Red Deer County

Part of the Red Deer River Basin
Tp 034 to 039, R 21 to 28, W4M and Tp 034 to 039, R 01 to 04, W5M
Regional Groundwater Assessment

Red Deer County

In conjunction with

Agriculture and Agri-Food Canada | Agriculture et Agroalimentaire Canada
Prairie Farm Rehabilitation Administration | Administration du rétablisseme agricole des Prairies

Canada

Prepared by
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Our File No.: **03-186**

May 2005

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Geologists and Geophysicists of Alberta

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Mr. Tim Martin – Alberta Agriculture, Food and Rural Development

For additional copies of the report/CD-ROM, please contact the following:

- 1-800-GEO-WELL
- The Groundwater Centre/Regional Groundwater Assessment

http://www.groundwatercentre.com/m_info_rgwa.asp

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 also creates a solid base for increased economic activity. **Though this report’s scope is regional, it is a first step for Red Deer County in managing their groundwater. It is also a guide for future groundwater-related projects.**

1.1 Purpose

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

The regional groundwater assessment will:

- identify the aquifers[1] within the surficial deposits[2] and the upper bedrock
- spatially identify the main aquifers
- describe the quantity and quality of the groundwater associated with each aquifer
- identify the hydraulic relationship between aquifers
- identify possible groundwater depletion areas associated with each upper bedrock aquifer.

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 used in the regional groundwater assessment for Red Deer County.

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[1] See glossary

[2] See glossary

1.2 The Project

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

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

Task 1 - Data Collection and Review
Task 2 - Hydrogeological Maps, Figures, Digital Data Files
Task 3 - Hydrogeological Evaluation and Preparation of Report
Task 4 - Groundwater Information Query Software
Task 5 - Review of Draft Report and GIS Data Files
Task 6 - Report Presentation and Familiarization Session
Task 7 - Provision of Report, Maps, Data Layers and Query
Task 8 - Provision of Compact Disk for Sale to General Public.

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

1.3 About This Report

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

Additional technical details are available from files on the CD-ROM provided with the final version of this report. The files include the geo-referenced electronic groundwater database, maps showing distribution of various hydrogeological parameters, the groundwater query, ArcView files and ArcExplorer files. Likewise, all of the illustrations and maps shown in this report, plus additional maps, figures and cross-sections, are available on the CD-ROM. In order to avoid map-edge effects, all maps are based on an analysis of hydrogeological data from townships 034 to 039, ranges 21 to 28, W4M and townships 034 to 039, ranges 01 to 04, W5M, plus a buffer area of 5,000 metres. 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. A plastic County map outline is provided to overlay the maps, and contains information such as towns, main rivers, etc.

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

Appendix C includes the following:

1) a procedure for conducting aquifer tests with water wells[3]
2) a table of contents for the Water (Ministerial) Regulation under the *Water Act*
3) interpretation of chemical analysis of drinking water
4) additional information.

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

Appendix D includes page-size copies of the poster-size figures provided with this report.

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

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[3] See glossary

2 INTRODUCTION

2.1 Setting

Red Deer County is situated between the City of Edmonton and the City of Calgary in south-central Alberta, as shown on Figure 1 and on page A-3. A part of the County's northern boundary and the County's entire eastern boundary is the Red Deer River; a small section of the northwestern boundary is defined by the Medicine River. The other County boundaries follow township or section lines, which include parts of the area bounded by townships 034 to 039, ranges 21 to 28, W4M and townships 034 to 039, ranges 01 to 04, W5M.

Regionally, the topographic surface varies between 700 and 1,100 metres above mean sea level (AMSL). The lowest elevations occur mainly in the northeastern parts of the County along the Red Deer River; the highest elevations are in the southwestern parts of the County, as shown on the adjacent figure. The County is within the South Saskatchewan River basin; the sub-basin is the Red Deer River basin. The area is drained by the Red Deer River, the Medicine River and the Ghostpine, Threehills and Kneehills creeks.

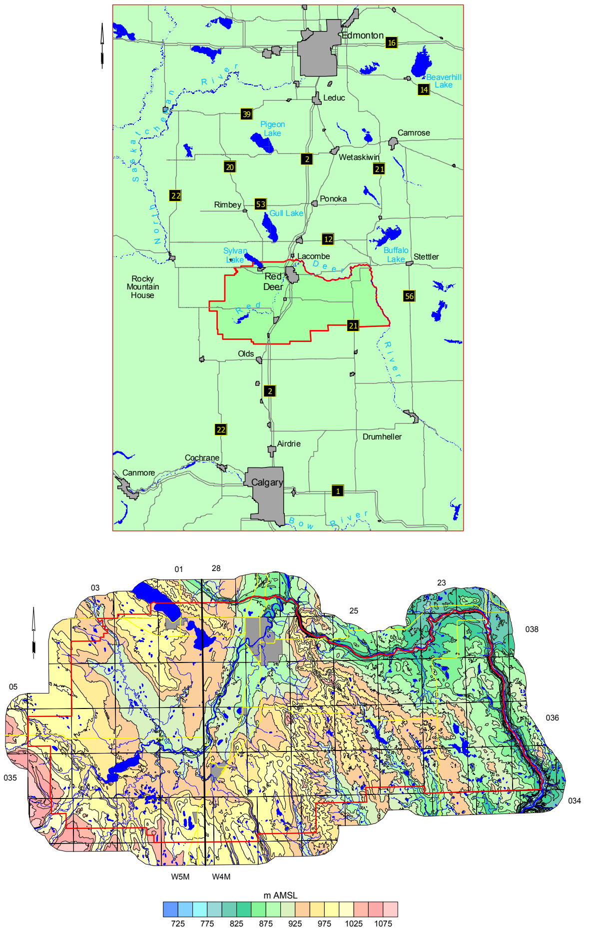

Figure 1. Index Map/Surface Topography

2.2 Climate

Red Deer County lies within the transition zone between a humid, continental Dfb[4] climate and a semiarid Bsk[5] climate. This classification is based on potential evapotranspiration[6] 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 Leggat, 1981) shows that the County is located in the Aspen Parkland region, a transition between boreal and grassland environments. Increased precipitation and cooler temperatures, resulting in additional moisture availability, influence these vegetation changes.

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. A Bsk climate is characterized by its moisture deficiency, where mean annual potential evapotranspiration exceeds the mean annual precipitation.

The mean annual precipitation averaged from two meteorological stations within the County and three meteorological stations just outside of the County measured 491 millimetres (mm), based on data from 1971 to 2000. The mean annual temperature averaged 2.8° C, with the mean monthly temperature reaching a high of 15.6° C in July, and dropping to a low of -11.9° C in January. The calculated annual potential evapotranspiration is 501 millimetres.

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[4] See glossary
[5] See glossary
[6] See glossary

2.3 Background Information

2.3.1 Number, Type and Depth of Water Wells

There are currently 14,654 records in the groundwater database for the County, of which 11,827 are water wells. Of the 11,827 water wells, there is a proposed use for 11,316 water wells. Of the 11,316 water wells, there are records for domestic (7,034), domestic/stock (2,583) or stock (1,057) purposes. The remaining 642 water wells were completed for industrial (328), municipal (102), observation (61) purposes, and other numerous categories (151). Based on a rural population of 18,639 (Phinney, 2004), there are 2.3 domestic, domestic/stock and stock water wells per family of four. There are 6,635 domestic or stock water wells with a completed depth, of which 5,311 (80%) are completed at depths of less than 60 metres below ground surface. Details for lithology[7] are available for 7,684 water wells.

2.3.2 Number of Water Wells in Surficial and Bedrock Aquifers

There are 6,694 water wells with completion interval and lithologic information, such that the aquifer in which the water wells are completed can be identified. The water wells that were not drilled deep enough to encounter the bedrock plus water wells that have the bottom of their completion interval above the top of the bedrock are water wells completed in surficial aquifers. Of the 6,694 water wells for which aquifers could be defined, 167 are completed in surficial aquifers, with 134 (80%) having a completion depth of less than 35 metres below ground surface. The adjacent map shows that the water wells completed in the surficial deposits occur mainly in the western half of the County, frequently in the vicinity of linear bedrock lows.

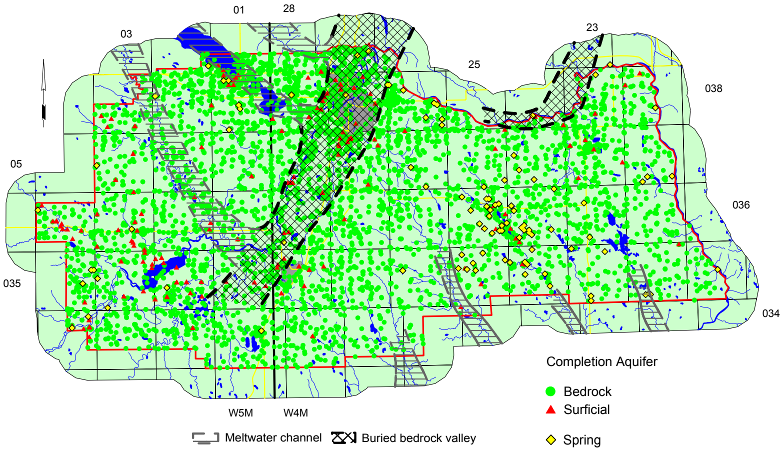

Figure 2. Location of Water Wells and Springs

The data for 6,527 water wells show that the top of the water well completion interval is below the bedrock surface, indicating that the water wells are completed in at least one bedrock aquifer. From Figure 2 (also see page A-6), it can be seen that water wells completed in bedrock aquifers occur throughout the County.

Within Red Deer County, there are currently records for 108 springs in the groundwater database, including three springs that were documented by Borneuf (1983). There are 73 springs having at least one total dissolved solids (TDS) value, with nearly 75% having a TDS of less than 800 milligrams per litre (mg/L). There are six springs in the groundwater database with flow rates ranging from 4.5 to 550 litres per minute (lpm).

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[7] See glossary

2.3.3 Casing Diameter and Type

Data for casing diameters are available for 7,939 water wells, with 7,775 (98%) indicated as having a diameter of less than 275 mm and 164 (2%) having a diameter of more than 275 mm. The casing diameters of greater than 275 mm are mainly bored or dug water wells and those with a surface-casing diameter of less than 275 mm are mainly drilled water wells. The groundwater database suggests that the 164 above-mentioned water wells in the County were mainly bored or hand dug. The complete water well database for the County suggests that 521 of the water wells in the County were bored or hand dug.

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. Some 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. Within the County, casing-diameter information is available for 157 of the 167 water wells completed in the surficial deposits, of which 139 surficial water wells have a casing diameter of less than 275 millimetres and are assumed to be drilled water wells. Within the County, casing-diameter information is available for 6,402 of the 6,527 water wells completed below the top of bedrock, of which 6,389 have a surface-casing diameter of less than 275 mm and have been mainly completed with either a perforated liner or as open hole; there are 25 bedrock water wells completed with a water well screen.

Where the casing material is known, steel surface casing materials have been used in 66% of the drilled water wells over the last 50 years. For the remaining drilled water wells with known surface casing material, 7% were completed with galvanized steel casing, 15% with plastic casing, and 12% with wood, concrete or other surface casing materials (used mostly in the 1960s and 1970s). Prior to the mid-1960s, the type of surface casing used in drilled water wells was mainly undocumented. Steel casing was in use in the 1950s and is still used in 68% of the water wells being drilled in the County. Steel and galvanized steel were the main casing types until the start of the 1990s, at which time plastic casing started to replace the use of galvanized steel casing.

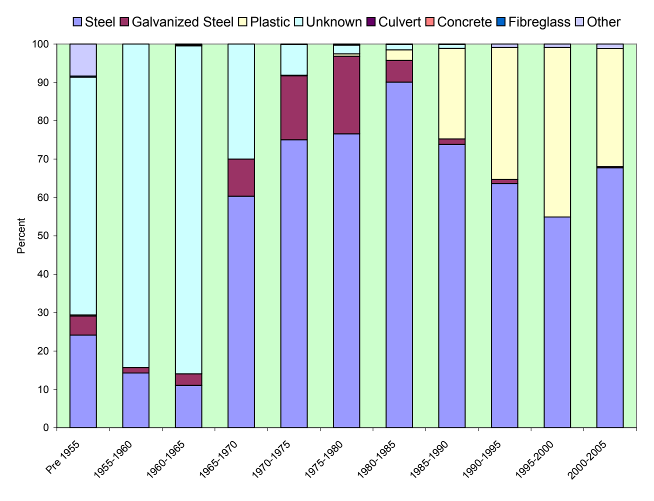

Figure 3. Surface Casing Types Used in Drilled Water Wells

Steel casing has been dominant in the County probably because it has resisted corrosion and also because water well drillers may be reluctant to use plastic (PVC) casing if there have been no documented problems with steel casing in the area.

2.3.4 Dry Water Test Holes

In the County, there are 14,654 records in the groundwater database. Of these 14,654 records, 148 are indicated as being “dry” or abandoned with “insufficient water”[8]. Also included in these “dry” test holes is any record that includes comments that state the water well goes dry in dry years. Of the 148 “dry” water test holes, 136 are completed in bedrock aquifers; 11 “dry” water test holes are completed in surficial deposits; and the remaining one has an unknown completion interval. This is a remarkably low rate of dry or unsuccessful test holes or water wells. Nearly 20% of all water wells with apparent yield estimates were judged to yield less than 6.5 cubic metres per day (m³/day) (one imperial gallon per minute ([1 igpm]).

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[8] “dry” can be due to a variety of reasons: skill of driller, type of drilling rig/method used, the geology

2.3.5 Requirements for Licensing

With some exemptions, a diversion of groundwater starting after 01 Jan 1999 must have a licence. Exemptions include (1) the diversion for household use of up to 3.4 cubic metres per day (1,250 m^3/year [750 imperial gallons per day[9]]), (2) the diversion of groundwaters with total dissolved solids in excess of 4,000 mg/L, (3) the diversion from a manually pumped water well, or (4) a diversion of groundwater that was eligible for registration as "Traditional Agriculture Use" but was not registered can continue to be used for Traditional Agriculture Use but without the protection of the *Water Act*.

Including the last update from the Alberta Environment (AENV) licensing database, 1,957 groundwater allocations were shown to be within the County, with the most recent groundwater user being authorized in May 2003. Of the 1,957 authorized groundwater users (licences and registrations), 1,448 are registrations of Traditional Agriculture Use under the *Water Act*. These 1,448 registered users will continue to divert groundwater for stock watering and/or crop spraying. Typically, the groundwater diversion for crop spraying is less than one m^3/day so most registered groundwater diversion is for stock watering. Of the 1,448 registrations, 780 (54%) could be linked to the AENV groundwater database. Of the remaining 509 groundwater users, 372 are for agricultural purposes (mainly stock watering), 63 are for municipal purposes (mainly urban), 36 are for recreation purposes, 21 are for commercial purposes, seven are for industrial purposes (mainly oil injection), three are for fisheries, three are for irrigation, two are for dewatering purposes, and the remaining two are listed as for other purposes. Of these 509 licensed groundwater users in the County, 262 (51%) could be linked to the AENV groundwater database. The total maximum authorized diversion from the water wells associated with these licences and registrations is 20,658 m^3/day, although actual use could be less. Of the 20,658 m^3/day, 9,716 m^3/day (47%) is licensed for municipal purposes, 5,534 m^3/day (26.8%) is licensed for agricultural purposes, 4,106 m^3/day (19.9%) is registered for Traditional Agriculture Use, 483 m^3/day (2.3%) is licensed for recreation use, 418 m^3/day (2%) is licensed for commercial purposes, 193 m^3/day (0.9%) is licensed for industrial purposes, 97 m^3/day (0.5%) is licensed for dewatering purposes, 78 m^3/day (0.4%) is licensed for irrigation purposes, and the remaining 30 m^3/day (0.2%) is licensed for fishery purposes, as shown below in Table 1. A figure showing the locations of the groundwater users with either a licence or a registration is in Appendix A (page A-7) and on the CD-ROM. Table 1 also shows a breakdown of the 1,957 groundwater licences and/or registrations by the aquifer in which the water well is completed. Approximately 76% of the total quantity of licensed and/or registered groundwater use is from the Dalehurst Aquifer. The water wells associated with the 126 licensed and/or registered use where a specific aquifer cannot be determined is because insufficient completion information is available.

Aquifer **	No. of Licences and/or Registrations	Registrations (m^3/day)	Licenced Groundwater Users * (m^3/day)									Total Quantity of Licensed and/or Registered Groundwater Diversion (m^3/day)	Percentage
			Agricultural	Commercial	Dewatering	Fishery	Industrial	Irrigation	Municipal	Recreation	Other		
Multiple Surficial Completions	67	143	259	0	0	0	0	10	54	0	0	466	2.3
Upper Surficial	54	92	83	180	74	0	0	59	14	3	0	506	2.5
Lower Surficial	17	52	41	2	22	0	68	0	0	0	0	185	0.9
Multiple Bedrock Completions	135	232	475	76	0	14	0	0	262	98	0	1,157	5.6
Dalehurst	1,346	2,935	3,876	115	0	17	125	8	8,458	68	0	15,603	75.5
Upper Lacombe	50	64	132	17	0	0	0	0	181	216	4	614	3.0
Lower Lacombe	3	3	0	0	0	0	0	0	0	0	0	3	0.0
Haynes	42	87	91	0	0	0	0	0	108	3	0	290	1.4
Upper Scollard	89	211	233	27	0	0	0	0	274	0	0	745	3.6
Lower Scollard	25	48	104	0	0	0	0	0	0	0	0	152	0.7
Battle	3	7	0	0	0	0	0	0	0	0	0	7	0.0
Unknown	126	231	240	0	0	0	0	0	365	95	0	930	4.5
Total(1)	1,957	4,106	5,534	418	97	30	193	78	9,716	483	4	20,658	100
Percentage		19.9	26.8	2.0	0.5	0.2	0.9	0.4	47.0	2.3	0	100	

* data from AENV ** Aquifer identified by HCL

(1) The values given in the table have been rounded and, therefore, the columns and rows may not add up equally

Table 1. Licensed and/or Registered Groundwater Diversions

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[9] see conversion table on page 65

Based on the 2001 Agriculture Census (Statistics Canada), the calculated water requirement for 692,818 livestock for the County is in the order of 23,200 m³/day. This number includes intensive livestock use but not domestic animals and is based on an estimate of water use per livestock type. Of the 23,200 m³/day calculated livestock use, AENV has authorized a groundwater diversion of 9,640 m³/day (agricultural and registration) (42%) and licensed a surface-water diversion based on consumptive use of 1,629 m³/day (7%) for a total diversion of 11,269 m³/day. Agriculture purpose includes water diverted and used for stockwatering and feedlot use. This assumes the majority of the groundwater and surface water authorized for diversion and use as Traditional Agriculture Use is used for watering livestock. Using this assumption, 49% of the estimated total water requirements of 23,200 m³/day is accounted for.

The remaining 11,931 m³/day (51%) of the calculated water requirement for livestock use would have to be from other, including unlicensed, sources. The discrepancy may be partially accounted for in several ways. Based on some monitoring and reporting situations, the estimated water requirements for livestock, used by AENV, tend to be somewhat high. Some livestock water requirements would be made up from free-standing water following precipitation events, thus reducing the expected quantity needed. Also, it should be noted that ‘household use’, as defined in the *Water Act*, can provide sufficient water for about 75 head of cattle, with no need for a licence. It is possible that some such use may have been registered as Traditional Agriculture Use and would therefore be included in the registration quantity. Also, diversions of groundwater and surface water that were eligible for registration as Traditional Agriculture Use can continue to be used for traditional agricultural purposes without the need for authorization.

2.3.6 Base of Groundwater Protection

In general, Alberta Environment defines the Base of Groundwater Protection (BGP) as the elevation below which the groundwater will have more than 4,000 mg/L of total dissolved solids. By using the ground elevation, formation elevations, and Alberta Energy and Utilities Board (EUB) information indicating the formations containing the deepest useable water for agricultural needs, a value for the depth to the BGP can be determined. These values are gridded using the Kriging[10] method to prepare a depth to the BGP surface. This depth, for the most part, would be the maximum drilling depth for a water well for agricultural purposes or for a potable water supply. If a water well has total dissolved solids exceeding 4,000 mg/L, the groundwater use does not require licensing by AENV. In the County, the depth to the BGP ranges from less than 200 metres in the north-central part of the County along parts of the Red Deer River and in the south-central part of the County, to more than 550 metres in the western part of the County, as shown on the following page in Figure 4, and on page A-8.

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[10] See glossary

There are 10,940 water wells with completed depth data, of which two appear to be completed below the Base of Groundwater Protection. These two water wells drilled for industrial purposes in the 1950s are completed at more than 400 metres below ground surface in multiple bedrock aquifers. The two industrial water wells, in section 07, township 039, range 01, W5M, are in an area where the depth to the Base of Groundwater Protection is between 350 and 400 metres below ground surface. Chemistry data are not available for the two industrial water wells.

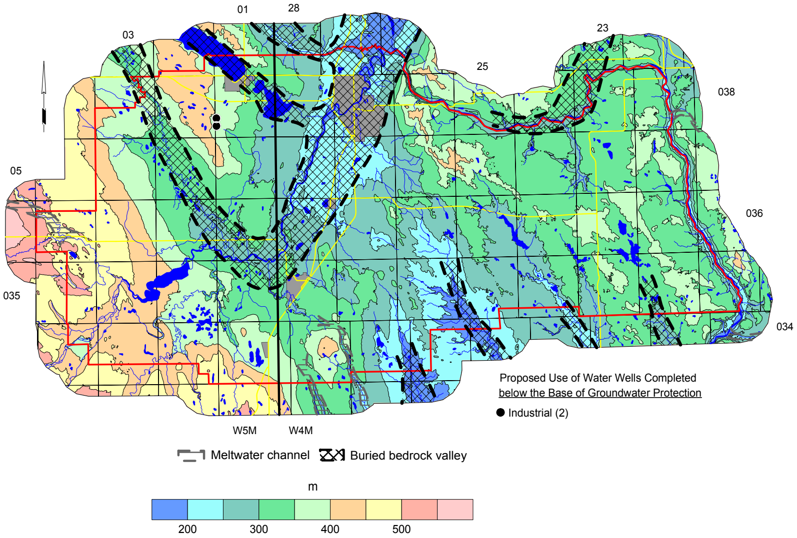

Figure 4. Depth to Base of Groundwater Protection (after EUB, 1995)

Proper management of the groundwater resource requires water-level data. These data are often collected from observation water wells. At the present time, there are eight AENV-operated observation water wells within the County (see page A-58 for observation water well locations). Additional data can be obtained from some of the authorized groundwater diversions. In the past, the data for authorized diversions have been difficult to obtain from AENV, in part because of the failure of the applicant to provide the data.

Even with the available sources of data, the number of water level data points relative to the size of the County is too few to provide a reliable groundwater budget (see section 6.0 of this report). 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, as has been the case in the Wildrose Country Ground Water Monitoring Association and Flagstaff County.

