 metres AMSL, an elevation that corresponds closely to the top of the Muriel Lake Formation (Andriashek, 1985), the lower surficial deposits can be expected under approximately 10% of the County, in association with linear bedrock lows. The lowest part of the lower surficial deposits includes pre-glacial sand and gravel deposits. These deposits would generally be expected to directly overlie the bedrock surface in the Buried Beverly Valley. The lowest sand and gravel deposits are of fluvial origin and are usually no more than a few metres thick.

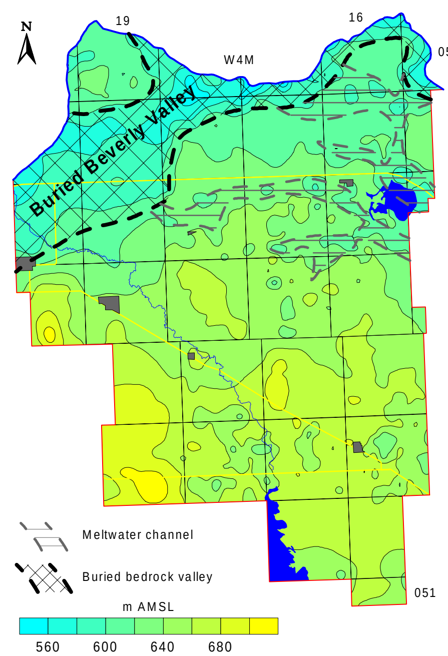

Figure 7. Bedrock Topography

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11 See glossary
12 See glossary

The upper surficial deposits are either directly or indirectly a result of glacial activity. The deposits include clay and till, and sand and gravel deposits of meltwater origin. The thickness of the upper surficial deposits is mainly less than 20 metres.

Sand and gravel deposits can occur throughout the entire unconsolidated section. The combined thickness of all sand and gravel deposits has been determined as a function of the total thickness of the surficial deposits. Over approximately 25% of the County, the sand and gravel deposits are more than 50% of the total thickness of the surficial deposits. These areas are associated with buried bedrock lows and meltwater channels.

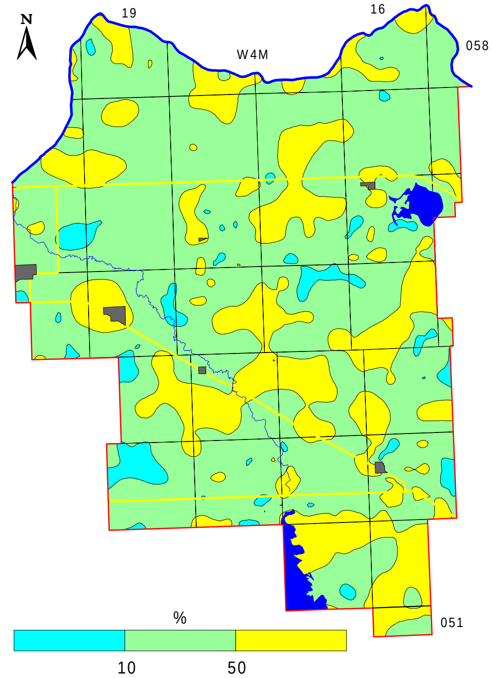

Figure 8. Amount of Sand and Gravel in Surficial Deposits

5.2.2 Sand and Gravel Aquifer(s)

An important source of groundwater in the County is aquifers in the surficial deposits. The particular aquifer used is in a large part dictated by the aquifers present.

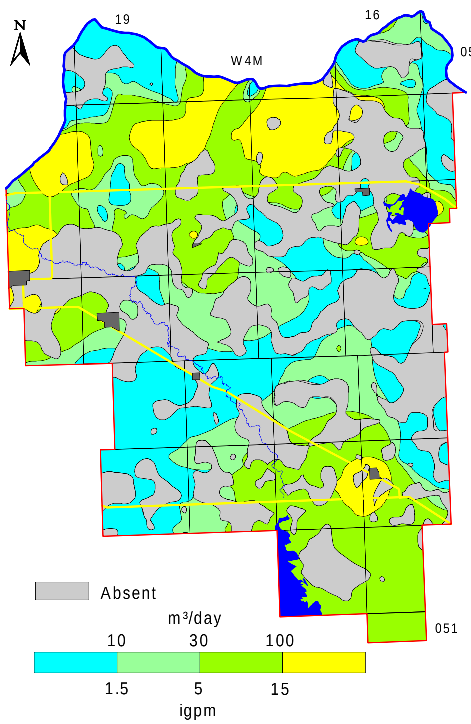

Figure 9. Apparent Yield for Water Wells Completed in Sand and Gravel Aquifer(s)

The adjacent map shows the water well yields that are expected in the County based on the aquifers that have been developed. Based on these data, water well yields of more than 100 m³/day can be expected in 20% of the County; however, water well yields of more than 30 m³/day would be considered exceptional. The higher values for water well yields are more frequently located in the northern part of the County, where the general trend of the Buried Beverly Valley can be seen. The higher yields near the Town of Mundare could be associated with meltwater channels.

A detailed study (Hydrogeological Consultants Ltd., 1976) conducted for the Village of Bruderheim determined that a water supply well located within the Buried Beverly Valley in township 056, range 21, W4M had a long-term yield of more than 1,000 m³/day.

5.2.2.1 Chemical Quality of Groundwater from Surficial Deposits

The chemical analysis results of groundwaters from the surficial deposits have not been differentiated based on aquifers in the upper or lower surficial deposits. The main reason for not separating the chemical analysis results into the different aquifers is the lack of control. The majority of the chemical analysis results are not associated with water wells that have water well drilling reports. Consequently, it is not known from which aquifer the water sample has been obtained. However, all available chemical analysis results have been used; otherwise, only 15% of the available chemical analyses could be used.

The other justification for not separating the analyses was that there appeared to be no major chemical difference between groundwater from the upper and lower sand and gravel aquifers. The groundwaters from these aquifers are generally chemically hard and high in dissolved iron.

The groundwaters from the surficial deposits are mainly calcium-magnesium-bicarbonate-type waters with 30% of the total dissolved solids less than 1,000 mg/L. All of the groundwaters from the surficial deposits are expected to have concentrations of dissolved iron of greater than 1 mg/L.

The groundwater from a water supply well for the Village of Bruderheim (Hydrogeological Consultants Ltd., 1976) had a TDS concentration of more than 1,000 mg/L and an iron concentration of more than 7 mg/L.

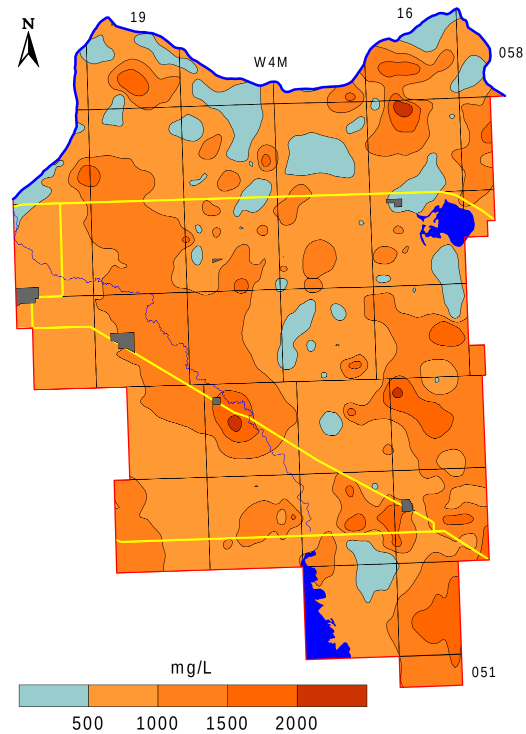

Figure 10. Total Dissolved Solids in Groundwater from Surficial Deposits

Even though the majority of the groundwaters are calcium-magnesium-bicarbonate-type waters, there are groundwaters with sodium as the main cation and there are also groundwaters with significant concentrations of the sulfate ion. The groundwaters with elevated levels of sulfate occur in areas of elevated levels of total dissolved solids. There are very few groundwaters with appreciable concentrations of the chloride ion and in most of the County the chloride ion concentration is less than 100 mg/L.

5.3 Bedrock Aquifers

5.3.1 Geological Characteristics of the Bedrock

The upper bedrock in the County includes the Bearpaw Formation and part of the Belly River Group.

The Bearpaw Formation is the upper bedrock in the southwest portion of the County but has been eroded in two-thirds of the County. The Bearpaw Formation is generally less than 100 metres thick. “The Bearpaw Formation consists of marine shale, siltstone and minor sandstone, and represents the final widespread marine unit in the Western Canada Foreland Basin” (Catuneanu et al, 1997).

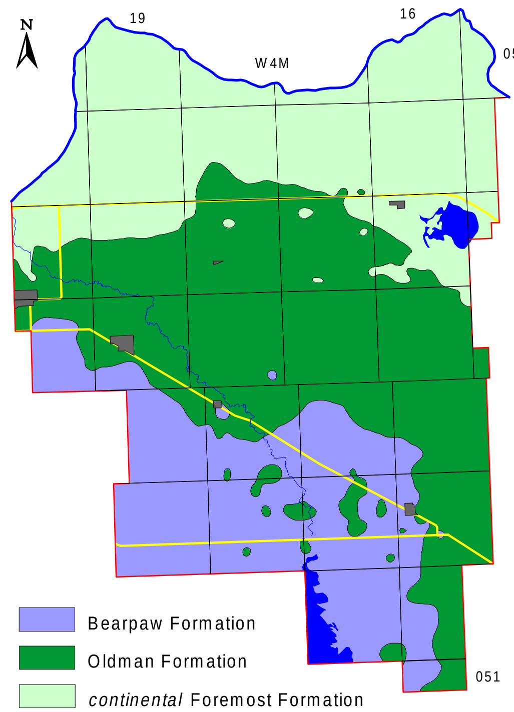

Figure 11. Bedrock Geology

The Belly River Group in the area of the County has a maximum thickness of nearly 250 metres and includes the Oldman Formation, and both the *continental* and *marine* facies of the Foremost Formation.

The Oldman Formation is the upper bedrock throughout the central portion of the County. It also subcrops in a few areas to the north and south. The Oldman Formation has a maximum thickness of up to 75 metres and is composed of continental deposits, sandstone, siltstone, shale and coal. The Oldman Formation is the upper part of the Belly River Group and is composed of three parts: the Comrey Member, the Upper Siltstone and the Dinosaur Member. The uppermost part of the Dinosaur Member is the Lethbridge Coal Zone. Sandstone is predominantly present in the Comrey Member, siltstone is the predominant bedrock unit in the Upper Siltstone, and shale and coal are predominantly deposited in the Dinosaur Member.

The *continental* Foremost Formation has been eroded in the southern two-thirds of the County and subcrops in the northern third of the County. The *continental* Foremost Formation, a backshore deposit, consists mainly of shale deposits with minor amounts of sandstone present. Coal zones occur within the *continental* Foremost Formation with the main ones referred to as the McKay and the Taber Coal zones. There are also minor amounts of ironstone, a chemical deposit. In most of the County, the *continental* Foremost Formation is close to the bedrock surface, has been fractured or weathered and can be a significant aquifer. Underlying the *continental* Foremost Formation is the *marine* Foremost Formation, which includes five sandstone members, and has a maximum thickness of less than 50 metres.

The sandstone members thicken toward the western edge of the *marine* Foremost Formation and distinguishing between the individual members is blurred. This condition is evident along the boundary between the *continental* and *marine* facies of the Foremost Formation. Because of the presence of a significant sandstone unit having high permeabilities, this interval has been designated the Milan Aquifer. The Milan Aquifer includes the lower 10 metres of the *continental* Foremost Formation and up to 40 metres of the *marine* Foremost Formation

The Lea Park Formation underlies the Foremost Formation and is mostly composed of shale with only minor amounts of bentonitic sandstone. Generally, the Lea Park Formation is an aquitard.

5.3.2 Aquifers

In general, the upper bedrock aquifer(s) in the County of Lamont can be expected to yield only limited quantities of groundwater. The adjacent map shows the water well yields that are expected in the County based on the upper bedrock aquifer(s) that have been developed. Approximately 40% of the water wells completed in upper bedrock aquifer(s) have apparent yields of more than 10 m³/day.

The producing water wells mainly occur within the area underlain by either the Oldman Formation or the *continental* Foremost Formation. Some of the bedrock water wells are completed in areas where the Bearpaw is indicated as being the upper bedrock.

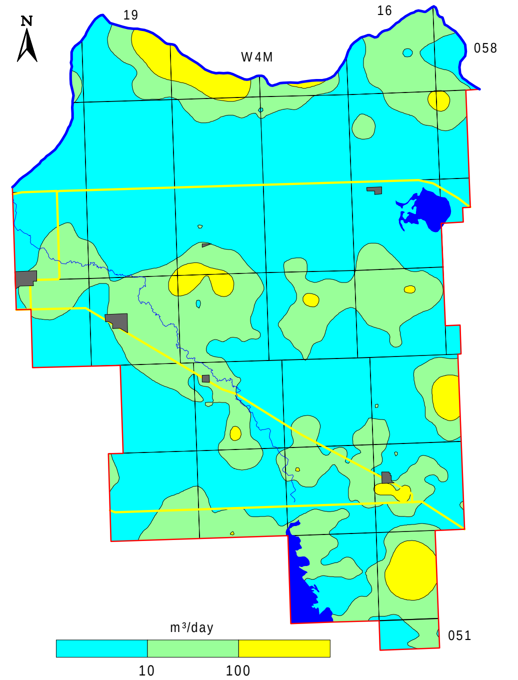

Figure 12. Apparent Yield for Water Wells Completed in Upper Bedrock Aquifer(s)

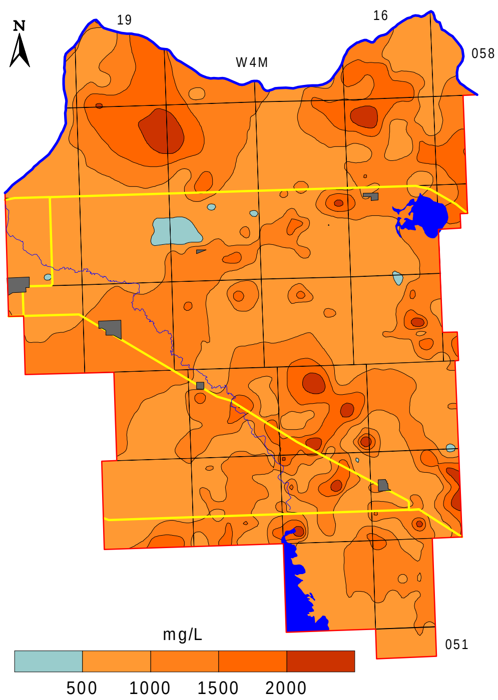

Figure 13. Total Dissolved Solids in Groundwater from Upper Bedrock Aquifer(s)

5.3.3 Chemical Quality of Groundwater

The TDS concentrations in the groundwaters from the upper bedrock aquifer(s) range from less than 500 to more than 2,000 mg/L. In more than 50% of the area, TDS values range from 1,000 to 1,500 mg/L.

A relationship between TDS and sulfate concentrations shows that when TDS values in the upper bedrock aquifer(s) exceed 1,200 mg/L, the sulfate concentrations exceed 400 mg/L.

The Piper tri-linear diagrams show that all chemical types of groundwater occur in the bedrock aquifers. However, the majority of the groundwaters are a sodium-bicarbonate type.

5.3.4 Bearpaw Aquifer

The Bearpaw Aquifer comprises the porous and permeable parts of the Bearpaw Formation that underlies the southwestern one-third of the County. The thickness of the Bearpaw Formation is generally less than 100 metres; in two-thirds of the County, the Bearpaw Formation has been eroded.

5.3.4.1 Depth to Top

The depth to the top of the Bearpaw Formation is mainly less than 20 metres. The largest area where the top of the Bearpaw Formation is more than 40 metres below ground level is in the southwestern part of the County, south of Beaverhill Creek.

5.3.4.2 Apparent Yield

The projected long-term yields for individual water wells completed in the Bearpaw Aquifer are mainly less than 10 m³/day. The higher yields in the southwestern part of the County may correspond to the Elk Island High.

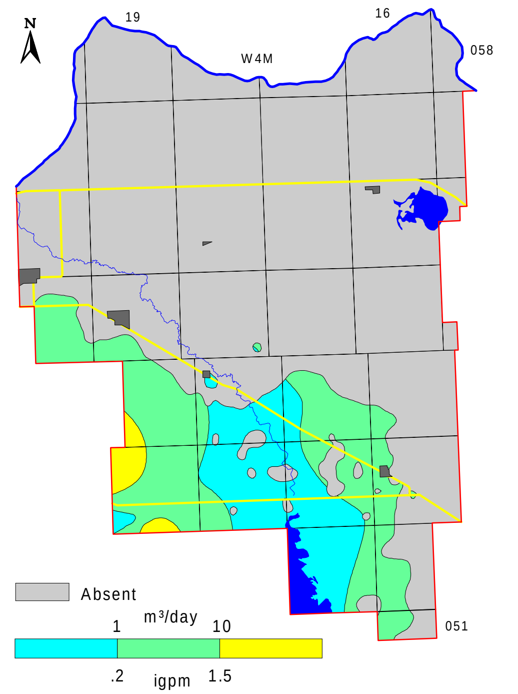

Figure 14. Apparent Yield for Water Wells Completed through Bearpaw Aquifer

5.3.4.3 Quality

The Piper tri-linear diagrams show that all chemical types of groundwater occur in the Bearpaw Aquifer. However, the majority of the groundwaters are sodium-bicarbonate or sodium-sulfate types.

The TDS concentrations range from 500 to over 2,000 mg/L in the Bearpaw Aquifer. The groundwaters with a TDS of less than 1,000 mg/L occur south of Lamont and may correspond to the Elk Island High. Groundwaters with a TDS of over 1,000 mg/L can be expected between Chipman and Mundare. When TDS values in the Bearpaw Aquifer exceed 1,800 mg/L, the sulfate concentrations exceed 400 mg/L.

The chloride concentration of the groundwaters from the Bearpaw Aquifer in some areas is expected to be more than 250 mg/L.

5.3.5 Oldman Aquifer

The Oldman Aquifer comprises the porous and permeable parts of the Oldman Formation that underlies the Bearpaw Formation and is present under the central third of the County. The thickness of the Oldman Formation ranges from 40 to 75 metres; in two-thirds of the County, the Oldman Formation has been eroded.

5.3.5.1 Depth to Top

The depth to the top of the Oldman Formation is mainly less than 20 metres and directly underlies the surficial deposits in the central part of the County. The largest area where the top of the Oldman Formation is more than 60 metres below ground level is in the southwestern part of the County.

5.3.5.2 Apparent Yield

The projected long-term yields for individual water wells completed in the Oldman Aquifer are variable and range from less than 10 m^3/day to more than 100 m^3/day. There are an equal number of yields that are less than 10 m^3/day as there are yields that are greater than 100 m^3/day.

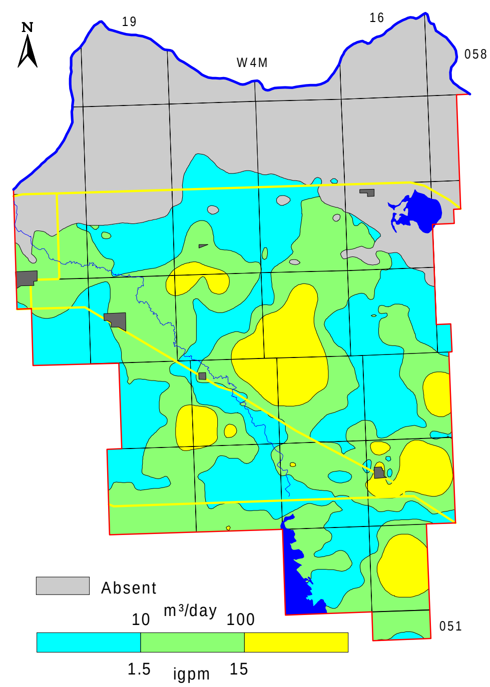

Figure 15. Apparent Yield for Water Wells Completed through Oldman Aquifer

5.3.5.3 Quality

The TDS concentrations in the groundwaters from the Oldman Aquifer range from less than 500 to more than 2,000 mg/L. There are several areas with TDS values of less than 500 mg/L. In addition, there are more areas with TDS less than 1,000 mg/L than in the groundwaters from the Bearpaw Aquifer. When TDS values in the Oldman Aquifer exceed 1,200 mg/L, the sulfate concentrations exceed 400 mg/L.

The chloride concentration of the groundwaters from the Oldman Aquifer in the southwestern part of the County can be expected to be more than 250 mg/L. In water wells completed to depths of less than 40 metres, chloride concentrations are typically less than 400 mg/L.

5.3.6 *Continental* Foremost Aquifer

The *continental* Foremost Aquifer comprises the porous and permeable parts of the *continental* Foremost Formation and subcrops under the northeastern third of the County. The thickness of the *continental* Foremost Aquifer can be up to 175 metres in the west-central part of the County.

5.3.6.1 Depth to Top

The depth to the top of the *continental* Foremost Formation is variable, ranging from less than 20 to more than 60 metres. The largest area where the top of the *continental* Foremost Formation is more than 60 metres below ground level is in the vicinity of the Towns of Bruderheim, Lamont, Chipman and Mundare.

5.3.6.2 Apparent Yield

The projected long-term yields for individual water wells completed through the *continental* Foremost Aquifer are mainly less than 1 m^3/day but can be more than 60 m^3/day. The higher yields are mainly in the northern part of the County along the North Saskatchewan River, and in the central part of the County. The higher yield areas appear to be related to channels and not to weathering or fracturing.

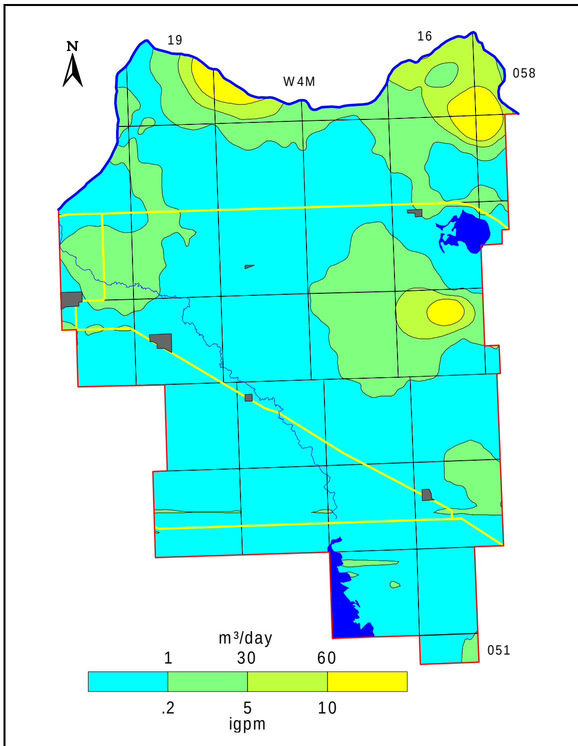

Figure 16. Apparent Yield for Water Wells Completed through continental Foremost Aquifer

5.3.6.3 Quality

The Piper tri-linear diagrams show that all chemical types of groundwater occur in the *continental* Foremost Aquifer. However, the majority of the groundwaters are sodium-bicarbonate or sodium-chloride types.

The TDS concentrations in the groundwaters from the *continental* Foremost Aquifer range from less than 1,000 to over 2,000 mg/L in the *continental* Foremost Aquifer. When TDS values exceed 1,200 mg/L, the sulfate concentrations exceed 600 mg/L. Because the groundwater quality is so variable, establishing meaningful trends based on the data is not practical.

Chloride concentrations of more than 250 mg/L can be expected in the groundwaters from the *continental* Foremost Aquifer.

Very few chemical analysis results indicate a fluoride concentration above 1.0 mg/L.

5.3.7 Milan Aquifer

The upper 40 metres of the *marine* Foremost Formation and the lower 10 metres of the *continental* Foremost Formation are classified as a separate aquifer referred to as the Milan Aquifer. The Milan Aquifer is present underlying the Bearpaw and Oldman formations in two-thirds of the County but subcrops only in a few areas along the North Saskatchewan River. However, there are approximately a dozen water wells in the County of Lamont completed in the Milan Aquifer, of which eight are located above Tp 057, W4M.

5.3.7.1 Depth to Top

The top of the Milan Aquifer underlies the northeastern two-thirds of the County, reaching depths of as much as 300 metres below ground to less than 50 metres along the North Saskatchewan River.

5.3.7.2 Apparent Yield

The projected long-term yields for individual water wells completed in the Milan Aquifer can be expected to be more than 100 m³/day.

The projected long-term yield for the Deep Water Supply Well (WSW) owned by the Town of Mundare (Hydrogeological Consultants Ltd., 1977) and completed in the Milan Aquifer was 111 m³/day (17 gpm).

5.3.7.3 Quality

The Piper tri-linear diagrams show that all chemical types of groundwater occur in the Milan Aquifer. However, the majority of the groundwaters are sodium-bicarbonate or sodium-chloride types.

The TDS concentrations in the groundwaters from the Milan Aquifer are mainly more than 2,000 mg/L. Chloride concentrations of more than 250 mg/L can be expected in the groundwaters from the Milan Aquifer. A groundwater sample was collected from the Town of Mundare Deep WSW on April 11, 1977 (Hydrogeological Consultants Ltd., 1977). The TDS concentration was 13,720 mg/L and the chloride concentration was 8,120 mg/L. Additional groundwater samples were collected from this water well during April 1977 and there was little variation in the TDS and chloride results.

There are significant quantities of groundwater available from the Milan Aquifer, but because of the poor quality, the groundwater has limited applications.

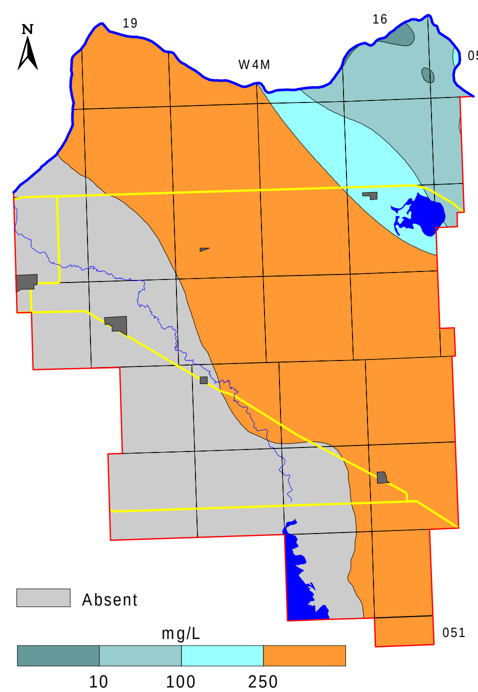

Figure 17. Chloride in Groundwater from Milan Aquifer

6 GROUNDWATER BUDGET

Estimation of the groundwater budget for the sand and gravel aquifers and the bedrock aquifers requires different methods. This is because recharge to and discharge from the bedrock aquifers is mainly through the surficial deposits while most of the recharge to and discharge from the surficial deposits is from the land surface.

6.1 Aquifers in Surficial Deposits

The groundwater in the surficial deposits is the net result of recharge to and discharge from these deposits. The recharge is mainly from precipitation, although some groundwater enters the surficial deposits from the underlying bedrock. The discharge includes losses to bedrock aquifers, discharge from springs, evapotranspiration, and discharge from water wells. The change in the quantity of groundwater in the surficial deposits is apparent from the change in the water level associated with individual aquifers within the surficial deposits.

6.1.1 Quantity of Groundwater

An estimate of the volume of groundwater stored in the sand and gravel aquifers in the surficial deposits is 0.4 to 2.5 cubic kilometres. This volume is based on an areal extent of 2,600 square kilometres and a saturated sand and gravel thickness of four metres. The variation in the total volume is based on the value of porosity that is used for the sand and gravel. One estimate of porosity is 5%, which gives the low value of the total volume. The high estimate is based on a porosity of 30% (Ozoray, Dubord and Cowen, 1990).