3 TERMS

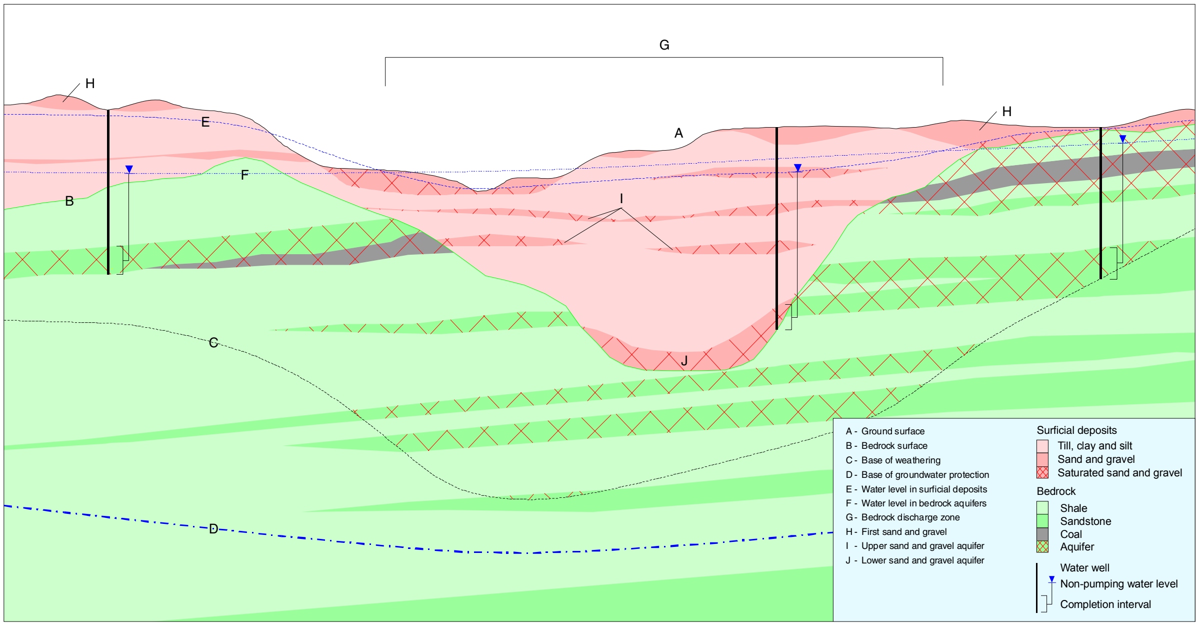

Figure 5. Generalized Cross-Section (for terminology only)

(for larger version, see page A-9)

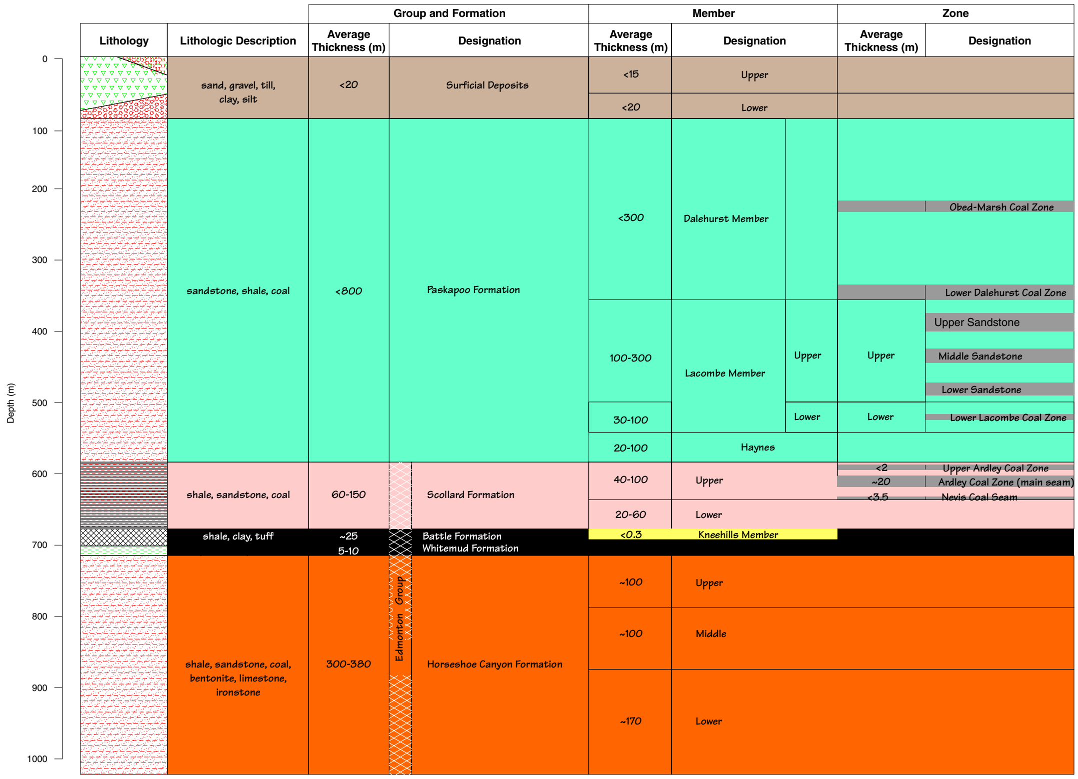

Figure 6. Geologic Column

(for larger version, see page A-10)

4 METHODOLOGY

4.1 Data Collection and Synthesis

The AENV 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) locations for some water wells determined during water well surveys
5) chemical analyses for some groundwaters[11]
6) location of some flowing shot holes
7) location of some structure test holes
8) a variety of data related to the groundwater resource.

The main disadvantage to the database is the reliability of the information entered into the database. 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. Any duplicate water wells that have been identified within the County have been removed from the database used in this regional groundwater assessment.

The AENV groundwater database uses an area-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 based on the NAD27 datum. This means that a record for the SW ¼ of section 12, township 035, range 27, W4M would have a horizontal coordinate with an Easting of 86,449 metres and a Northing of 5,757,463 metres, the centre of the quarter section. If the water well has been repositioned by AAFC-PFRA using orthorectified aerial photographs, the location will be more accurate, possibly within several tens of metres of the actual location. Once the horizontal coordinates are determined for a record, a ground elevation for that record is obtained from the 1:20,000 Digital Elevation Model (DEM); AltaLIS Ltd. provides the DEM.

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 at a given location.

After assigning spatial control for the ground location for 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.

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[11] Since 1986, Alberta Health and Wellness has restricted access to chemical analysis data, and hence the database includes only limited amounts of chemical data after 1986.

Where possible, determinations are made from individual records in order to assign water wells to aquifers and to obtain values for the following:

1) depth to bedrock
2) total thickness of sand and gravel below 15 metres
3) total thickness of saturated sand and gravel
4) depth to the top and bottom of completion intervals[12].

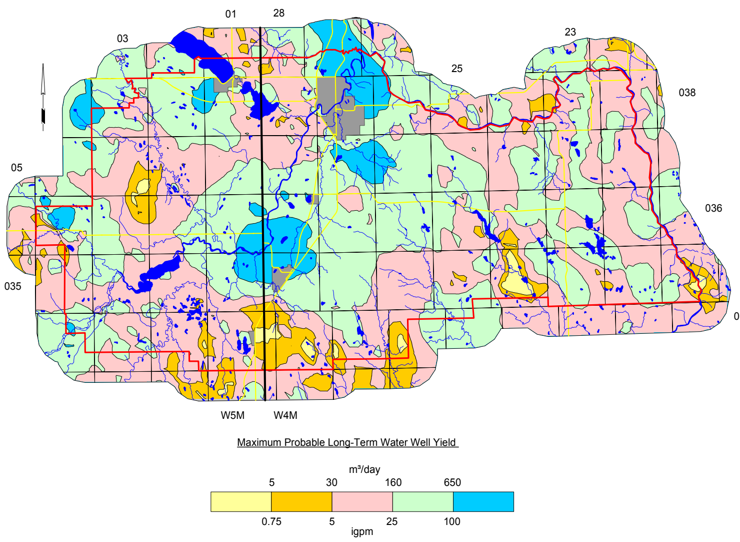

Figure 7. Hydrogeological Map

Also, where sufficient information is available, values for apparent transmissivity[13] and apparent yield[14] are calculated, based on the aquifer test summary data supplied on the water well drilling reports. Where valid detailed aquifer test results exist, the interpreted data provide values for aquifer transmissivity and effective transmissivity. Since the last regional hydrogeological maps covering at least a part of the County were published in 1971 (Tokarsky, 1971; LeBreton, 1971), 3,838 values for apparent transmissivity and 3,250 values for apparent yield have been added to the groundwater database. The median apparent yield of the water wells with apparent yield values is 31 m^3/day. Approximately 27% of the apparent yield values for these water wells are less than ten m^3/day. With the addition of the apparent yield values, including a 0.1 m^3/day value assigned to “dry” water wells and water test holes, a hydrogeological map has been prepared to help illustrate the general groundwater availability across the County (Figure 7 and page A-11). The map is based on groundwater being obtained from all aquifers and has been prepared to allow direct comparison with the results provided on the Alberta Research Council (ARC) hydrogeological maps. In general, the ARC maps show higher estimated long-term yields. The differences between the 1971 and the 2004 maps may be a result of fewer apparent yield values and the gridding method employed by the ARC.

The EUB well database includes records for wells drilled for 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 geologic units
3) type and intervals for various down-hole geophysical logs
4) drill stem test (DST) summaries.

Values for apparent transmissivity and apparent yield 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 support the geological interpretation of geophysical logs but cannot be distributed because of a licensing agreement.

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[12] See glossary
[13] For definitions of Transmissivity, see glossary
[14] For definitions of Yield, see glossary

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) geophysical logs for wells drilled by the oil and gas industry
4) data from existing cross-sections.

The aquifers are defined by mapping the tops and bottoms of individual geologic units. The values for the elevation of the top and bottom of individual geologic units at specific locations help to determine the spatial distribution of the individual surfaces. Establishment of a surface distribution digitally requires preparation of a grid. The inconsistent quality of the data 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 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.

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 depth of a water well cannot be established, 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), apparent transmissivity, and apparent water well yield. The NPWL given on the water well record is usually the water level recorded when the water well was drilled, measured prior to the initial aquifer test. In areas where groundwater levels have since fallen, the NPWL may now be lower and accordingly, potential apparent yield would be reduced. The total dissolved solids, sulfate and chloride concentrations from the chemical analyses of the groundwaters are also assigned to applicable aquifers. In addition, chemical parameters of nitrate + nitrite (as N) are assigned to surficial aquifers and fluoride is assigned to upper bedrock aquifer(s).

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. The representative data set included using the available data from townships 034 to 039, ranges 21 to 28, W4M and townships 034 to 039, ranges 01 to 04, W5M, plus a buffer area of at least 5,000 metres. Even when only limited data are available, grids are prepared. However, the grids prepared from the limited data must be used with extreme caution because the gridding process can be unreliable; for the maps, the areas with little or no data are identified.

On some maps, values are posted as a way of showing anomalies to the underlying grid or as a means of emphasizing either the lack of sufficient data or areas where there is concentrated hydrogeological data control.

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 geologic units. For example, the relationship between the uppermost bedrock unit and the bedrock surface must be determined. This process provides both the outline and the thickness of the geologic unit.

Once the appropriate grids are available, the maps are prepared by contouring the grids. For the upper bedrock aquifer(s) where areas of sufficient data are not available from the groundwater database, prepared maps have been masked with a solid faded pink colour to indicate these areas. These masks have been added to the Lacombe and Scollard 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.

Blue hues have been chosen to represent map areas where the chemical parameters are below the Summary of Guidelines for Canadian Drinking Water Quality (SGCDWQ) and orange hues have been chosen to represent map areas where the chemical parameters are above the SGCDWQ.

Constituent	Recommended Maximum Concentration SGCDWQ (mg/L)	Colour Blends Used on Maps to Indicate Areas that are Below SGCDWQ	Colour Blends Used on Maps to Indicate Areas that Exceed SGCDWQ
Total Dissolved Solids	500	🟦	🟧
Nitrate + Nitrite (as N)	10		
Sulfate	500		
Chloride	250		
Fluoride	1.5		

Concentration in milligrams per litre unless otherwise stated
Note: indicated concentrations are for Aesthetic Objectives except for
Fluoride and Nitrate + Nitrite (as N), which are for Maximum Acceptable Concentrations (MAC)
SGCDWQ - Summary of Guidelines for Canadian Drinking Water Quality
Federal-Provincial-Territorial Committee on Drinking Water, April 2003

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 non-pumping water levels. Data from individual geologic 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. Seven cross-sections are presented in Appendix A of this report and as poster-size drawings forwarded with this report; only two (A-A’ and B-B’) are included in the text of this report. The cross-sections are also included on the CD-ROM; page-size maps of the poster-size cross-sections are included in Appendix D of this report.

4.5 Software

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

- Acrobat 6.0
- AquaChem 3.6
- ArcView 3.2
- ArcGIS 9
- AutoCAD 2004
- CorelDraw! 12.0
- Grapher 3
- Microsoft Office 2003
- Surfer 8

5 AQUIFERS

5.1 Background

An aquifer is a permeable rock unit that is saturated. In this context, rock refers to subsurface materials, such as sand, gravel, sandstone and coal. If the NPWL is above the top of the rock unit, this type of aquifer is a confined or artesian aquifer. If the rock unit is not entirely saturated and the water level is below the top of the rock unit, this type of aquifer is a water-table or unconfined aquifer. These types of aquifers occur in one of two general geological settings in the County. The first geological setting includes the sediments that overlie the bedrock surface. In this report, these sediments 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 aquifer(s) within different geologic units, and the general chemical quality of the groundwater associated with each setting are reviewed separately.

5.2 Aquifers in Surficial Deposits

The surficial deposits are the sediments above the bedrock surface. These include pre-glacial materials, which were deposited before glaciation, and materials deposited directly or indirectly as a result of glaciation. The *lower surficial deposits* include pre-glacial fluvial[15] deposits. The *upper surficial deposits* include the traditional glacial sediments of till[16] and ice-contact deposits. Pre-glacial materials are expected to be mainly present in association with linear bedrock lows. Meltwater channels are associated with glaciation.

5.2.1 Geological Characteristics of Surficial Deposits

While the surficial deposits are treated as one hydrogeologic unit, they consist of three hydraulic units. The first unit is the preglacial sand and gravel deposits of the lower surficial deposits that directly overlie the bedrock surface, when present (see page A-28). These deposits are mainly saturated. The second and third hydraulic units are associated with the sand and gravel deposits in the upper surficial deposits. The sand and gravel deposits in the upper surficial deposits occur mainly as pockets. The second hydraulic unit is the saturated part of these sand and gravel deposits; the third hydraulic unit is the unsaturated part of these deposits that occur close to ground surface. For a graphical depiction of the above description, please refer to Figure 5 on page 9 and to page A-9. While the unsaturated deposits are not technically an aquifer, they are significant, as they provide a pathway for soluble contaminants to move downward into the groundwater.

The base of the surficial deposits is the bedrock surface, represented by the bedrock topography, as shown on Figure 8 on the following page. Regionally, the bedrock surface varies between 690 and 1,090 metres AMSL. The lowest elevations occur along the present-day Red Deer River, as shown on Figure 8 and on page A-19.

Over the majority of the County, the surficial deposits are less than 30 metres thick (see CD-ROM). The exceptions are mainly in association with areas where linear bedrock lows are present, where the deposits can have a thickness of more than 40 metres. The main linear bedrock lows in the County are southwest-northeast features that have been designated as the Buried Red Deer Valley and Buried Buffalo Valley (after Farvolden et al, 1963).

The Buried Red Deer Valley trends from the southwest to the northeast in the central part of the County. The southern extent of the Buried Red Deer Valley is not well defined. The Valley is approximately six to nine kilometres wide, with local bedrock relief being less than 60 metres. Sand and gravel deposits can be expected in association with this bedrock low, but the thickness of the sand and gravel deposits is expected to be mainly less than ten metres.

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[15] See glossary
[16] See glossary

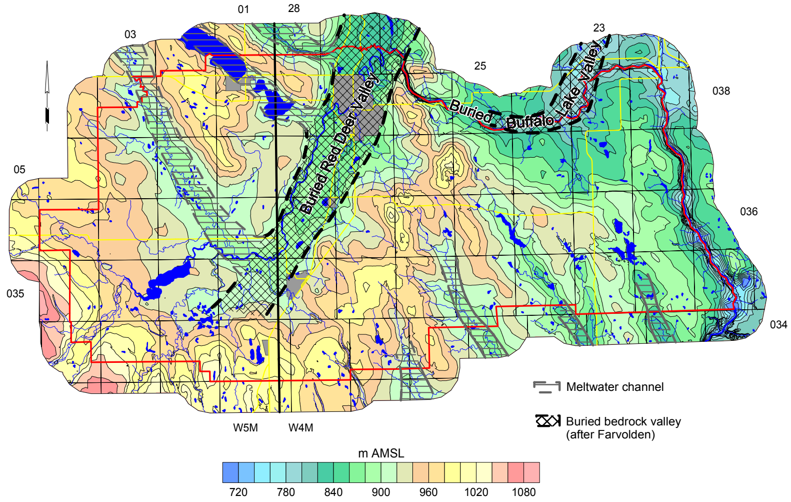

Figure 8. Bedrock Topography

The Buried Buffalo Lake Valley occupies the present-day Red Deer River Valley, trends mainly from the west-southwest to the northeast in the extreme northern part of Red Deer County. The Buried Buffalo Lake Valley is a tributary to the Buried Red Deer Valley in Wainwright County. The Valley is approximately two to six kilometres wide, with local relief being less than 40 metres. Sand and gravel deposits can be expected in association with linear bedrock lows, but the thickness of the sand and gravel deposits is expected to be mainly less than ten metres.

The lower sand and gravel units are composed of fluvial deposits and are mainly identified in association with linear bedrock lows, as shown below on Cross-Section B-B'. In these areas, the total thickness of the lower sand and gravel deposits can be more than five metres (see CD-ROM). Another area where thick lower sand and gravel deposits can be expected is along the North Raven River in both Red Deer and Clearwater counties and along the Red Deer River in the extreme southwestern part of Red Deer County.

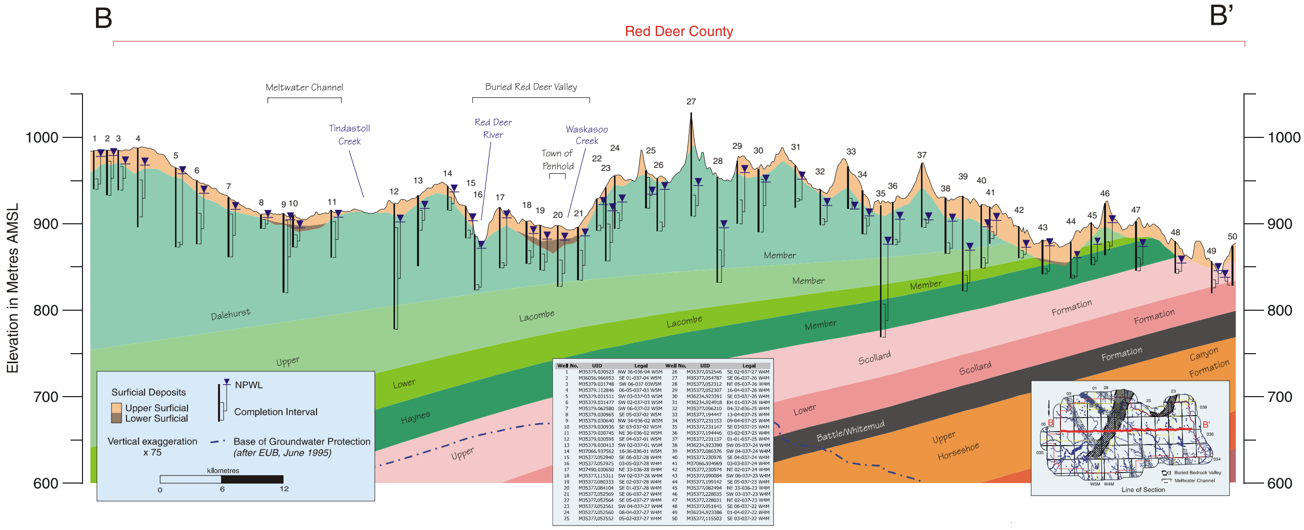

Figure 9. Cross-Section B – B'

In the County, there are numerous linear bedrock lows that trend southeast to northwest and are indicated as being of meltwater origin. Because sediments associated with the lower sand and gravel deposits are indicated as being present in parts of the meltwater channels, it is possible that the meltwater channels were originally tributaries to the Buried Red Deer Valley (see CD-ROM). Of the two significant surface-water bodies in the County (Sylvan Lake and Gleniffer Lake), Sylvan Lake appears to be associated with meltwater channels. Gleniffer Lake is the result of the damming of surface-water flow at the Dickson Dam.

The upper surficial deposits are either directly or indirectly a result of glacial activity. The deposits include till, with minor sand and gravel deposits of meltwater origin, which are expected to occur mainly as isolated pockets. The thickness of the upper surficial deposits is mainly less than ten metres. Upper surficial deposits are present throughout the County (see CD-ROM). Because the meltwater channels are mainly an erosional feature, the sand and gravel deposits associated with these features are considered not to be significant aquifers. The upper sand and gravel deposits are usually less than two metres thick but can be more than five metres in association with linear bedrock lows and in the southwestern part of the County (see CD-ROM).

Sand and gravel deposits can occur throughout the surficial deposits. The total thickness of sand and gravel deposits is generally less than two metres but can be more than five metres in association with the linear bedrock lows and in the southwestern part of the County (Figure 10). The northwest-southeast-trending sand and gravel deposits of more than five metres thick shown in the southwestern part of the County continue into the southeastern part of Clearwater County (HCL, Feb 2004).

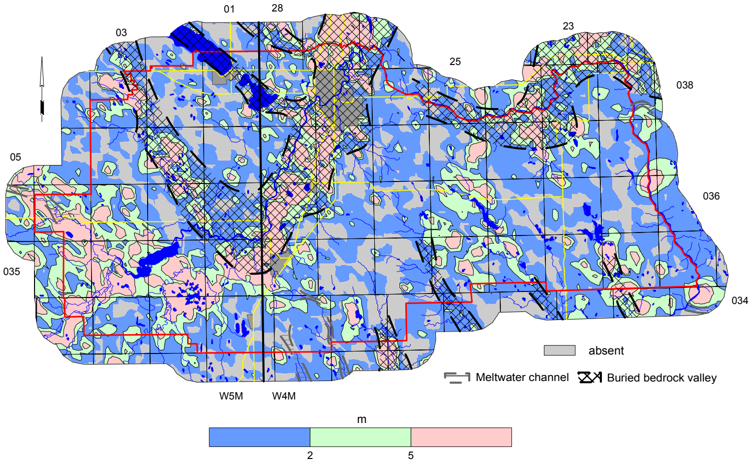

Figure 10. Thickness of Sand and Gravel Deposits

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 15% of the County where sand and gravel deposits are present, the sand and gravel deposits are more than 40% of the total thickness of the surficial deposits (page A-22). The areas where sand and gravel deposits constitute more than 40% of the total thickness of the surficial deposits are mainly in association with linear bedrock lows and in the southwestern part of the County.

5.2.2 Sand and Gravel Aquifer(s)

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 non-pumping water level in water wells that are less than 20 metres deep. The base of the surficial deposits is the bedrock surface.

Since the Sand and Gravel Aquifer(s) are not present everywhere, the actual aquifer that is developed at a given location is usually dictated by the aquifer that is present. Over approximately 35% of the County, the sand and gravel deposits are not present, or if present, are not saturated; these areas are designated as grey on the adjacent map. In 50% of the County, the thickness of the Sand and Gravel Aquifer(s), where present, is less than two metres, but can be more than five metres in areas of, or near, linear bedrock lows, and in the southwestern part of the County, as shown in Figure 11, on page A-23 and on the CD-ROM.

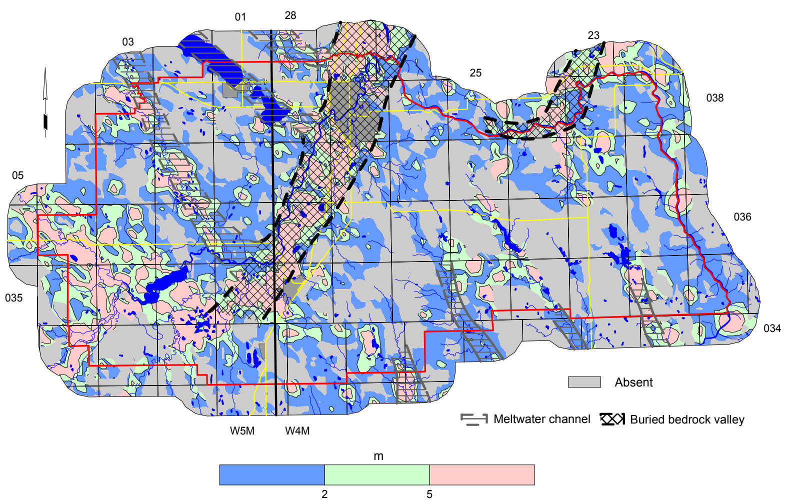

Figure 11. Thickness of Sand and Gravel Aquifer(s)

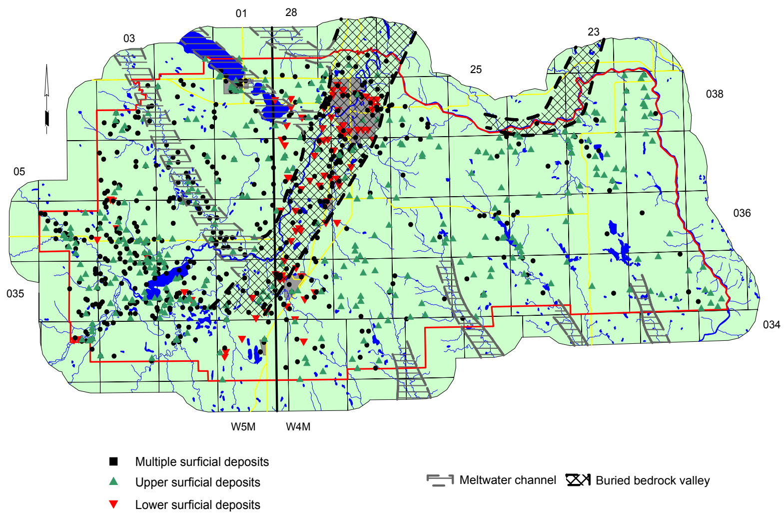

Figure 12. Water Wells Completed in Surficial Deposits

Of the 11,827 water wells in the database, 167 were defined as being completed in surficial aquifers, based on lithologic information and water well completion details. From the present hydrogeological analysis, 1,067 water wells are completed in aquifers in the surficial deposits. Of the 1,067 water wells, 370 are completed in aquifers in the upper surficial deposits, 90 are completed in aquifers in the lower surficial deposits, and 607 water wells are completed in multiple surficial aquifers. This number of water wells (1,067) is nearly six and a half times the number (167) determined to be completed in aquifers in the surficial deposits, based on lithologies given on the water well drilling reports. The larger number is obtained by comparing the elevation of the reported depth of a water well to the elevation of the bedrock surface at the same location. For example, if only the depth of a water well is known, the elevation of the completed depth can be calculated. If the elevation of the completed depth is above the elevation of the bedrock surface determined from the gridded bedrock topographic surface at the same location, then the water well is considered to be completed in an aquifer in the surficial deposits.

Water wells completed in the upper surficial deposits are located throughout the County, and water wells completed in the lower surficial deposits are mainly along the Buried Red Deer Valley, as shown in Figure 12.

In the County, there are 78 records for surficial water wells with apparent yield data, which is 7% of the 1,067 surficial water wells. Eleven (14%) of the 78 water wells completed in the Sand and Gravel Aquifer(s) have apparent yields that are less than ten m³/day, 34 (44%) have apparent yield values that range from 10 to 100 m³/day, and 33 (42%) have apparent yields that are greater than 100 m³/day. In addition to the 78 records for surficial water wells with apparent yield data, there are 11 records that indicate that the water test hole is "dry". In order to depict a more accurate yield map, an apparent yield of 0.1 m³/day was assigned to each of the 11 "dry" water test holes prior to gridding.

Aquifer	No. of Water Wells with Values for Apparent Yield (*)	Number of Water Wells with Apparent Yields <10 m³/day	 10 to 100 m³/day	 >100 m³/day
Upper Sand and Gravel	8	2	3	3
Lower Sand and Gravel	8	3	2	3
Multiple Completions	62	6	29	27
Totals	78	11	34	33

Table 2. Apparent Yields of Sand and Gravel Aquifer(s)

The adjacent map shows expected yields for water wells completed in the Sand and Gravel Aquifer(s).

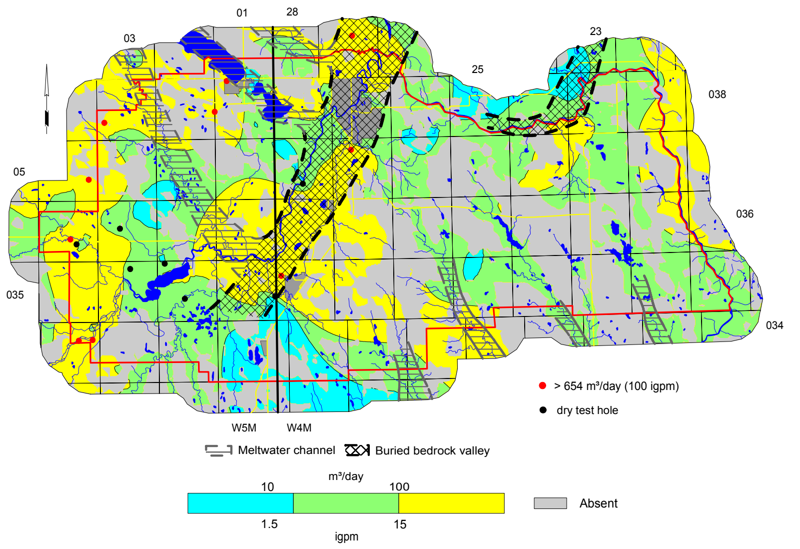

Figure 13. Apparent Yield for Water Wells Completed in Sand and Gravel Aquifer(s)

Based on the aquifers that have been developed by existing water wells, these data show that water wells with yields of more than 100 m³/day from the Sand and Gravel Aquifer(s) can be expected in 40% of the County where the Sand and Gravel Aquifer(s) are present. The most notable areas where apparent yield values of more than 654 m³/day (100 igpm) are expected are in association with the Buried Red Deer Valley and in the extreme western part of the County.

Apparent yields for water wells completed in the Sand and Gravel Aquifer(s) vary significantly over the County both with location and with depth. As Figure 14 shows, most apparent yields are less than 100 m³/day and the majority of the water wells completed in the Sand and Gravel Aquifer(s) are less than 60 metres deep. Most of the water wells that have apparent yields of greater than 100 m³/day are less than 40 metres deep.

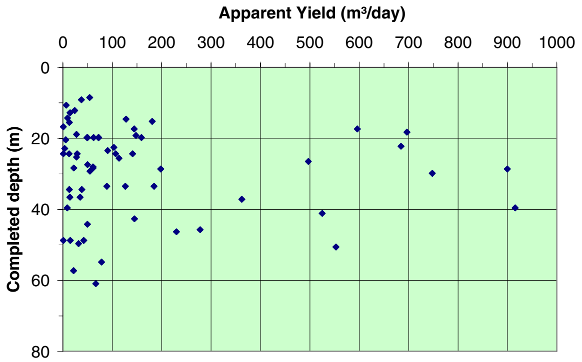

Figure 14. Sand and Gravel Water Well Yields vs Completed Depth

In the County, there are 138 licensed and/or registered water wells that are completed in the Sand and Gravel Aquifer(s), for a total authorized diversion of 1,157 m^3/day (Table 1, page 6).

5.2.2.1 Chemical Quality of Groundwater from Surficial Deposits

Groundwaters from an aquifer in the surficial deposits can be expected to be chemically hard, having a total hardness of at least a few hundred mg/L, and a dissolved iron concentration such that the groundwater must be treated before being used for domestic needs.

In the County, groundwaters from the surficial aquifers mainly have a chemical hardness of greater than 100 mg/L (see CD-ROM).

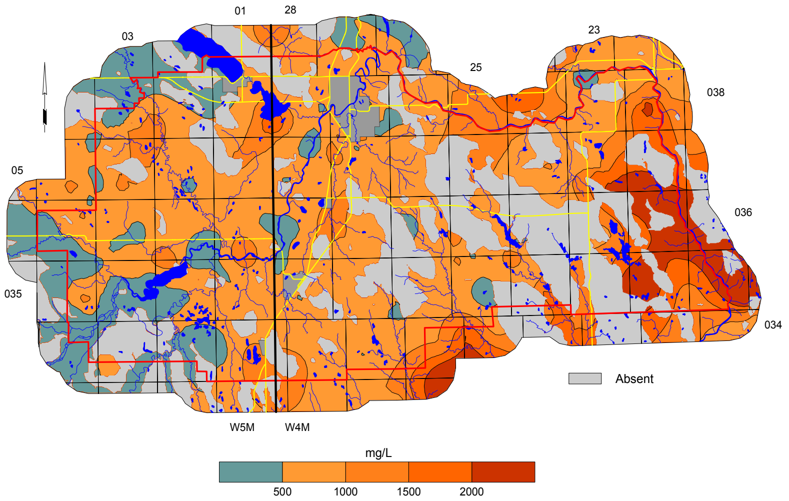

Figure 15. Total Dissolved Solids in Groundwater from Surficial Deposits

The Piper tri-linear diagram [17] for surficial deposits (page A-31) shows that the groundwaters from the surficial deposits are mainly calcium-magnesium-bicarbonate or sodium-bicarbonate-type waters. Sixty-five percent of the groundwaters from the surficial deposits have a TDS concentration of more than 500 mg/L. Groundwaters having TDS concentrations of less than 500 mg/L mainly occur in association with the Red Deer River, Little Red Deer River and the North Raven River in the southwestern part of the County. Fifty-five percent of the groundwaters from the surficial deposits are reported to have dissolved iron concentrations of less than or equal to the aesthetic objective (AO) of 0.3 mg/L. However, many iron analyses results are questionable due to varying sampling and analytical methodologies.

In some areas, the groundwater chemistry of the surficial aquifers is such that sulfate is the major anion[18]. The groundwaters with elevated levels of sulfate generally occur in areas where there are elevated levels of total dissolved solids. There are very few groundwaters from the surficial deposits with appreciable concentrations of the chloride ion; in more than 80% of the samples analyzed for surficial deposits in the County, the chloride ion concentration is less than 20 mg/L (see CD-ROM).

		Range for County in mg/L			Recommended Maximum Concentration
Constituent	No. of Analyses	Minimum	Maximum	Median	SGCDWQ
Total Dissolved Solids	320	172	3,213	620	500
Sodium	210	0	620	122	200
Sulfate	322	0	1,877	57	500
Chloride	321	0	254	4	250
Nitrate + Nitrite (as N)	190	0	84	0	10

Concentration in milligrams per litre unless otherwise stated
Note: indicated concentrations are for Aesthetic Objectives except for Nitrate + Nitrite (as N), which is for Maximum Acceptable Concentration (MAC)

SGCDWQ - Summary of Guidelines for Canadian Drinking Water Quality Federal-Provincial-Territorial Committee on Drinking Water, April 2003

Table 3. Concentrations of Constituents in Groundwaters from Surficial Deposits

In the County, the nitrate + nitrite (as N) concentrations in the groundwaters from the surficial deposits exceed the maximum acceptable concentrations (MAC) of ten mg/L in 14 of the 190 groundwater samples analyzed (up to about 1986); a plot of nitrate + nitrite (as N) in surficial aquifers is on the accompanying CD-ROM.

The minimum, maximum and median concentrations of TDS, sodium, sulfate, chloride and nitrate and nitrite (as N) in the groundwaters from water wells completed in the surficial deposits in the County have been compared to the SGCDWQ in the adjacent table. Of the five constituents that have been compared to the SGCDWQ, the median value of TDS concentrations exceeds the guidelines.

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[17] See glossary

[18] See glossary

5.2.3 Upper Sand and Gravel Aquifer

The Upper Sand and Gravel Aquifer includes saturated sand and gravel deposits in the upper surficial deposits. Typically, these aquifers are present within the surficial deposits at no particular depth. Saturated sand and gravel deposits in the upper surficial deposits are not usually continuous over large areas but are expected over approximately 20% of the County.

5.2.3.1 Aquifer Thickness

The thickness of the Upper Sand and Gravel Aquifer is a function of two parameters: (1) the elevation of the non-pumping water-level surface associated with the surficial deposits; and (2) the depth to the bedrock surface or the depth to the top of the lower surficial deposits when present. In the County, the thickness of the Upper Sand and Gravel Aquifer is generally less than five metres.

5.2.3.2 Apparent Yield

The permeability of the Upper Sand and Gravel Aquifer can be high. The high permeability combined with significant thickness leads to an extrapolation of high yields for water wells; however, because the sand and gravel deposits occur mainly as hydraulically discontinuous pockets, the long-term yields of the water wells are expected to be less than the apparent yields.

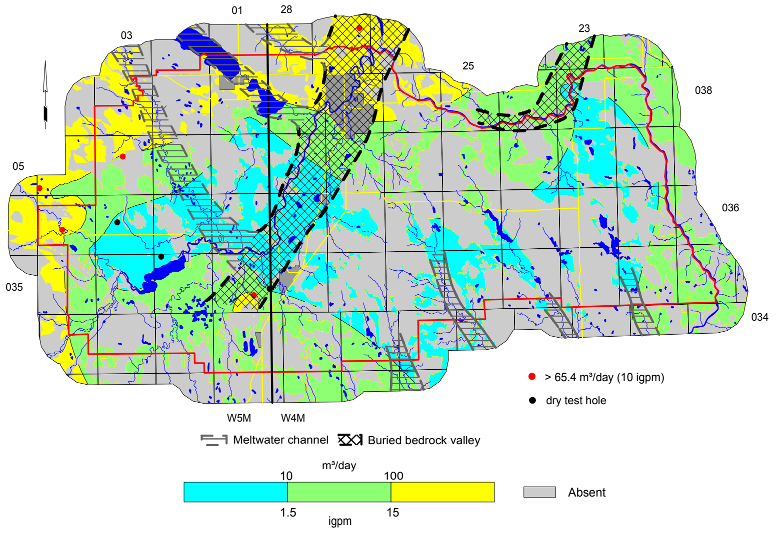


Figure 16. Apparent Yield for Water Wells Completed through Upper Sand and Gravel Aquifer

Where the Upper Sand and Gravel Aquifer is absent and where the yields are low, the shallow surficial deposits can be more susceptible to drought, and the development of water wells for the domestic needs of single families may not be possible from this Aquifer. Construction of a water supply well into the underlying bedrock may be the only alternative, provided that yields and quality of groundwater from the bedrock aquifer(s) are suitable.

In the County, there are eight water wells completed in the Upper Sand and Gravel Aquifer with apparent yield values. The higher yielding water wells are located north of the City of Red Deer and south of the Town of Innisfail in association with the Buried Red Deer Valley, and in the northwestern part of the County. In the County, there are three “dry” water test holes completed in the Upper Sand and Gravel Aquifer.

In the County, there are 54 licensed and/or registered water wells that are completed through the Upper Sand and Gravel Aquifer for a total authorized diversion of 506 m^3/day (Table 1, page 6), having a median authorized amount of 3.4 m^3/day. The highest authorized groundwater use is for a water supply well completed in the Upper Sand and Gravel Aquifer in SW 21-036-25 W4M that is licensed to divert 89.6 m^3/day for commercial purposes.

Twenty-three of the 54 licences and registrations for water wells completed through the Upper Sand and Gravel Aquifer could be linked to a water well in the AENV groundwater database.

5.2.4 Lower Sand and Gravel Aquifer

The Lower Sand and Gravel Aquifer is a saturated sand and gravel deposit that occurs at or near the base of the surficial deposits in the deeper part of the linear bedrock lows.

5.2.4.1 Aquifer Thickness

The thickness of the Lower Sand and Gravel Aquifer is mainly less than five metres, but can be up to ten metres in the linear bedrock lows and in the southwestern part of the County (see CD-ROM).

5.2.4.2 Apparent Yield

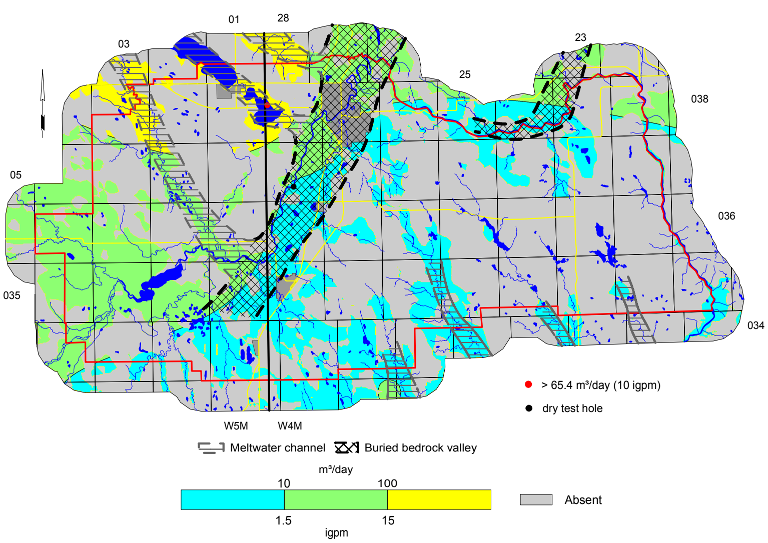


Figure 17. Apparent Yield for Water Wells Completed through Lower Sand and Gravel Aquifer

Apparent yields for water wells completed through the Lower Sand and Gravel Aquifer range from less than 10 m³/day to more than 100 m³/day. In the County, there are only eight water wells with apparent yield values. The highest yielding water well in NW 19-038-28 W4M, is in association with a meltwater channel west of the City of Red Deer.

In the County, there is one "dry" water test hole completed in the Lower Sand and Gravel Aquifer.

In the County, there are 17 licensed and registered water wells that are completed through the Lower Sand and Gravel Aquifer, for a total authorized diversion of 185 m^3/day.

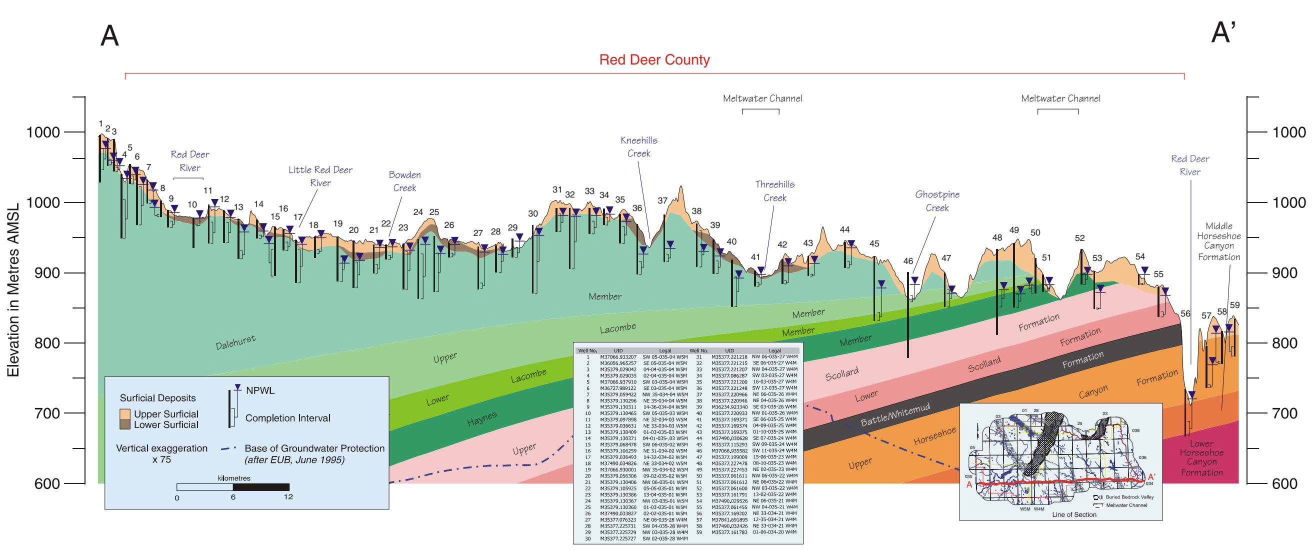
The highest authorized groundwater use is for a water source well completed in the Lower Sand and Gravel Aquifer in 07-03-035-01 W5M that is licensed to divert 67.6 m³/day for industrial purposes.

Eight of the 17 licences and/or registrations for water wells completed through the Lower Sand and Gravel Aquifer could be linked to a water well in the AENV groundwater database

5.3 Bedrock

5.3.1 Bedrock Aquifers

The upper bedrock includes formations that are generally less than 200 metres below the bedrock surface. In the County, the upper bedrock includes the Paskapoo Formation (Dalehurst, Upper and Lower Lacombe, and Haynes members), as well as the Scollard, Battle and Whitemud and Horseshoe Canyon formations, as shown below on cross-section A-A' (see page A-12). Some of this bedrock contains 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, although some of the sandstones may be friable[19] and water well screens are a necessity.



Well No.	UID	Legal	Well No.	UID	Legal
1	M37066.933207	SW 05-035-04 W5M	31	M35377.221218	NW 06-035-27 W4M
2	M36056.965257	SE 05-035-04 W5M	32	M35377.221215	SE 06-035-27 W4M
3	M35379.029042	04-04-035-04 W5M	33	M35377.221207	NW 04-035-27 W4M
4	M35379.029035	02-04-035-04 W5M	34	M35377.086287	SW 03-035-27 W4M
5	M37066.937910	SW 03-035-04 W5M	35	M35377.221200	16-03-035-27 W4M
6	M36727.989122	SE 03-035-04 W5M	36	M35377.221248	SW 12-035-27 W4M
7	M35379.059422	NW 35-034-04 W5M	37	M35377.220966	NE 06-035-26 W4M
8	M35379.130296	NE 35-034-04 W5M	38	M35377.220946	NE 04-035-26 W4M
9	M35379.130311	14-36-034-04 W5M	39	M36234.923340	SE 03-035-26 W4M
10	M35379.130465	SW 05-035-03 W5M	40	M35377.220933	NW 01-035-26 W4M
11	M35379.097898	NE 32-034-03 W5M	41	M35377.169371	SE 06-035-25 W4M
12	M35379.036631	NE 33-034-03 W5M	42	M35377.169374	04-09-035-25 W4M
13	M35379.130409	01-03-035-03 W5M	43	M35377.169375	01-10-035-25 W4M
14	M35379.130371	04-01-035-.03 W5M	44	M37490.030628	SE 07-035-24 W4M
15	M35379.068478	SW 06-035-02 W5M	45	M35377.115293	SW 09-035-24 W4M
16	M35379.106259	NE 31-034-02 W5M	46	M37066.935582	SW 11-035-24 W4M
17	M35379.036493	14-32-034-02 W5M	47	M35377.199009	15-06-035-23 W4M
18	M37490.034826	NE 33-034-02 W5M	48	M35377.227478	08-10-035-23 W4M
19	M37066.930001	NW 35-034-02 W5M	49	M35377.227453	NE 02-035-23 W4M
20	M35379.056306	09-02-035-02 W5M	50	M35377.061611	NW 06-035-22 W4M
21	M35379.130406	NW 06-035-01 W5M	51	M35377.061612	NE 06-035-22 W4M
22	M35379.105925	05-05-035-01 W5M	52	M35377.061600	NW 03-035-22 W4M
23	M35379.130386	13-04-035-01 W5M	53	M35377.161791	13-02-035-22 W4M
24	M35379.130367	NW 03-035-01 W5M	54	M37490.029526	NE 06-035-21 W4M
25	M35379.130360	01-03-035-01 W5M	55	M35377.061455	NW 04-035-21 W4M
26	M37490.033827	02-02-035-01 W5M	56	M35377.169202	NE 33-034-21 W4M
27	M35377.076323	NE 06-035-28 W4M	57	M37841.691895	12-35-034-21 W4M
28	M35377.225731	SW 04-035-28 W4M	58	M37490.032426	NE 33-034-21 W4M
29	M35377.225729	NW 03-035-28 W4M	59	M35377.161783	01-06-034-20 W4M
30	M35377.225727	SW 02-035-28 W4M			

Figure 18. Cross-Section A – A'

In the study area, the BGP is variable, extending from a depth of 25 metres to a depth of over 550 metres below ground surface. In the County, the BGP is below the Haynes Member. A map showing the depth to the Base of Groundwater Protection is given on page 8 of this report, in Appendix A (page A-8), and on the CD-ROM.