Because the sand and gravel deposits are mainly confined aquifers, the change in water level in the aquifer remains a function of the storativity of the aquifer rather than the porosity. The storativity values for the sand and gravel range from 8.9 x 10^{-4} to 2.2 x 10^{-4}. Based on a storativity value of 5 x 10^{-4}, and an available drawdown of 20 metres, a total volume of available groundwater from the confined aquifer is 0.03 cubic kilometres.

The groundwater in the Sand and Gravel Aquifer(s) in the Buried Beverly Valley flows in general from the southwest to the northeast toward the North Saskatchewan River Valley. Based on an average transmissivity of 50 m²/day, a gradient of 0.004, and an average valley width of ten kilometres, total estimated flow for the Buried Beverly Valley is 2,000 m³/day.

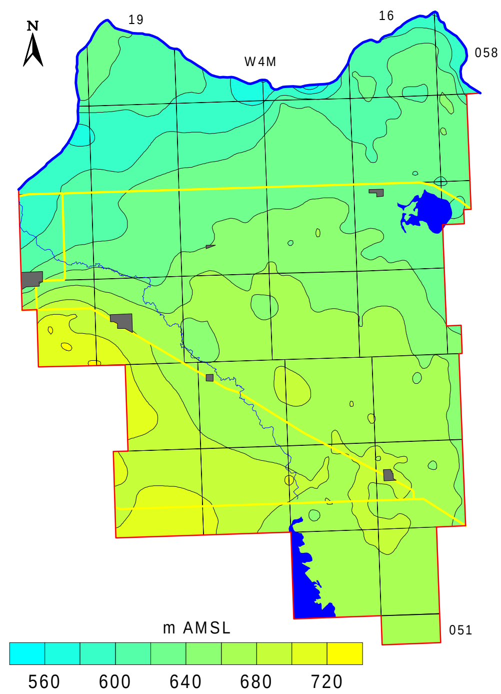

Figure 18. Non-Pumping Water-Level Surface in Surficial Deposits

Based on a gradient of 0.002, an average transmissivity for the surficial deposits of 1 m^2/day and an average aquifer width of 20 kilometres, the groundwater flow from the central part of the County toward the Buried Beverly Valley through the surficial deposits would be 400 m^3/day.

6.1.2 Recharge/Discharge

The hydraulic relationship between the groundwater in the sand and gravel aquifer and the groundwater in the bedrock aquifer is given by the non-pumping water levels associated with each of the hydraulic units. Where the water level in the surficial deposits is at a higher elevation than the water level in the bedrock aquifers, there is the opportunity for groundwater to move from the surficial deposits into the bedrock aquifers. This condition would be considered as an area of recharge to the bedrock aquifers and an area of discharge from the surficial deposits. The amount of groundwater that would move from the surficial deposits to the bedrock aquifers is directly related to the vertical permeability of the sediments separating the two aquifers.

When the hydraulic gradient is from the bedrock aquifers to the surficial deposits, the condition is a discharge area from the bedrock aquifers.

The hydraulic gradient between the surficial deposits and the bedrock aquifers has been determined by subtracting the non-pumping water levels in the surficial deposits from the non-pumping water levels in the bedrock. The bedrock recharge classification includes those areas where the water level in the surficial deposits is more than five metres above the water level in the uppermost bedrock aquifer. The area classified as a bedrock discharge area is one where the water level in the surficial deposits is more than five metres lower than the water level in the bedrock. When the water level in the surficial deposits is between five metres above and five metres below the water level in the bedrock, the area is classified as a transition area.

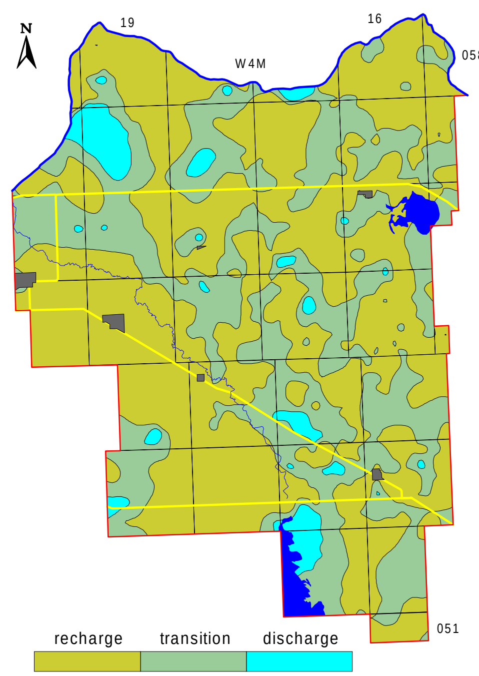

Figure 19. Recharge/Discharge Areas between Surficial Deposits and Upper Bedrock Aquifer(s)

The adjacent map shows that in more than 60% of the County there is a downward hydraulic gradient between the surficial deposits and the upper bedrock aquifer(s). The main area where there is an upward hydraulic gradient is associated with buried valleys or meltwater channels that have been incised into the bedrock. The largest areas of upward hydraulic gradient are in the Buried Beverly Valley north of the Village of Bruderheim and in the meltwater channels near the Town of Mundare. The Buried Beverly Valley area is approximately the size of four townships and in this area, groundwater from the bedrock could recharge the sand and gravel aquifers in the surficial deposits.

Because of the paucity of data, a meaningful calculation of the volumes of groundwater entering and leaving the surficial deposits is not possible.

6.2 Bedrock Aquifers

Recharge to the bedrock aquifers within the County takes place from the overlying surficial deposits. The recharge/discharge maps show that in most of the County, there is a downward hydraulic gradient from the surficial deposits to the bedrock. On a regional basis, calculating the quantity of water involved is not possible because of the complexity of the geological setting and the limited amount of data. However, because of the generally low permeability of the upper bedrock materials, the volume of water is expected to be small.

The calculation of groundwater recharge has been attempted in the four main bedrock aquifers in the County: the Bearpaw, Oldman, *continental* Foremost and the Milan Aquifers.

6.2.1 Bearpaw Aquifer Recharge

An estimate of groundwater recharge to the bedrock has been calculated in the Bearpaw Aquifer, the upper bedrock in the southwestern one-third of the County. The non-pumping water level indicates that most of the groundwater flows from the southwest to the northeast. The water-level map for the Bearpaw Aquifer shows that the hydraulic gradient is in the order of two metres per kilometre. With an average transmissivity for the Aquifer of 1 m^2/day and an Aquifer width of 40 kilometres, the flow through the Aquifer would be 80 m^3/day.

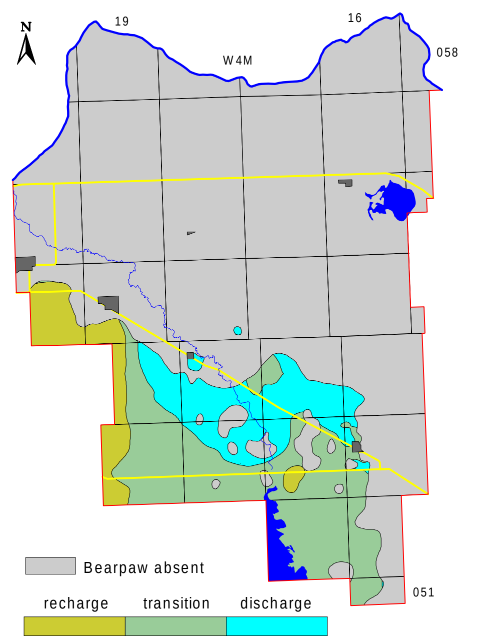

Figure 20. Recharge/Discharge Areas between Surficial Deposits and Bearpaw Aquifer

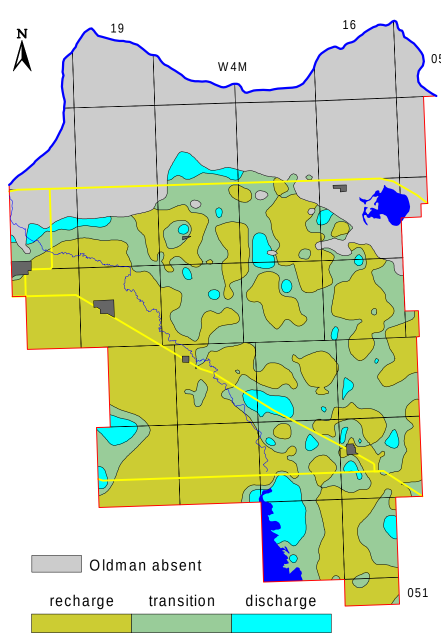

Figure 21. Recharge/Discharge Areas between Surficial Deposits and Oldman Aquifer

6.2.2 Oldman Aquifer Recharge

An estimate of groundwater recharge to the bedrock has been calculated in the Oldman Aquifer, the upper bedrock in the central part of the County. The non-pumping water level indicates that most of the groundwater flows from the south to the north and northeast. It appears that recharge is occurring within the meltwater channels of the surficial deposits. The water-level map for the Oldman Aquifer shows that the hydraulic gradient is in the order of four metres per kilometre. With an average transmissivity for the Aquifer of 5 m^2/day and an Aquifer width of 40 kilometres, the flow through the Aquifer would be 800 m^3/day.

6.2.3 *Continental* Foremost Aquifer Recharge

An estimate of groundwater recharge to the bedrock has been calculated in the *continental* Foremost Aquifer, the upper bedrock in the northeastern one-third of the County. The non-pumping water level indicates that most of the groundwater flows from the south to the north toward the Buried Beverly Valley and the North Saskatchewan River. The water-level map for the *continental* Foremost Aquifer shows that the hydraulic gradient is in the order of four metres per kilometre. With an average transmissivity for the Aquifer of 2 m²/day and an Aquifer width of 40 kilometres, the flow through the Aquifer would be 320 m³/day.

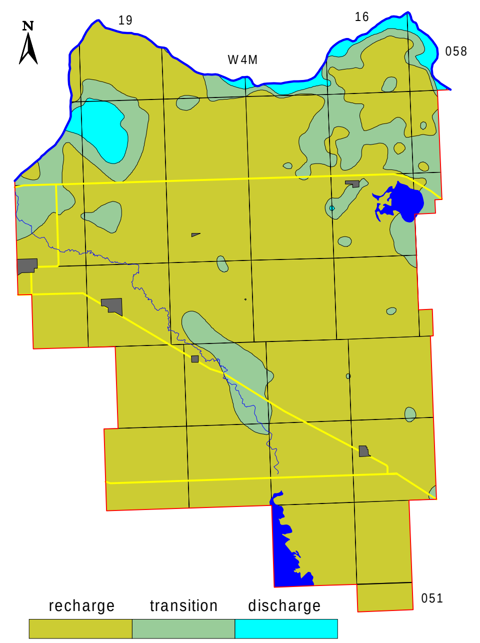

Figure 22. Recharge/Discharge Areas between Surficial Deposits and continental Foremost Aquifer

6.2.4 Milan Aquifer Recharge

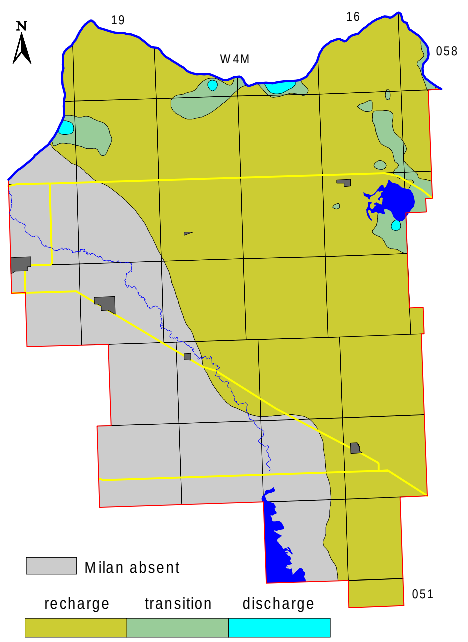

Figure 23. Recharge/Discharge Areas between Surficial Deposits and Milan Aquifer

An estimate of groundwater recharge to the bedrock has been calculated in the Milan Aquifer, the upper bedrock in a few places in the northern part of the County. The non-pumping water level indicates that most of the groundwater flows from the southeast to the northwest, in general, toward the Buried Beverly Valley. The water-level map for the Milan Aquifer shows that the hydraulic gradient is in the order of four metres per kilometre. With an average transmissivity for the Aquifer of 10 m²/day and an Aquifer width of 30 kilometres, the flow through the Aquifer would be 1,200 m³/day.

No attempt has been made to estimate the flow through any of the other bedrock aquifers.

7 POTENTIAL FOR GROUNDWATER CONTAMINATION

The most common sources of contaminants that can impact groundwater originate on or near the ground surface. The contaminant sources can include leachate from landfills, effluent from leaking lagoons or from septic fields, and petroleum products from storage tanks or pipeline breaks. The agricultural activities that generate contaminants include spreading of fertilizers, pesticides, herbicides and manure. The spreading of highway salt can also degrade groundwater quality.

When activities occur that do or can produce a liquid which could contaminate groundwater, it is prudent (from a hydrogeological point of view) to locate the activities where the risk of groundwater contamination is minimal. Alternatively, if the activities must be located in an area where groundwater can be more easily contaminated, the necessary action must be taken to minimize the risk of groundwater contamination.

The potential for groundwater contamination is based on the concept that the easier it is for a liquid contaminant to move downward, the easier it is for the groundwater to become contaminated. In areas where there is groundwater discharge, liquid contaminants cannot enter the groundwater flow systems to be distributed throughout the area. When there are groundwater recharge areas, low-permeability materials impede the movement of liquid contaminants downward. Therefore, if the soils develop on a low-permeability parent material of till or clay, the downward migration of a contaminant is slower relative to a high-permeability parent material such as sand and gravel of fluvial origin. Once a liquid contaminant enters the subsurface, the possibility for groundwater contamination increases if it coincides with a higher permeability material within one metre of the land surface.

To determine the nature of the materials on the land surface, the surficial geology map prepared by the Alberta Research Council (Shetsen, 1990) has been reclassified based on the relative permeability. The classification of materials is as follows:

1. high permeability - sand and gravel;
2. moderate permeability - silt, sand with clay, gravel with clay, and bedrock; and
3. low permeability - clay and till.

To identify the areas where sand and gravel can be expected within one metre of the ground surface, all groundwater database records with lithologies were reviewed. From a total of 1,872 records in the area of the County with lithology descriptions, 255 have sand and gravel within one metre of ground level. In the remaining 1,617 records, the first sand and gravel is deeper or not present. This information was then gridded to prepare a distribution of where the first sand and gravel deposit could be expected within one metre of ground level.

7.1.1 Risk of Contamination Map

The information from the reclassification of the surficial geology map is the basis for preparing the initial risk map. The depth to the first sand and gravel is then used to modify the initial map and to prepare the final map. The criteria used for preparing the final Risk of Groundwater Contamination map are outlined in the adjacent table.

Surface Permeability	Sand or Gravel Present To Within One Metre Of Ground Surface	Groundwater Contamination Risk
Low	No	Low
Moderate	No	Moderate
High	No	High
Low	Yes	High
Moderate	Yes	High
High	Yes	Very High

Table 2. Risk of Groundwater Contamination Criteria

The Risk of Groundwater Contamination map shows that, in 35% of the County, there is a high or very high risk of the groundwater being contaminated. These areas would be considered the least desirable ones for a development that has a product or by-product that could cause groundwater contamination. However, because the map has been prepared as part of a regional study, the designations are a guide only; detailed hydrogeological studies must be completed at any proposed development site to ensure the groundwater is protected from possible contamination. At all locations, good environmental practices should be exercised in order to ensure that groundwater contamination would not affect groundwater quality.

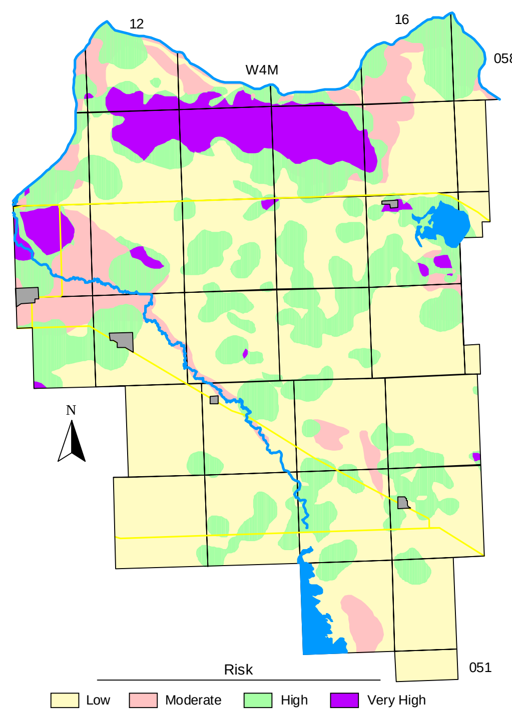

Figure 24. Risk of Groundwater Contamination

8 RECOMMENDATIONS

The present study has been based on information available from the groundwater database. The database has three problems:

1) the quality of the data;
2) the coordinate system used for the horizontal control; and
3) the distribution of the data.

The quality of the data in the groundwater database is affected by two factors: a) the technical training of the persons collecting the data, and b) the quality control of the data. The possible options to upgrade the database include the creation of a "super" database, which includes only verified data. The level of verification would have to include identifying the water well in the field, obtaining meaningful horizontal coordinates for the water well and the verification of certain parameters such as water level and completed depth. An attempt to update the quality of the entire database is not recommended.

In addition to the quality of the information in the database, there is only a limited understanding of the distribution of individual geological units, both in the bedrock and the surficial deposits. The complexity of the depositional environment and a limited amount of subsurface control exacerbate the problem of trying to develop digital surfaces. The best example of this is the indication of significant yields for water wells completed in both the Oldman Aquifer and the Milan Aquifer. This anomaly can only be explained by conducting a detailed investigation of the local conditions, for example, the meltwater channels. This would require a detailed program involving geophysical techniques and test drilling. Because of the broad nature of the condition, a study would need to be completed to better define the anomaly and provide direction for a field program.

One of the main shortages of data for the determination of a groundwater budget is water levels as a function of time. Two observation water wells are totally inadequate to obtain meaningful values for the groundwater budget. One method to obtain additional water-level data is to solicit the assistance of the water well owners who are stakeholders in the groundwater resource. In the M.D. of Rocky View, for example, water well owners are being provided with a tax credit if they accurately measure the water level in their water well once per week for a year. A pilot project indicated that approximately five years of records are required to obtain a reasonable data set. The cost of a five-year project involving 50 water wells would be less than the cost of one drilling program that may provide two or three observation water wells.

In general, for the next level of study, the database needs updating. It requires more information from existing water wells, and additional information from new ones.

Before an attempt is made to upgrade the level of interpretation provided in this report and the accompanying maps and groundwater query, it is recommended that all water wells for which water well drilling reports are available be subjected to the following actions:

1. The horizontal location of the water well should be determined within 10 metres. The coordinates must be in 10TM NAD 27 or some other system that will allow conversion to 10TM NAD 27 coordinates.

2. A four-hour aquifer test (two hours of pumping and two hours of recovery) should be performed with the water well to obtain a realistic estimate for the transmissivity of the aquifer in which the water well is completed.
3. Water samples should be collected for chemical analysis after 5 and 115 minutes of pumping, and analyzed for major and minor ions.

In addition to the data collection associated with the existing water wells, all available geophysical logs should be interpreted to establish a more accurate spatial definition of individual aquifers.

There is also a need to provide the water well drillers with feedback on the reports they are submitting to the regulatory agencies. The feedback is necessary to allow for a greater degree of uniformity in the reporting process. This is particularly true when trying to identify the bedrock surface. The water well drilling reports should be submitted to the AEP Resource Data Division in an electronic form. The money presently being spent by AEP and Prairie Farm Rehabilitation Administration (PFRA) to transpose the paper form to the electronic form should be used to allow for a technical review of the data and follow-up discussions with the drillers.

An effort should be made to form a partnership with the petroleum industry. The industry spends millions of dollars each year collecting information relative to water wells. Proper coordination of this effort could provide significantly better information from which future regional interpretations could be made. This could be accomplished by the County taking an active role in the activities associated with the construction of lease sites for the drilling of hydrocarbon wells and conducting of seismic programs.

Groundwater is a renewable resource and it must be managed.

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10 GLOSSARY

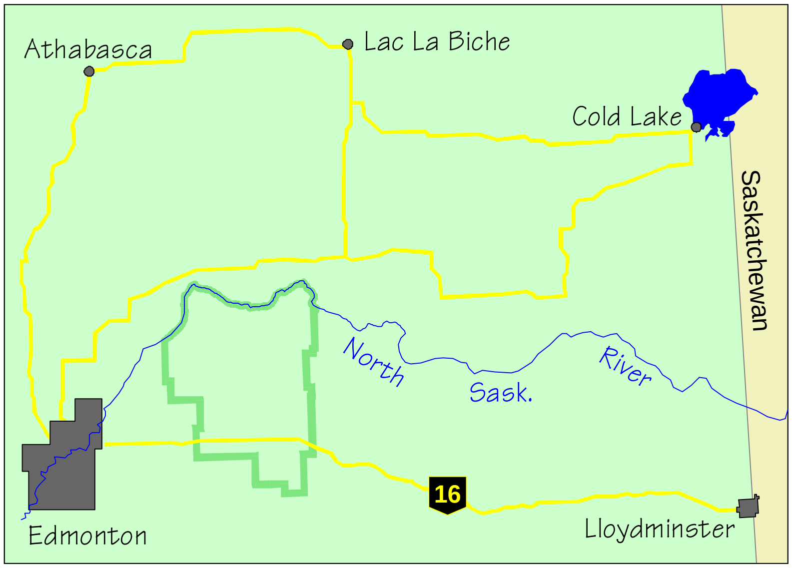
Aquifer	a formation, group of formations, or part of a formation that contains saturated permeable rocks capable of transmitting groundwater to water wells or springs in economical quantities.
Aquitard	a confining bed that retards but does not prevent the flow of water to or from an adjacent aquifer.
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.
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.
Kriging	a geo-statistical method for gridding irregularly-spaced data.
Lacustrine	fine-grained sedimentary deposits associated with a lake environment and not including shore-line deposits.
Surficial Deposits	includes all sediments above the bedrock.
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.
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.

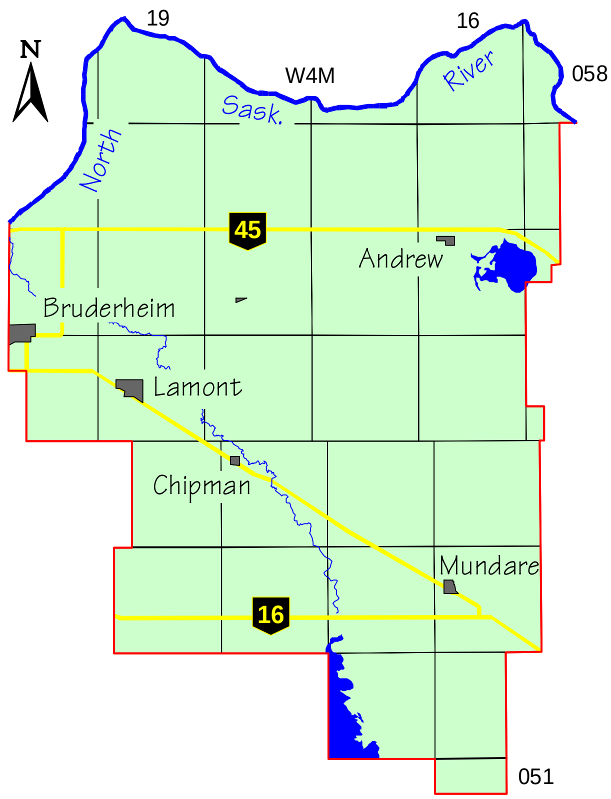
COUNTY OF LAMONT NO. 30

Appendix A

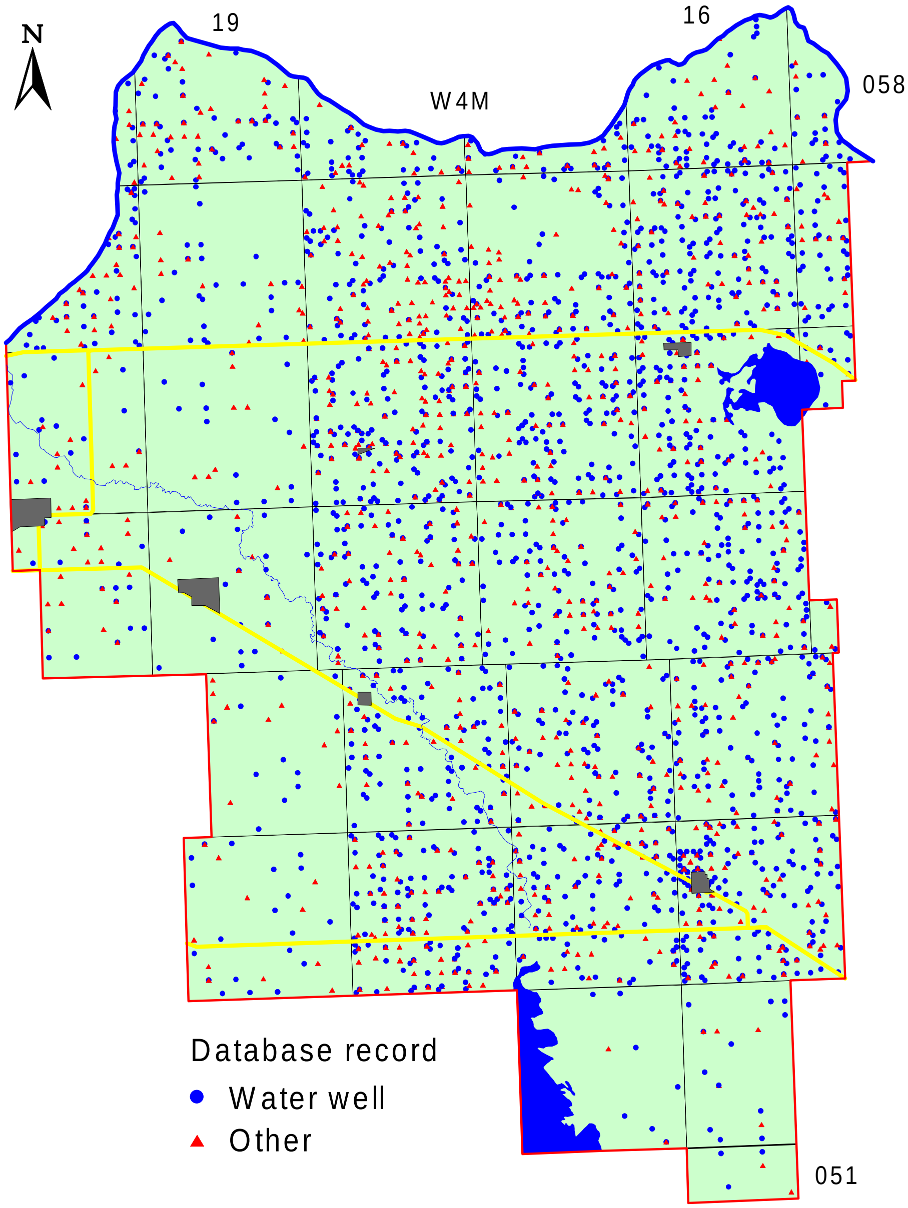
HYDROGEOLOGICAL MAPS AND FIGURES

Index Map

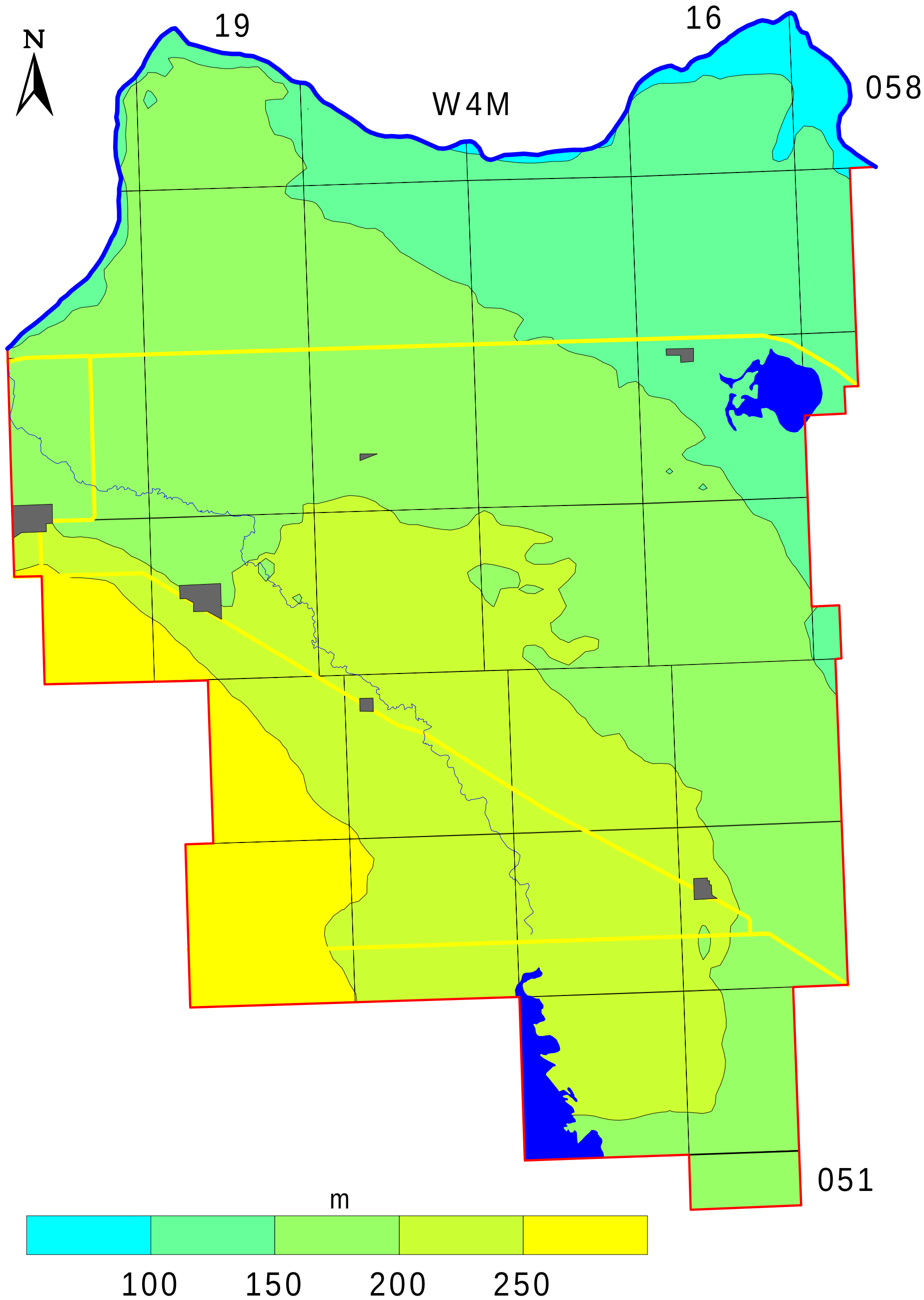

Athabasca
Lac La Biche
Cold Lake
Saskatchewan
North
Sask.
River
16
Edmonton
Lloydminster