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[19] See glossary

5.3.2 Geological Characteristics

The upper bedrock in the County study area includes the Paskapoo Formation and the Edmonton Group. The adjacent bedrock geology map, showing the subcrop of different geological units, has been prepared in part from the interpretation of geophysical logs related to oil and gas activity.

The Paskapoo Formation in central Alberta consists of the Dalehurst, Lacombe and Haynes members (Demchuk and Hills, 1991). The Edmonton Group underlies the Paskapoo Formation, and includes the Scollard, Battle and Whitemud and Horseshoe Canyon formations.

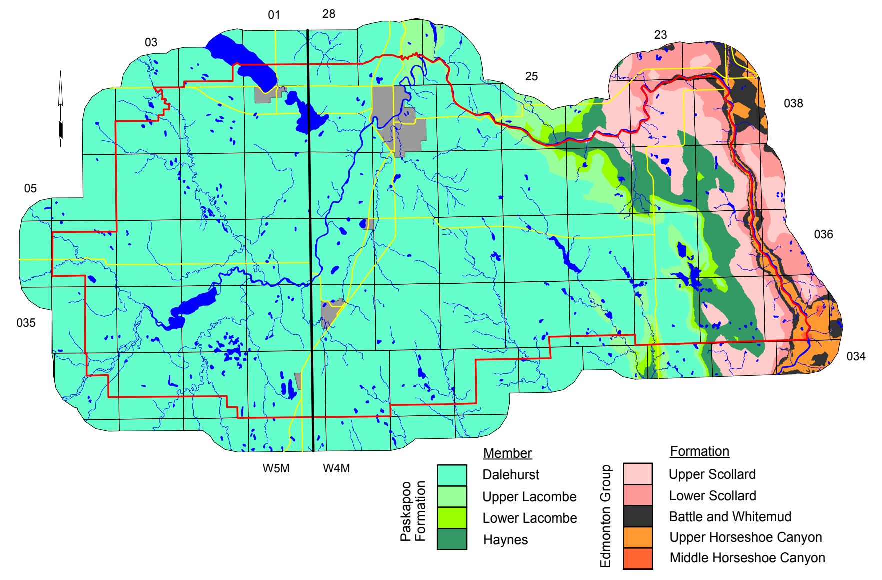

Figure 19. Bedrock Geology

The Paskapoo Formation is the upper bedrock and subcrops mainly west of range 23, W4M in the County. The Paskapoo Formation consists of cycles of thick, tabular sandstone, siltstone and mudstone layers (Glass, 1990). The maximum thickness of the Paskapoo Formation is generally less than 800 metres; in the County, the thickness is less than 600 metres.

The Dalehurst Member is the upper bedrock and subcrops in most of the County. This Member has a maximum thickness of 300 metres within the County and is mostly composed of shale and siltstone with sandstone, bentonite and coal seams or zones. Two prominent coal zones within the Dalehurst are the Obed-Marsh Coal (up to 30 metres thick) and the Lower Dalehurst Coal (up to 50 metres thick). The bottom of the Lower Dalehurst Coal is the border between the Dalehurst and Lacombe members (Demchuck and Hills, 1991). In the County, the coal seams are generally less than two metres thick but have been recorded as up to six metres thick. If the coal seams are not fractured, they are impermeable.

The Lacombe Member underlies the Dalehurst Member and has a maximum thickness of 200 metres in the County. The upper part of the Lacombe Member is mostly composed of shale interbedded with sandstone, and has a maximum thickness of 130 metres. The lower part of the Lacombe Member is composed of sandstone and coal layers. In the middle of the lower part of the Lacombe Member is a coal zone, which can be up to five metres thick. In the County, the Lower Lacombe Member has a maximum thickness of 70 metres.

The Haynes Member underlies the Lacombe Member and is composed mainly of sandstone with some siltstone, shale and coal. In other parts of Alberta, the Haynes Member has a maximum thickness of 100 metres; in the County, the Haynes Member has a maximum thickness of 60 metres.

The Scollard Formation underlies the Haynes Member, generally has a maximum thickness of 160 metres and has two separate designations: Upper and Lower. The Upper Scollard consists mainly of sandstone, siltstone, shale and coal seams or zones. The Lower Scollard is composed mainly of shale and sandstone. In the County, the Scollard Formation has a maximum thickness of 180 metres.

Beneath the Scollard Formation are two formations having a maximum thickness of 30 metres; the two are the Battle and Whitemud formations. The Battle Formation is composed mainly of claystone, tuff, shale and bentonite, and includes the Kneehills Member, a 2.5- to 30-cm-thick tuff bed. The Whitemud Formation is composed mainly of shale, siltstone, sandstone and bentonite. The Battle and Whitemud formations are significant geologic markers, and were used in the preparation of various geological surfaces within the bedrock. Because of the ubiquitous nature of the bentonite in the Battle and Whitemud formations, there is very little significant permeability within these two formations and there will be no direct review of the Battle and Whitemud formations.

The Horseshoe Canyon Formation is the lower part of the Edmonton Group and is the upper bedrock in the eastern Red Deer River Valley (the eastern border of the County). In the County, the Horseshoe Canyon Formation has a maximum thickness of 380 metres and has three separate designations: Upper, Middle and Lower. In Red Deer County, the Upper Horseshoe Canyon has a maximum thickness of 100 metres, the Middle Horseshoe Canyon has a maximum thickness of 80 metres, and the Lower Horseshoe Canyon has a maximum thickness of 200 metres.

The Horseshoe Canyon Formation consists of deltaic[20] and fluvial sandstone, siltstone and shale with interbedded coal seams, bentonite and thin nodular beds of limestone and ironstone. Because of the low-energy environment in which deposition occurred, the sandstones, when present, tend to be finer grained. The lower 60 to 70 metres and the upper 30 to 50 metres of the Horseshoe Canyon Formation can include coarser grained sandstone deposits.

There will be no direct review of the Horseshoe Canyon formations in the text of this report; there are insufficient or no hydrogeological data within the study area to prepare meaningful maps; the only maps associated with these formations to be included on the CD-ROM will be structure-contour maps.

5.3.3 Upper Bedrock Completion Aquifer(s)

Of the 11,827 water wells in the database, 6,527 were defined as being completed below the top of bedrock, based on lithologic information and water well completion details. However, at least a reported completion depth is available for 11,810 water wells completed below the bedrock surface. Assigning a water well to a specific geologic unit is possible only if the completion interval is identified. In order to make use of additional information within the groundwater database, it was assumed that the top of the completion interval was the bottom 20% of the total completed depth of a water well. With this assumption, it has been possible to designate the specific bedrock aquifer of completion for an additional 3,395 bedrock water wells, giving a total of 9,922 water wells. The remaining 1,888 of the total 11,810 upper bedrock water wells are identified as being completed in more than one bedrock aquifer, as shown in Table 5. The upper bedrock water wells are mainly completed in the Dalehurst Aquifer.

Geologic Unit	No. of Bedrock Water Wells
Dalehurst	8,376
Upper Lacombe	444
Lower Lacombe	54
Haynes	198
Upper Scollard	611
Lower Scollard	136
Battle and Whitemud	15
Upper Horseshoe Canyon	83
Middle Horseshoe Canyon	5
Multiple Completions	1,888
Total	11,810

Table 4. Completion Aquifer for Upper Bedrock Water Wells

Seven of the 15 water wells shown to be completed in the Battle and Whitemud formations have been determined on completed depth only, without the benefit of lithologic description or any other supporting documentation, and therefore the completion formations are suspect.

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[20] See glossary

There are 3,490 records for bedrock water wells that have apparent yield values, which is 30% of the 11,810 bedrock water wells in the County.

Yields for water wells completed in the Upper Bedrock Aquifer(s) are mainly between 10 and 100 m^3/day and have a median apparent yield of 30 m^3/day. Most of the areas with yields of more than 100 m^3/day are east of the 5th Meridian. Some of the areas with data indicating apparent yields of more than 654 m^3/day (100 igpm) are in association with the Buried Red Deer Valley. These higher yield areas may identify locations of increased permeability resulting from the weathering process.

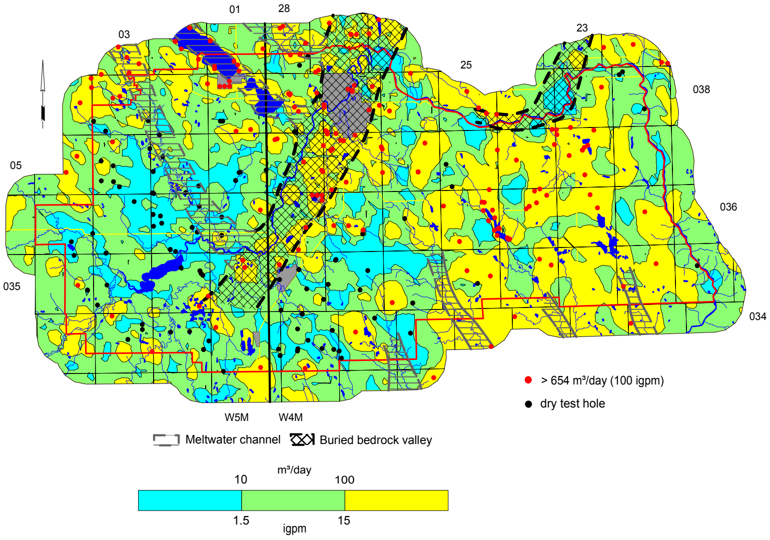

Figure 20. Apparent Yield for Water Wells Completed in Upper Bedrock Aquifer(s)

In addition to the 3,490 records for bedrock water wells with apparent yield values, there are 136 records that indicate that the water well/water test hole is “dry”, or abandoned with “insufficient water”. In order to depict a more accurate yield map, an apparent yield of 0.1 m^3/day was assigned to the 136 “dry” water test holes prior to gridding.

Of the 3,490 water well records with apparent yield values, 2,596 have been assigned to the Dalehurst Aquifer. Twenty-eight percent (980) of the 3,490 water wells completed in bedrock aquifers have apparent yields that are less than ten m^3/day, 45% (1,552) have apparent yield values that range from 10 to 100 m^3/day, 14% (501) have apparent yields that are range from 100 to 300 m^3/day, and 13% (457) have apparent yield values that are greater than 300 m^3/day, as shown in Table 5. The water well record completed in the Battle and Whitemud Aquifers showing an apparent yield value of greater than ten m^3/day is suspect.

Aquifer	No. of Water Wells with Values for Apparent Yield (*)	Number of Water Wells with Apparent Yields			
		<10 m^3/day	10 to 100 m^3/day	100 to 300 m^3/day	>300 m^3/day
Dalehurst	2,596	766	1,161	356	313
Upper Lacombe	182	39	91	27	25
Lower Lacombe	11	0	7	3	1
Haynes	39	2	14	12	11
Battle and Whitemud	4	3	1	0	0
Upper Scollard	93	9	38	19	27
Lower Scollard	20	6	11	3	0
Upper Horseshoe Canyon	8	3	5	0	0
Multiple Completions	537	152	224	81	80
Totals	3,490	980	1,552	501	457

* - does not include dry test holes

Table 5. Apparent Yields of Bedrock Aquifers

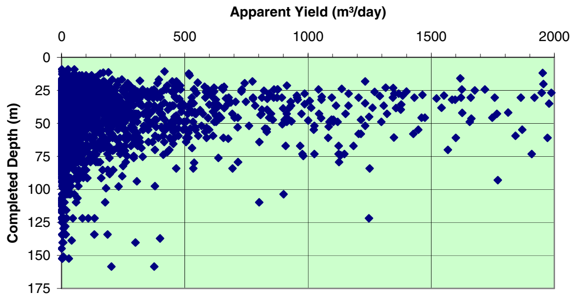

Figure 21. Bedrock Water Well Yields vs Completed Depth

Apparent yields for water wells completed in the Upper Bedrock Aquifer(s) vary significantly over the County both with location and with depth. As Figure 21 shows, most apparent yields are less than 300 m^3/day and the majority of the water wells completed in the Upper Bedrock Aquifer(s) are less than 100 metres deep. Water wells that have apparent yields of greater than 500 m^3/day are mainly less than 75 metres deep.

In the County, there are 1,693 licensed and/or registered water wells that are completed in the Upper Bedrock Aquifer(s), for a total authorized diversion of 18,570 m^3/day (Table 1, page 6)

5.3.4 Chemical Quality of Groundwater

The Piper tri-linear diagram for bedrock aquifers (page A-31) shows that all chemical types of groundwater occur in the bedrock aquifers. However, the majority of the groundwaters are sodium-bicarbonate types; the majority of these groundwaters have a sodium ion concentration that exceeds 200 mg/L. Because the sodium concentration can be elevated, the groundwater can pose a risk to people on low sodium diets.

In the County, approximately 40% of the groundwater samples from Upper Bedrock Aquifer(s) have fluoride concentrations that are too low (less than 0.5 mg/L) to meet the recommended daily needs of people. Approximately 32% of the groundwater samples from the entire County are between 0.5 and 1.5 mg/L and approximately 28% exceed the MAC for fluoride of 1.5 mg/L. Fluoride concentrations of greater than 1.5 mg/L occur mainly in the western half of the County (see page A-34).

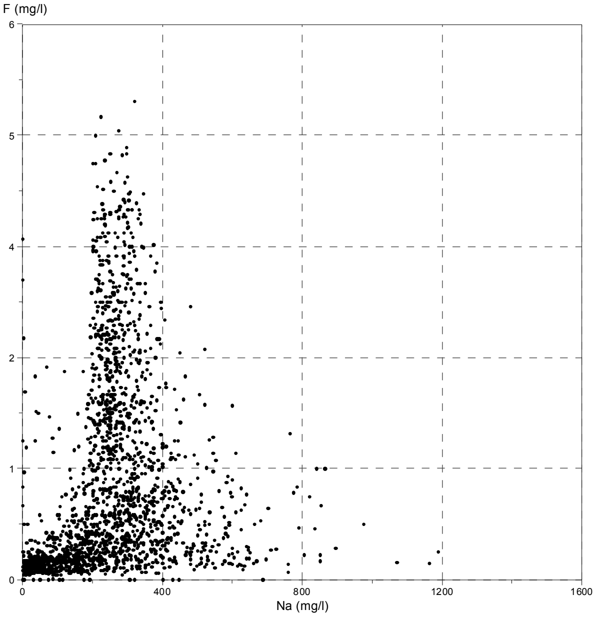

Figure 22. Fluoride vs Sodium Concentrations in Groundwater from Upper Bedrock Aquifer(s)

The fluoride concentrations in the groundwaters appear to be a function of the sodium concentration. Below a sodium concentration of 180 mg/L, there is generally very little fluoride in the groundwater. When the sodium concentration reaches 180 mg/L, the maximum fluoride concentration can increase dramatically. As the sodium concentration increases, the maximum solubility of fluoride decreases and once the sodium concentration reaches 600 mg/L, the maximum solubility of fluoride is below the MAC of 1.5 mg/L, as shown above in Figure 22 and on page A-35.

The TDS concentrations in the groundwaters from the Upper Bedrock Aquifer(s) range from less than 500 mg/L to more than 1,500 mg/L, with most of the groundwaters with lower TDS concentrations occurring in the extreme western parts of the County, and the higher TDS concentrations occurring in the extreme eastern parts of the County. The lower TDS concentrations may be a result of more active flow systems and shorter flow paths.

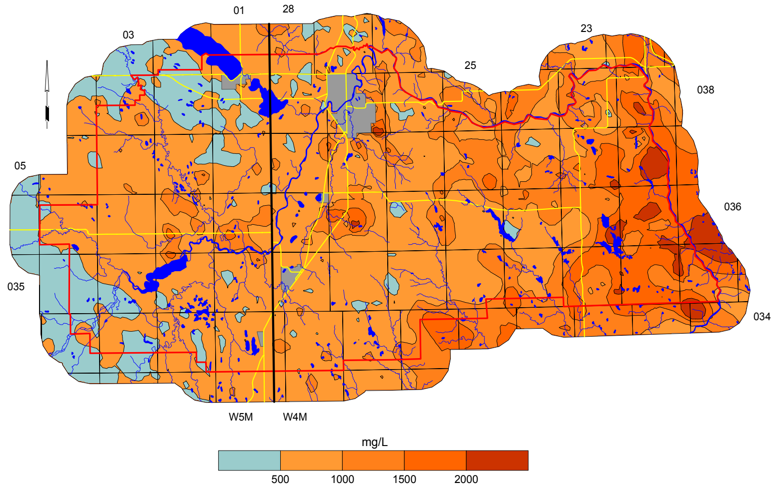

Figure 23. Total Dissolved Solids in Groundwater from Upper Bedrock Aquifer(s)

The relationship between TDS and sulfate concentrations shows that when TDS values in the groundwaters from the Upper Bedrock Aquifer(s) exceed 1,200 mg/L, the sulfate concentrations exceed 400 mg/L.

In the County, nearly 95% of the chloride concentrations in the groundwaters from the Upper Bedrock Aquifer(s) are less than 50 mg/L.

Constituent	No. of Analyses	Range for County in mg/L Minimum	Maximum	Median	Recommended Maximum Concentration SGCDWQ
Total Dissolved Solids	2,943	54	8,672	708	500
Sodium	2,229	0	1,188	250	200
Sulfate	2,944	0	1,500	85	500
Chloride	2,937	0	720	4	250
Fluoride	2,457	0	15	0.7	1.5

Concentration in milligrams per litre unless otherwise stated
Note: indicated concentrations are for Aesthetic Objectives except for Fluoride, which is for Maximum Acceptable Concentration (MAC)

SGCDWQ - Summary of Guidelines for Canadian Drinking Water Quality
Federal-Provincial-Territorial Committee on Drinking Water, April 2003

Table 6. Apparent Concentrations of Constituents in Groundwaters from Upper Bedrock Aquifer(s)

The minimum, maximum and median[21] concentrations of TDS, sodium, sulfate, chloride and fluoride in the groundwaters from water wells completed in the upper bedrock in the County have been compared to the SGCDWQ in Table 6. Of the five constituents compared to the SGCDWQ, median concentrations of TDS and sodium exceed the guidelines.

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[21] see glossary

5.3.5 Dalehurst Aquifer

The Dalehurst Aquifer comprises the permeable parts of the Dalehurst Member, as defined for the present program. The Dalehurst Member subcrops under the surficial deposits in the western two-thirds of the County. The thickness of the Dalehurst Member varies from less than two metres at the eastern edge of the subcrop to 300 metres in the western part of the County. The regional groundwater flow direction in the Dalehurst Aquifer is toward the Medicine and Red Deer rivers (see CD-ROM).

5.3.5.1 Depth to Top

The depth to the top of the Dalehurst Member is mainly less than 30 metres and is a reflection of the thickness of the surficial deposits.

5.3.5.2 Apparent Yield

The apparent yields for individual water wells completed through the Dalehurst Aquifer range mainly from 10 to 100 m^3/day, and have a median apparent yield value of 30 m^3/day. The higher yielding areas appear to be mainly east of the 5th Meridian, as shown on Figure 24.

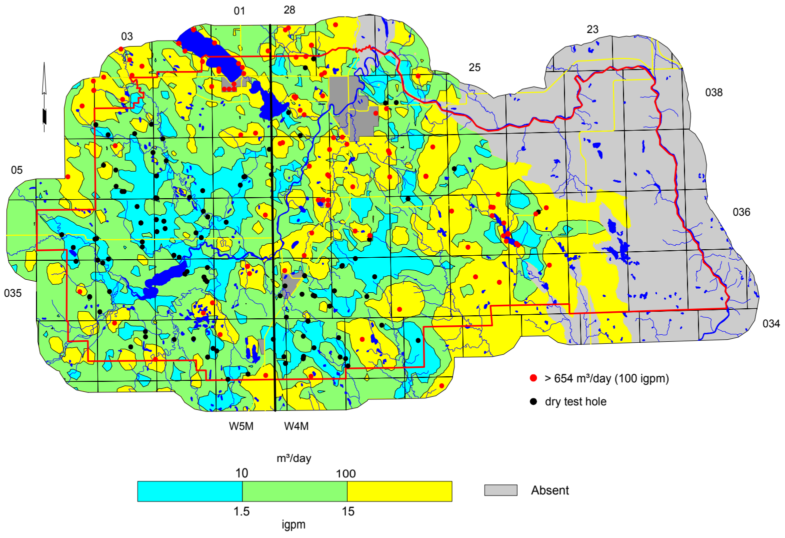

Figure 24. Apparent Yield for Water Wells Completed through Dalehurst Aquifer

There are 116 “dry” water test holes that are completed in the Dalehurst Aquifer.

In September and October 1985, four water test holes were drilled for C.F.B. Penhold in section 13, township 037, range 27, W4M and section 18, township 037, range 28, W4M and completed in the Dalehurst Aquifer (HCL, Nov-1985). Extended aquifer tests conducted with Water Test Hole (WTH) No. 1-85 and WTH No. 2-85 indicated a long term yield of 980 m^3/day for the two water test holes together, based on a transmissivity of 130 metres squared per day (m^2/day). WTH No. 1-85 (Water Supply Well (WSW) No. 10) is currently licensed to divert 425 m^3/day and WTH No. 2-85 (WSW No. 11) is licensed to divert 439 m^3/day for municipal purposes. The licence is now held by Red Deer County.

There are 1,346 licensed and/or registered groundwater users that have water wells completed through the Dalehurst Aquifer, for a total groundwater diversion of 15,603 m^3/day. The highest licensed groundwater use is for seven licences that allow the Town of Sylvan Lake to divert up to 4,001 m^3/day for municipal purposes in sections 28, 29, and 32, township 038, range 01, W5M and sections 9 and 10, township 039, range 01, W5M.

Of the 1,346 licences and/or registrations, 777 could be linked to water wells in the AENV groundwater database.

5.3.5.3 Quality

The groundwaters from the Dalehurst Aquifer are mainly a sodium-bicarbonate-type, with no dominant cation (see Piper diagram on CD-ROM), with nearly 80% of the groundwater samples having TDS concentrations ranging from 500 to 1,500 mg/L (page A-38). The lower TDS values are expected at the southwestern and northwestern parts of the County and the higher TDS values are expected at the southeastern edge of the Aquifer. Eighty percent of the sulfate concentrations in groundwaters from the Dalehurst Aquifer are less than 200 mg/L. The sulfate concentrations are expected to increase from west to east. Seventy-five percent of the chloride concentrations from the Dalehurst Aquifer are less than ten mg/L, and nearly 25% of the groundwater samples have fluoride concentrations that are greater than 1.5 mg/L.

A chemical analysis of a groundwater sample collected in July 1988 from C.F.B. Penhold WSW No. 10 in 01-13-037-28 W4M indicates the groundwater is a sodium-bicarbonate type, with a TDS concentration of 888 mg/L, a sulfate concentration of 120 mg/L, a chloride concentration of 2 mg/L, and a fluoride concentration of 0.91 mg/L.

Of the five constituents that have been compared to the SGCDWQ, the median values of TDS and sodium exceed the guidelines. The median concentrations in the Dalehurst Aquifer are all at or below the median concentrations from water wells completed in all Upper Bedrock Aquifer(s).

Constituent	No. of Analyses	Range for County in mg/L Minimum	Maximum	Median	All Bedrock Median	Recommended Maximum Concentration SGCDWQ
Total Dissolved Solids	2,238	54	8,672	684	708	500
Soduim	1,719	0	1,163	245	250	200
Sulfate	2,230	0	1,500	70	85	500
Chloride	2,225	0	400	4	4	250
Fluoride	1,876	0	15	0.7	0.7	1.5

Concentration in milligrams per litre unless otherwise stated
Note: indicated concentrations are for Aesthetic Objectives except for Fluoride, which is for Maximum Acceptable Concentration (MAC)

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Federal-Provincial-Territorial Committee on Drinking Water, April 2003

Table 7. Apparent Concentrations of Constituents in Groundwater from Dalehurst Aquifer

5.3.6 Upper Lacombe Aquifer

The Upper Lacombe Aquifer comprises the permeable parts of the Upper Lacombe Member, as defined for the present program. Structure contours have been prepared for the top of the Upper Lacombe Member. The structure contours show that the Upper Lacombe Member ranges in elevation from less than 730 to more than 900 metres AMSL and has a maximum thickness of 130 metres. The non-pumping water level in the Upper Lacombe Aquifer is downgradient to the northeast toward the Red Deer River (see CD-ROM).

5.3.6.1 Depth to Top

The depth to the top of the Upper Lacombe Member ranges from less than ten metres to more than 300 metres in the western part of the County (page A-39).

5.3.6.2 Apparent Yield

The apparent yields for individual water wells completed through the Upper Lacombe Aquifer are mainly in the range of 10 to 100 m³/day, and have a median apparent yield value of 25 m³day. The higher yielding areas appear to be south of the City of Red Deer, and in the southeastern part of the County, as shown on Figure 25. There are little or no data for the Aquifer in the western parts of the County. In these areas, the depth to burial is more than 100 metres below ground surface.

There is only one "dry" water test hole completed in the Upper Lacombe Aquifer.

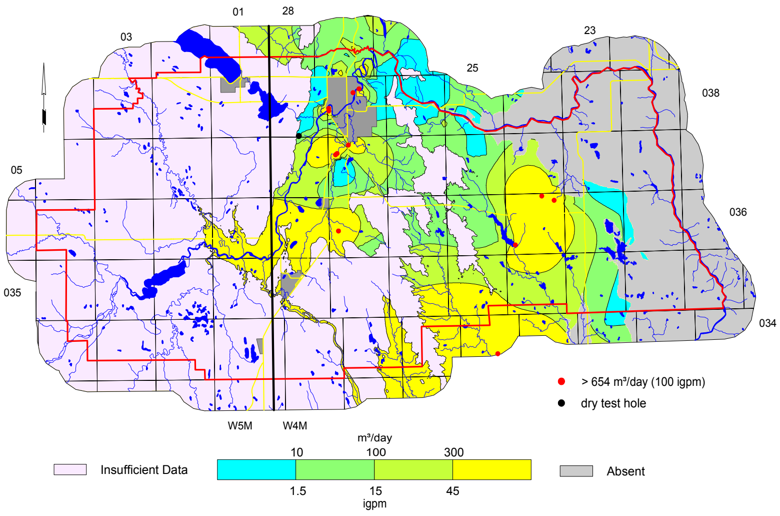

Figure 25. Apparent Yield for Water Wells Completed through Upper Lacombe Aquifer

An example of a high yielding water well south of the City of Red Deer is a water supply well drilled for Red Deer County in 15-29-037-27 W4M and completed from 53.6 to 59.4 metres below ground surface in the Upper Lacombe Aquifer (HCL, Feb-1996). The water supply well (WTH No. 1-95) was drilled to identify the possible sources of groundwater for the proposed Red Deer County distribution system. Extended aquifer tests conducted with WTH No. 1-95 indicated a long-term yield of 200 m³/day. WTH No. 1-95 is licensed to divert up to 150 m³/day for municipal purposes, and is the highest licensed groundwater use for a water well completed in the Upper Lacombe Aquifer.

There are 50 licensed and/or registered groundwater users that have water wells completed through the Upper Lacombe Aquifer, for a total authorized groundwater diversion of 614 m³/day. Twenty of the 50 licences and/or registrations could be linked to water wells in the AENV groundwater database.

5.3.6.3 Quality

The groundwaters from the Upper Lacombe Aquifer are mainly a sodium-bicarbonate type (see Piper diagram on CD-ROM), with nearly 70% of the groundwater samples having TDS concentrations ranging from 500 to 1,000 mg/L. The lower TDS values are expected northwest of the City of Red Deer and the higher TDS values are expected at the southeastern edge of the Aquifer (page A-41). Eighty percent of the sulfate concentrations in groundwaters from the Upper Lacombe Aquifer are less than 200 mg/L. Sulfate concentrations of greater than 500 mg/L are at the eastern parts of the Aquifer. The chloride concentrations from the Upper Lacombe Aquifer are mainly less than ten mg/L. More than 55% of the groundwater samples have fluoride concentrations that are greater than 1.5 mg/L. The fluoride concentrations are expected to increase from east to west.

A chemical analysis of a groundwater sample collected in October 1995 from WTH No. 1-95 in NE 29-037-27 W4M indicates the groundwater is a sodium-bicarbonate type, with a TDS concentration of 556 mg/L, a sulfate concentration of 2 mg/L, a chloride concentration of 12 mg/L, and a fluoride concentration of 2.42 mg/L.

Of the five constituents that have been compared to the SGCDWQ, the median values of TDS and sodium exceed the guidelines. The median concentrations of fluoride from water wells completed in the Upper Lacombe Aquifer are greater than the median concentrations from water wells completed in all Upper Bedrock Aquifer(s).

		Range for County in mg/L				
Constituent	No. of Analyses	Minimum	Maximum	Median	All Bedrock Median	Recommended Maximum Concentration SGCDWQ
Total Dissolved Solids	123	266	2,316	656	708	500
Sodium	89	1	621	240	250	200
Sulfate	124	0	710	65	85	500
Chloride	125	0	188	4	4	250
Fluoride	97	0	5	1.9	0.7	1.5

Concentration in milligrams per litre unless otherwise stated
Note: indicated concentrations are for Aesthetic Objectives except for Fluoride, which is for Maximum Acceptable Concentration (MAC)

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Federal-Provincial-Territorial Committee on Drinking Water, April 2003

Table 8. Apparent Concentrations of Constituents in Groundwaters from Upper Lacombe Aquifer

5.3.7 Lower Lacombe Aquifer

The Lower Lacombe Aquifer comprises the permeable parts of the Lower Lacombe Member, as defined for the present program. Structure contours have been prepared for the top of the Lower Lacombe Member. The structure contours show that the Lower Lacombe Member ranges in elevation from less than 600 to more than 880 metres AMSL and has a maximum thickness of 70 metres. The non-pumping water level in the Lower Lacombe Aquifer is downgradient to the east toward the Red Deer River (see CD-ROM).

5.3.7.1 Depth to Top

The depth to the top of the Lower Lacombe Member ranges from less than ten metres below ground level where the Member subcrops to more than 400 metres at the southwestern edge of the County (page A-42).

5.3.7.2 Apparent Yield

The apparent yields for individual water wells completed through the Lower Lacombe Aquifer are mainly in the range of 10 to 100 m³/day. Water wells with higher yields are expected at the eastern edge of the Aquifer. There are little or no data for the Aquifer in the western two-thirds of the County.

There are no "dry" water test holes that are completed in the Lower Lacombe Aquifer.

There are three registered groundwater users that have water wells completed through the Lower Lacombe Aquifer, for a total registered groundwater diversion of three m³/day. Two of the three registrations could be linked to water wells in the AENV groundwater database.

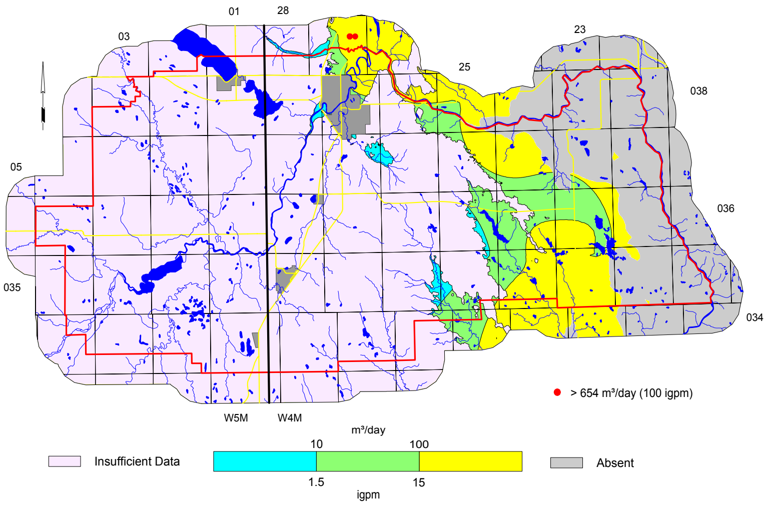

Figure 26. Apparent Yield for Water Wells Completed through Lower Lacombe Aquifer

5.3.7.3 Quality

The groundwaters from the Lower Lacombe Aquifer are a sodium-bicarbonate-sulfate-type (see Piper diagram on CD-ROM). The TDS concentrations are mainly greater than 500 mg/L (page A-44). The sulfate concentrations in groundwaters from the Lower Lacombe Aquifer are mainly less than 200 mg/L. The chloride concentrations from the Lower Lacombe Aquifer are less than ten mg/L, and, one of the eight groundwater samples has a fluoride concentration that is greater than 1.5 mg/L.

Of the five constituents that have been compared to the SGCDWQ, the median values of TDS and sodium exceed the guidelines. The median concentrations of TDS, sodium and sulfate from water wells completed in the Lower Lacombe Aquifer are greater than the median concentrations from water wells completed in all Upper Bedrock Aquifer(s).

Constituent	No. of Analyses	Range for County in mg/L Minimum	Maximum	Median	All Bedrock Median	Recommended Maximum Concentration SGCDWQ
Total Dissolved Solids	10	384	1,461	1,047	708	500
Sodium	7	255	533	488	250	200
Sulfate	10	2	586	319	85	500
Chloride	10	0	8	2	4	250
Fluoride	8	0	2	0.6	0.7	1.5

Concentration in milligrams per litre unless otherwise stated

Note: indicated concentrations are for Aesthetic Objectives except for Fluoride, which is for Maximum Acceptable Concentration (MAC)

SGCDWQ - Summary of Guidelines for Canadian Drinking Water Quality Federal-Provincial-Territorial Committee on Drinking Water, April 2003

Table 9. Apparent Concentrations of Constituents in Groundwaters from Lower Lacombe Aquifer

5.3.8 Haynes Aquifer

The Haynes Aquifer comprises the permeable parts of the Haynes Member, as defined for the present program. Structure contours have been prepared for the top of the Haynes Member. The structure contours show that the Haynes Member ranges in elevation from less than 500 to more than 880 metres AMSL and has a maximum thickness of 65 metres. The non-pumping water level in the Haynes Aquifer is downgradient to the northeast toward the Red Deer River (see CD-ROM).

5.3.8.1 Depth to Top

The depth to the top of the Haynes Member ranges from less than 50 metres below ground surface at the eastern extent to more than 500 metres in the western part of the County (page A-45).

5.3.8.2 Apparent Yield

The apparent yields for individual water wells completed through the Haynes Aquifer are mainly in the range of 10 to 100 m³/day, and have a median apparent yield value of 105 m³/day. Nearly 60% (23) of the 39 water wells completed in the Haynes Aquifer have apparent yield values that are greater than 100 m³/day.

There are little or no data for the Aquifer in the western parts of the County. In these areas, the depth to burial is more than 150 metres below ground surface.

There are no "dry" water test holes that are completed in the Haynes Aquifer.

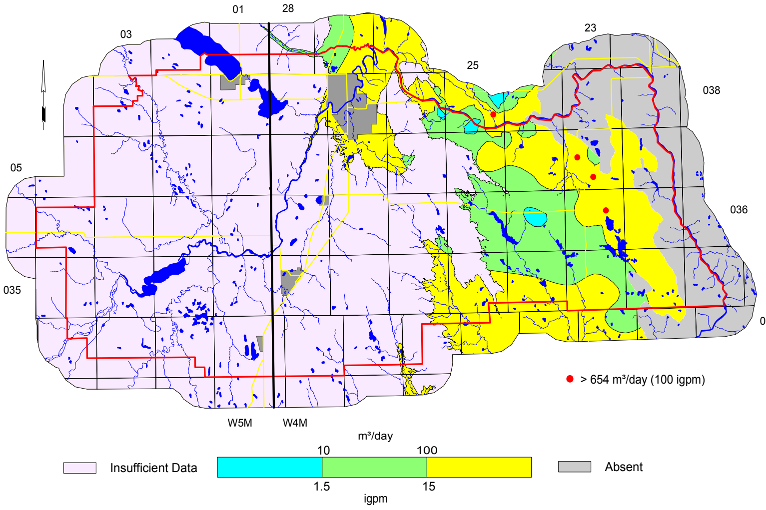

Figure 27. Apparent Yield for Water Wells Completed through Haynes Aquifer

A groundwater study was conducted for a subdivision developer in the Balmoral Area in 08-19-038-26 W4M. An extended aquifer test conducted with a water test hole completed from 201 to 232 metres below ground surface in both the Lower Lacombe and Haynes aquifers indicated a long-term yield of 82 m³/day, based on a transmissivity of 6.7 m²/day (HCL, Nov-1995a).

There are no "dry" water test holes that are completed in the Haynes Aquifer.

There are 42 licensed and/or registered groundwater users that have water wells completed through the Haynes Aquifer, for a total authorized groundwater diversion of 290 m³/day, of which 108 m³/day (62%) is used to divert groundwater for municipal purposes. The highest allocation is for a water supply well completed from 69.7 to 88.3 metres below ground surface in the Haynes Aquifer that is licensed to divert 94.6 m³/day for the Village of Elnora in 09-10-035-23 W4M.

Of the 42 licences and/or registrations, 28 could be linked to water wells in the AENV groundwater database.

5.3.8.3 Quality

The groundwaters from the Haynes Aquifer are mainly a sodium-bicarbonate or sodium-sulfate type (see Piper diagram on CD-ROM). The TDS concentrations range from less than 500 to more than 2,000 mg/L. The higher values are expected to be at the southeastern edge of the Aquifer (see page A-47). The sulfate concentrations in groundwaters from the Haynes Aquifer are mainly less than 500 mg/L. The higher sulfate concentrations are expected to be at the southeastern edge of the Aquifer. The chloride concentrations from the Haynes Aquifer are mainly less than ten mg/L. Eighty-five percent of the fluoride concentrations are less than 1.5 mg/L. The lower values are expected at the eastern edge of the Aquifer and the higher values are expected in the northwestern part of the area where sufficient data are present, north of the City of Red Deer.

A chemical analysis of a groundwater sample collected in October 1995 from the Balmoral area water supply well in 08-19-038-26 W4M indicates the groundwater is a sodium-bicarbonate type, with a TDS concentration of 677 mg/L, a sulfate concentration of 93 mg/L, a chloride concentration of 2.3 mg/L, and a fluoride concentration of 4.4 mg/L.

Of the five constituents that have been compared to the SGCDWQ, the median values of TDS and sodium exceed the guidelines. The median concentrations of TDS, sodium and sulfate from water wells completed in the Haynes Aquifer are greater than the median concentrations from water wells completed in all Upper Bedrock Aquifer(s).

		Range for County in mg/L				
Constituent	No. of Analyses	Minimum	Maximum	Median	All Bedrock Median	Recommended Maximum Concentration SGCDWQ
Total Dissolved Solids	41	478	3,724	1,204	708	500
Sodium	28	174	760	292	250	200
Sulfate	41	0	890	350	85	500
Chloride	41	0	50	3	4	250
Fluoride	33	0	3	0.6	0.7	1.5

Concentration in milligrams per litre unless otherwise stated

Note: indicated concentrations are for Aesthetic Objectives except for Fluoride, which is for Maximum Acceptable Concentration (MAC)

SGCDWQ - Summary of Guidelines for Canadian Drinking Water Quality Federal-Provincial-Territorial Committee on Drinking Water, April 2003

Table 10. Apparent Concentrations of Constituents in Groundwaters from Haynes Aquifer

5.3.9 Upper Scollard Aquifer

The Upper Scollard Aquifer comprises the permeable parts of the Upper Scollard Formation that underlie the Haynes Member. Structure contours have been prepared for the top of the Formation. The structure contours show that the Upper Scollard Formation ranges in elevation from less than 500 to more than 850 metres AMSL and has a maximum thickness that is in the order of 110 metres. The non-pumping water level in the Upper Scollard Aquifer slopes to the north toward the Red Deer River (see CD Rom).

5.3.9.1 Depth to Top

The depth to the top of the Upper Scollard Formation ranges from less than 50 metres below ground surface at the eastern extent to more than 550 metres in the western part of the County (page A-48).

5.3.9.2 Apparent Yield

The apparent yields for individual water wells completed through the Upper Scollard Aquifer are mainly greater than 100 m³/day, and have a median apparent yield value of 80 m³/day.

The apparent yields of greater than 654 m³/day are mainly in the northeastern part of the County, as shown on Figure 28. There are little or no data for the Aquifer in the western two-thirds of the County. In these areas, the depth to burial is more than 100 metres below ground surface.

There is one "dry" water test hole that is completed in the Upper Scollard Aquifer.

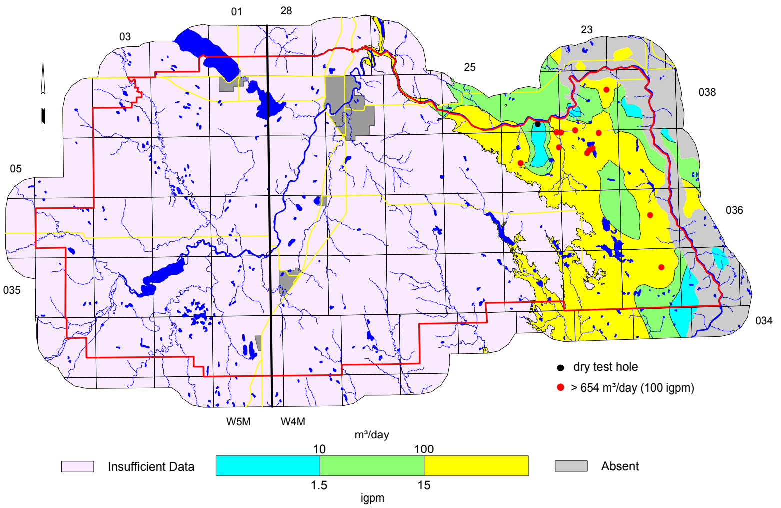

Figure 28. Apparent Yield for Water Wells Completed through Upper Scollard Aquifer

An example of a high yielding water well in the northeastern part of the County is a water supply well (WSW No. 2) drilled for the Village of Delburne in NW 21-037-23 W4M and completed from 30.5 to 42.7 metres below ground surface in the Upper Scollard Aquifer (HCL, Nov-1970). An extended aquifer test conducted with the water supply well indicated a long-term yield of 275 m³/day. WSW No. 2 was reconditioned in 1994 and is currently licensed to divert 24 m³/day for municipal purposes.

There are 89 licensed and/or registered groundwater users that have water wells completed through the Upper Scollard Aquifer, for a total authorized groundwater diversion of 745 m³/day, of which 274 m³/day (37%) is used to divert groundwater for municipal purposes. The highest allocations are for two Village of Delburne water supply wells completed in the Upper Scollard Aquifer in NW 21-037-23 W4M that are licensed to divert a total of 225 m³/day for municipal purposes.

Of the 89 licences and/or registrations, 60 could be linked to water wells in the AENV groundwater database.

5.3.9.3 Quality

The groundwaters from the Upper Scollard Aquifer are mainly a sodium-bicarbonate or sodium-sulfate type (see Piper diagram on CD-ROM), with only six (4%) of the groundwater samples having TDS concentrations less than 500. TDS concentrations of greater than 2,000 mg/L are expected at the eastern edge of the Aquifer (see page A-50). The sulfate concentrations mainly range from 500 to 1,000 mg/L. The chloride concentrations from the water wells completed in the Upper Scollard Aquifer are mainly less than ten mg/L. There are only four analyses in which fluoride concentrations exceed 1.5 mg/L.

A chemical analysis of a groundwater sample collected during the aquifer test with the Village of Delburne WSW No. 2 in 1970 indicated the groundwater is a sodium-bicarbonate type, with a TDS concentration of 528 mg/L, a sulfate concentration of 40 mg/L, a chloride concentration of 40 mg/L, a fluoride concentration of 0.24 mg/L, and a total hardness of 244 mg/L. The chemical analysis indicated high concentrations of nitrates (66 mg/L). It was determined that the source of the nitrate contamination was probably due to mice remnants discovered during the pump removal of an old water well, which was used for observation. Consequently, a gallon of bleach was dumped in the observation water well prior to an aquifer test. Subsequently, a second groundwater sample was collected from WSW No. 2 and the high concentration of nitrates was reduced to 20 mg/L.

Of the five constituents that have been compared to the SGCDWQ, the median value of TDS and sodium exceed the guidelines. The median concentrations of TDS, sodium and sulfate from water wells completed in the Upper Scollard Aquifer are greater than the median concentrations from water wells completed in all Upper Bedrock Aquifer(s).

Constituent	No. of Analyses	Range for County in mg/L Minimum	Maximum	Median	All Bedrock Median	Recommended Maximum Concentration SGCDWQ
Total Dissolved Solids	138	442	2,771	1,221	708	500
Soduim	100	0	850	342	250	200
Sulfate	140	10	1,450	327	85	500
Chloride	139	0	720	3	4	250
Fluoride	105	0	3	0.4	0.7	1.5

Concentration in milligrams per litre unless otherwise stated
Note: indicated concentrations are for Aesthetic Objectives except for Fluoride, which is for Maximum Acceptable Concentration (MAC)

SGCDWQ - Summary of Guidelines for Canadian Drinking Water Quality
Federal-Provincial-Territorial Committee on Drinking Water, April 2003

Table 11. Apparent Concentrations of Constituents in Groundwaters from Upper Scollard Aquifer

5.3.10 Lower Scollard Aquifer

The Lower Scollard Aquifer comprises the porous and permeable parts of the Lower Scollard Formation that underlie the Upper Scollard Formation. Structure contours have been prepared for the top of the Formation. The structure contours show that the Lower Scollard Formation ranges in elevation from less than 350 to more than 800 metres AMSL and has a maximum thickness of 70 metres. The non-pumping water level in the Lower Scollard Aquifer is mainly downgradient to the north toward the Red Deer River.

5.3.10.1 Depth to Top

The depth to the top of the Lower Scollard Formation ranges from less than 50 metres below ground surface at the eastern extent to more than 600 metres in the western part of the County (page A-51).