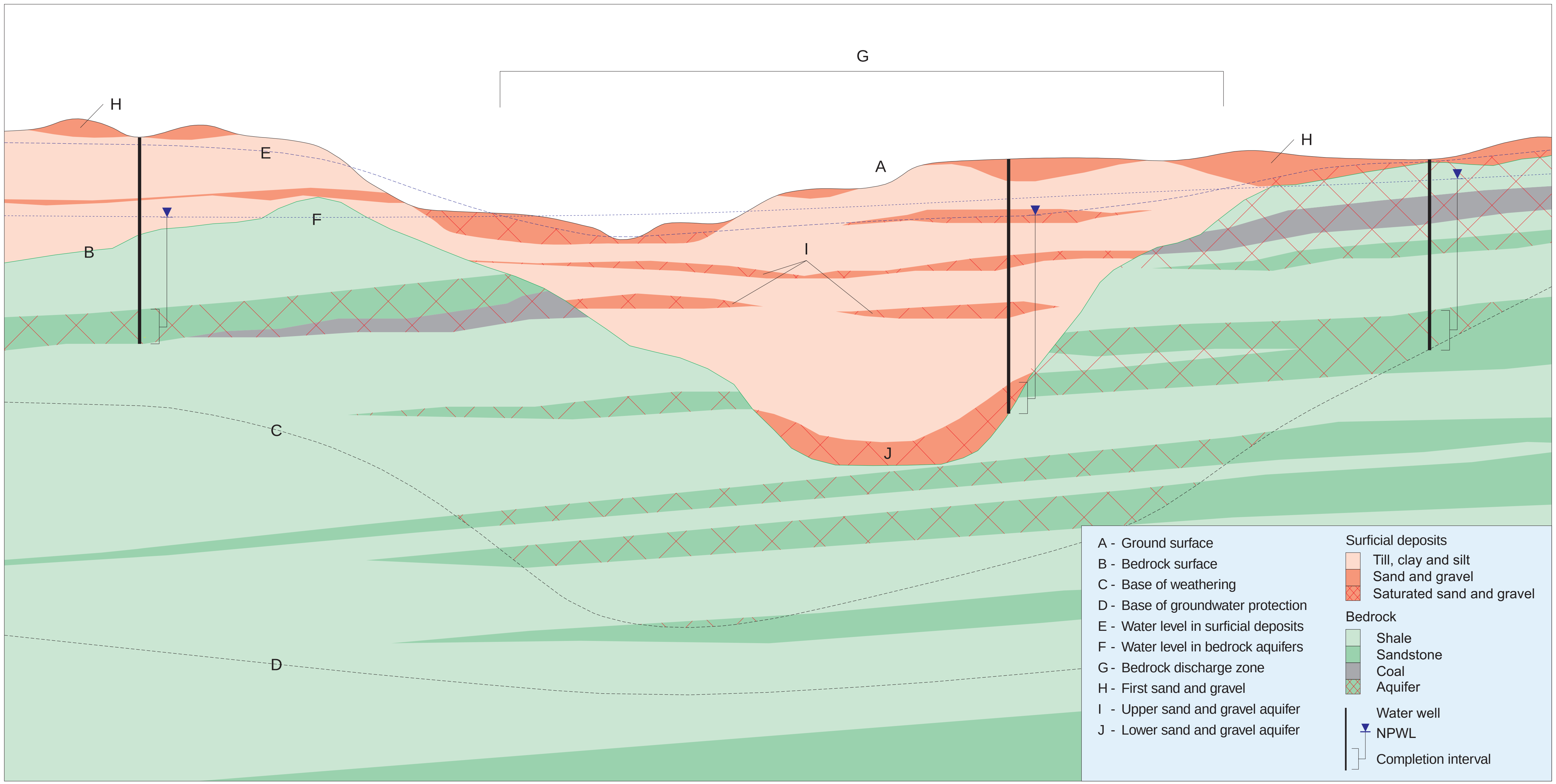

N
19
16
W4M
058
Sask.
River
North
45
Andrew
Bruderheim
Lamont
Chipman
Mundare
16
051

Location of Water Wells



Depth to Base of Groundwater Protection





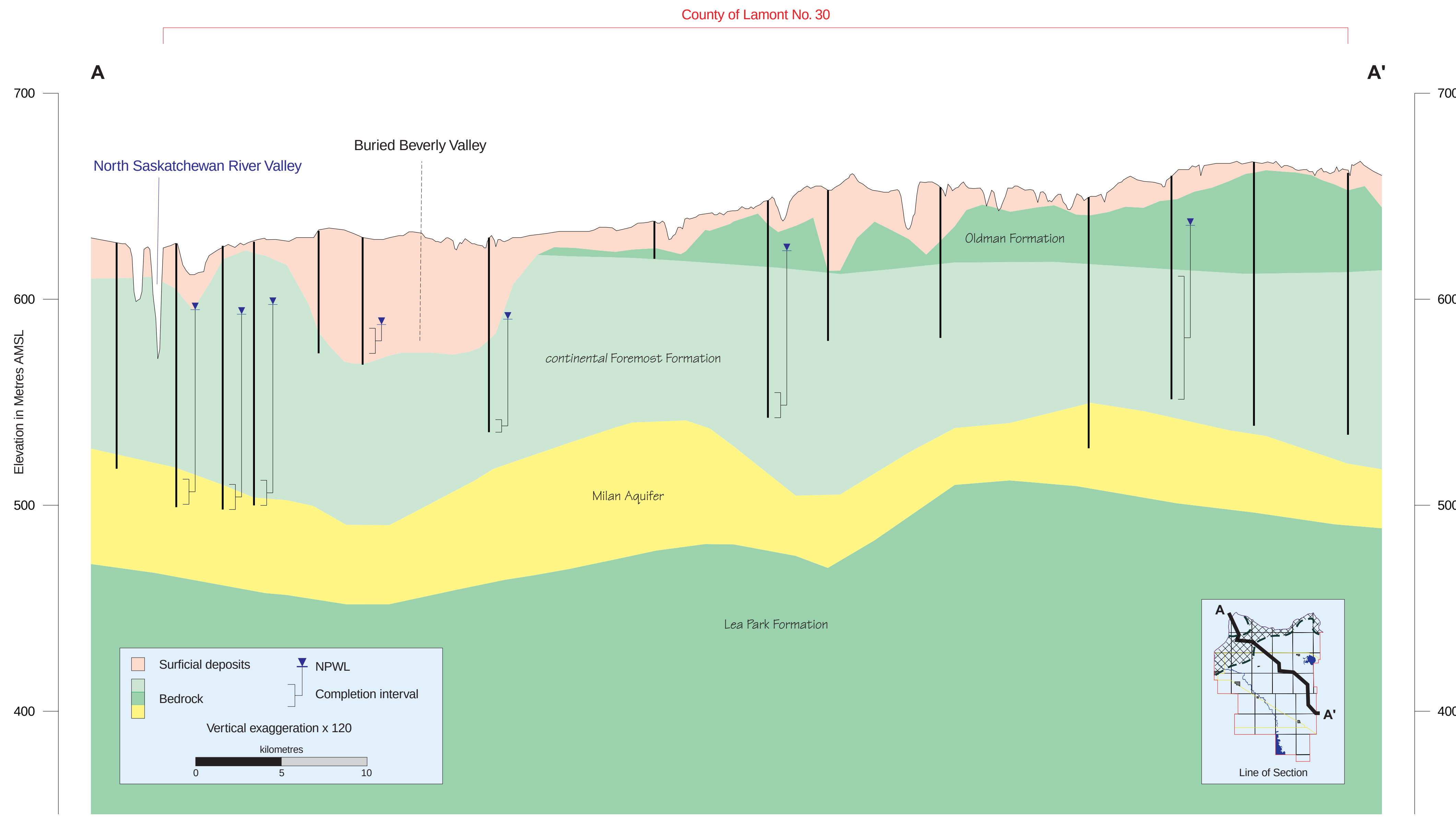
Generalized Cross-Section

(For terminology only)

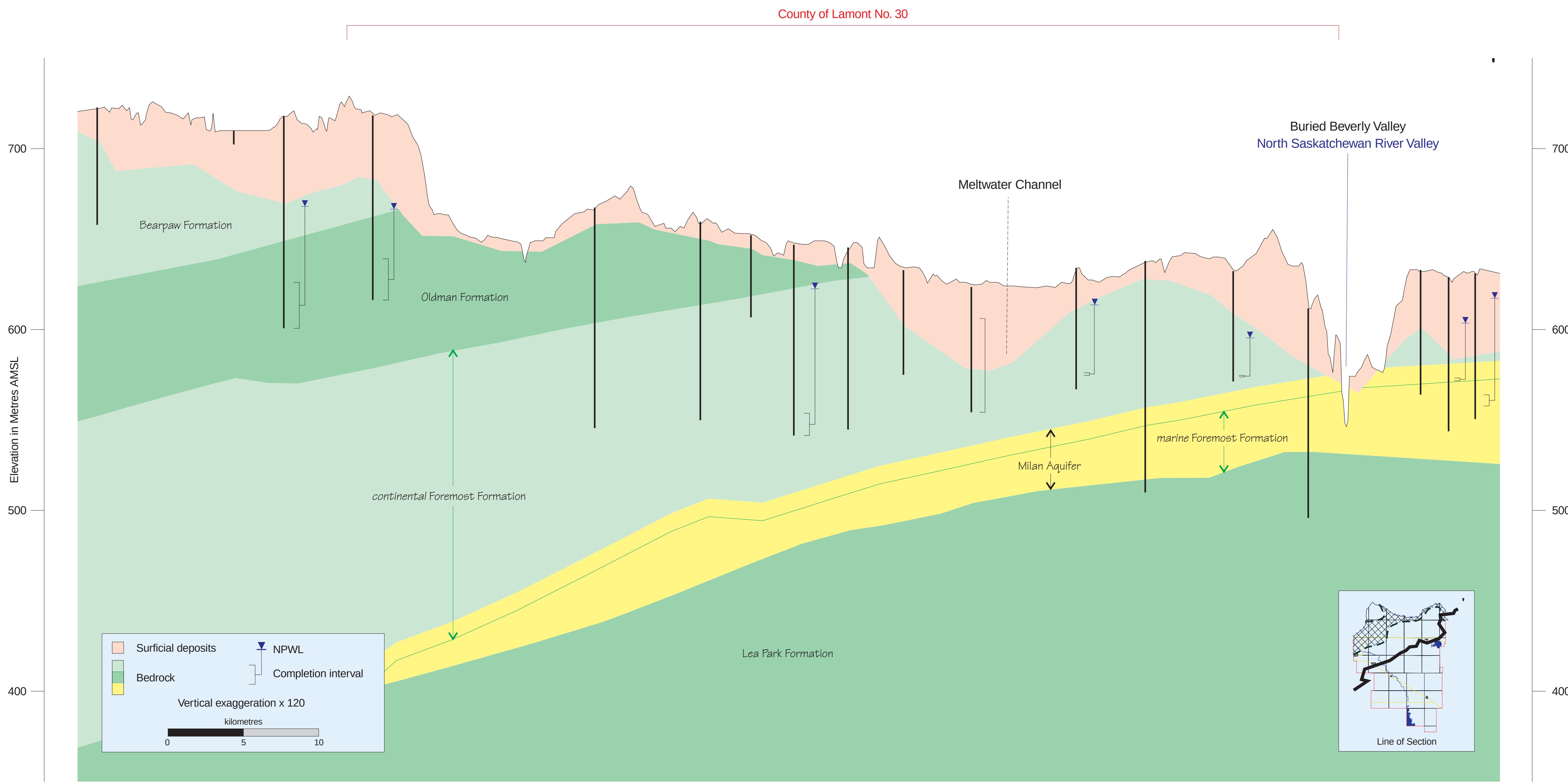
Depth (m): 0, 100, 200, 300, 400, 500, 600

Lithologic Description	Group and Formation: Thickness (m)	Group	Group and Formation: Designation	Member: Thickness (m)	Member: Designation	Zone: Thickness (m)	Zone: Designation
sand, gravel, till, clay, silt	<80		Surficial Deposits	<80	Upper	<30	First Sand and Gravel
				<80	Lower		
sandstone, siltstone, shale, coal	40-80	Belly River Group	Oldman Formation	<30	Dinosaur Member	<25	Lethbridge Coal Zone
				<20	Upper Siltstone Member		
				8-20	Comrey Member		
shale, sandstone, coal	10-220		*continental* Foremost Formation			<20	Taber Coal Zone
						<20	McKay Coal Zone
sandstone, shale	<200		*marine* Foremost Formation (Basal Belly River Sandstone)	<30	Birch Lake Member		Milan Aquifer
				<30	Ribstone Creek Member		
				<30	Victoria Member		
				<30	Brosseau Member		
shale, siltstone	100-200		Lea Park Formation	50-100	Upper		
				50-100	Lower		

Geologic Column

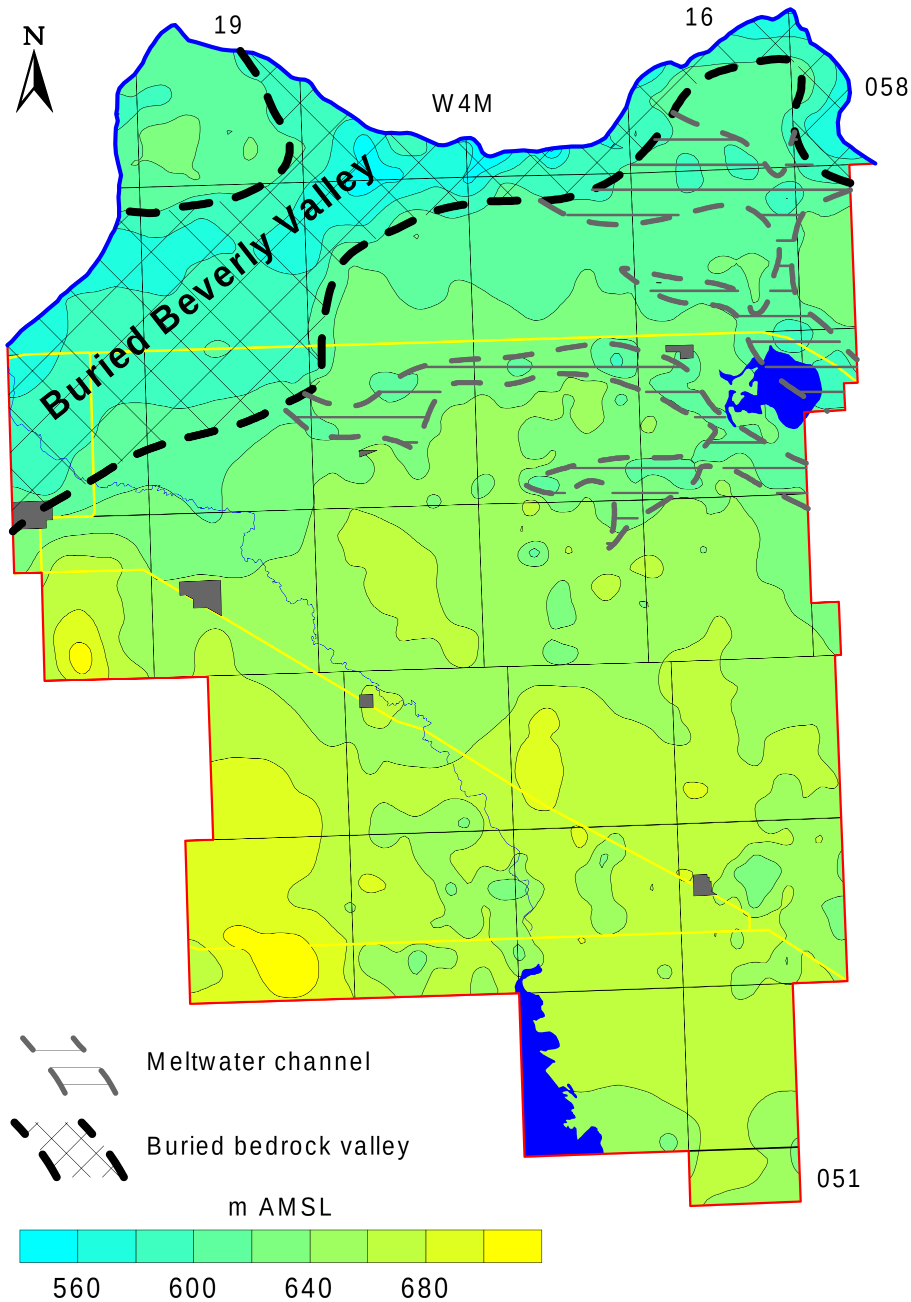


Cross-Section A - A'

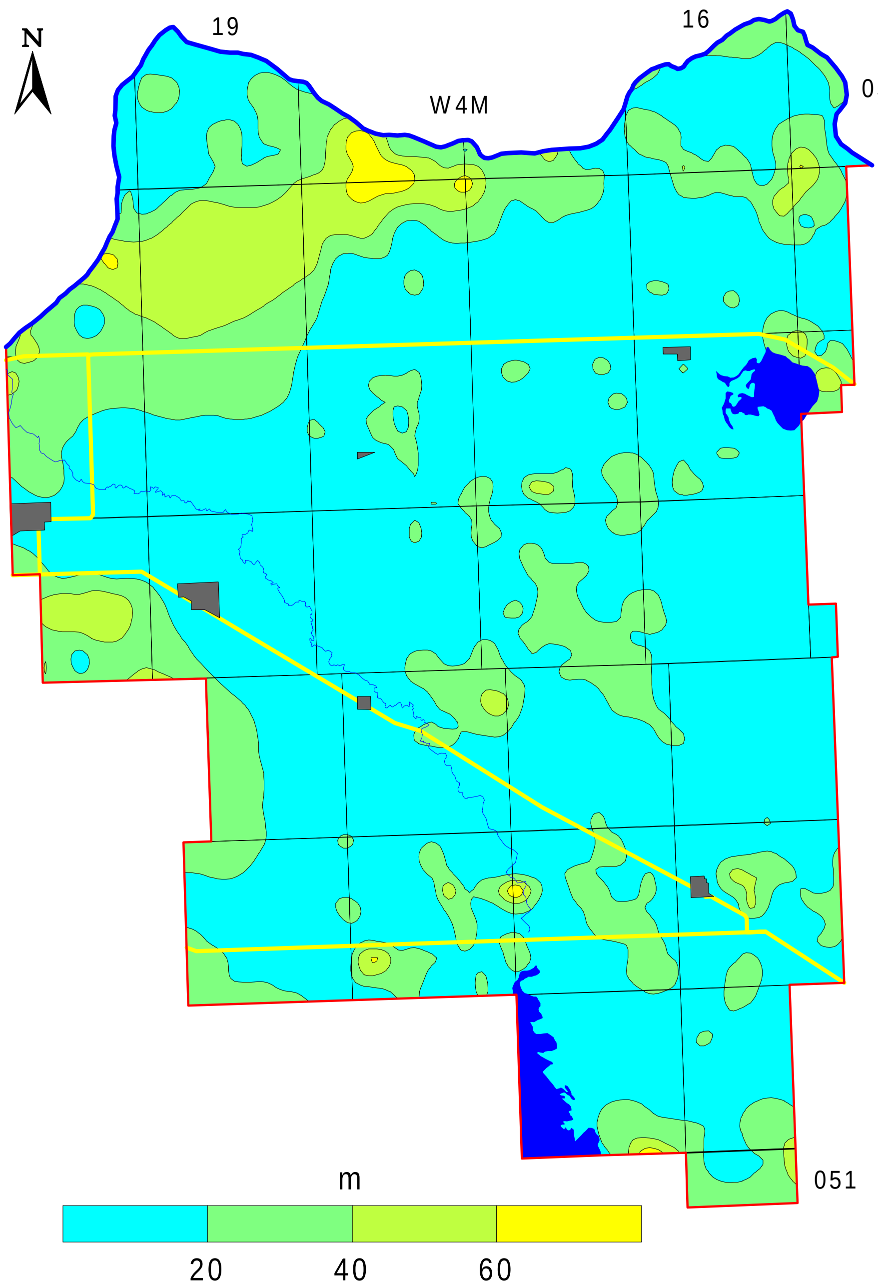


Cross-Section B - B'

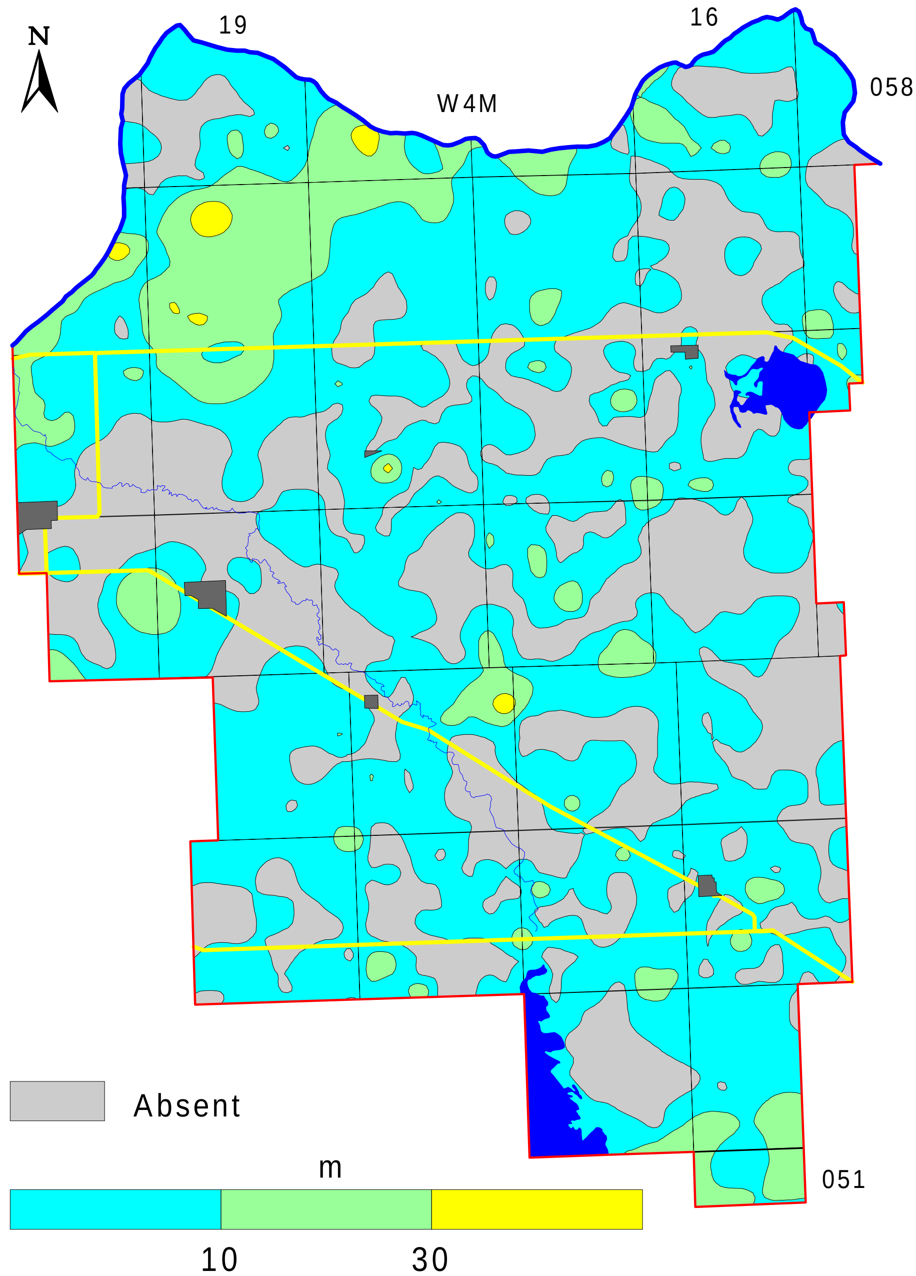
Bedrock Topography



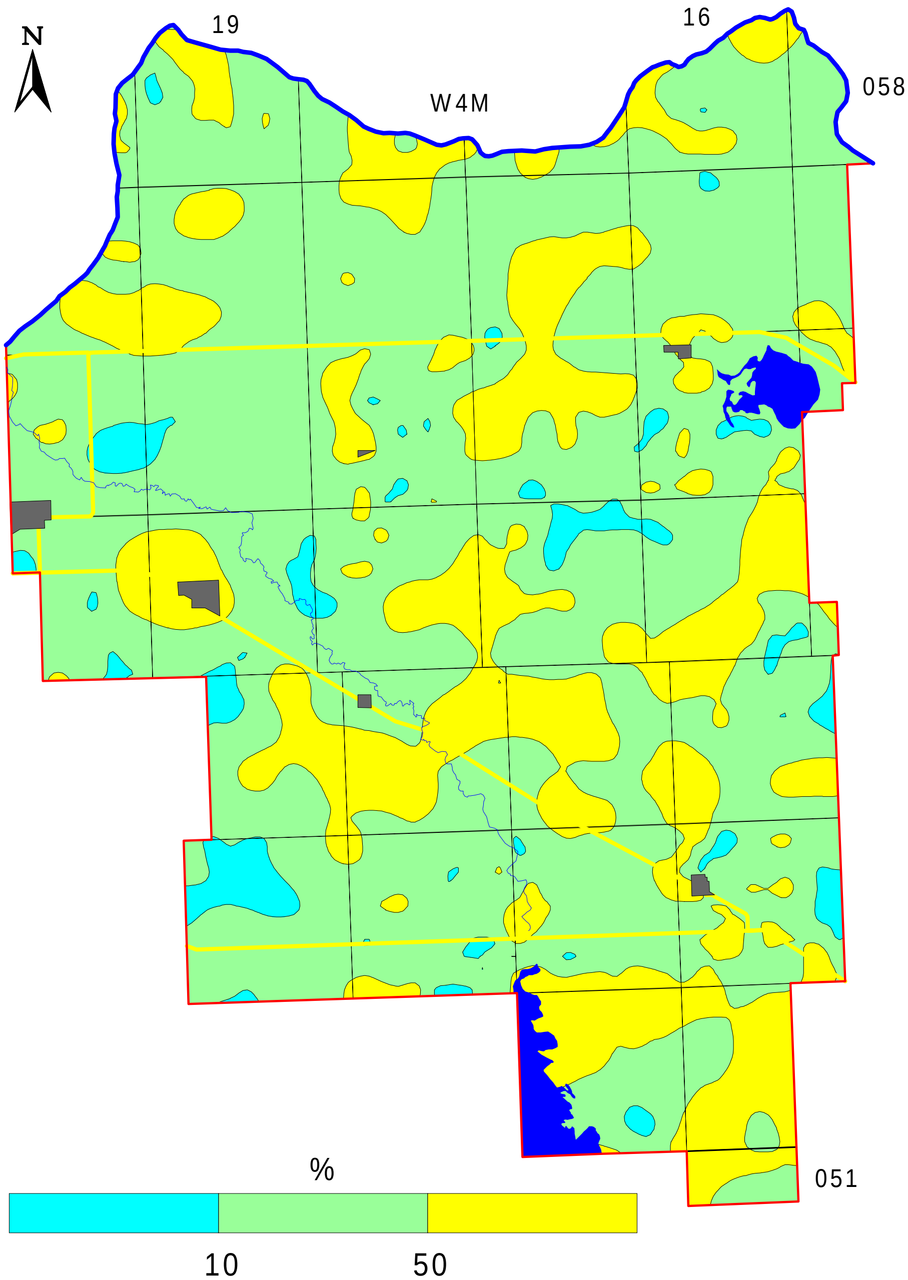
Thickness of Surficial Deposits



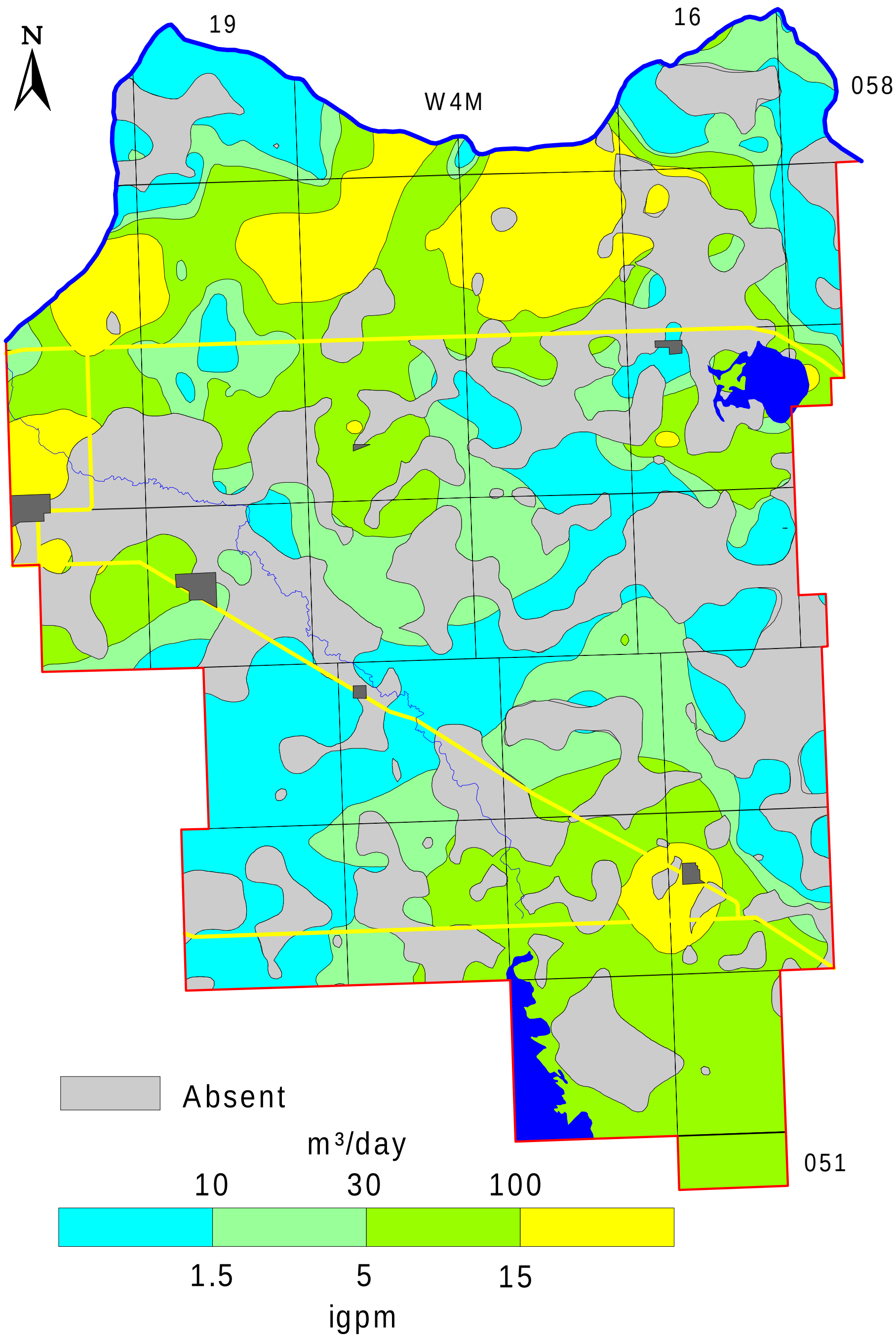
Thickness of Sand and Gravel Aquifer(s)



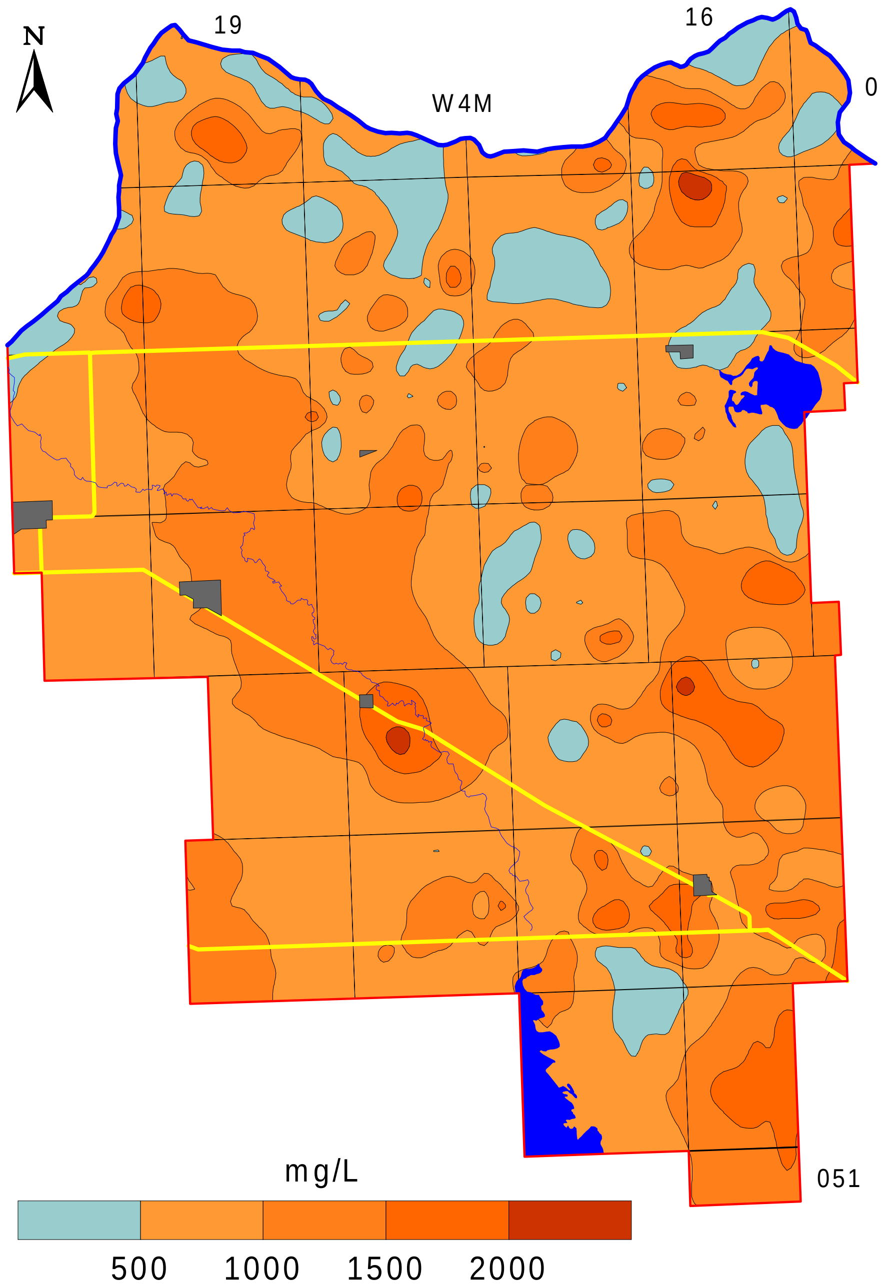
Amount of Sand and Gravel in Surficial Deposits



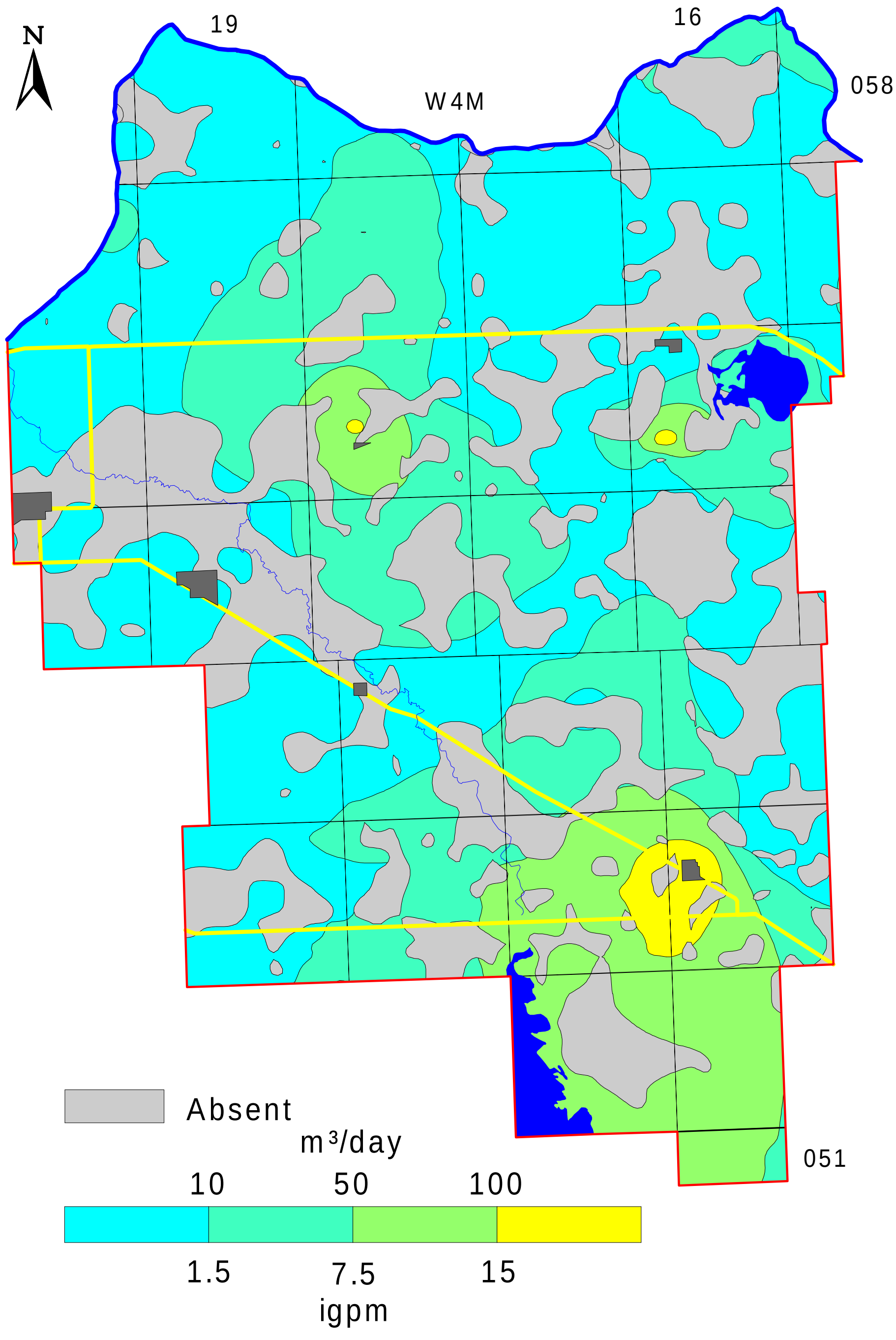
Apparent Yield for Water Wells Completed in Sand and Gravel Aquifer(s)



Total Dissolved Solids in Groundwater from Surficial Deposits



Apparent Yield for Water Wells Completed through Upper Sand and Gravel Aquifer



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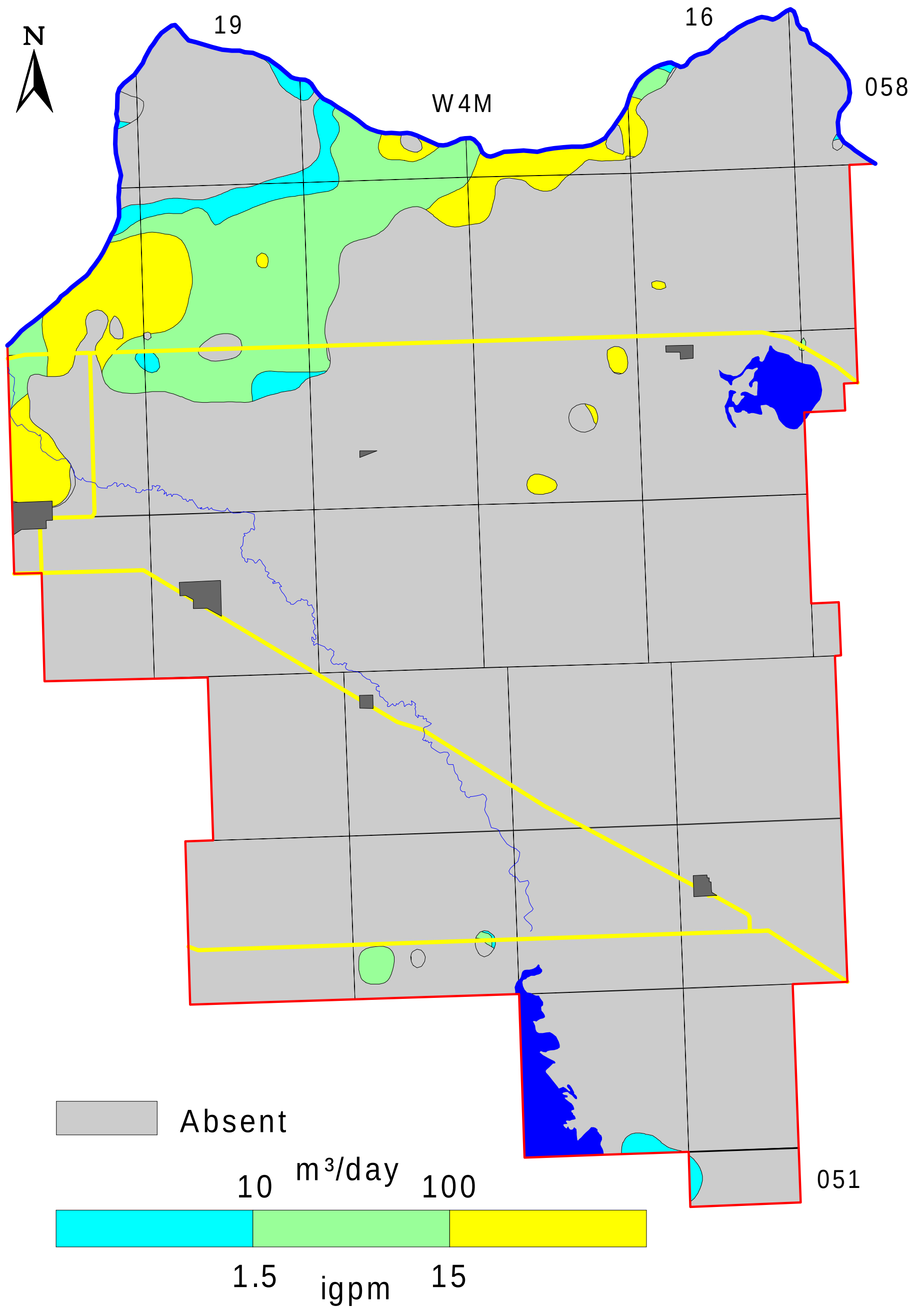
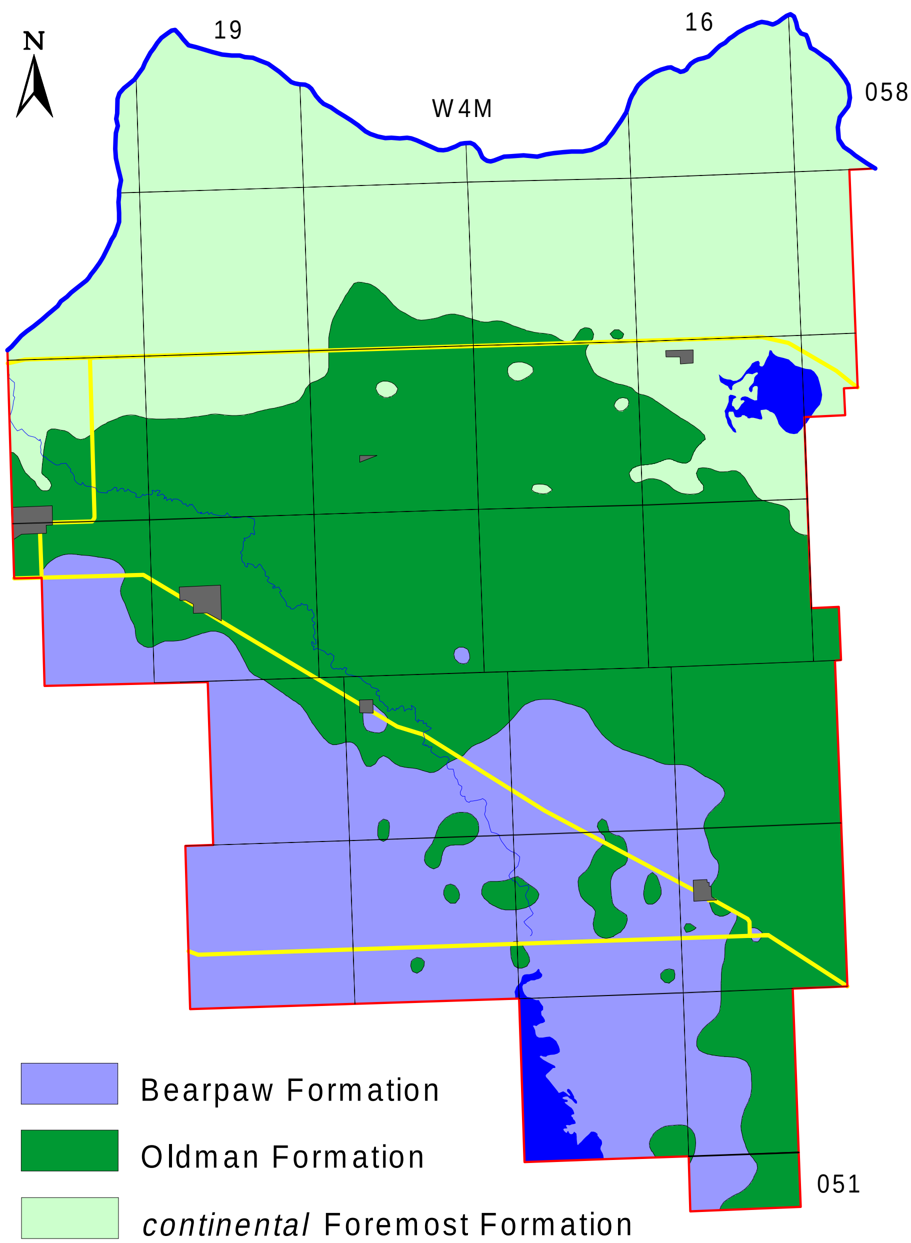
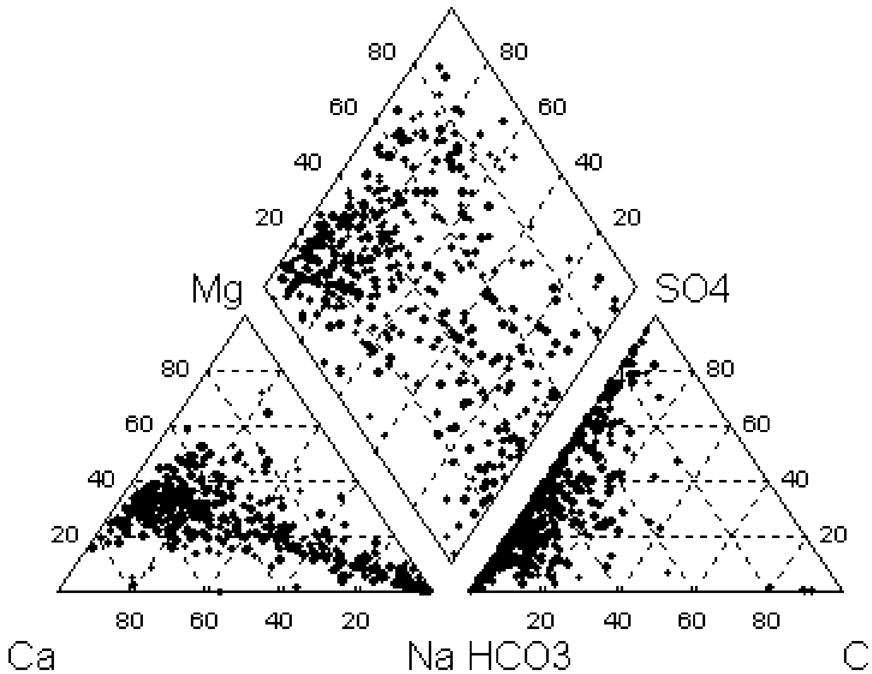