5.3.10.2 Apparent Yield

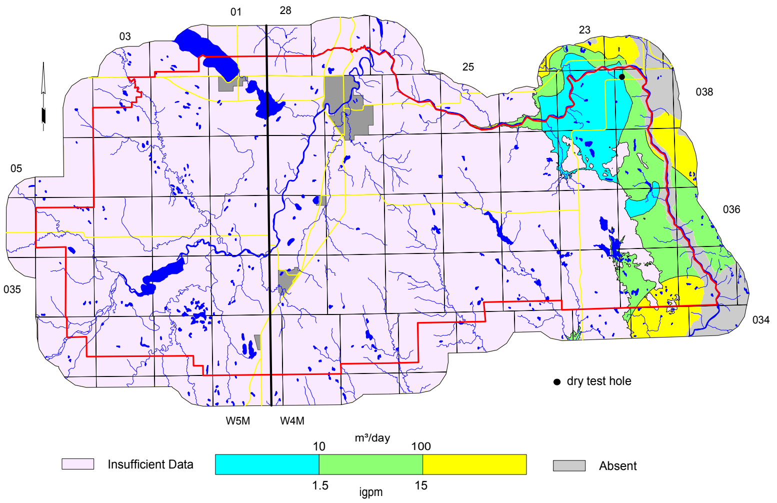

Figure 29. Apparent Yield for Water Wells Completed through Lower Scollard Aquifer

The apparent yields for individual water wells completed through the Lower Scollard Aquifer range mainly from 10 to 100 m³/day, and have a median apparent yield value of 30 m³/day. There are little or no data for the Aquifer in most of the County. In these areas, the depth to burial is more than 80 metres below ground surface.

There is one "dry" water test hole that is completed in the Lower Scollard Aquifer.

In the County, there are 25 licensed and/or groundwater users that have water wells that are completed in the Lower Scollard Aquifer, for a total authorized diversion of 152 m³/day. The highest single allocation of 44 m³/day is for a water supply well in 06-04-038-22 W4M licensed to divert groundwater for agricultural purposes. Eighteen of the 25 licensed and/or registered water wells could be linked to a water well in the AENV groundwater database.

5.3.10.3 Quality

Constituent	No. of Analyses	Range for County in mg/L Minimum	Maximum	Median	All Bedrock Median	Recommended Maximum Concentration SGCDWQ
Total Dissolved Solids	26	600	2,602	1,679	708	500
Sodium	10	300	571	393	250	200
Sulfate	26	38	1,196	558	85	500
Chloride	25	0	102	4	4	250
Fluoride	11	0	2	0.5	0.7	1.5

Concentration in milligrams per litre unless otherwise stated
Note: indicated concentrations are for Aesthetic Objectives except for Fluoride, which is for Maximum Acceptable Concentration (MAC)

SGCDWQ - Summary of Guidelines for Canadian Drinking Water Quality
Federal-Provincial-Territorial Committee on Drinking Water, April 2003

Table 12. Apparent Concentrations of Constituents in Groundwaters from Lower Scollard Aquifer

The groundwaters from the Lower Scollard Aquifer are mainly a sodium-bicarbonate type (see Piper diagram on CD-ROM), with 70% of the groundwater samples having TDS concentrations ranging from 1,000 to 2,000 mg/L (page A-53). The sulfate concentrations are mainly greater than 100 mg/L and the chloride concentrations are mainly less than ten mg/L. There are only two analyses in which fluoride concentrations exceed 1.5 mg/L.

Of the five constituents that have been compared to the SGCDWQ, the median values of TDS, sodium and sulfate exceed the guidelines. The median concentrations of TDS, sodium and sulfate from water wells completed in the Lower Scollard Aquifer are greater than the median concentrations from water wells completed in all Upper Bedrock Aquifer(s).

6 GROUNDWATER BUDGET

6.1 Hydrographs

In the County, there are eight observation water wells (Obs WWs) that are currently active in the AENV regional groundwater monitoring network. These are locations at which water levels are being measured and recorded as a function of time (see page A-58). These eight Obs WWs are in four main areas of the County. Of the eight Obs WWs, three are located in the vicinity of Dickson Dam (15, 31 and 33-035-02 W5M), three are in the vicinity of Pine Lake (24-036-25 W4M), one is in the vicinity of the Village of Elnora (16-36-034-26 W4M), and one is in the vicinity of a Meadowglen subdivision (19-038-26 W4M). One Obs WW from each of these areas is discussed below.

The AENV Dickson Dam Obs WW No. 82-1 (M35379.095565) is completed from 28.9 to 32.0 metres below ground surface in the Dalehurst Aquifer. The hydrograph shows that there has been no net water-level decline in the Obs WW, as shown by the blue line, since monitoring began in 1983 (see page A-59).

From the data provided in Figure 30, there is a striking relationship between the changes in water level the Gleniffer Reservoir and the water level measured in the Dalehurst Aquifer. The comparison shows that for every metre change in the water levels measured in AENV Dickson Dam Obs WW No. 82-1, there is a corresponding change in the surface-water level in the Gleniffer Reservoir. The relationship does not indicate that there is a direct hydraulic connection between the water in the reservoir and the groundwater. Most likely the groundwater level is responding to the pressure being exerted on the confined aquifer by the weight of the water.

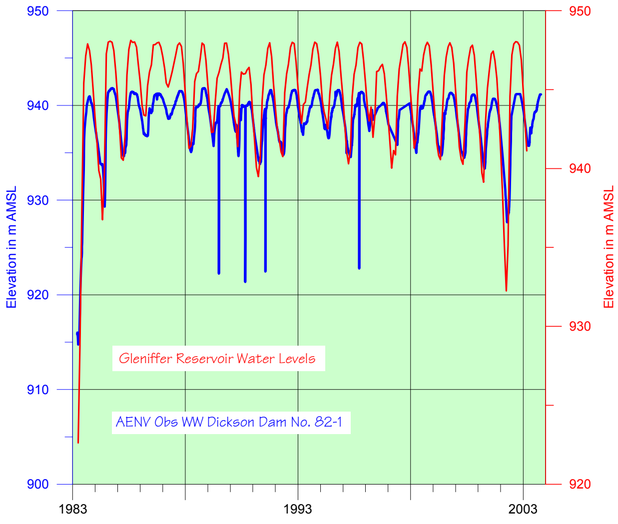

Figure 30. Comparison of Water Levels in AENV Dickson Dam Obs WW No. 82-1 and Gleniffer Reservoir

The AENV Pine Lake Obs WW No. 2676E (M35377.115301) is completed from 36.3 to 37.8 metres below ground surface in the Upper Lacombe Aquifer. The hydrograph shows that the water levels in the AENV Pine Lake Obs WW No. 2676E have declined by roughly one metre since 1994 (see page A-60).

In an area where there are no pronounced seasonal uses of groundwater, the highest yearly water level will mostly occur in late spring/early summer and the lowest yearly water level will be in late winter/early spring. In Figure 31, it is apparent that the lowest water levels are mainly during the summer/fall months. This situation is a result of increased groundwater use in the Pine Lake area prior to and during the summer months.

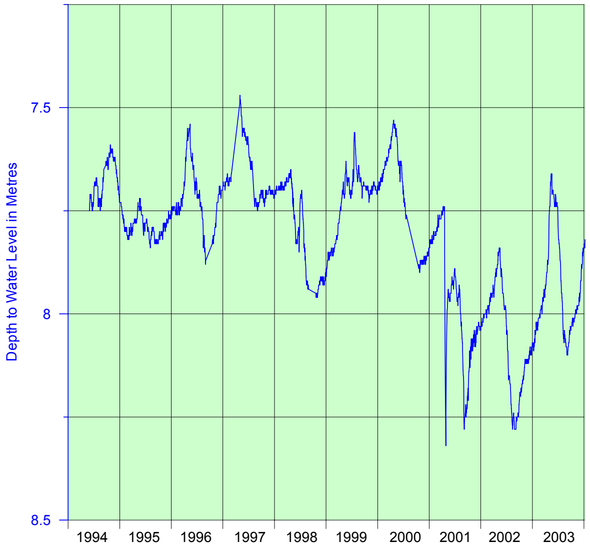

Figure 31. Water Levels in AENV Pine Lake Obs WW No. 2676E

The AENV Elnora Obs WW No. 5 (M37267.767255) is completed from 9.1 to 13.7 metres below ground surface in the Upper Sand and Gravel Aquifer. The water level in the Obs WW has been monitored since 1962 (see page A-61). The complete hydrograph shows that there has been an overall net water-level rise in AENV Elnora Obs WW No. 5 of less than 0.25 metres.

There are annual fluctuations in the water level, with rises in late spring/early summer and a decline throughout the remainder of the year. Overall annual fluctuations ranged in the order of 0.5 to 1.2 metres between 1962 and 1990. Since 1990, the overall annual fluctuations mainly ranged in the order of one to two metres.

The water-level fluctuations in AENV Elnora Obs WW No. 5 from 1999 to 2003 have been compared to the monthly precipitation measured at the Elnora South Weather Station. A five-year interval was chosen in order to make an easier visual comparison. From 1999 to 2001, and in 2003, there appears to a close relationship between the monthly precipitation and the water-level measurements in AENV Elnora Obs WW No. 5. In 2002, there is no apparent relationship between precipitation and the water-level measurements in the observation water well.

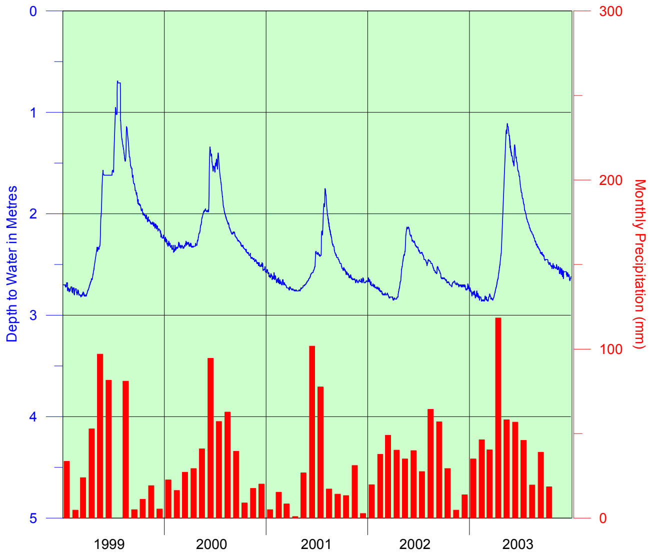

Figure 32. Monthly Precipitation and Water Levels in AENV Elnora Obs WW No. 5

The AENV Meadowglen Obs WW (M36076.564445) is completed from 29.0 to 67.1 metres below ground level in the Dalehurst Aquifer. The water levels in the Meadowglen Obs WW decreased by more than one metre during 1993. The water level remained at a level of approximately 56 metres below ground level from 1993 until early 1998. In 1998 and 1999, the water level fluctuated between 54 and 58 metres below ground surface. By late 1999, the water level had risen to 54 metres below ground surface and then steadily declined over the next three years to just under 58 metres below ground surface. The water-level rise in mid-1999 may be a result of the above-average precipitation in June 1999. The water-level decline from 1999 to 2002 may be related to improperly completed water wells that allow the shallow aquifers to be drained. In 2003, the water level rose to just over 56 metres below ground surface (see page A-62).

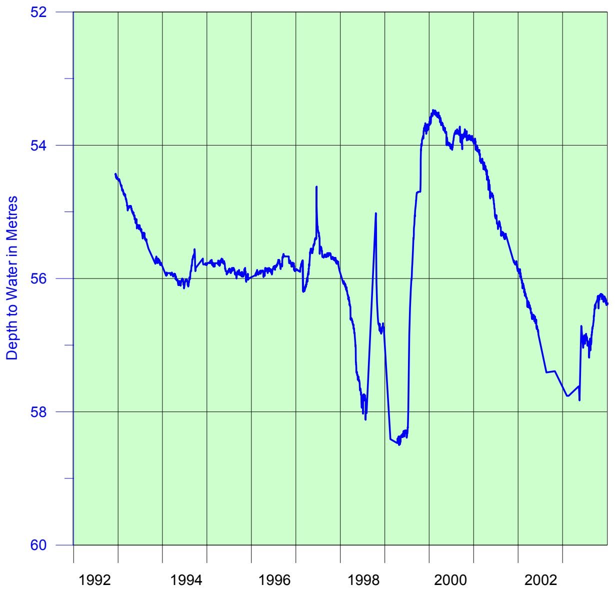

Figure 33. Water Levels in AENV Meadowglen Obs WW

6.2 Estimated Groundwater Use in Red Deer County

An estimate of the quantity of groundwater removed from each geologic unit in Red Deer County must include both the groundwater diversions with licences and/or registrations and the groundwater diversions without licences and/or registrations. As stated previously on page 7 of this report, the daily water requirement for livestock for the County based on the 2001 census is 23,200 cubic metres. As of May 2003, AENV has licensed the use of 11,269 m^3/day for livestock, which includes both surface water (based on consumptive use) and groundwater. To obtain an estimate of the quantity of groundwater being diverted from the individual geologic units, it has been assumed that the remaining 11,931 m^3/day of water required for livestock watering is obtained from unauthorized groundwater use.

In the County, there are a total of 3,640 water wells being used for domestic/stock (2,583) or stock (1,057) purposes. There are 1,820 licensed and/or registered groundwater users for agricultural (stock) and registration (stock) purposes, giving 1,820 unlicensed and not registered stock water wells. By dividing the number of unlicensed and not registered stock and domestic/stock water wells (1,820) into the quantity required for stock purposes that is not licensed and registered (11,931 m^3/day), the average unlicensed and not registered water well diverts 6.6 m^3/day per stock water well.

Groundwater for household use requires authorization if the use is more than 1,250 m^3/year. Under the *Water Act*, a residence is protected for up to 3.4 m^3/day. However, the standard groundwater use for household purposes (a family of four) is 1.1 m^3/day. Since there are 9,617 domestic or domestic/stock water wells in Red Deer County serving a population of 18,639, the domestic use per water well is 0.5 m^3/day.

To obtain an estimate of the groundwater from each geologic unit, there are three possibilities for a water well. A summary of the possibilities and the quantity of water for each use is as follows:

Domestic	0.5 m^3/day
Stock	6.6 m^3/day
Domestic and stock	7.1 m^3/day

Aquifer Designation	Number of Domestic	Total Domestic Use (0.5 m^3/day)	Number of Stock	Number of Domestic and Stock	Number of Licensed Stock and/or Registrations	Total Number of Stock Water Wells Without Licences and/or Registrations	Total Stock Use Without Licenses and/or Registrations (6.6 m^3/day)	Total Licensed Stock and/or Registered Groundwater Use (m^3/day)	Total Stock Use (m^3/day)
Multiple Surficial Completions	476	238	51	172	65	158	1,043	402	1,444
Upper Surficial	307	154	25	149	46	128	845	175	1,020
Lower Surficial	75	38	5	26	14	17	112	93	205
Multiple Bedrock Completions	1,075	538	169	295	112	352	2,323	707	3,031
Dalehurst	6,048	3,024	672	1,491	1,279	884	5,834	6,811	12,646
Upper Lacombe	335	168	17	67	37	47	310	196	507
Lower Lacombe	31	16	3	16	3	16	106	3	109
Haynes	150	75	23	76	35	64	422	179	601
Upper Scollard	366	183	56	186	83	159	1,049	444	1,494
Lower Scollard	60	30	16	36	25	27	178	152	330
Battle and Whitemud	9	5	1	3	3	1	7	7	14
Upper Horseshoe Canyon	13	7	0	5	0	5	33	0	33
Unknown	672	336	19	61	118	-38 (0)	0	470	470
Totals (1)	9,617	4,809	1,057	2,583	1,820	1820 (1,858)	12,263	9,640	21,902

(1) The values given in the table have been rounded and, therefore, the columns and rows may not add up equally

Table 13. Total Domestic and Stock Groundwater Diversions by Aquifer

Because of the limitations of the data, no attempt has been made to compensate for dugouts, springs or inactive water wells.

Based on using all available domestic, domestic/stock, and stock water wells and corresponding calculations, Table 13 was prepared. Table 13 show a breakdown of the domestic water wells and stock water wells with or without licences and registrations by the geologic unit in which each water well is completed. The total domestic groundwater use is 4,809 m^3/day and the total stock groundwater use is 21,902 m^3/day, giving a total domestic and stock groundwater use of 26,711 m^3/day. The data provided in Table 13 indicate that nearly 60% of the 26,711 m^3/day is from the Dalehurst Aquifer.

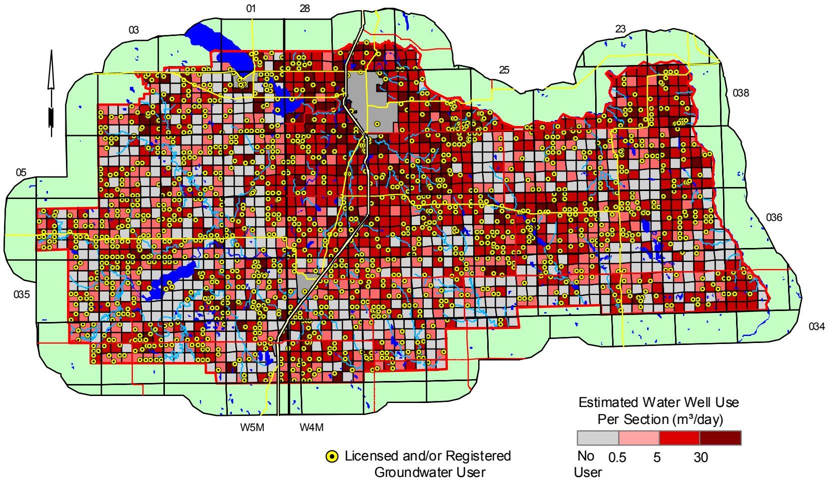

Figure 34. Estimated Water Well Use Per Section

By assigning 0.5 m³/day for domestic use, 6.6 m³/day for stock use and 7.1 m³/day for domestic/stock use, and using the total maximum authorized diversion associated with any licensed and/or registered water well, a map has been prepared that shows the estimated groundwater use in terms of volume per section per day for the County (not including springs).

There are 1,713 sections in the County. In 32% (546) of the sections in the County, there is no domestic, stock or licensed and/or registered groundwater user. The range in groundwater use for the remaining 1,167 sections is from 0.5 m³/day to 1,658 m³/day (municipal), with an average use per section of 17 m³/day (2.6 igpm). The estimated water well use per section can be more than 30 m³/day in 163 of the 1,713 sections. There are 309 of the total 1,793 authorized groundwater users in areas of greater than 30 m³/day. The most notable areas where water well use of more than 30 m³/day is expected to occur is in the perimeter around the City of Red Deer (townships 036 to 039, ranges 26 to 28, W4M); in township 036, ranges 24 and 25, W4M; and in townships 037 and 038, range 22, W4M, as shown above on Figure 34.

Groundwater Use within Red Deer County (m³/day)		%
Domestic/Stock (including agriculture and registrations)	26,711	71
Municipal (licensed)	9,716	26
Commercial/Industrial/Dewatering et al (licensed)	1,302	3
Total	37,729	100

Table 14. Total Groundwater Diversions

In summary, the estimated total groundwater use within Red Deer County is 37,729 m³/day, with the breakdown as shown in Table 14.

An estimated 37,259 m³/day is being withdrawn from a specific aquifer. The remaining 1,323 m³/day (3%) is being withdrawn from unknown aquifer units. Of the 37,729 m³/day, 87% is being diverted from bedrock aquifers and 10% from surficial aquifers. Approximately 55% of the total estimated groundwater use is from licensed and/or registered water wells.

6.3 Groundwater Flow

A direct measurement of groundwater recharge or discharge is not possible from the data that are available for the County. One indirect method of measuring recharge is to determine the quantity of groundwater flowing laterally through each individual aquifer. This method assumes that there is sufficient recharge to the aquifer to maintain the flow through the aquifer and the discharge is equal to the recharge. However, even the data that can be used to calculate the quantity of flow through an aquifer must be averaged and estimated. To determine the flow requires a value for the average transmissivity of the aquifer, an average hydraulic gradient and an estimate for the width of the aquifer. For the present program, the flow has been estimated for individual aquifers within the County.

The flow through each aquifer assumes that by taking a large enough area, an aquifer can be considered as homogeneous, the average gradient can be estimated from the non-pumping water-level surface, and flow takes place through the entire width of the aquifer; flow through the aquifers takes into consideration hydrogeological conditions outside the County border. Based on these assumptions, the estimated lateral groundwater flow through the individual aquifers has been summarized in Table 15.

Aquifer	Aquifer Flow (m^3/day)	Licensed and/or Registered Diversion (m^3/day)	Not Licensed and/or Registered Diversion (m^3/day)	Total (m^3/day)
Upper Surficial	2,537	506	845	1,351
Lower Surficial	1,200	185	112	297
Dalehurst	30,339	15,602	5,834	21,436
Upper Lacombe	7,760	614	310	924
Lower Lacombe	135	3	106	109
Haynes	7,000	290	422	712
Upper Scollard	2,851	744	1049	1,793
Lower Scollard	505	151	178	329

Table 15. Groundwater Budget

Table 15 indicates that there is more groundwater flowing through the aquifers than has been authorized to be diverted from the individual aquifers. However, even where use is less than the calculated aquifer flow, there can still be local impacts on water levels. The calculations of flow through individual aquifers as presented in Table 15 are very approximate and are intended only as a guide; more detailed investigations are needed to better understand the groundwater flow.

6.3.1 Quantity of Groundwater

An estimate of the volume of groundwater stored in the surficial deposits is 1.1 to 6.6 cubic kilometres. This volume is based on an areal extent of 4,436 square kilometres and a saturated thickness of five metres. The variation in the total volume is based on the value of porosity that is used for the surficial deposits. 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).

The adjacent water-level map has been prepared from water levels associated with water wells completed to depths of less than 20 metres in aquifers in the surficial deposits. The water levels from these water wells were used for the calculation of the saturated thickness of the surficial deposits. In areas where the elevation of the water-level surface is below the bedrock surface, the surficial deposits are not saturated (indicated by grey areas on the map). The water-level map for the surficial deposits shows a flow direction northeast toward the Red Deer River.

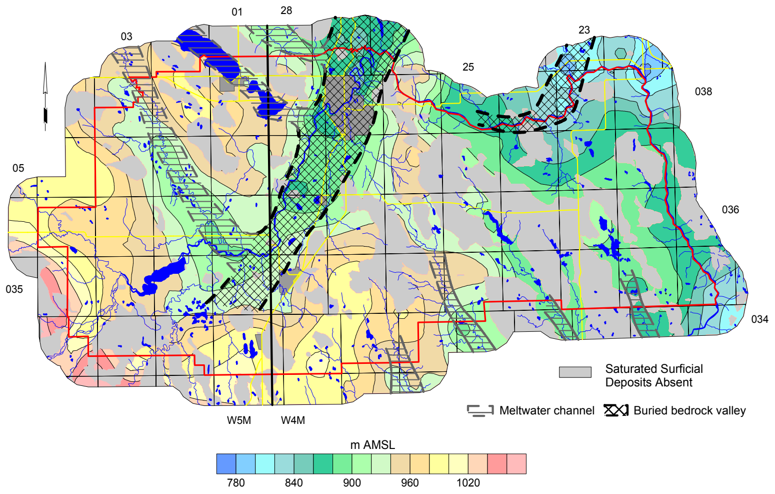

Figure 35. Non-Pumping Water-Level Surface in Surficial Deposits Based on Water Wells Less than 20 Metres Deep

6.3.2 Recharge/Discharge

The hydraulic relationship between the groundwater in the surficial deposits and the groundwater in the bedrock aquifers is given by the non-pumping water-level surface associated with each hydraulic unit. 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. In areas where the surficial deposits are unsaturated, the extrapolated water level for the surficial deposits is used.

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

6.3.2.1 Bedrock Aquifers

Recharge to the bedrock aquifers within the County takes place from the overlying surficial deposits and from flow in the aquifer from outside the County. 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.