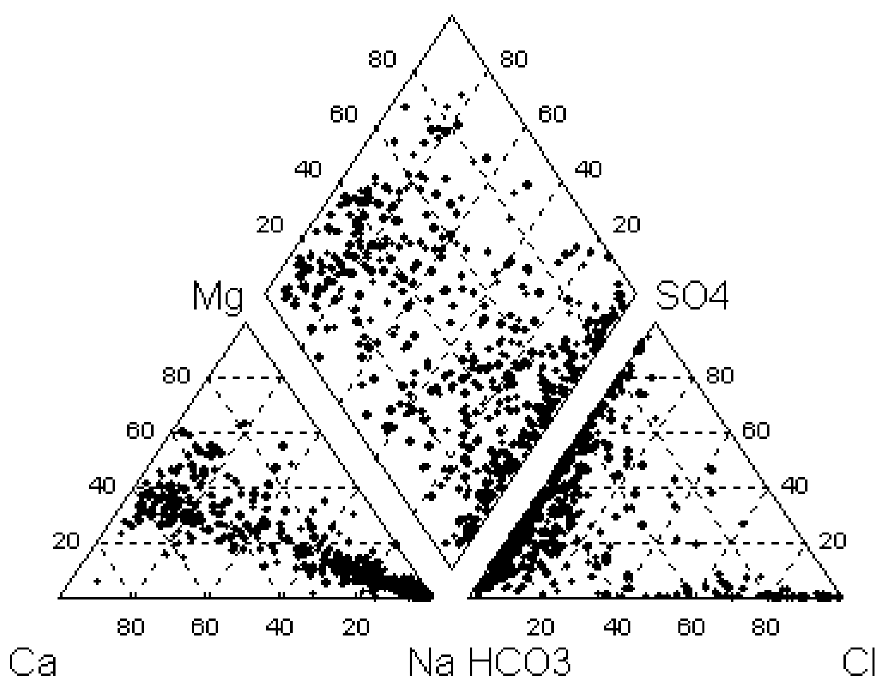
Bedrock Geology



Piper Diagrams

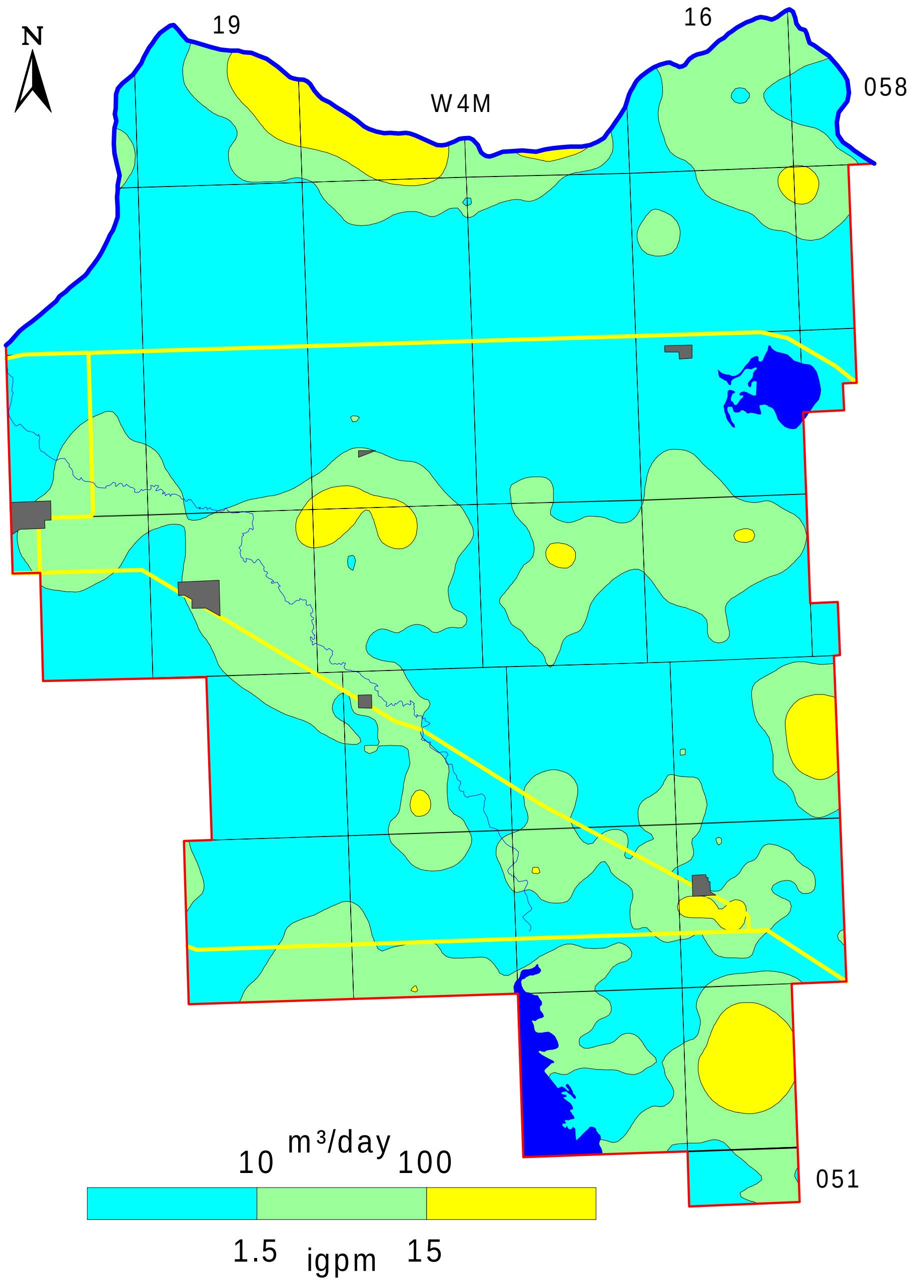


Surficial Deposits

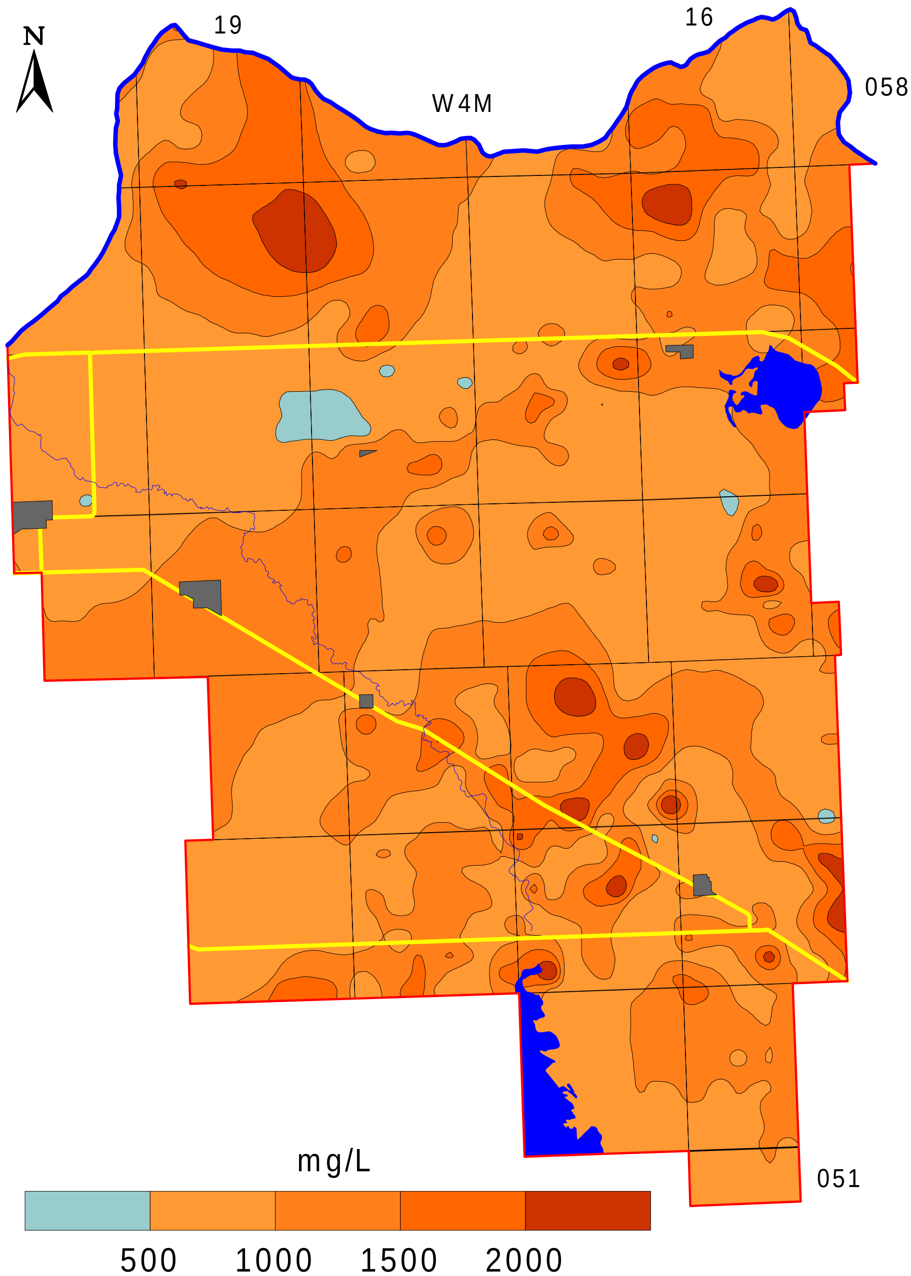


Bedrock Aquifers

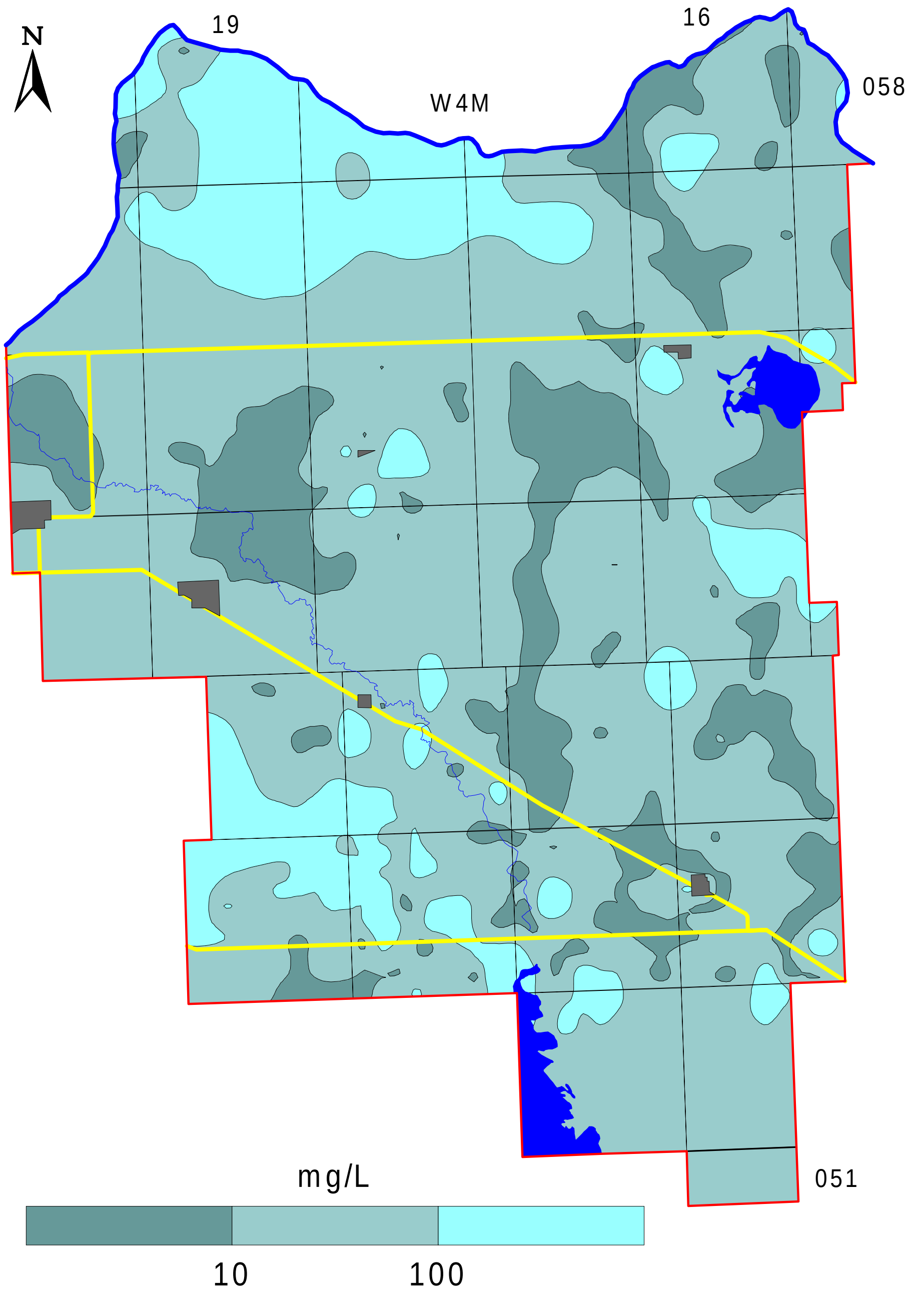
Apparent Yield for Water Wells Completed in Upper Bedrock Aquifer(s)



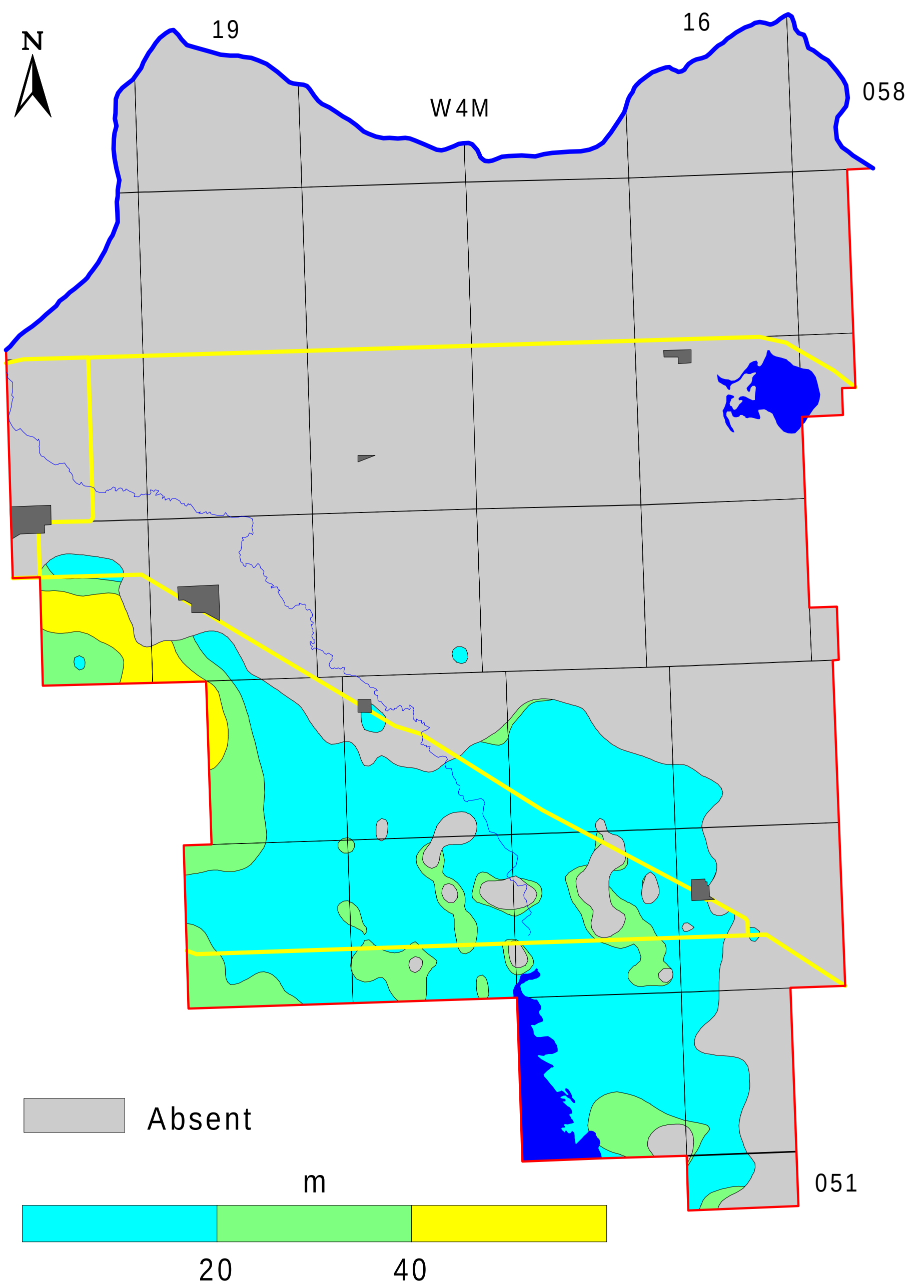
Total Dissolved Solids in Groundwater from Upper Bedrock Aquifer(s)



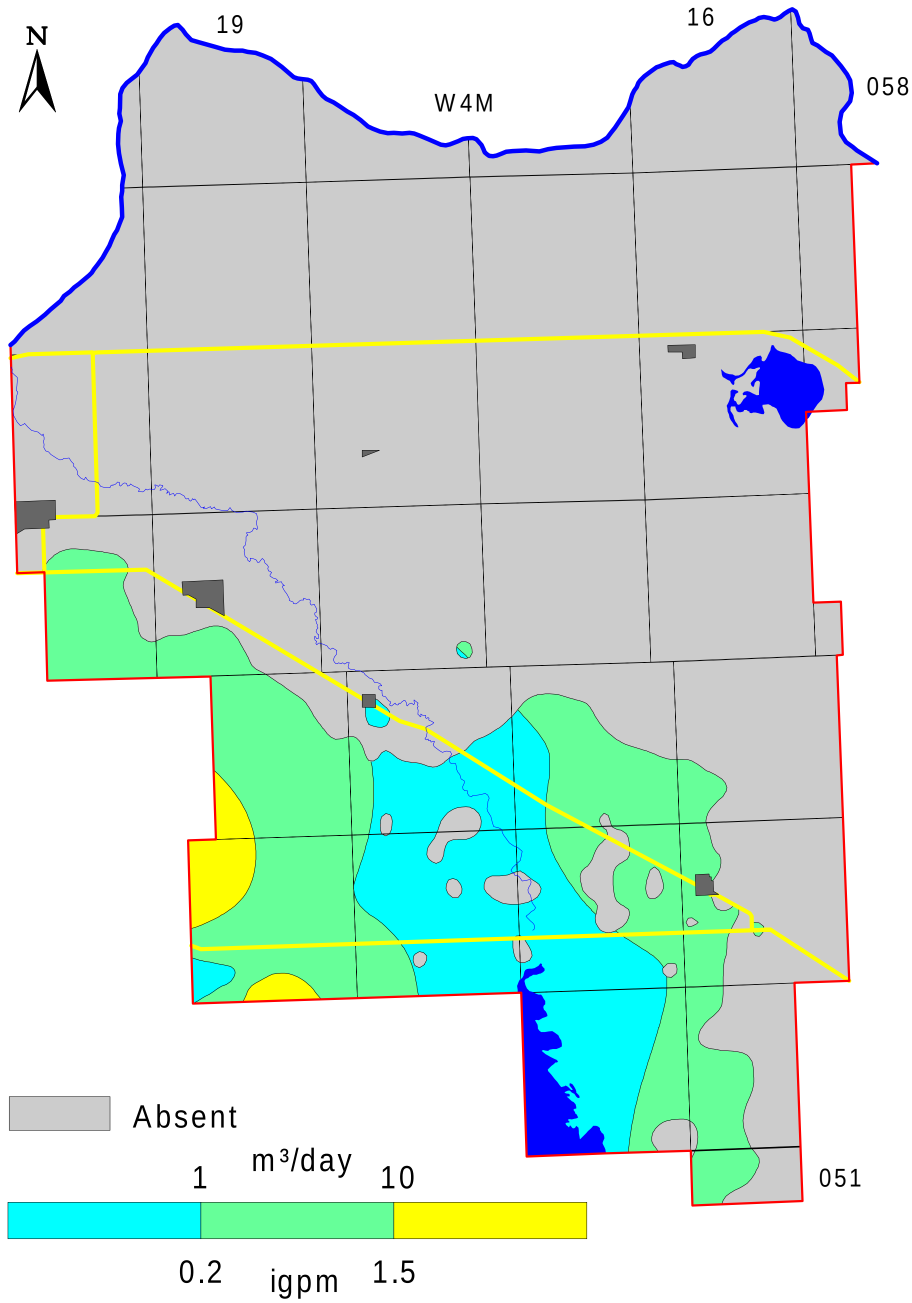
Chloride in Groundwater from Upper Bedrock Aquifer(s)



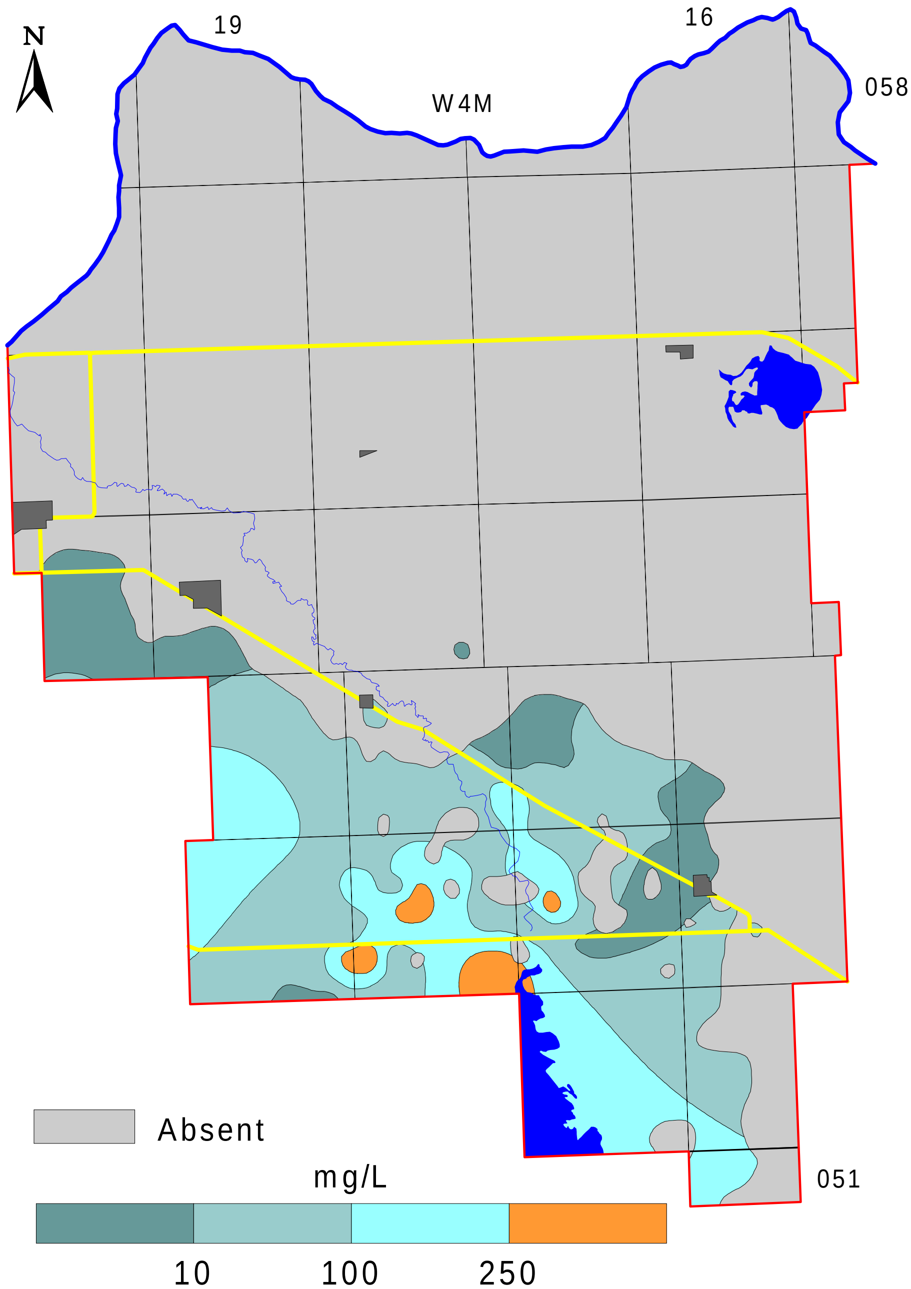
Depth to Top of Bearpaw Formation



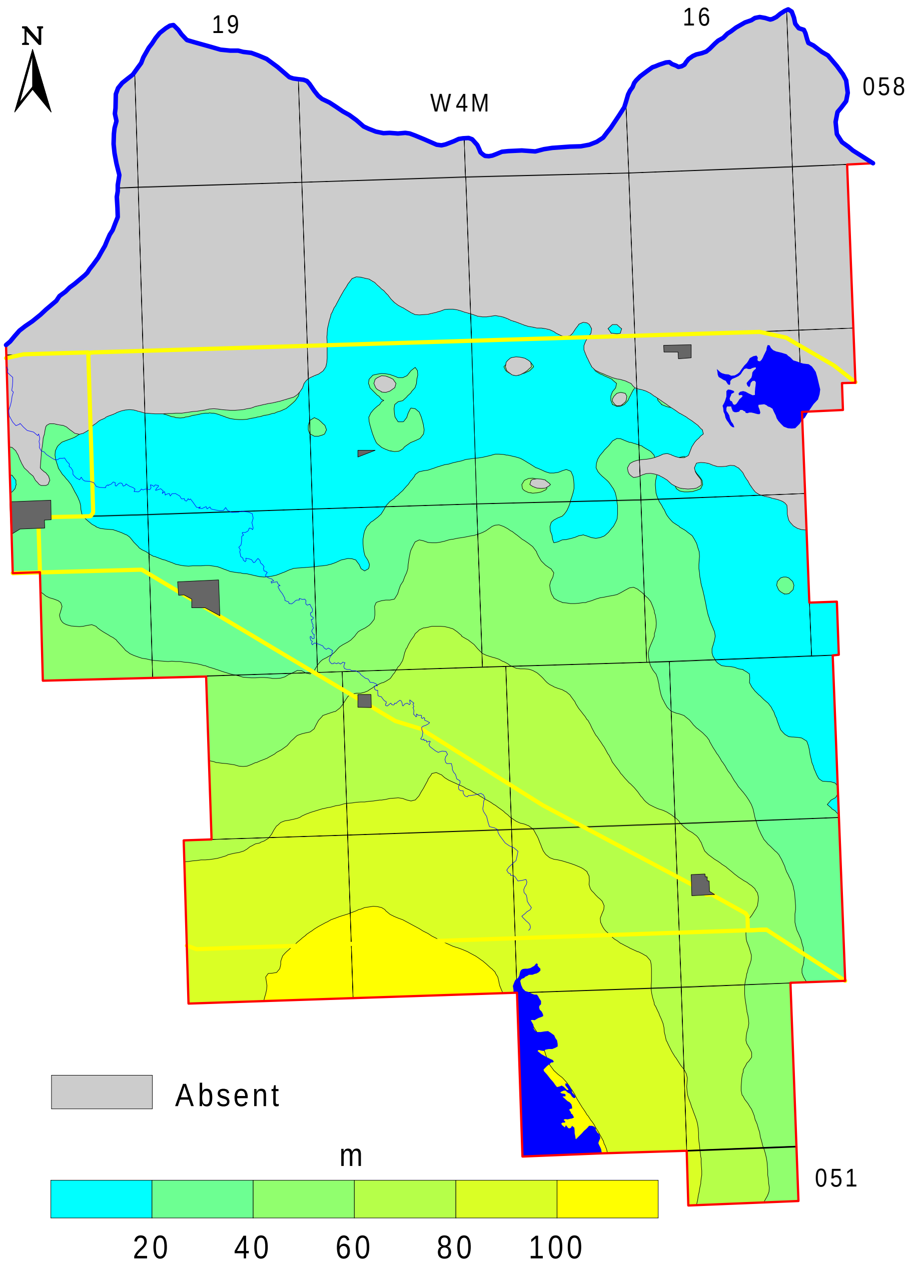
Apparent Yield for Water Wells Completed through Bearpaw Aquifer



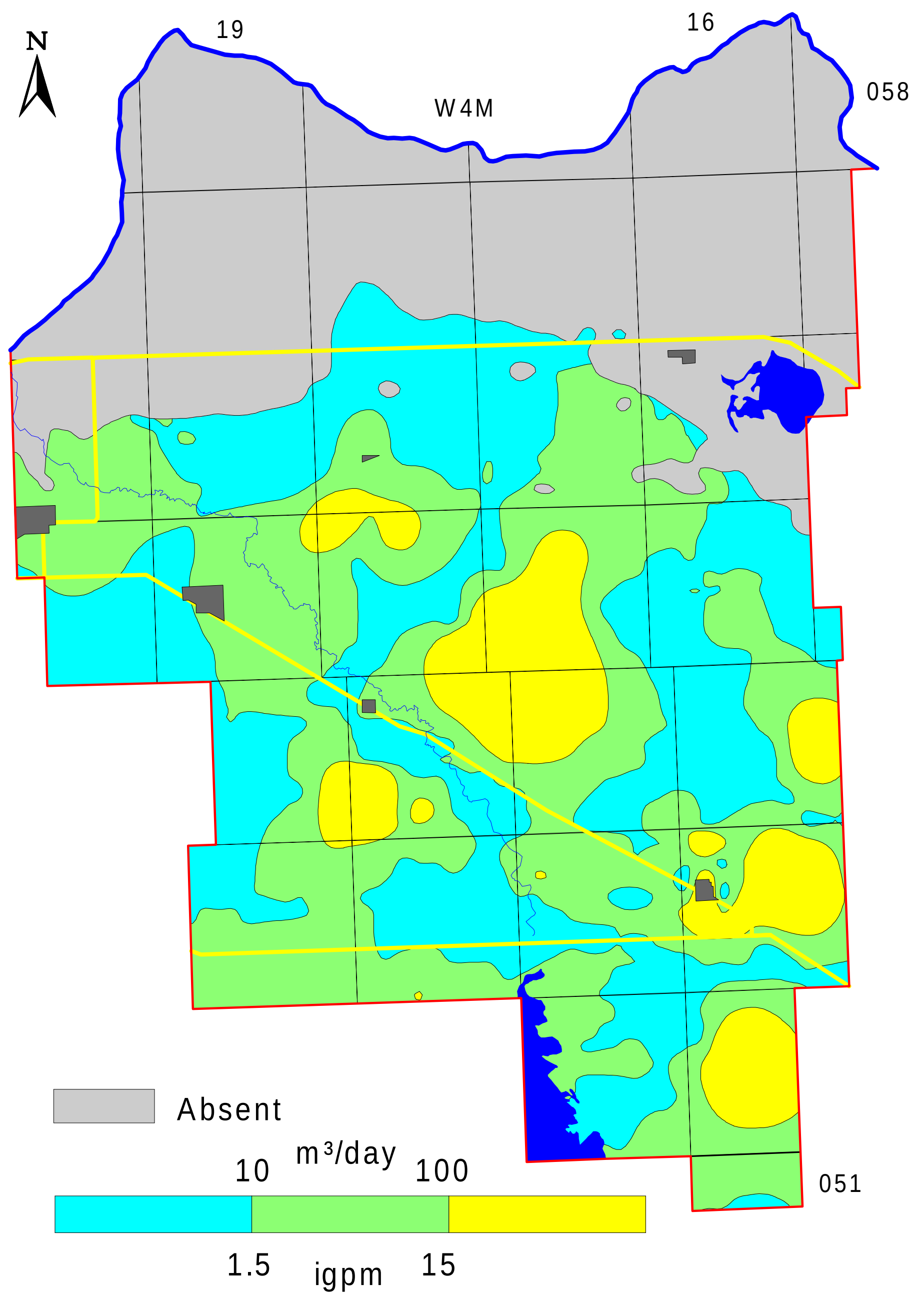
Chloride in Groundwater from Bearpaw Aquifer



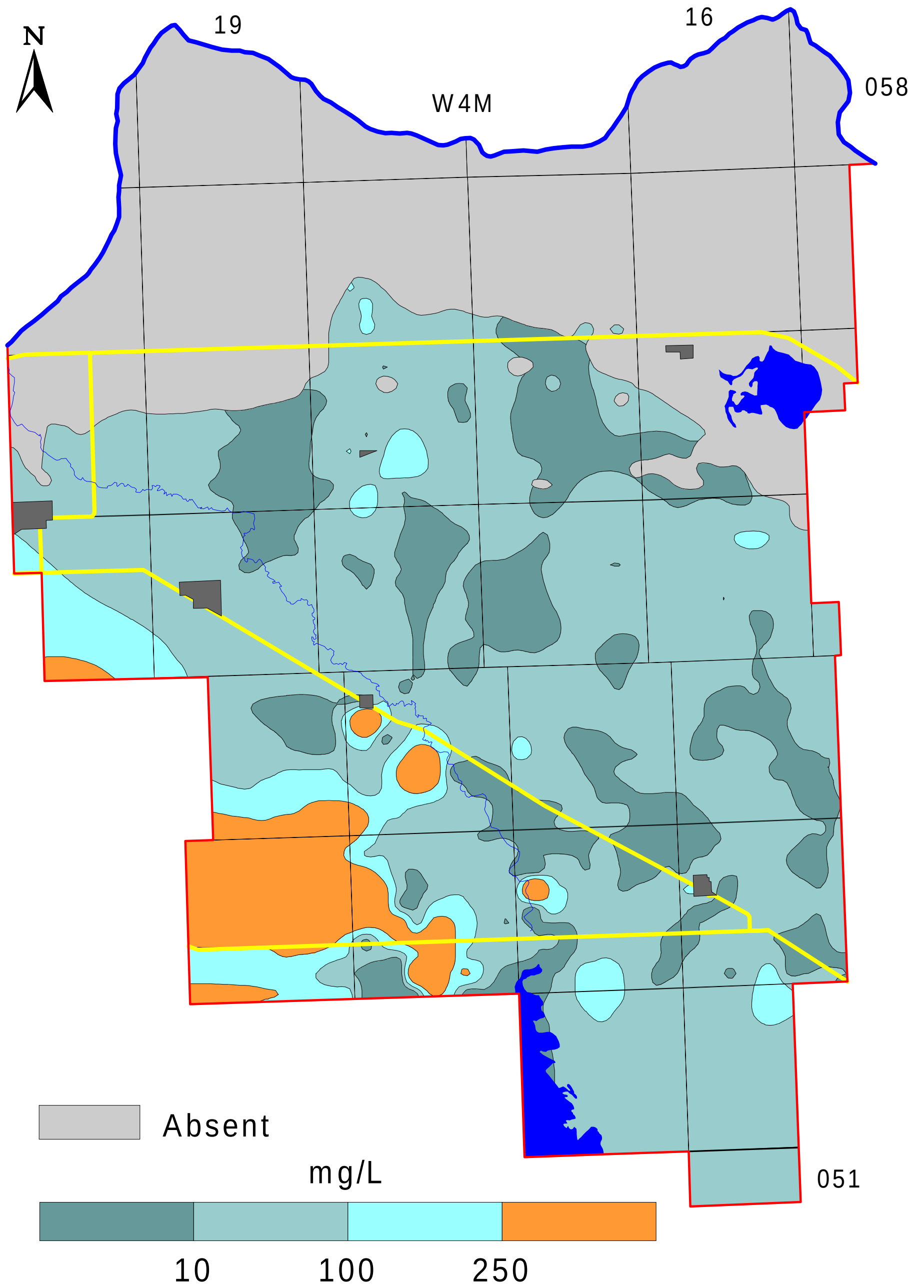
Depth to Top of Oldman Formation



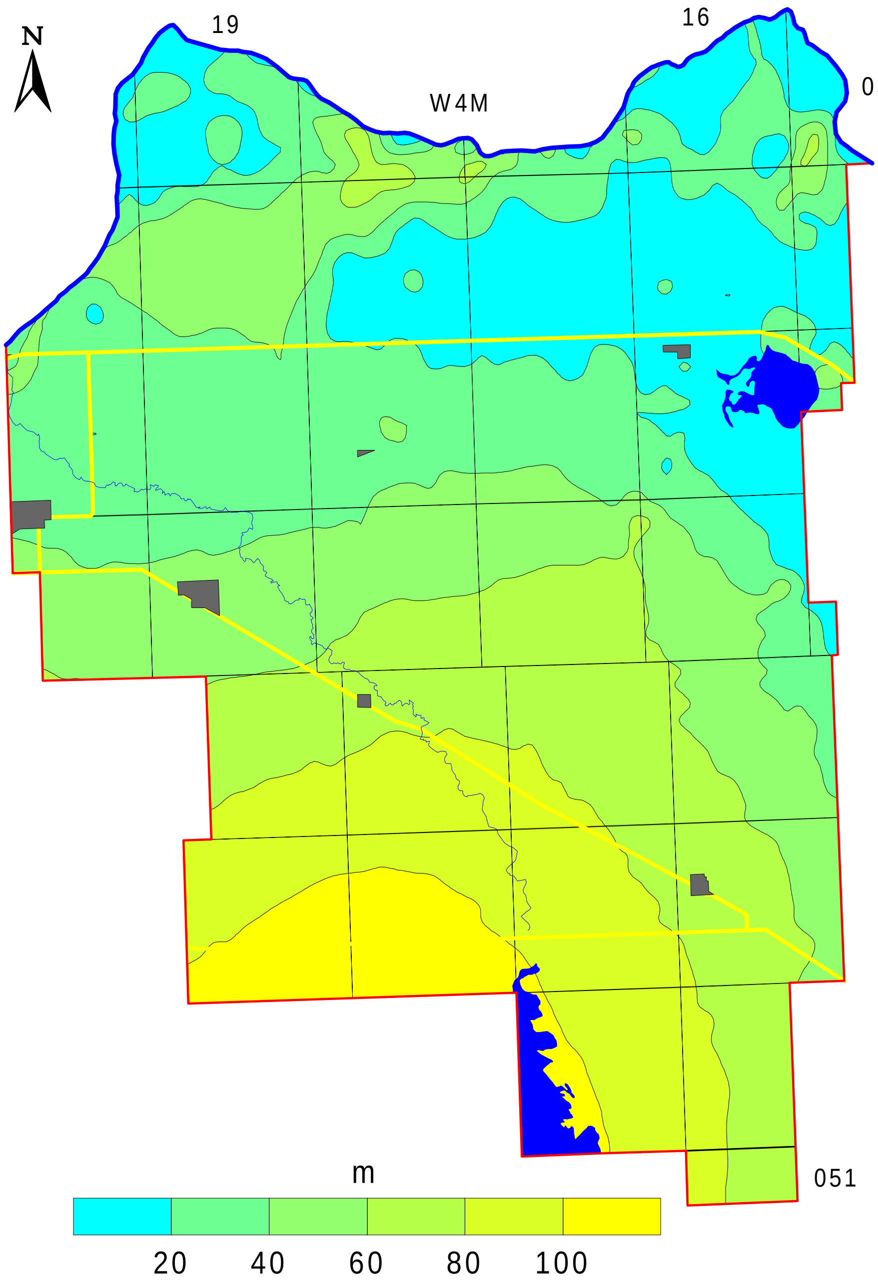
Apparent Yield for Water Wells Completed through Oldman Aquifer



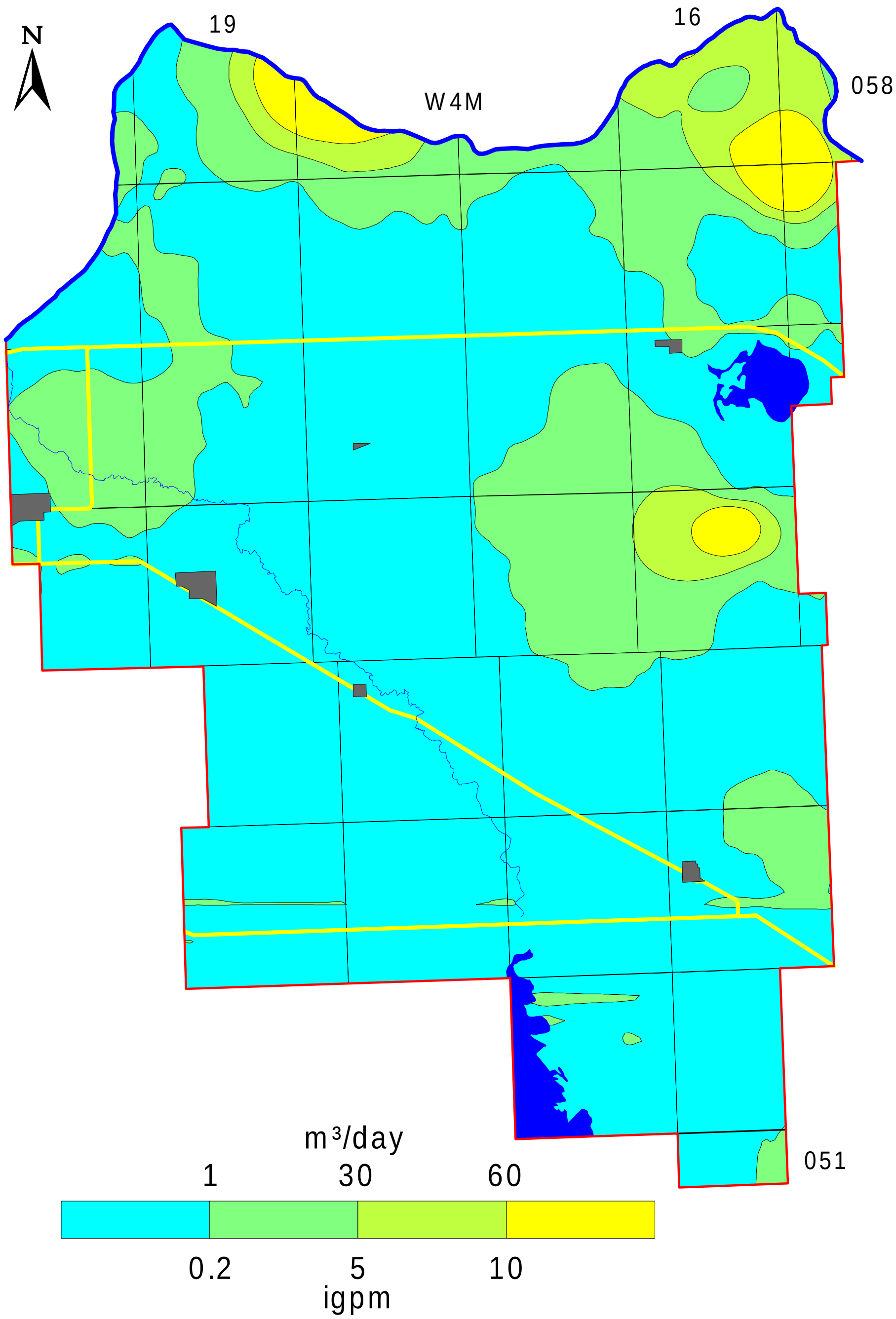
Chloride in Groundwater from Oldman Aquifer



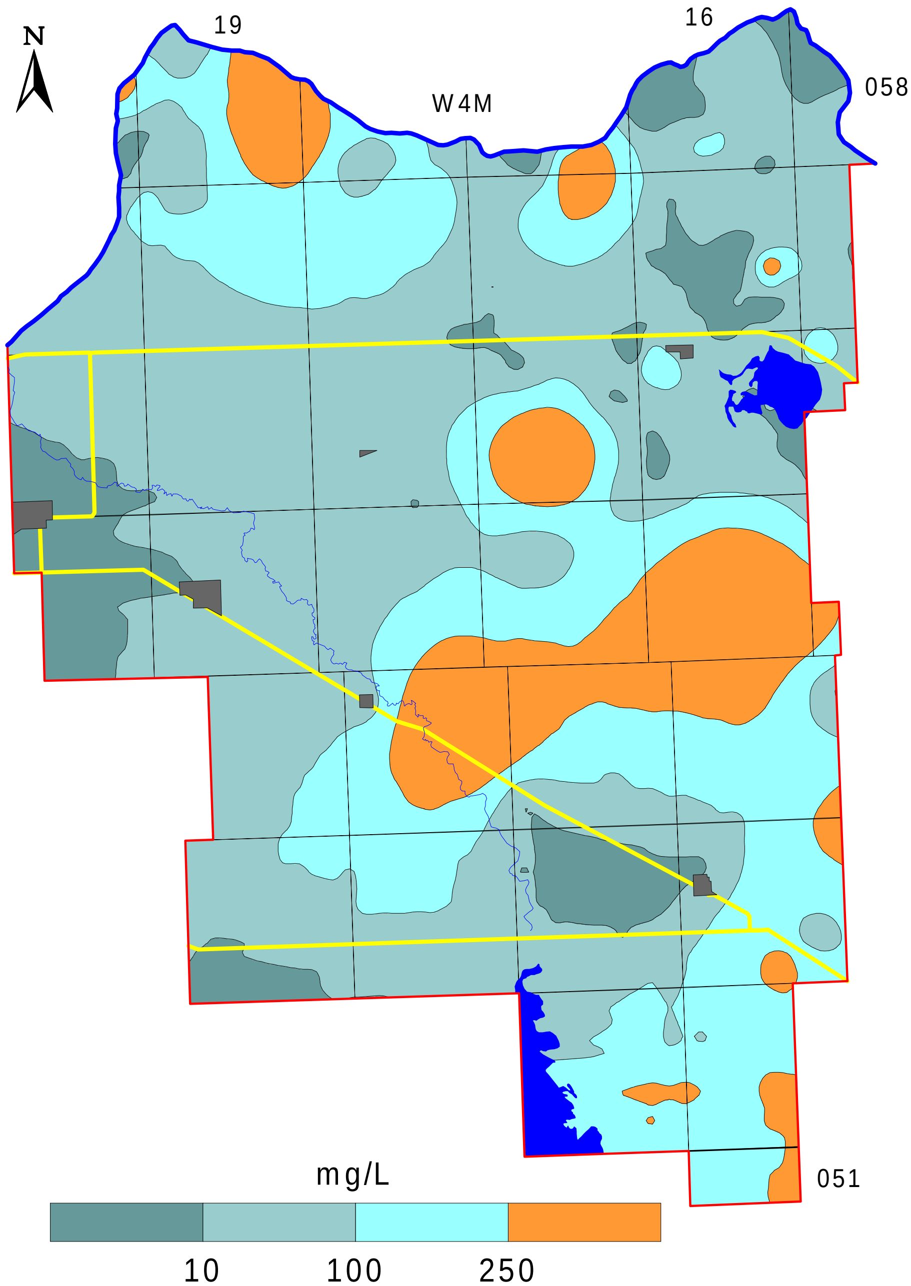
Depth to Top of continental Foremost Formation



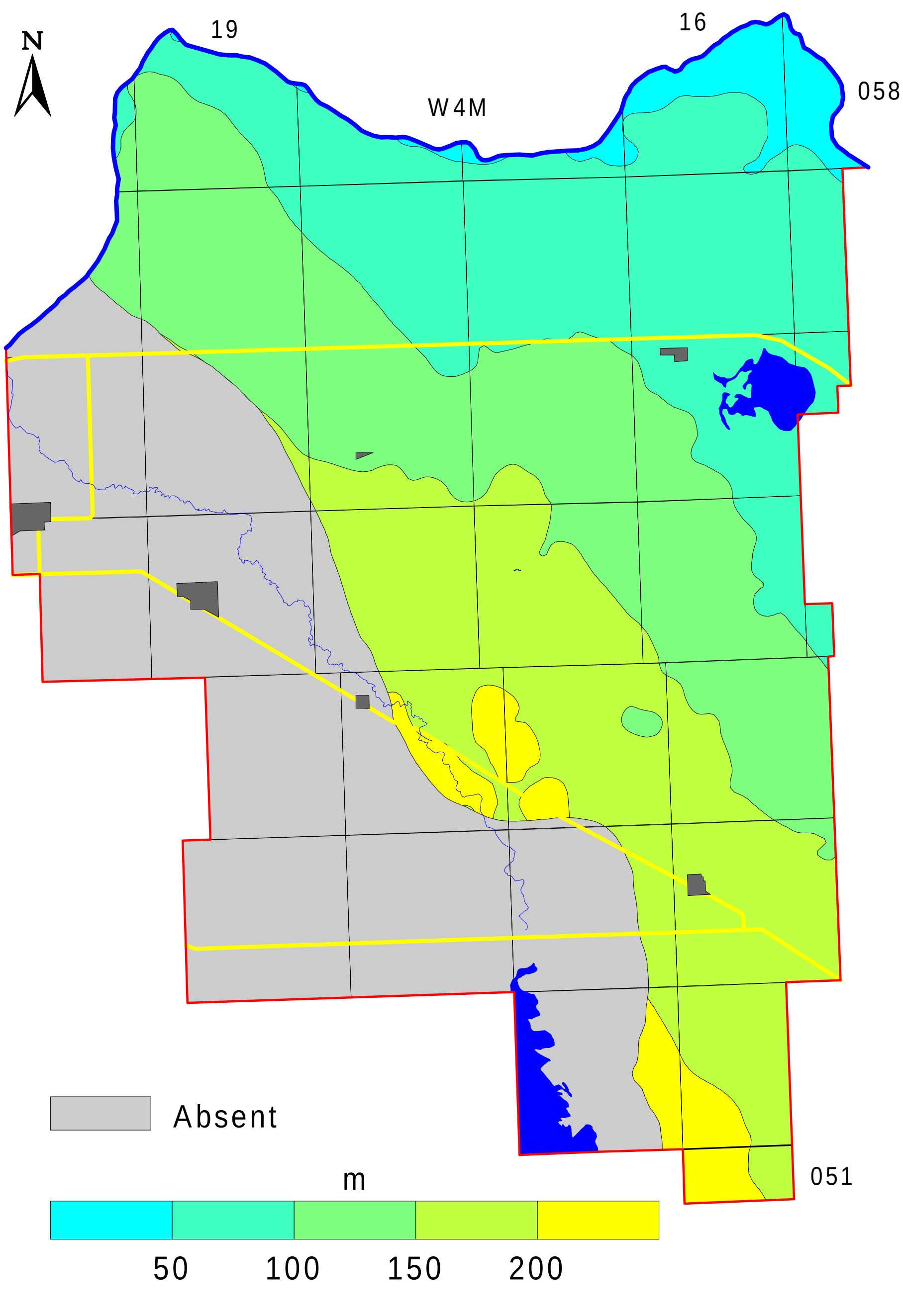
Apparent Yield for Water Wells Completed through continental Foremost Aquifer



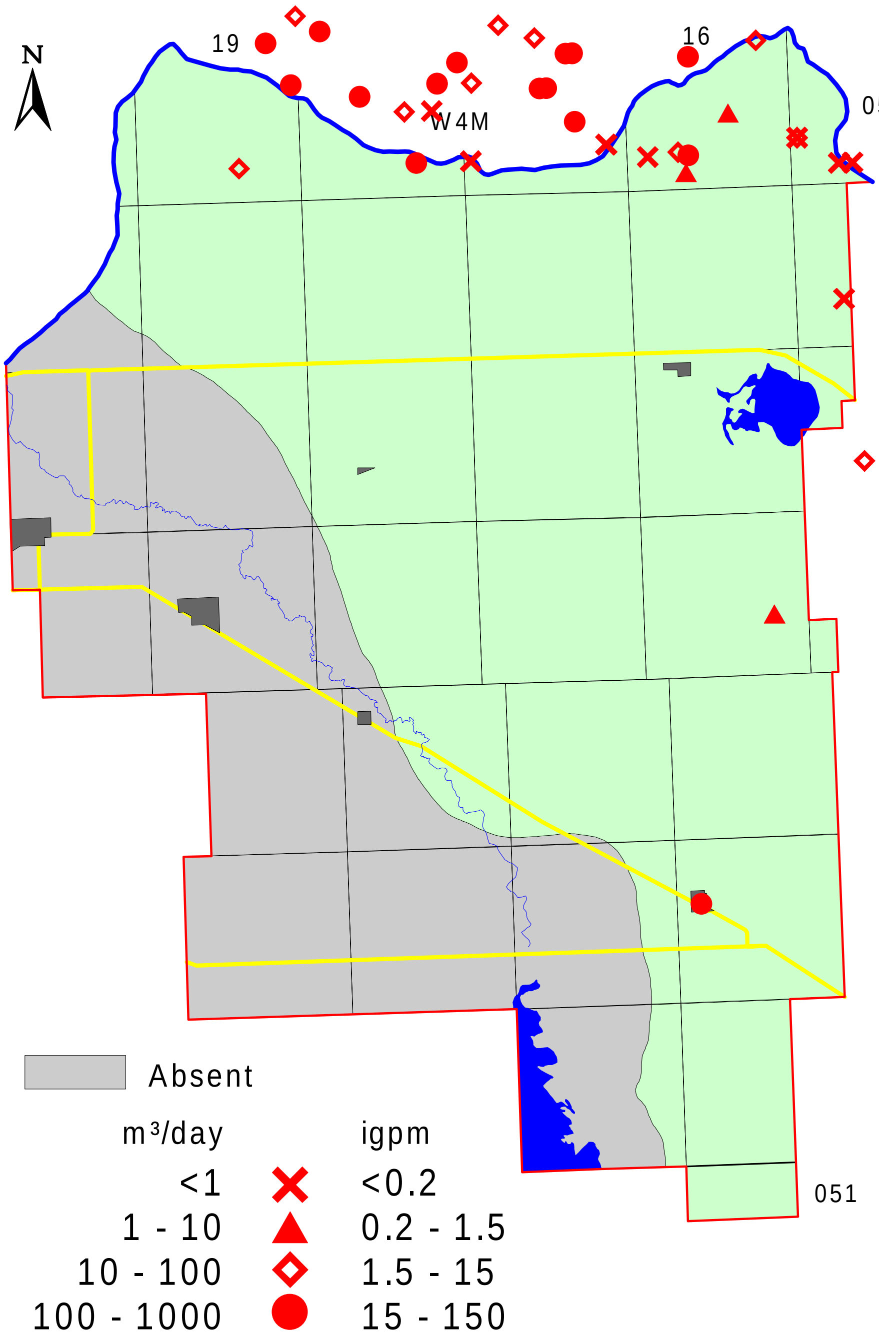
Chloride in Groundwater from continental Foremost Aquifer



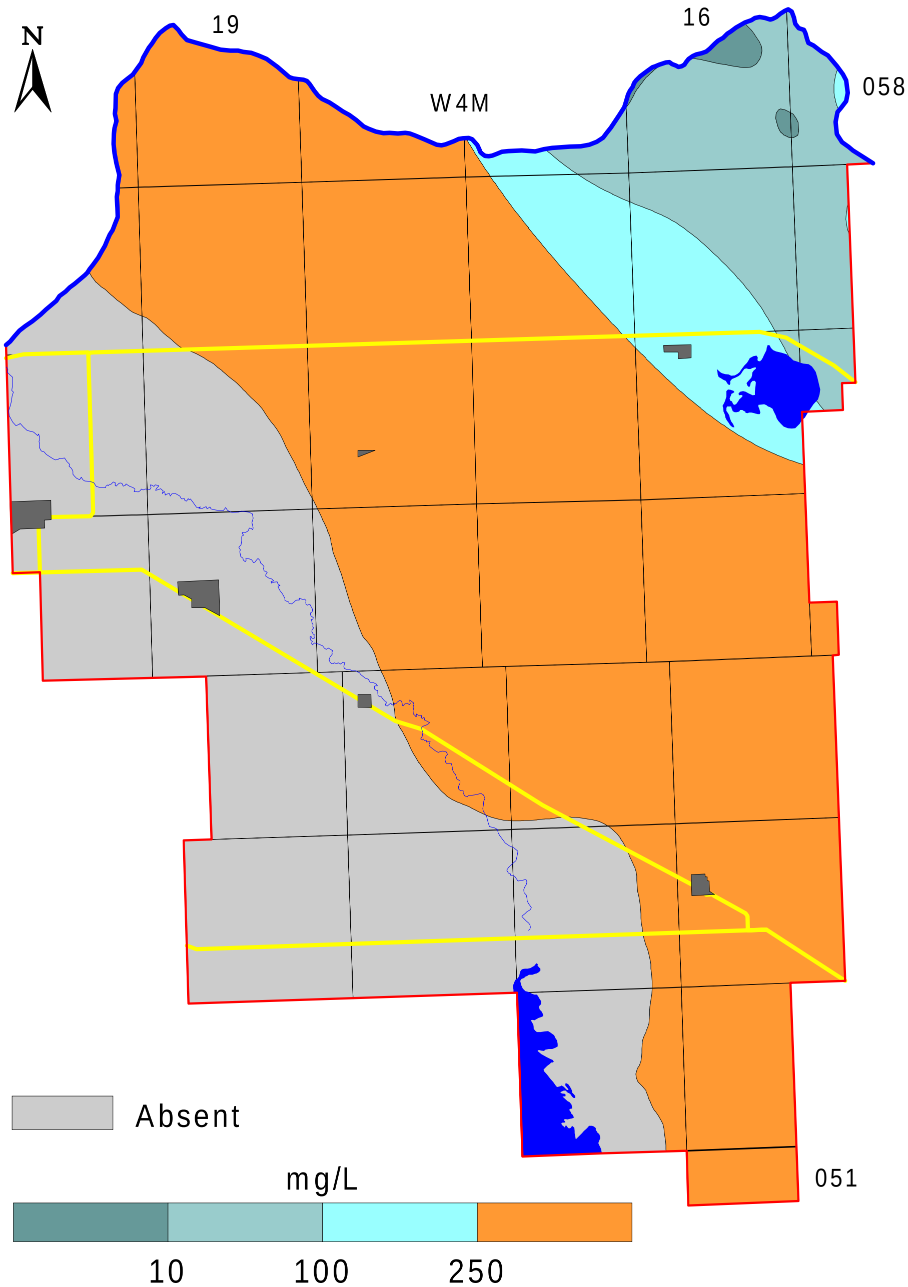
Depth to Top of Milan Aquifer



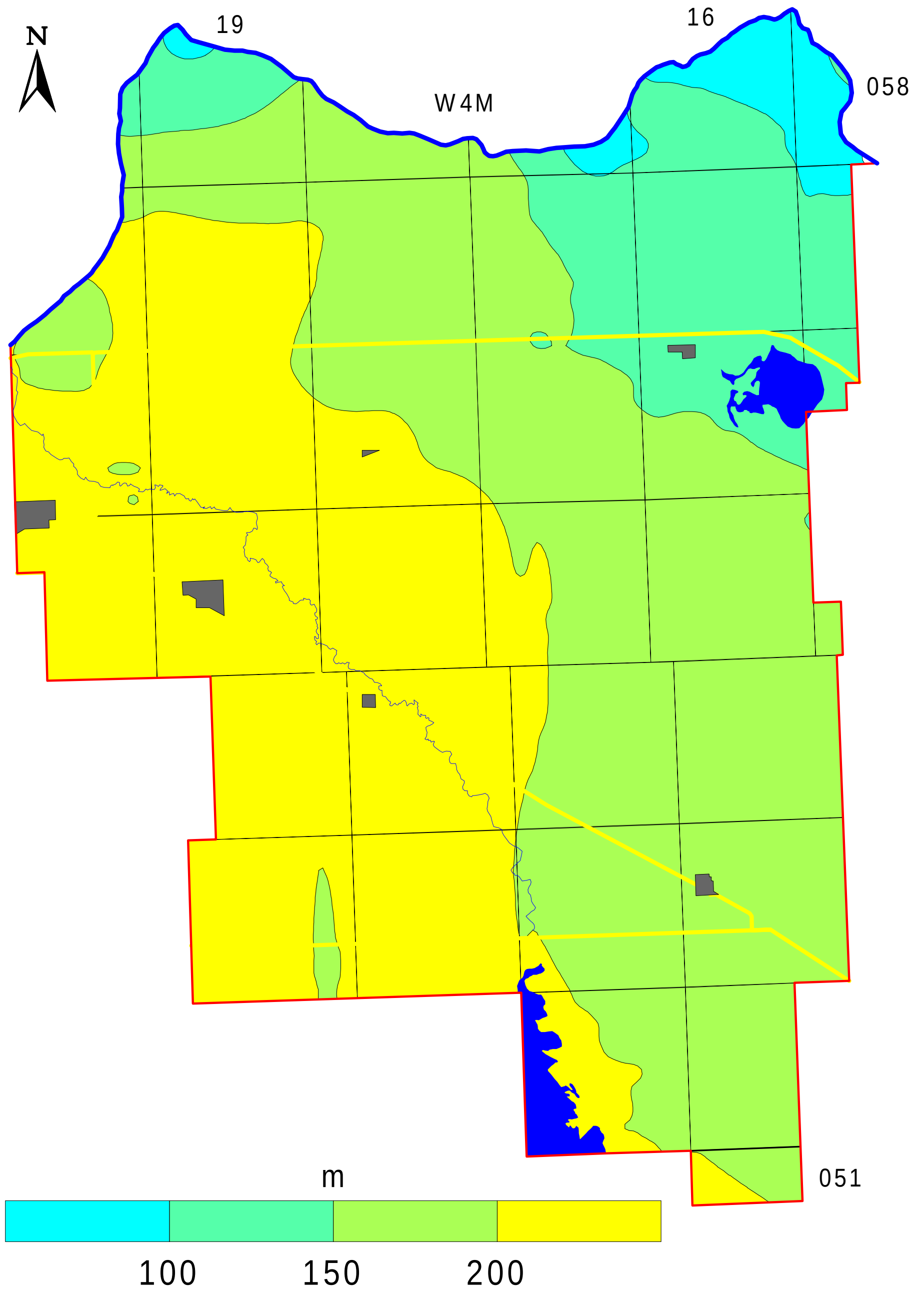
Apparent Yield for Water Wells Completed through Milan Aquifer