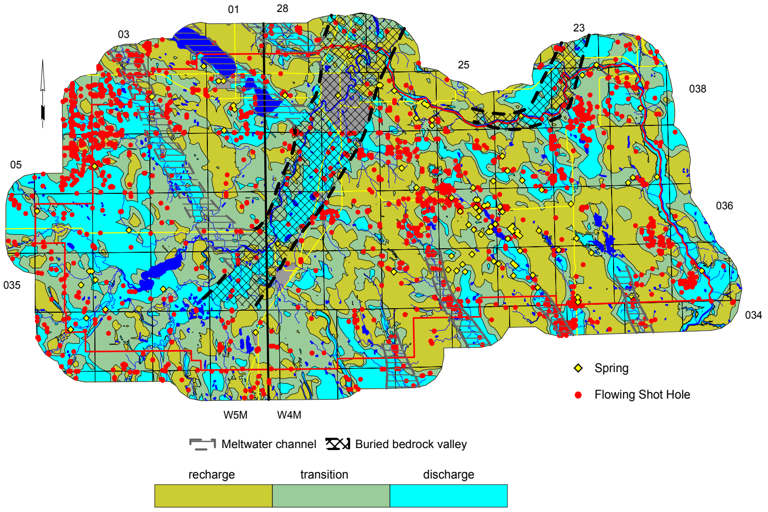

Figure 36. Bedrock Recharge/Discharge Areas

In the absence of sufficient water-level data in the surficial deposits, a reasonable hydraulic gradient between the surficial deposits and the Upper Bedrock Aquifer(s) could not be determined. Therefore, an alternative approach has been used to establish approximate recharge and discharge areas. The first objective was to determine the location of springs, flowing shot holes and any water wells that had a water level measurement depth of less than 0.1 metres. These locations would reflect where there is an upward hydraulic gradient from the bedrock to the surficial deposits (i. e. discharge). The depth to water level for water wells completed in the Upper Bedrock Aquifer(s) has been determined by subtracting the non-pumping water-level surface associated with all water wells completed in the Upper Bedrock Aquifer(s) from the non-pumping water level associated with all the water wells completed in the Sand and Gravel Aquifer(s). This resulting depth to water level grid was contoured to reflect the positioning of springs, flowing shot holes and flowing water wells (i. e. discharge). The recharge classification is used where the water level in the Upper Bedrock Aquifer(s) is more than five metres below the water level in the surficial aquifer(s). The discharge areas are where the water level in the Upper Bedrock Aquifer(s) is more than five metres above the water level in the surficial aquifer(s). When the depth to water level in the Upper Bedrock Aquifer(s) is between five metres below the bedrock surface and five metres above the bedrock surface, the area is classified as a transition, that is, no recharge and no discharge.

Figure 36 shows that, in more than 35% of the County, there is a downward hydraulic gradient from the bedrock surface toward the Upper Bedrock Aquifer(s) (i. e. recharge). These areas tend to be mainly at higher elevations. Areas where there is an upward hydraulic gradient from the bedrock to the bedrock surface (i. e. discharge) are mainly in the vicinity of linear bedrock lows. The remaining parts of the County are areas where there is a transition condition.

Because of the paucity of data, recharge/discharge maps for the individual bedrock aquifers have not been attempted.

With 35% of the County land area being one of recharge to the bedrock, and the average precipitation being 491 mm per year, 1.1 percent of the annual precipitation is sufficient to provide the total calculated quantity of groundwater flowing through the Upper Bedrock Aquifer(s).

6.4 Areas of Groundwater Decline

In order to determine the areas of possible water-level decline in the Sand and Gravel Aquifer(s) and in the Upper Bedrock Aquifer(s), the following approach was used. The method of calculating changes in water levels is at best an estimate. The areas of groundwater decline in the Sand and Gravel Aquifer(s) and in the Upper Bedrock Aquifer(s) have been calculated by determining the frequency of non-pumping water level control points per five-year period. Additional data would be needed to verify water-level change.

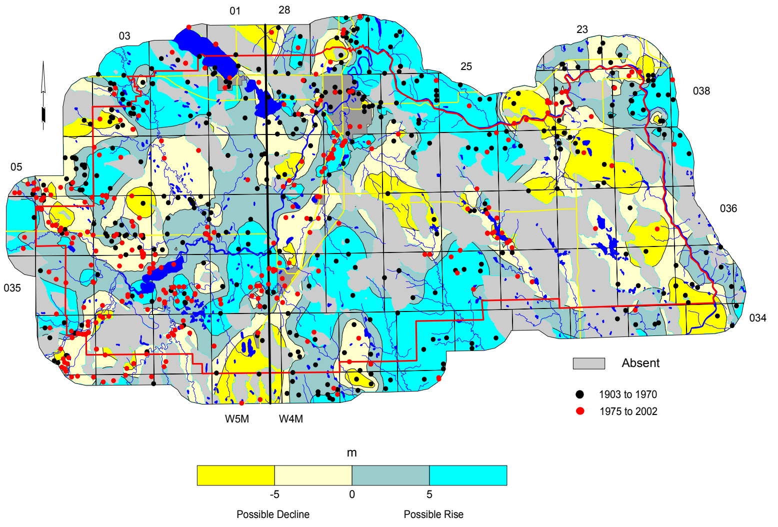

Figure 37. Changes in Water Levels in Surficial Deposits

Of the 900 surficial water wells with a non-pumping water level and date in the County and buffer area, 443 are from water wells completed before 1970 and 363 are from water wells completed after 1975.

Where the earliest water level (before 1970) is at a higher elevation than the latest water level (after 1975), there is the possibility that some groundwater decline has occurred. The interpretation of the adjacent map should be limited to areas where both earliest and latest water level control points are present. Most of the areas in which the map suggests that there has been a rise in NPWL of more than five metres may reflect the nature of gridding a limited number of control points. The adjacent map, where sufficient control exists, indicates that there may have been a decline in the NPWL of more than five metres trending along a northwest-southeast area in the eastern part of the County, as shown in Figure 37 and on page A-65.

Where the earliest water level is at a lower elevation than the latest water level, there is the possibility that the groundwater has risen at that location. The water level may have risen as a result of recharge in wetter years or may be a result of the water well being completed in a different surficial aquifer.

Figure 37 indicates that in 55% of the County where surficial deposits are present, it is possible that the non-pumping water level has declined.

Estimated Water Well Use Per Section (m³/day)	*% of Area with More than a 5-Metre Projected Decline*
<5	*22*
5 to 30	*42*
>30	*10*
no use	*26*
	100

Table 16. Water-Level Decline of More than 5 Metres in Sand and Gravel Aquifer(s)

In areas where a water-level decline of more than five metres is indicated, 26% of the areas has no estimated water well use; 22% of the use is less than five m³/day; 42% of the use is between five and 30 m³/day per section; and the remaining 10% of the declines occurred where the estimated groundwater use per section is greater than 30 m³/day, as shown in Table 16.

The areas of groundwater decline in the Sand and Gravel Aquifer(s) where there is no estimated water well use suggest that groundwater diversion is not having an impact and that the decline may be due to variations in recharge to the aquifer or because the water wells are not on file with AENV.

Of the 10,993 surficial water wells with a non-pumping water level and date in the County and buffer area, 2,351 are from water wells completed before 1970 and 4,379 are from water wells completed after 1985.

Where the earliest water level (before 1970) is at a higher elevation than the latest water level (after 1985), there is the possibility that some groundwater decline has occurred. Most of the areas in which the map suggests that there has been a rise in NPWL of more than ten metres may reflect the nature of gridding a limited number of control points. The adjacent map indicates that there may have been a decline in the NPWL of more than ten metres mainly east of the 5th Meridian, as shown in Figure 38 and on page A-66.

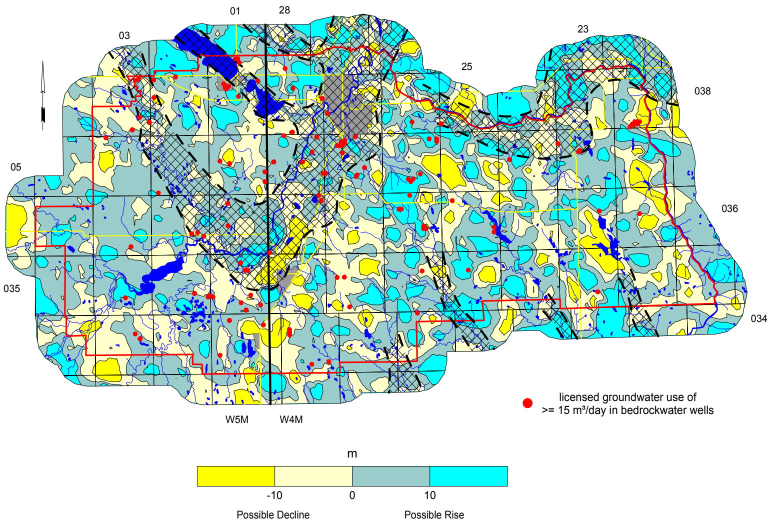

Figure 38. Areas of Potential Groundwater Depletion - Upper Bedrock Aquifer(s)

The adjacent map indicates that in nearly 40% of the County, it is possible that the NPWL has declined. There are 156 licensed and/or registered water wells that are authorized to divert at least 15 m^3/day. Of the 156 groundwater users, 123 are within one kilometre where it is possible that there has been a water-level decline in the Upper Bedrock Aquifer(s).

In areas where a water-level decline of more than ten metres is indicated, 32% of the area has no estimated water well use; 23% is less than five m^3/day; 39% is between five and 30 m^3/day per section; and the remaining 6% of the declines occurred where the estimated groundwater use per section is greater than 30 m^3/day, as shown below in Table 17.

Estimated Water Well Use Per Section (m^3/day)	*% of Area with More than a 10-Metre Projected Decline*
<5	*23*
5 to 30	*39*
>30	*6*
no use	*32*
	100

Table 17. Water-Level Decline of More than 10 Metres in Upper Bedrock Aquifer(s)

The areas of groundwater decline in the Upper Bedrock Aquifer(s) where there is no estimated water well use suggest that groundwater production is not having an impact and that the decline may be due to variations in recharge to the aquifer or because the water wells are not on file with AENV.

6.5 Discussion of Specific Study Areas

Red Deer County requested that comments be made, where possible, on the following two study areas. Figure 39 shows the two specific study areas in the County; in Figure 40, the two specific study areas have been colour outlined on the bedrock geology map; Figure 41 shows the apparent yield for water wells completed in the Sand and Gravel Aquifer(s); and Figure 42 shows the apparent yield for water wells completed in the Upper Bedrock Aquifer(s).

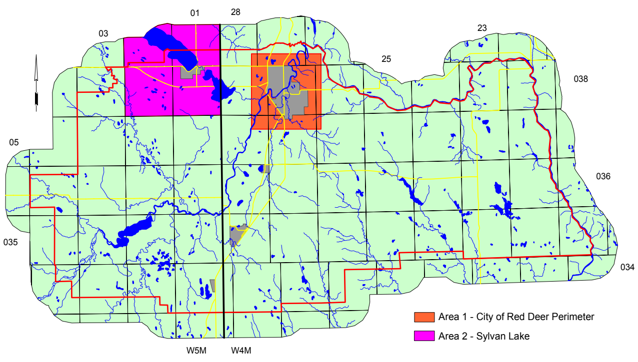

Figure 39. Location of Specific Study Areas

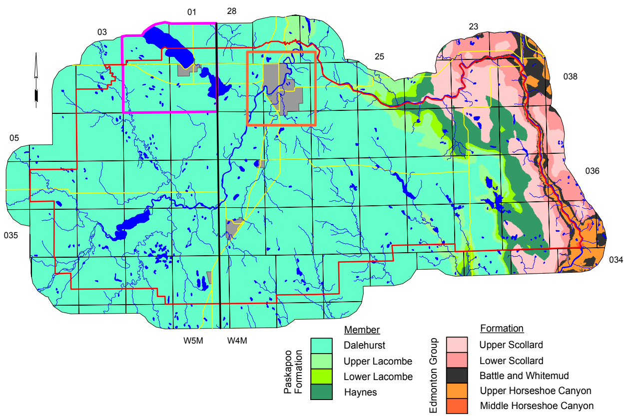

Figure 40. Bedrock Geology of Specific Study Areas

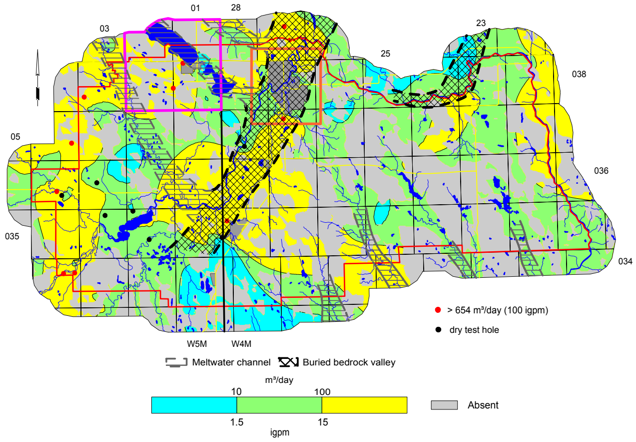

Figure 41. Apparent Yield for Water Wells Completed in Sand and Gravel Aquifer(s) – Specific Study Areas

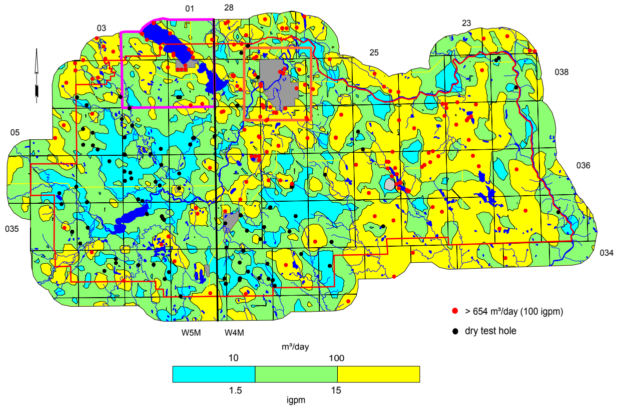

Figure 42. Apparent Yield for Water Wells Completed in Upper Bedrock Aquifer(s) – Specific Study Areas

6.5.1 Area 1 – City of Red Deer Perimeter (Parts of Tp 037 to 039, R 26 to 28, W4M)

What is the approximate extent and potential (yield and water quality) of the aquifers in this area?

The Sand and Gravel Aquifer(s) is present over 85% of Area 1. The saturated sand and gravel deposits are expected to be mainly more than two metres thick. The apparent yields for 13 individual water wells completed in the Sand and Gravel Aquifer(s) in Area 1 range mainly from 10 to 100 m³/day, and have a median apparent yield value of 55 m³/day. The total authorized groundwater use for water wells completed in the Sand and Gravel Aquifer(s) is 86.8 m³/day, as shown on the adjacent figure.

Groundwaters from water wells completed in Area 1 in the surficial deposits are expected to have TDS concentrations that are between 500 and 1,000 mg/L (see page A-72). Sulfate concentrations are less than 500 mg/L, chloride concentrations are less than 100 mg/L and nitrate + nitrite (as N) concentrations are mainly less than ten mg/L.

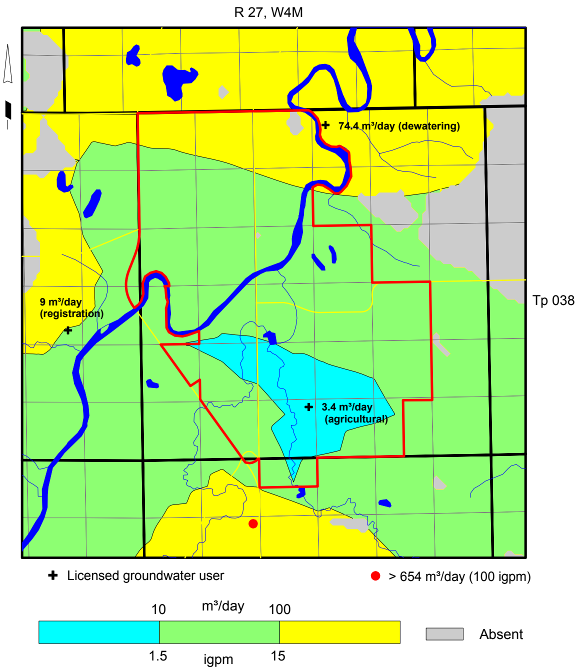

Figure 43. Apparent Yield for Water Wells Completed in Sand and Gravel Aquifer(s) – Area 1

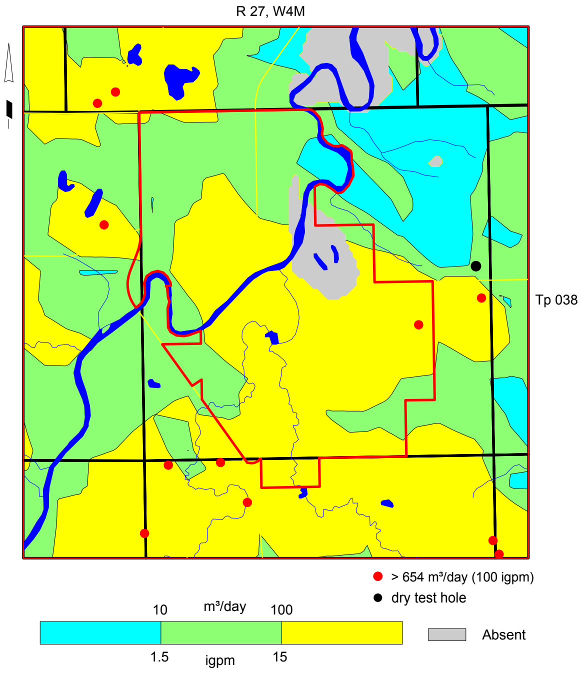

Figure 44. Apparent Yield for Water Wells Completed through Dalehurst Aquifer – Area 1

The upper bedrock in Area 1 is the Dalehurst Member. In Area 1, the apparent yields for 262 individual water wells completed in the Dalehurst Aquifer are mainly greater than ten m³/day, and have a median apparent yield value of 60 m³/day. There are 11 water wells completed in the Dalehurst Aquifer in Area 1 with apparent yield values of greater than 654 m³/day (100 igpm), as shown on the adjacent figure.

The total authorized groundwater use for the 16 water wells completed in the Dalehurst Aquifer is 479 m³/day, with the highest two allocations totaling 356 m³/day for municipal purposes.

Groundwaters from water wells completed in the Dalehurst Aquifer in the northwestern part of Area 1 are expected to have TDS concentrations that range between 500 and 1,000 mg/L. The TDS concentrations in the southeastern part of Area 1 are expected to be mainly greater than 1,000 mg/L (see page A-74). The sulfate concentrations in the northwestern part of Area 1 are mainly less than 500, but are frequently more than 500 mg/L in the southeastern part of Area 1. Chloride concentrations are mainly less than ten mg/L and fluoride concentrations range from less than 0.5 to more than 1.5 mg/L, with the elevated fluoride concentrations bordering the City of Red Deer to the west, east and south.

In Area 1, the depth to the top of the Upper Lacombe Member ranges from less than 25 metres along the Red Deer River Valley to more than 140 metres along the extreme eastern and extreme western edges of Area 1. In Area 1, there are 87 water wells completed in the Upper Lacombe Aquifer with apparent yield data. The completed depths of the water wells completed in the Upper Lacombe Aquifer range from 17 to 130 metres below ground surface.

In Area 1, the apparent yields for 87 individual water wells completed in the Upper Lacombe Aquifer are mainly greater than ten m³/day, and have a median apparent yield value of 30 m³/day. There are six water wells completed in the Upper Lacombe Aquifer with apparent yield values of greater than 654 m³/day (100 igpm), as shown on the adjacent figure.

The total authorized groundwater use for the 14 water wells completed in the Upper Lacombe Aquifer in Area 1 is 271 m³/day. The highest allocation is 150 m³/day for municipal purposes (see section 5.3.6).

Groundwaters from water wells completed in the Upper Lacombe Aquifer in the northwestern part of Area 1 are expected to have TDS concentrations that range between 500 and 1,000 mg/L. The sulfate concentrations in the southwestern part of Area 1 are mainly less than 100, but are mainly more than 100 mg/L in the southeastern part of Area 1. Chloride concentrations are mainly less than 50 mg/L in Area 1.

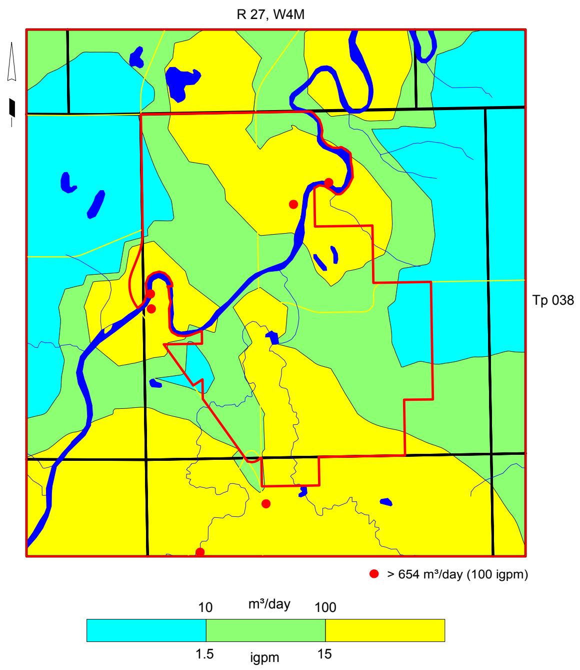

Figure 45. Apparent Yield for Water Wells Completed through Upper Lacombe Aquifer – Area 1

Fluoride concentrations range from less than 0.5 to more than three mg/L, with the elevated fluoride concentrations bordering the City of Red Deer mainly to the north, south and west.

Fifty-six percent of the available fluoride concentrations for water wells completed in the Upper Lacombe Aquifer are more than 1.5 mg/L. Water wells with fluoride concentrations of greater than 1.5 mg/L are shown in Figure 46.

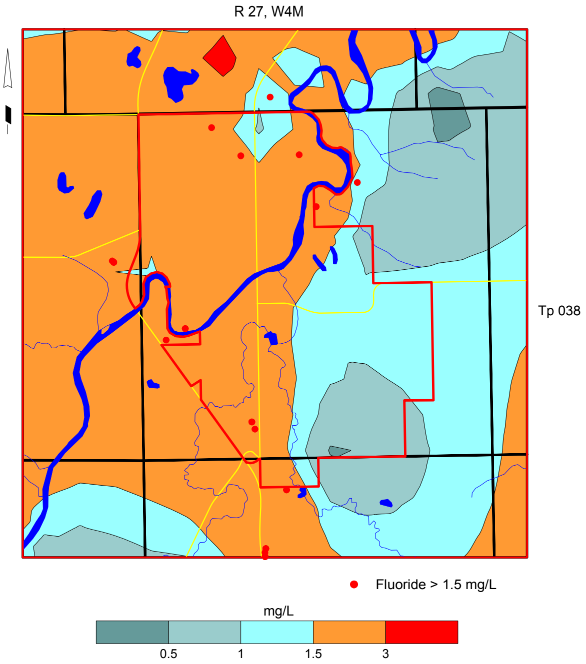

Figure 46. Fluoride in Groundwater from the Upper Lacombe Aquifer – Area 1

6.5.2 Area 2 – Sylvan Lake (Parts of Tp 038 and 039, R 01 and 02, W5M within County Border)

What is the approximate extent and potential (yield and water quality) of the aquifers in this area?

The Sand and Gravel Aquifer(s) is present over 40% of Area 2. The saturated sand and gravel deposits are expected to be less than two metres thick. In Area 2, the apparent yields for eight individual water wells completed in the Sand and Gravel Aquifer(s) range mainly from 10 to 100 m³/day, and have a median apparent yield value of 69 m³/day. The total authorized groundwater use for water wells completed in the Sand and Gravel Aquifer(s) is 18.3 m³/day, as shown on the adjacent figure.