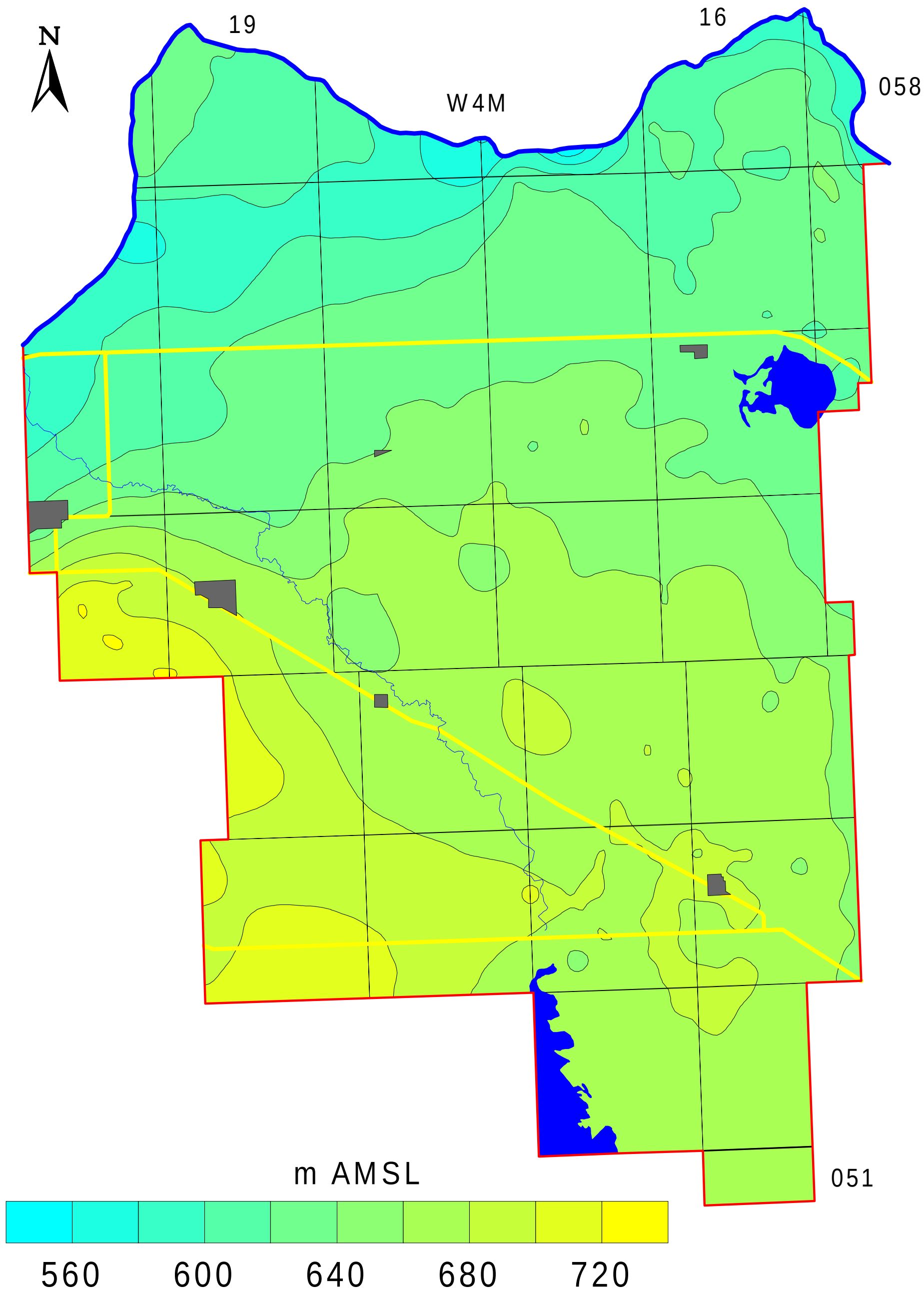
Chloride in Groundwater from Milan Aquifer



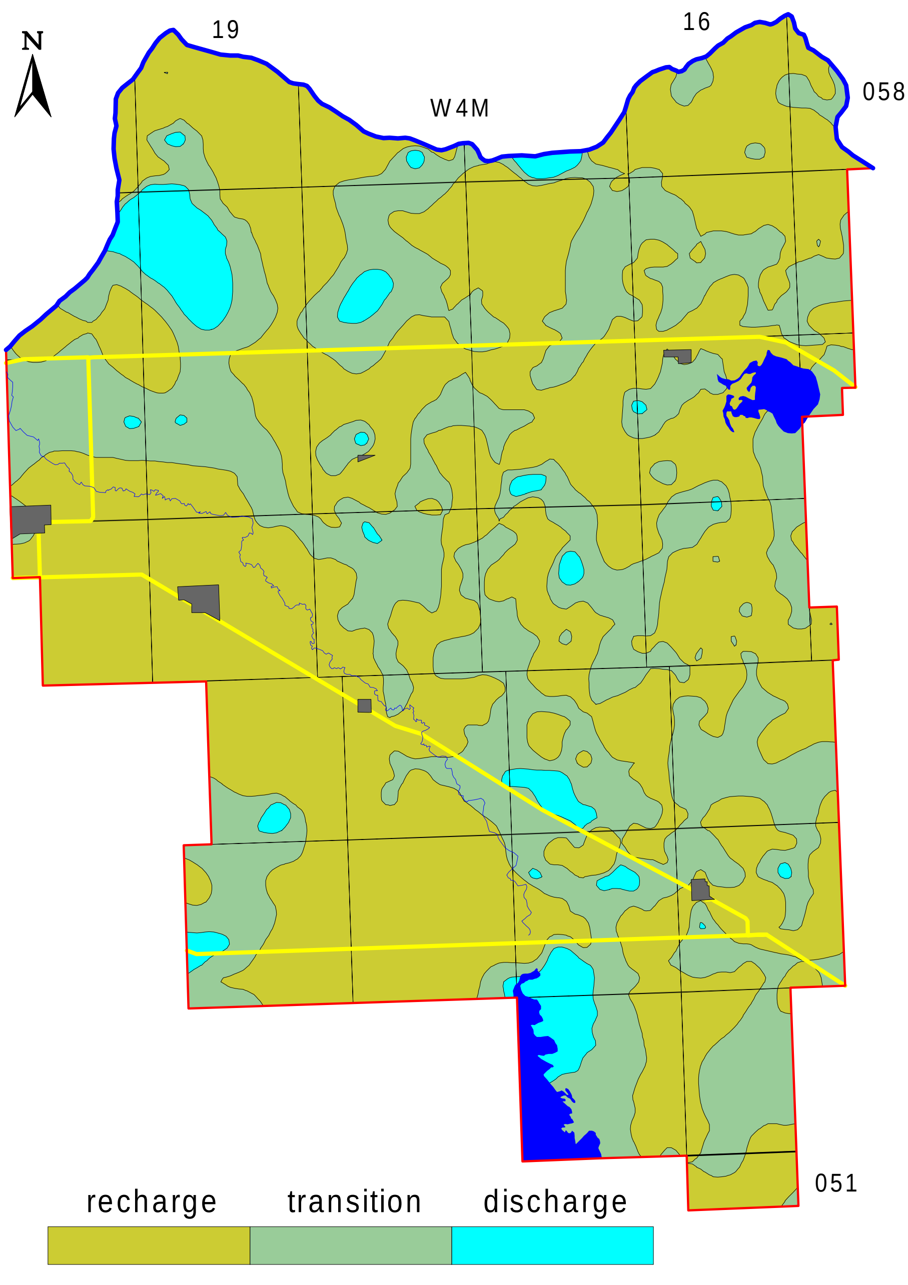
Depth to Top of Lea Park Formation



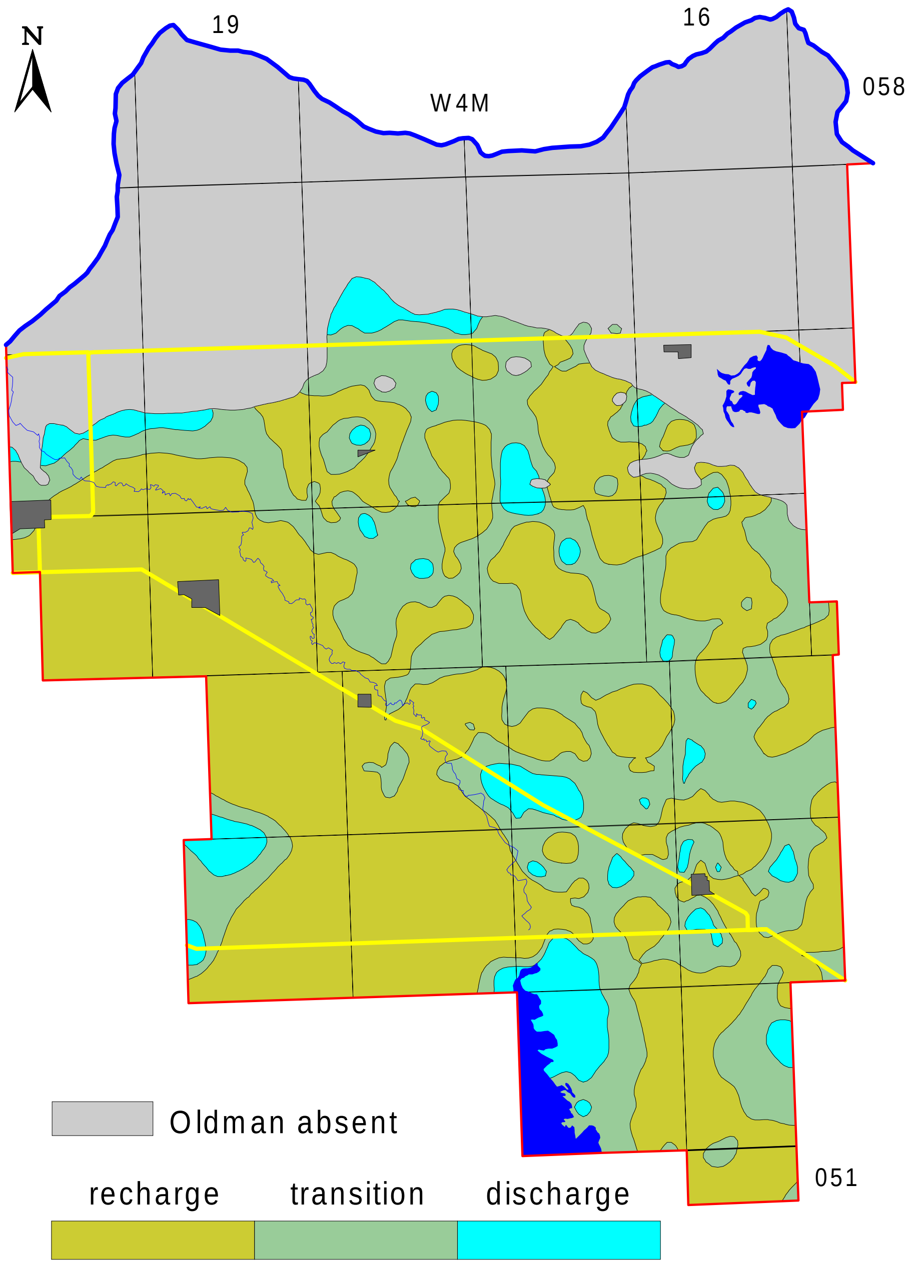
Non-Pumping Water-Level Surface in Surficial Deposits



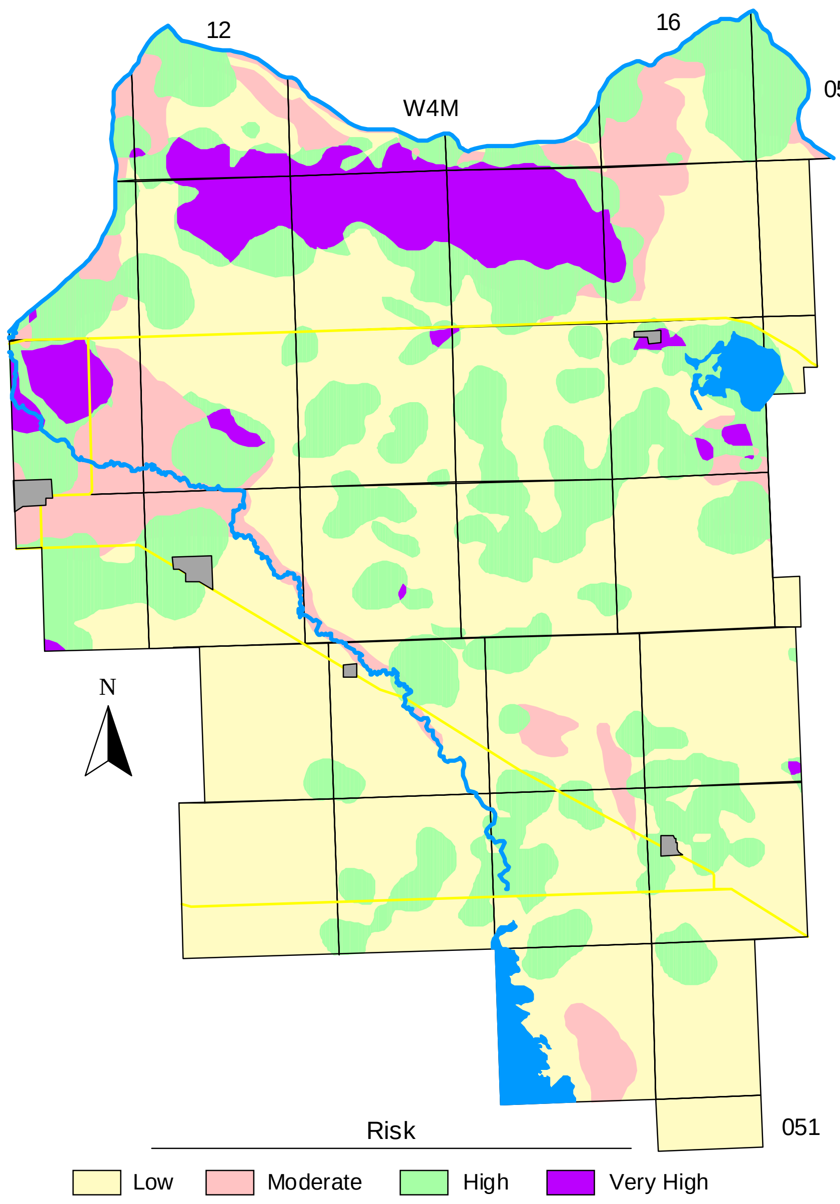
Recharge/Discharge Areas between Surficial Deposits and Upper Bedrock Aquifer(s)



Recharge/Discharge Areas between Surficial Deposits and Oldman Aquifer



Risk of Groundwater Contamination



COUNTY OF LAMONT NO. 30

Appendix B

MAPS AND FIGURES ON CD-ROM

CD-ROM

A) Database
B) ArcView Files
C) Query
D) Maps and Figures

1) General

Index Map
Location of Water Wells
Depth of Existing Water Wells
Depth to Base of Groundwater Protection
Bedrock Topography
Bedrock Geology
Cross-Section A - A'
Cross-Section B - B'
Geologic Column
Generalized Cross-Section (for terminology only)
Risk of Groundwater Contamination
Relative Permeability

2) Surficial Aquifers

a) Surficial Deposits

Thickness of Surficial Deposits
Non-Pumping Water-Level Surface in Water Wells Shallower than 15 metres
Non-Pumping Water-Level Surface in Surficial Deposits
Total Dissolved Solids in Groundwater from Surficial Deposits
Sulfate in Groundwater from Surficial Deposits
Chloride in Groundwater from Surficial Deposits
Piper Diagram - Surficial Deposits
Amount of Sand and Gravel in Surficial Deposits
Thickness of Sand and Gravel Aquifer(s)
Apparent Yield for Water Wells Completed in Sand and Gravel Aquifer(s)

b) First Sand and Gravel

Thickness of First Sand and Gravel
First Sand and Gravel - Saturation

c) Upper Sand and Gravel

Thickness of Upper Surficial Deposits
Thickness of Upper Sand and Gravel (not all drill holes fully penetrate surficial deposits)
Apparent Yield for Water Wells Completed through Upper Sand and Gravel Aquifer

d) Lower Sand and Gravel

Structure-Contour Map - Top of Lower Surficial Deposits
Depth to Top of Lower Sand and Gravel Aquifer
Thickness of Lower Surficial Deposits
Thickness of Lower Sand and Gravel (not all drill holes fully penetrate surficial deposits)
Apparent Yield for Water Wells Completed through Lower Sand and Gravel Aquifer
Non-Pumping Water-Level Surface in Lower Sand and Gravel Aquifer

3) Bedrock Aquifers

a) General

Apparent Yield for Water Wells Completed in Upper Bedrock Aquifer(s)
Total Dissolved Solids in Groundwater from Upper Bedrock Aquifer(s)
Sulfate in Groundwater from Upper Bedrock Aquifer(s)
Chloride in Groundwater from Upper Bedrock Aquifer(s)
Piper Diagram - Bedrock Aquifers
Recharge/Discharge Areas between Surficial Deposits and Upper Bedrock Aquifer(s)
Non-Pumping Water-Level Surface in Upper Bedrock Aquifer(s)

b) Bearpaw Aquifer

Depth to Top of Bearpaw Formation
Structure-Contour Map - Top of Bearpaw Formation
Non-Pumping Water-Level Surface - Bearpaw Aquifer
Apparent Yield for Water Wells Completed through Bearpaw Aquifer
Total Dissolved Solids in Groundwater from Bearpaw Aquifer
Sulfate in Groundwater from Bearpaw Aquifer
Chloride in Groundwater from Bearpaw Aquifer
Piper Diagram - Bearpaw Aquifer
Recharge/Discharge Areas between Surficial Deposits and Bearpaw Aquifer

c) Oldman Aquifer

Depth to Top of Oldman Formation
Structure-Contour Map - Top of Oldman Formation
Non-Pumping Water-Level Surface - Oldman Aquifer
Apparent Yield for Water Wells Completed through Oldman Aquifer
Total Dissolved Solids in Groundwater from Oldman Aquifer
Sulfate in Groundwater from Oldman Aquifer
Chloride in Groundwater from Oldman Aquifer
Piper Diagram - Oldman Aquifer
Recharge/Discharge Areas between Surficial Deposits and Oldman Aquifer

d) *continental* Foremost Aquifer

Depth to Top of *continental* Foremost Formation
Structure-Contour Map - Top of continental Foremost Formation
Non-Pumping Water-Level Surface - *continental* Foremost Aquifer
Apparent Yield for Water Wells Completed through *continental* Foremost Aquifer
Total Dissolved Solids in Groundwater from *continental* Foremost Aquifer
Sulfate in Groundwater from *continental* Foremost Aquifer
Chloride in Groundwater from *continental* Foremost Aquifer
Piper Diagram - *continental* Foremost Formation
Recharge/Discharge Areas between Surficial Deposits and *continental* Foremost Aquifer

e) Milan Aquifer

Depth to Top of Milan Aquifer
Structure-Contour Map - Top of Milan Aquifer
Non-Pumping Water-Level Surface - Milan Aquifer
Apparent Yield for Water Wells Completed through Milan Aquifer
Total Dissolved Solids in Groundwater from Milan Aquifer
Sulfate in Groundwater from Milan Aquifer
Chloride in Groundwater from Milan Aquifer
Piper Diagram - Milan Aquifer
Recharge/Discharge Areas between Surficial Deposits and Milan Aquifer

f) Lea Park Aquitard

Depth to Top of Lea Park Aquitard
Structure-Contour Map - Top of Lea Park Aquitard
Non-Pumping Water-Level Surface - Lea Park Aquitard
Apparent Yield for Water Wells Completed in Lea Park Aquitard
Total Dissolved Solids in Groundwater from Lea Park Aquitard

COUNTY OF LAMONT NO. 30

Appendix C

GENERAL WATER WELL INFORMATION

Domestic Water Well Testing

Purpose and Requirements

The purpose of the testing of domestic water wells is to obtain background data related to:

1) the non-pumping water level for the aquifer - Has there been any lowering of the level since the last measurement?
2) the specific capacity of the water well, which indicates the type of contact the water well has with the aquifer;
3) the transmissivity of the aquifer and hence an estimate of the projected long-term yield for the water well;
4) the chemical, bacteriological and physical quality of the groundwater from the water well.

The testing procedure involves conducting an aquifer test and collecting of groundwater samples for analysis by an accredited laboratory. The date and time of the testing are to be recorded on all data collection sheets. A sketch showing the location of the water well relative to surrounding features is required. The sketch should answer the question, "If this water well is tested in the future, how will the person doing the testing know this is the water well I tested?"

The water well should be taken out of service as long as possible before the start of the aquifer test, preferably not less than 30 minutes before the start of pumping. The non-pumping water level is to be measured 30, 10, and 5 minutes before the start of pumping and immediately before the start of pumping which is to be designated as time 0 for the test. All water levels must be from the same designated reference, usually the top of the casing. Water levels are to be measured during the pumping interval and during the recovery interval after the pump has been turned off; all water measurements are to be with an accuracy of ± 0.01 metres.

During the pumping and recovery intervals, the water level is to be measured at the appropriate times. An example of the time schedule for a four-hour test is as follows, measured in minutes after the pump is turned on and again after the pump is turned off:

1,2,3,4,6,8,10,13,16,20,25,32,40,50,64,80,100,120.

For a four-hour test, the reading after 120 minutes of pumping will be the same as the 0 minutes of recovery. Under no circumstance will the recovery interval be less than the pumping interval.

Flow rate during the aquifer test should be measured and recorded with the maximum accuracy possible. Ideally, a water meter with an accuracy of better than ±1% displaying instantaneous and total flow should be used. If a water meter is not available, then the time required to completely fill a container of known volume should be recorded, noting the time to the nearest 0.5 seconds or better. Flow rate should be determined and recorded often to ensure a constant pumping rate.

Groundwater samples should be collected as soon as possible after the start of pumping and within 10 minutes of the end of pumping. Initially only the groundwater samples collected near the end of the pumping interval need to be submitted to the accredited laboratory for analysis. All samples must be properly stored for transportation to the laboratory and, in the case of the bacteriological analysis, there is a maximum time allowed between the time the sample is collected and the time the sample is delivered to the laboratory. The first samples collected are only analyzed if there is a problem or a concern with the first samples submitted to the laboratory.

Procedure

Site Diagrams

These diagrams are a map showing the distance to nearby significant features. This would include things like a corner of a building (house, barn, garage etc.) or the distance to the half-mile or mile fence. The description should allow anyone not familiar with the site to be able to unequivocally identify the water well that was tested.

In lieu of a map, UTM coordinates accurate to within five metres would be acceptable. If a hand-held GPS is used, the post-processing correction details must be provided.

Surface Details

The type of surface completion must be noted. This will include such things as a pitless adapter, well pit, pump house, in basement, etc. Also, the reference point used for measuring water levels needs to be noted. This would include top of casing (TOC) XX metres above ground level; well pit lid, XX metres above TOC; TOC in well pit XX metres below ground level.

Groundwater Discharge Point

Where was the flow of groundwater discharge regulated? For example was the discharge through a hydrant downstream from the pressure tank; discharged directly to ground either by connecting directly above the well seal or by pulling the pump up out of the pitless adapter; from a tap on the house downstream from the pressure tank? Also note must be made if any action was taken to ensure the pump would operate continuously during the pumping interval and whether the groundwater was passing through any water-treatment equipment before the discharge point.

Water-Level Measurements

How were the water-level measurements obtained? If obtained using a contact gauge, what type of cable was on the tape, graduated tape or a tape with tags? If a tape with tags, when was the last time the tags were calibrated? If a graduated tape, what is the serial number of the tape and is the tape shorter than its original length (i.e. is any tape missing)?

If water levels are obtained using a transducer and data logger, the serial numbers of both transducer and data logger are needed and a copy of the calibration sheet. The additional information required is the depth the transducer was set and the length of time between when the transducer was installed and when the calibration water level was measured, plus the length of time between the installation of the transducer and the start of the aquifer test.

All water levels must be measured at least to the nearest 0.01 metres.

Discharge Measurements

Type of water meter used. This could include such things as a turbine or positive displacement meter. How were the readings obtained from the meter? Were the readings visually noted and recorded or were they recorded using a data logger?

Water Samples

A water sample must be collected between the 4- and 6-minute water-level measurements, whenever there is an observed physical change in the groundwater being pumped, and 10 minutes before the end of the planned pumping interval. Additional water samples must be collected if it is expected that pumping will be terminated before the planned pumping interval.

Environmental Protection and Enhancement Act

Water Well Regulation

PROVINCE OF ALBERTA

ENVIRONMENTAL PROTECTION AND ENHANCEMENT ACT

WATER WELL REGULATION

Alberta Regulation 123/93

EXTRACT FROM THE ALBERTA GAZETTE

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Environmental Protection and Enhancement Act

WATER WELL REGULATION

Filed: April 22, 1993

Made by the Minister of Environmental Protection pursuant to sections 81(1)(a) and (f), 138(a)-(e), (g), (h), (j)-(n) of the Environmental Protection and Enhancement Act.

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Additional Information

VIDEOS

Will the Well Go Dry Tomorrow? (Mow-Tech Ltd.: 1-800 GEO WELL)
Water Wells that Last (PFRA – Edmonton Office: 403-495-3307)
Ground Water and the Rural Community (Ontario Ground Water Association)

BOOKLET
Water Wells that Last (PFRA – Edmonton Office: 403-495-3307)

ALBERTA ENVIRONMENTAL PROTECTION

WATER WELL INSPECTORS
Jennifer McPherson (Edmonton: 403-427-6429)
Colin Samis (Lac La Biche: 403-623-5235)

GEOPHYSICAL INSPECTION SERVICE
Edmonton: 403-427-3932

COMPLAINT INVESTIGATIONS
Blair Stone (Red Deer: 403-340-5310)

UNIVERSITY OF ALBERTA – Department of Earth and Atmospheric Sciences - Hydrogeology
Carl Mendosa (Edmonton: 403-492-2664)

UNIVERSITY OF CALGARY – Department of Geology and Geophysics - Hydrogeology
Larry Bentley (Calgary: 403-220-4512)

FARMERS ADVOCATE
Paul Vasseur (Edmonton: 403-427-2433)

PRAIRIE FARM REHABILITATION ADMINISTRATION
Keith Schick (Vegreville: 403-632-2919)

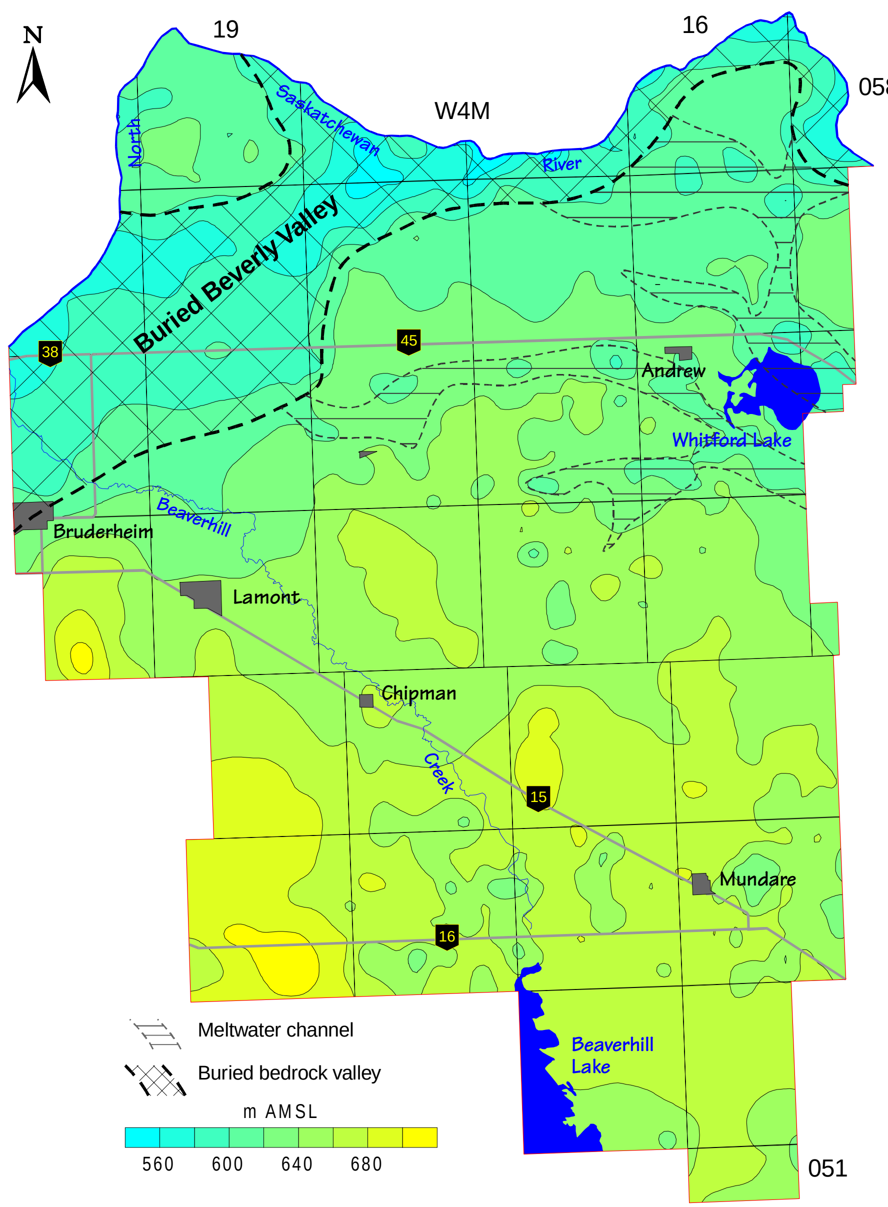
LOCAL HEALTH DEPARTMENTS

COUNTY OF LAMONT NO. 30

Appendix D

MAPS AND FIGURES INCLUDED AS LARGE PLOTS

County of Lamont No. 30
Bedrock Topography



Agriculture and Agri-Food Canada / Agriculture et Agroalimentaire Canada

PFRA
Prairie Farm Rehabilitation Administration

Note: This map is based on a regional study and as such, the results are to be used only as a guide. Detailed local studies are required to verify hydrogeological conditions at a given location.

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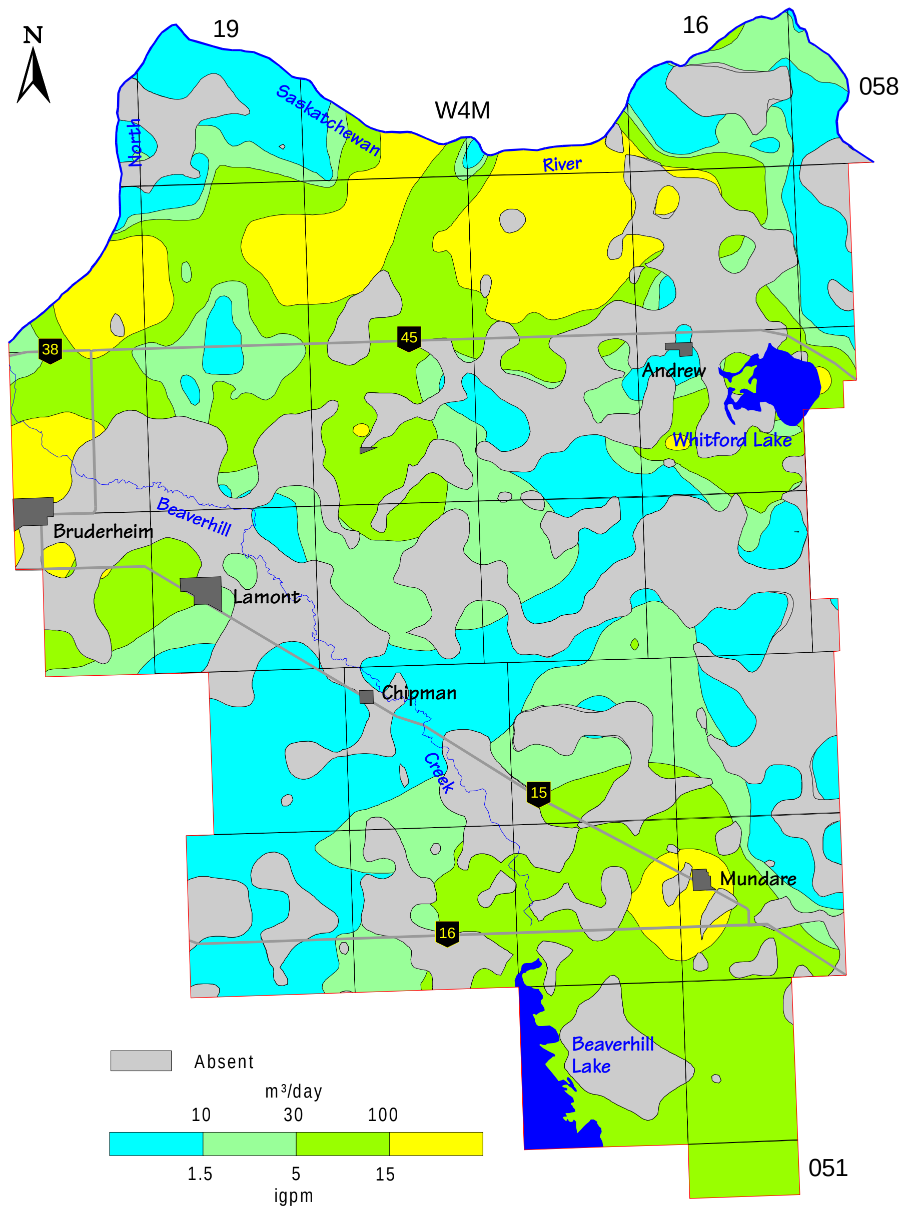
County of Lamont No. 30
Apparent Yield for Water Wells Completed in Sand and Gravel Aquifer(s)



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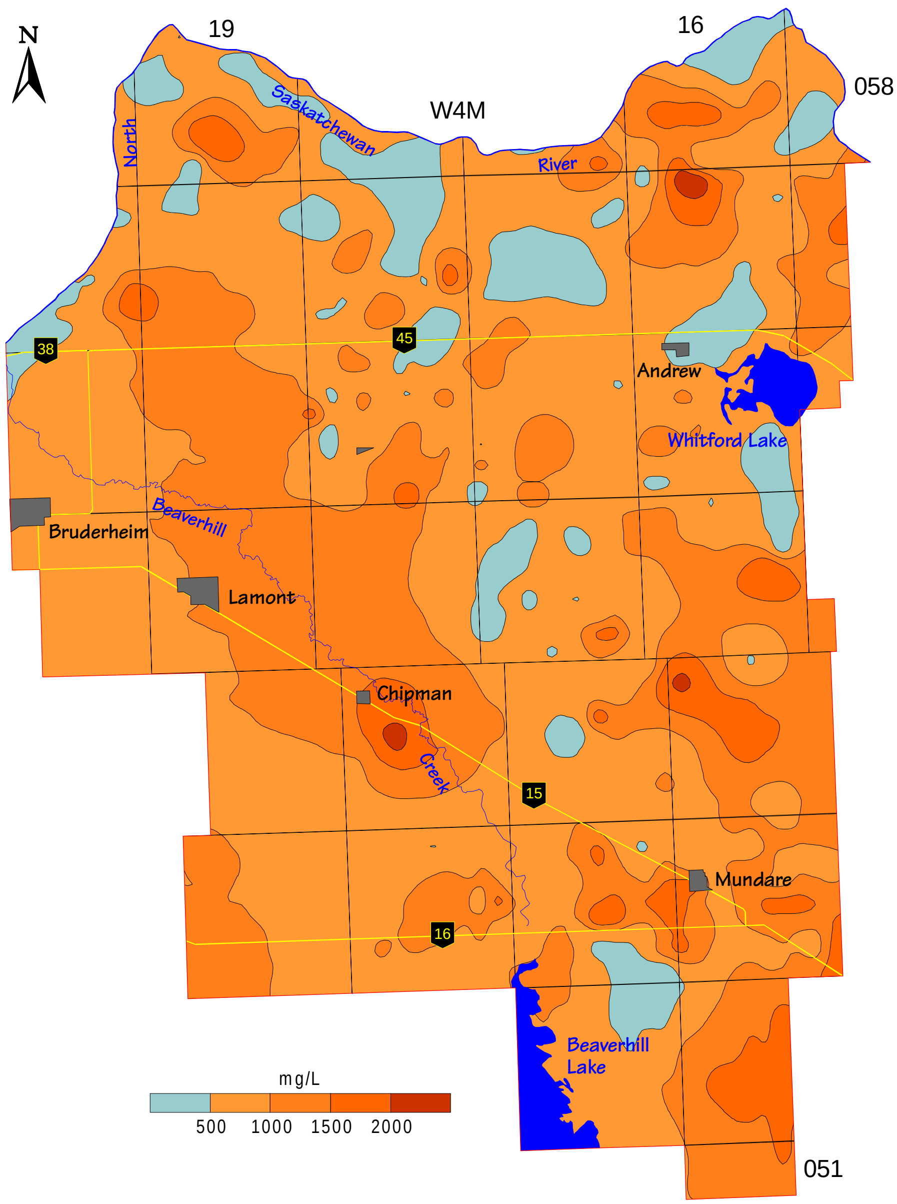
County of Lamont No. 30
Total Dissolved Solids in Groundwater from Surficial Deposits



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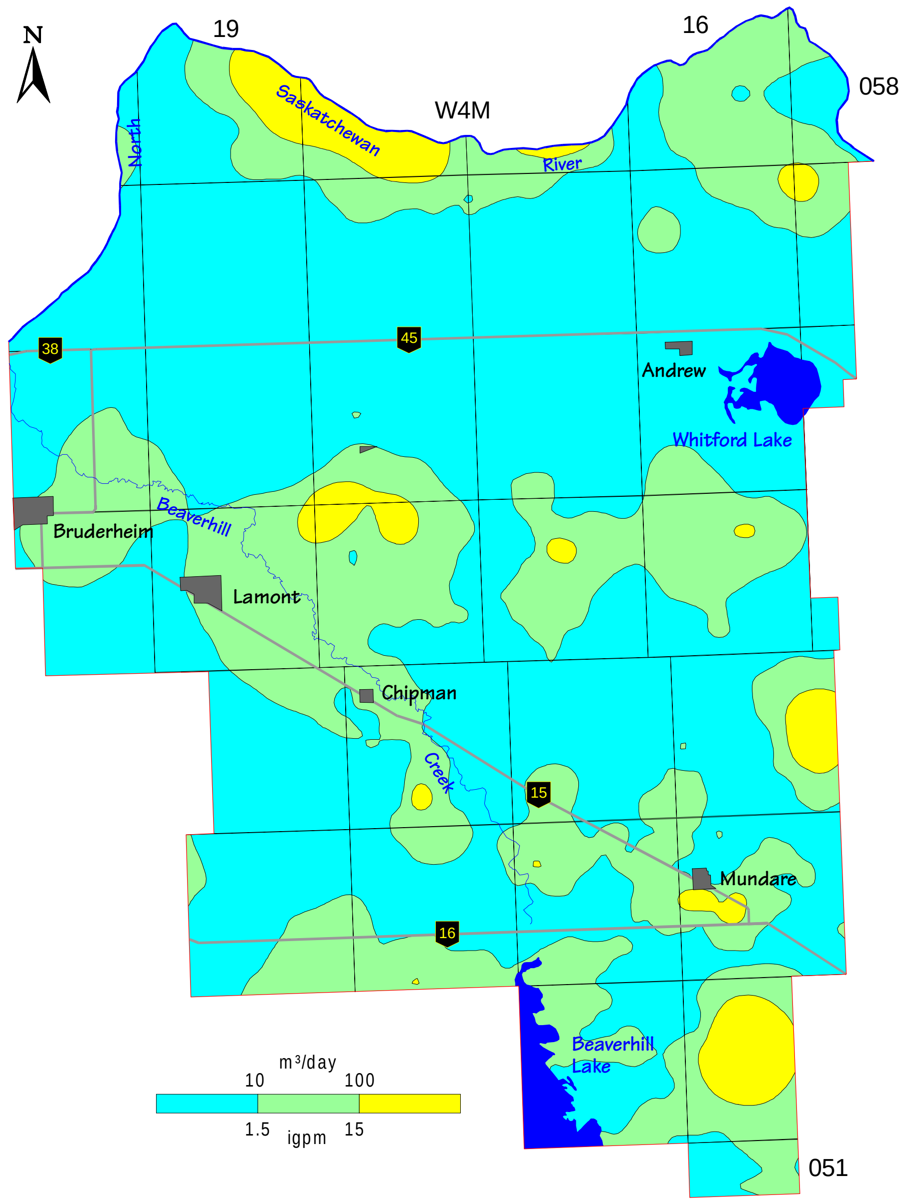
County of Lamont No. 30
Apparent Yield for Water Wells Completed in Upper Bedrock Aquifer(s)



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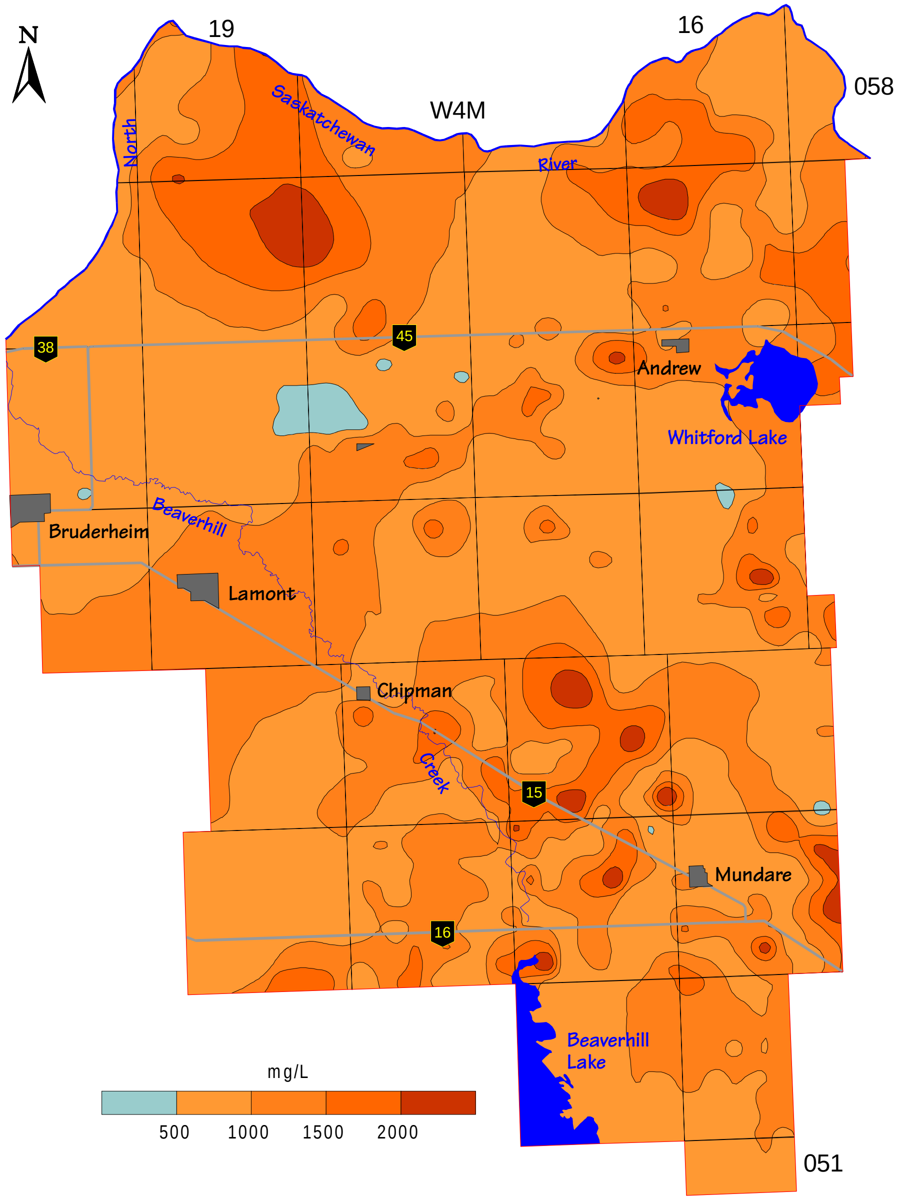
County of Lamont No. 30
Total Dissolved Solids in Groundwater from Upper Bedrock Aquifer(s)



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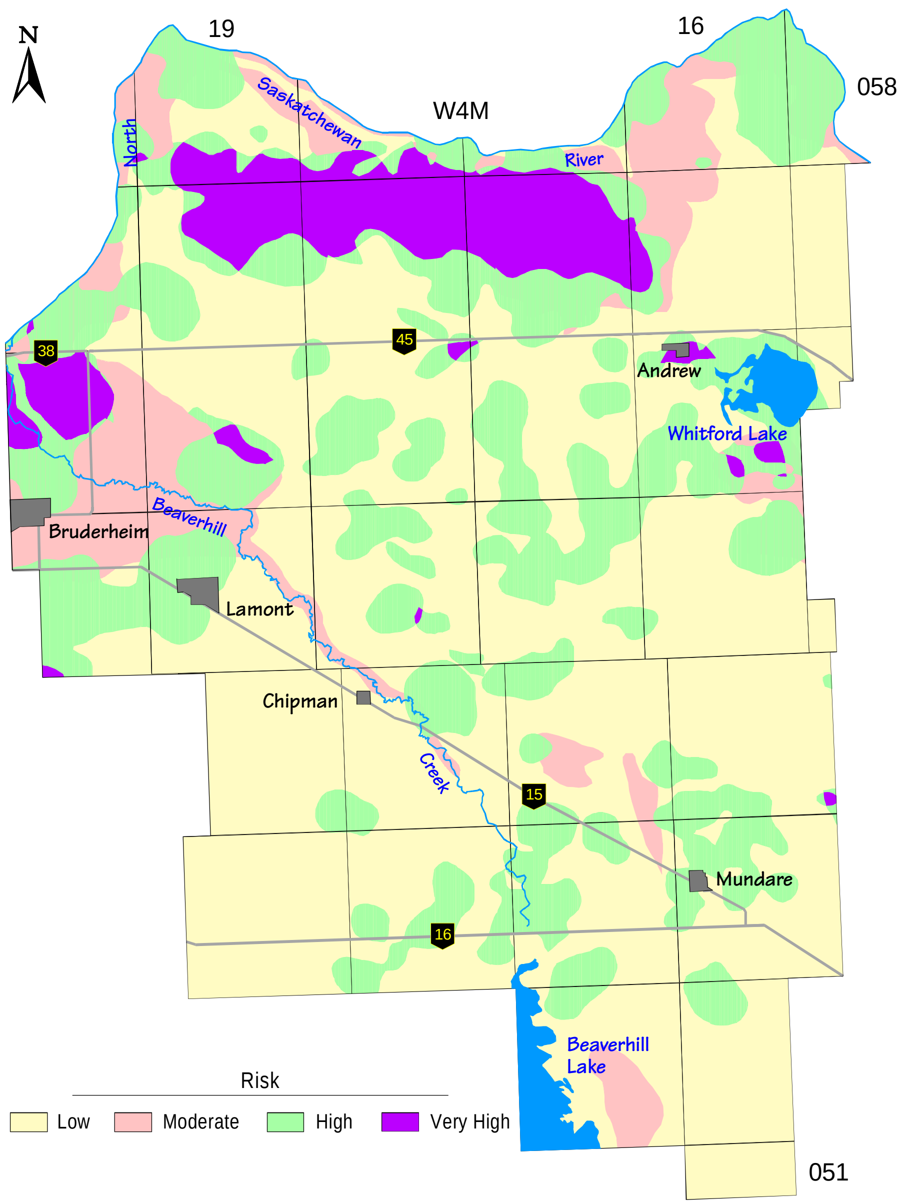
County of Lamont No. 30
Risk of Groundwater Contamination



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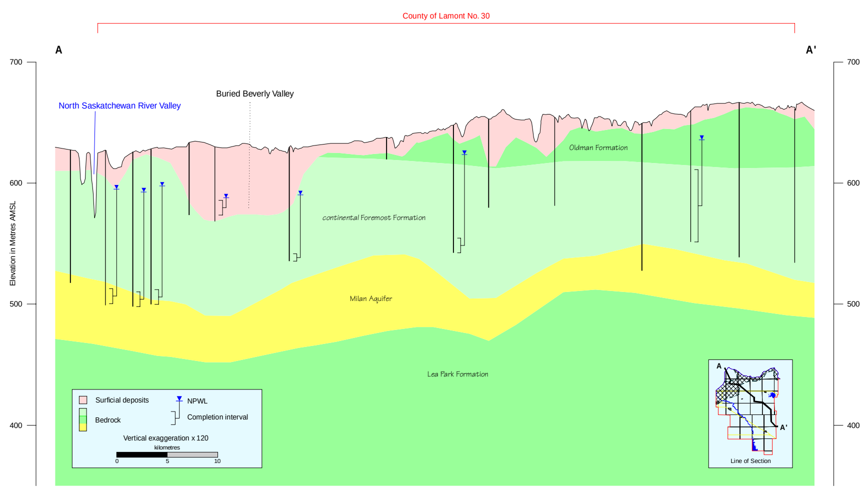
County of Lamont No. 30
Cross-Section A - A'



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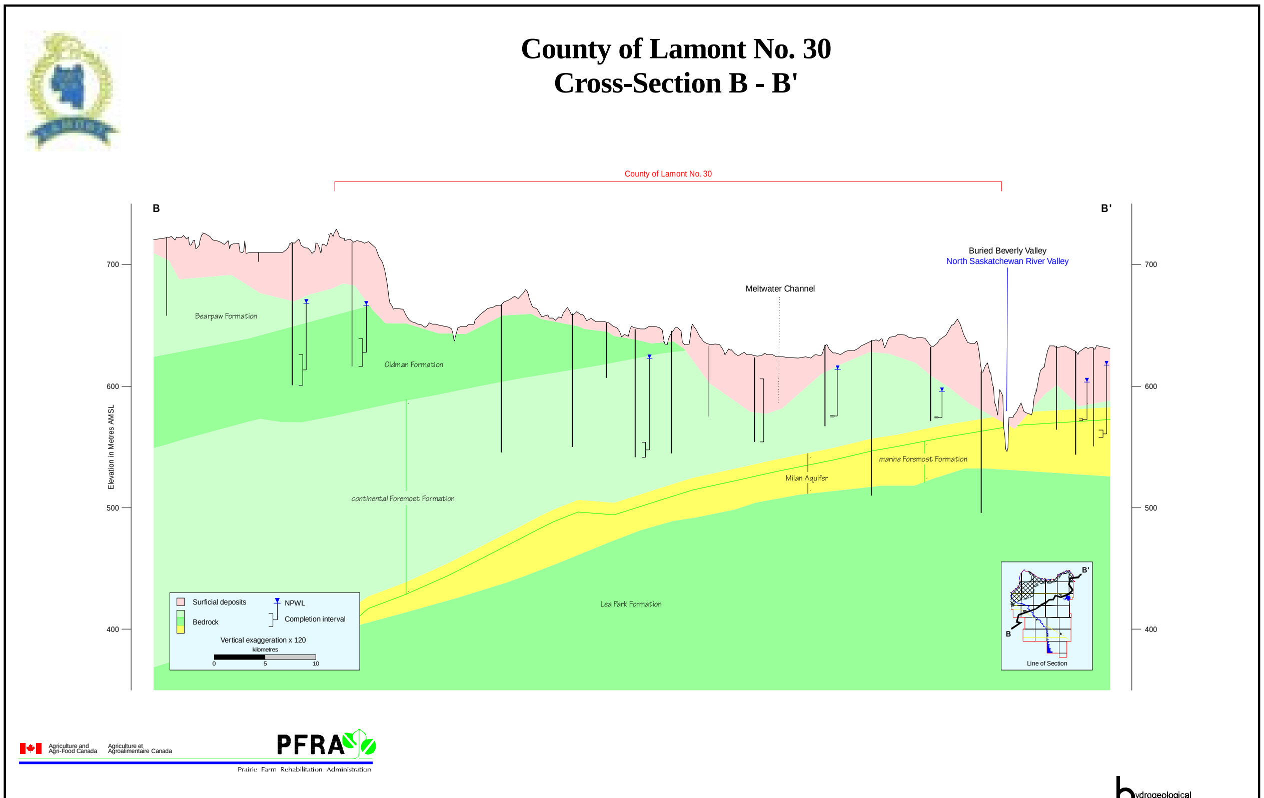

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