Groundwaters from water wells completed in Area 2 in the surficial deposits are expected to have TDS concentrations that are mainly less than 1,000 mg/L (see page A-79). Sulfate concentrations are mainly less than 500 mg/L, chloride concentrations are less than 100 mg/L and nitrate + nitrite (as N) concentrations are mainly less than ten mg/L.

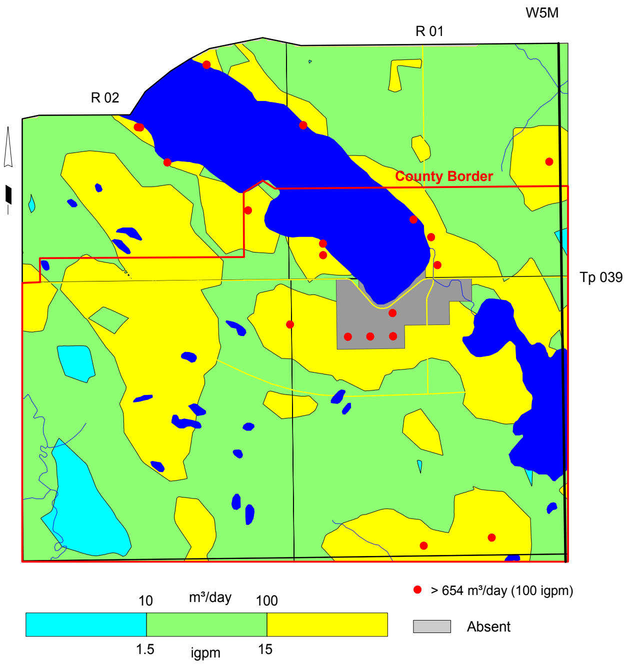

Figure 48. Apparent Yield for Water Wells Completed through Dalehurst Aquifer – Area 2

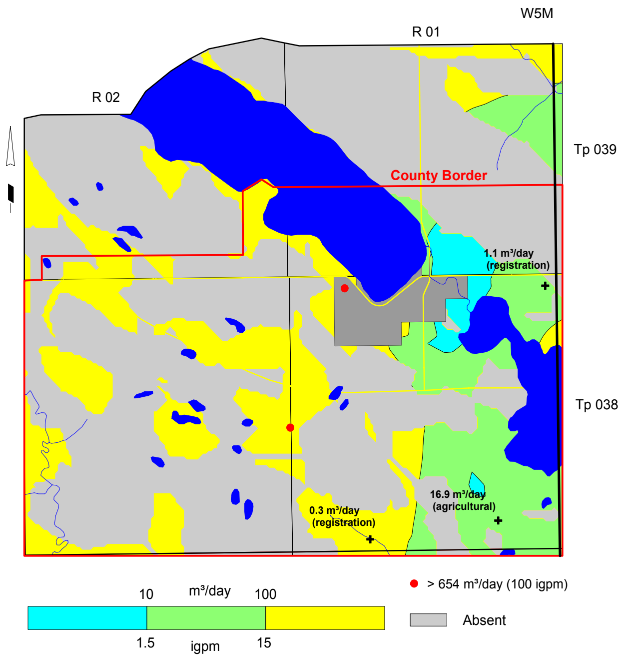

Figure 47. Apparent Yield for Water Wells Completed in Sand and Gravel Aquifer(s) – Area 2

The upper bedrock in Area 2 is the Dalehurst Member. In approximately 50% of Area 2, the apparent yields for water wells completed through the Dalehurst Aquifer are expected to be greater than 100 m³/day, and have a median apparent yield value of 58 m³/day.

Groundwaters from water wells completed in the Dalehurst Aquifer in Area 2 are expected to have TDS concentrations that are mainly less than 500 mg/L southwest of the Town of Sylvan Lake and more than 500 mg/L northeast of the Town of Sylvan Lake (see page A-81). Sulfate concentrations are expected to be mainly less than 100 mg/L, chloride concentrations are mainly less than ten mg/L, and fluoride concentrations are mainly less than one mg/L. Fluoride concentrations of more than 1.5 mg/L are expected northeast of the Town of Sylvan Lake and in the southern parts of Area 2.

6.5.3 Area 3 – Medicine Flat Area Sand and Gravel Aquifer

The sand and gravel aquifer is present over an area of approximately seven square kilometres, occupying most of section 13, the north half of section 12, both in 036-02 W5M, and the west half of section 18, and the north half of section 07, both in 036-01 W5M (HCL, Mar-2000). The aquifer is located west of the confluence of the Red Deer and Medicine rivers and occupies about 0.17 percent of the County area. Although very small in area, parts of the surficial deposits are porous, permeable and water-bearing and therefore the deposits make up an aquifer that is locally significant. The deposits have been a source of gravel and sand for many years.

The surficial materials consist mainly of fluvial sediments, with fine deposits (fine sand, silt, clay and minor gravel) along the Red Deer River and coarser deposits (gravel, sand and gravel, fine to coarse sand and minor silt) along the Medicine River. Coarse lacustrine deposits cover the remaining area (AMEC, May-2003). The surficial materials vary from four to nine metres in thickness and overlie Paskapoo Formation sandstones and shales. The Paskapoo Formation may discharge groundwater to the surficial deposits.

The saturated thickness of the surficial deposits varies from about three to four metres. Groundwater movement has been calculated at 0.9 to 2.3 metres per day. Groundwater movement is generally to the east and northeast from the Red Deer River to the Medicine River, which tends to follow the thalweg of the Gilbey preglacial valley. The water-table gradient has been calculated to range from 0.002 to 0.004. Analyses of aquifer test data from water wells completed in the surficial deposits indicate that the hydraulic conductivity ranges from 1.6 to 2.0 x 10^3 m/s. Aquifer yields have been calculated to range from about 450 to nearly 2,300 lpm (100 to 500 gpm) (AMEC, May-2003).

Groundwater elevations have been interpreted by AMEC as indicating that the aquifer is hydraulically connected to the Red Deer River and the Medicine River and that the Red Deer River is likely the main source of recharge. The author is unaware of any studies which specifically investigated the degree of recharge from the Red Deer River. Recharge could be significantly dependent on precipitation events between spring thaw and fall freeze-up.

Komex (Feb-2004) has indicated that the local significance of cumulative gravel extractions has not been addressed. There is insufficient data to define the distribution of the gravel aquifer and data on the hydraulic properties of backfill material is lacking. As a result, there are significant questions with regard to the long-term sustainability of the groundwater resources in the gravel aquifer down-gradient of section 12.

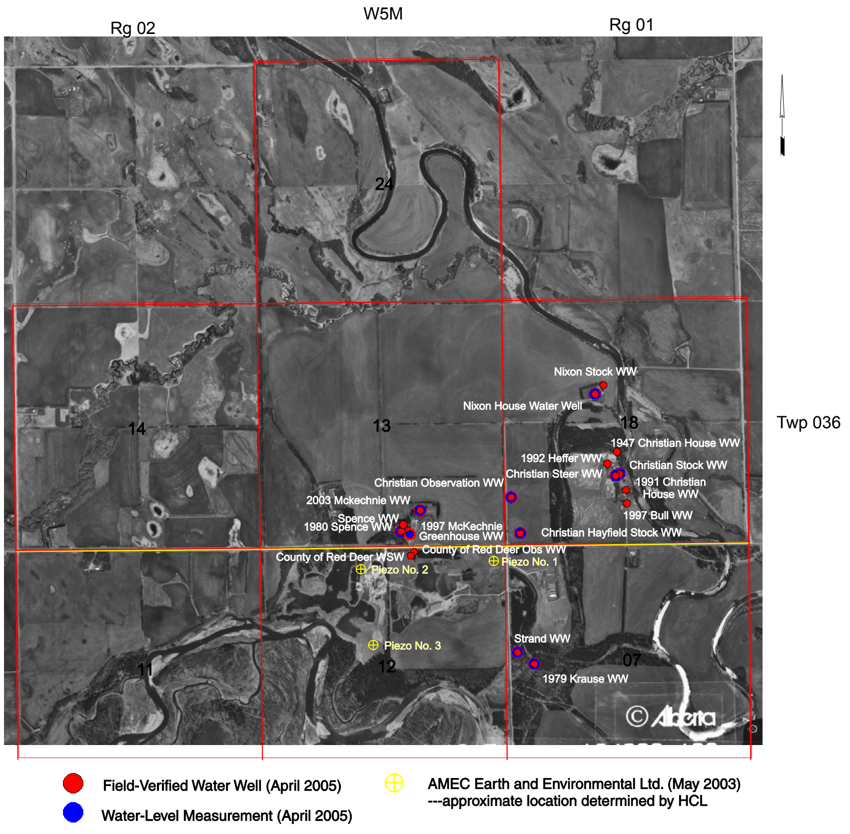

Figure 49. April 2005 Field-Verified Water Wells – Area 3

In the absence of available current water-level data in the AENV groundwater database, HCL conducted a field-verified water well survey on 01 Apr 05. A visit was made to 18 water well sites. Sixteen of the 18 field-verified water wells are on private land. The remaining two water wells are Red Deer County water wells. The 16 water wells are reported to be completed in the sand and gravel aquifer; however, lithologic details are available for only four of the 16 water wells. Of the 18 water wells, a water level was measured in ten water wells, as shown in Figure 49, on page A-82, and on the CD-ROM. Also shown in Figure 49 are three piezometers that were drilled as part of a study conducted by AGRA Earth and Environment in 1999. Information made available to HCL by the local landowners' group in the Medicine Flat area included a table of water levels measured from July 1998 to November 1999 in the three piezometers.

The adjacent hydrograph indicates there has been a water-level decline ranging from 0.5 metres in the Nixon House WW to nearly two metres in the Christian Hayfield Stock WW from August 1999 to April 2005. The water-level decline may be a result of seasonal fluctuations.

From August 1999 to the end of the monitoring period in November 1999, the water level in the three piezometers declined in the order of 0.3 metres.

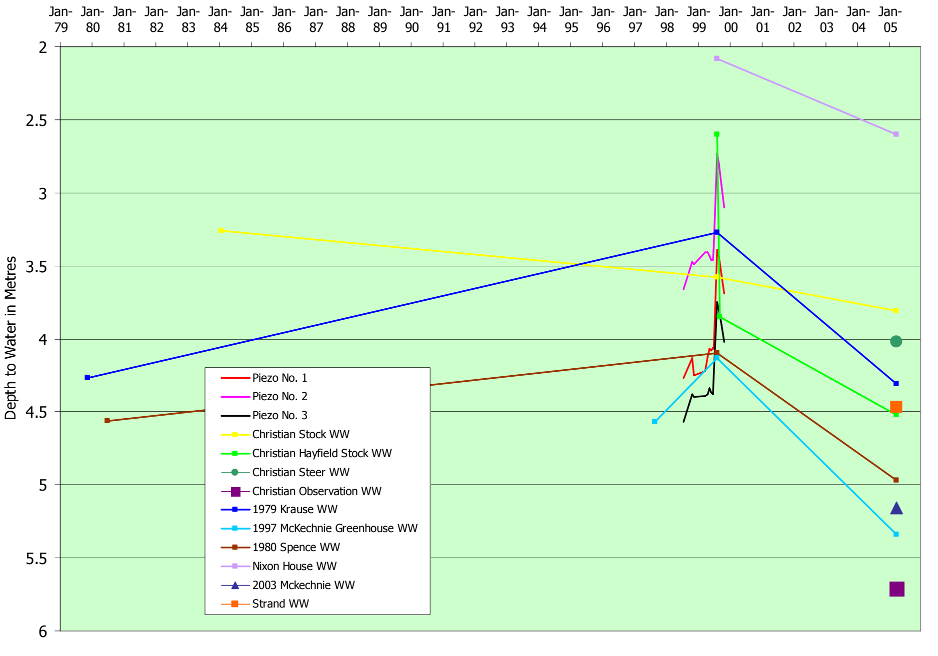

Figure 50. Hydrographs – Area 3

7 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
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 first step would be to field-verify the 271 existing water wells listed in Appendix E. These water well records indicate that a complete water well drilling report is available along with at least a partial chemical analysis. 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. There are six water wells for which the County has responsibility; the County-operated water wells are included in Appendix E. It is recommended that the County-operated water wells plus the 271 water wells be field-verified, water levels be measured, a water sample be collected for analysis, and a short aquifer test be conducted. An attempt to update the quality of the entire database is not recommended.

Before an attempt is made to provide a major upgrade to the level of interpretation provided in this report, the accompanying maps and the groundwater query, it is recommended that the 271 water wells listed in Appendix E for which water well drilling reports are available, plus the six County–operated water wells, be subjected to the following actions (see pages C-2 to C-3):

1) The horizontal location of the water well should be determined within ten 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 five and 115 minutes of pumping, and analyzed for major and minor ions.

This additional information would provide a baseline to be used for comparison to either existing chemical analyses or aquifer tests, or to determine if future monitoring would be necessary if significant changes in the aquifer parameters had occurred.

A list of the 277 water wells that could be considered for the above program is given in Appendix E and on the CD-ROM.

An attempt to link the AENV groundwater and licensing databases was 53% successful in this study (see CD-ROM); forty-seven percent of the licensed and/or registered water wells do not appear to have corresponding records in the AENV groundwater database. There is a need to improve the quality of the AENV licensing database. It is recommended that attempts be made in a future study to find and add missing drilling records to the AENV groundwater database and to determine the aquifer in which the unlicensed and not registered water wells are completed.

While there are a few areas where water-level data are available at different times, on the overall, there are an insufficient number of water levels to set up a 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 and in Flagstaff County, water well owners were being provided with a tax credit if they accurately measured 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. Monitoring of water levels in domestic and stock water wells is a practice that is recommended by AAFC-PFRA in the "Water Wells That Last for Generations" manual and accompanying videos (Buchanan, Bob (editor). Alberta Agriculture, Food and Rural Development, 1996).

A second approach to obtain water-level data would be to conduct a field survey to identify water wells not in use that could be used as part of an observation water well network. County personnel and/or local residents could measure the water levels in the water wells regularly.

Communities that are concerned about apparent water-level declines in the aquifers in which their water supply wells are completed should implement a conscientious groundwater monitoring program.

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. One method of obtaining uniformity would be to have the water well drilling reports submitted to the AENV Resource Data Division in an electronic form. The money presently being spent by AENV 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.

In summary, for the next level of study, the database needs updating. The updating of information for existing water wells requires more details for the water wells listed in Appendix E; the additional information for new water wells is mainly better spatial control.

Groundwater is a renewable resource and it must be managed.

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28. Government of Canada. NTS 1:50,000 Map: RED DEER. Red Deer. [83A05 .R4D4 map]

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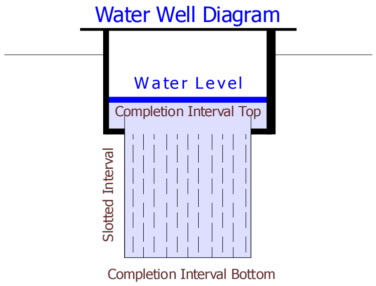
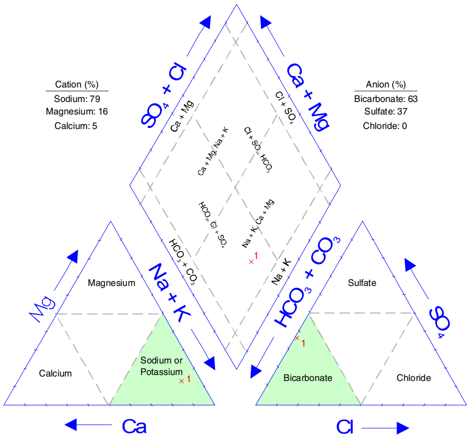
9 GLOSSARY

Anion	negatively charged ion
Aquifer	a formation, group of formations, or part of a formation that contains saturated permeable rocks capable of transmitting groundwater to water wells or springs in economical quantities
Aquitard	a confining bed that retards but does not prevent the flow of water to or from an adjacent aquifer
Available Drawdown	in a confined aquifer, the distance between the non-pumping water level and the top of the aquifer in an unconfined aquifer (water table aquifer), two thirds of the saturated thickness of the aquifer
Borehole	includes all “work types” except springs
Bsk	a climate classification that is characterized by its moisture deficiency, where mean annual potential evapotranspiration exceeds the mean annual precipitation (Thornthwaite and Mather, 1957).
Completion Interval	see diagram
Deltaic	a depositional environment in standing water near the mouth of a river
Dewatering	the removal of groundwater from an aquifer for purposes other than use
Dfb	one of the Köppen climate classifications; a Dfb climate consists of warm to cool summers, severe winters, and no dry season. The mean monthly temperature drops below -3° C in the coolest month, and exceeds 10° C in the warmest month.
Evapotranspiration	a combination of evaporation from open bodies of water, evaporation from soil surfaces, and transpiration from the soil by plants (Freeze and Cherry, 1979)
Facies	the aspect or character of the sediment within beds of one and the same age (Pettijohn, 1957)
Fluvial	produced by the action of a stream or river
Friable	poorly cemented
Hydraulic Conductivity	the rate of flow of water through a unit cross-section under a unit hydraulic gradient; units are length/time
km	kilometre
Kriging	a geo-statistical method for gridding irregularly-spaced data (Cressie, 1990)
Lacustrine	fine-grained sedimentary deposits associated with a lake environment and not including shore-line deposits
Lithology	description of rock material
Lsd	Legal Subdivision



Completion Interval

m	metres
mm	millimetres
m²/day	metres squared per day
m³	cubic metres
m³/day	cubic metres per day
mg/L	milligrams per litre
Median	the value at the centre of an ordered range of numbers
Obs WW	Observation Water Well
Piper tri-linear diagram	a method that permits the major cation and anion compositions of single or multiple samples to be represented on a single graph. This presentation allows groupings or trends in the data to be identified. From the Piper tri-linear diagram, it can be seen that the groundwater from this sample water well is a sodium-bicarbonate-type. The chemical type has been determined by graphically calculating the dominant cation and anion. For a more detailed explanation, please refer to Freeze and Cherry, 1979



Piper Tri-Linear Diagram

Rock	earth material below the root zone
Surficial Deposits	includes all sediments above the bedrock
Thalweg	the line connecting the lowest points along a stream bed or valley; *longitudinal profile*
Till	a sediment deposited directly by a glacier that is unsorted and consisting of any grain size ranging from clay to boulders
Transmissivity	the rate at which water is transmitted through a unit width of an aquifer under a unit hydraulic gradient: a measure of the ease with which groundwater can move through the aquifer Apparent Transmissivity: the value determined from a summary of aquifer test data, usually involving only two water-level readings Effective Transmissivity: the value determined from late pumping and/or late recovery water-level data from an aquifer test Aquifer Transmissivity: the value determined by multiplying the hydraulic conductivity of an aquifer by the thickness of the aquifer

Water Well	a hole in the ground for the purpose of obtaining groundwater; "work type" as defined by AENV includes test hole, chemistry, deepened, well inventory, federal well survey, reconditioned, reconstructed, new, old well-test
Yield	a regional analysis term referring to the rate a properly completed water well could be pumped, if fully penetrating the aquifer
	Apparent Yield: based mainly on apparent transmissivity
	Long-Term Yield: based on effective transmissivity
AAFC-PFRA	Prairie Farm Rehabilitation Administration Branch of Agriculture and Agri-Food Canada
AENV	Alberta Environment
AMSL	above mean sea level
BGP	Base of Groundwater Protection
DEM	Digital Elevation Model
DST	drill stem test
EUB	Alberta Energy and Utilities Board
GCDWQ	Guidelines for Canadian Drinking Water Quality
IAAM	*Infinite Aquifer Artesian Model.* The mathematical model is used to calculate water levels at a given location. The model has been used for more than 17 years by HCL for several hundred groundwater monitoring projects. The model aquifer is based on a solution of the well function equation. The simulation calculates drawdown by solving the well function equation using standard approximation methods. The drawdown at any given point at any given time uses the method of superposition.
NPWL	non-pumping water level
SGCDWQ	Summary of Guidelines for Canadian Drinking Water Quality
TDS	Total Dissolved Solids
WSW	Water Source Well or Water Supply Well

10 CONVERSIONS

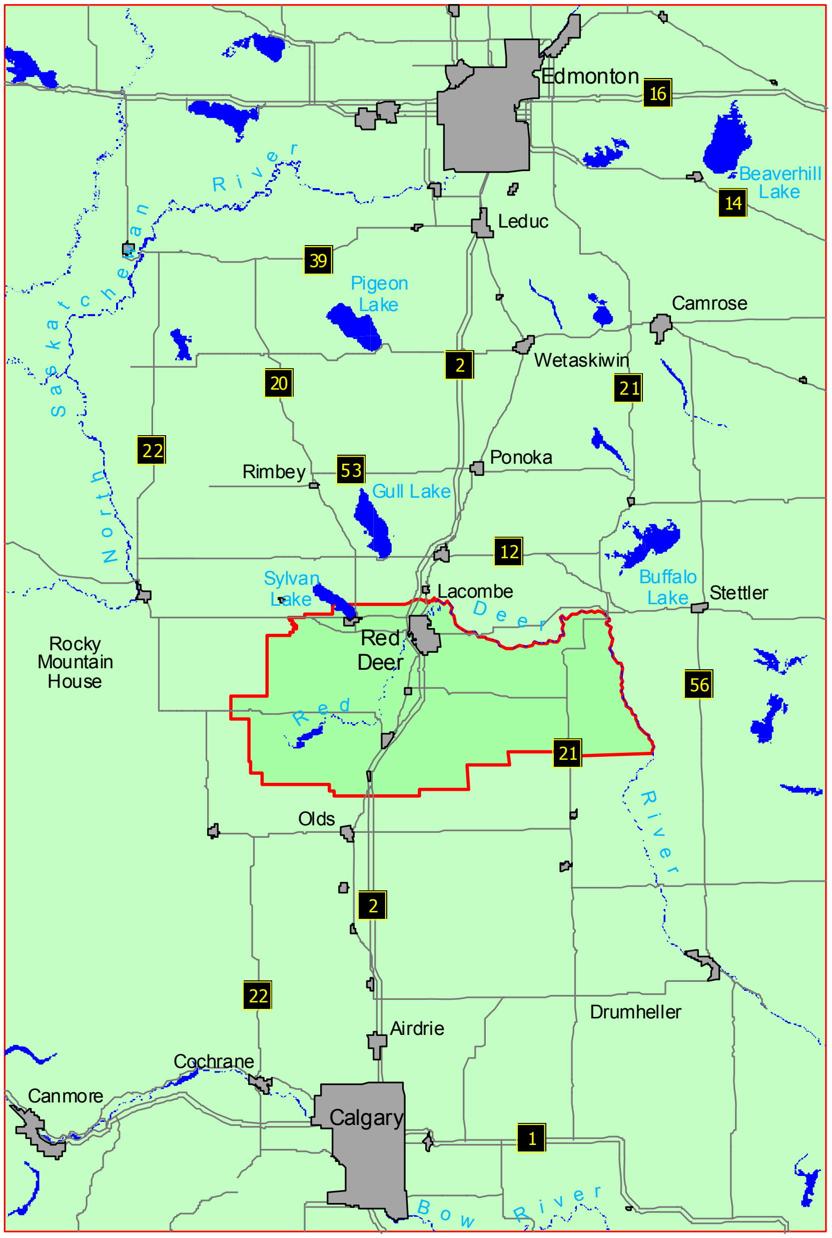
Multiply	by	To Obtain
Length/Area		
feet	0.304 785	metres
metres	3.281 000	feet
hectares	2.471 054	acres
centimetre	0.032 808	feet
centimetre	0.393 701	inches
acres	0.404 686	hectares
inchs	25.400 000	millimetres
miles	1.609 344	kilometres
kilometer	0.621 370	miles (statute)
square feet (ft^2)	0.092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

RED DEER COUNTY

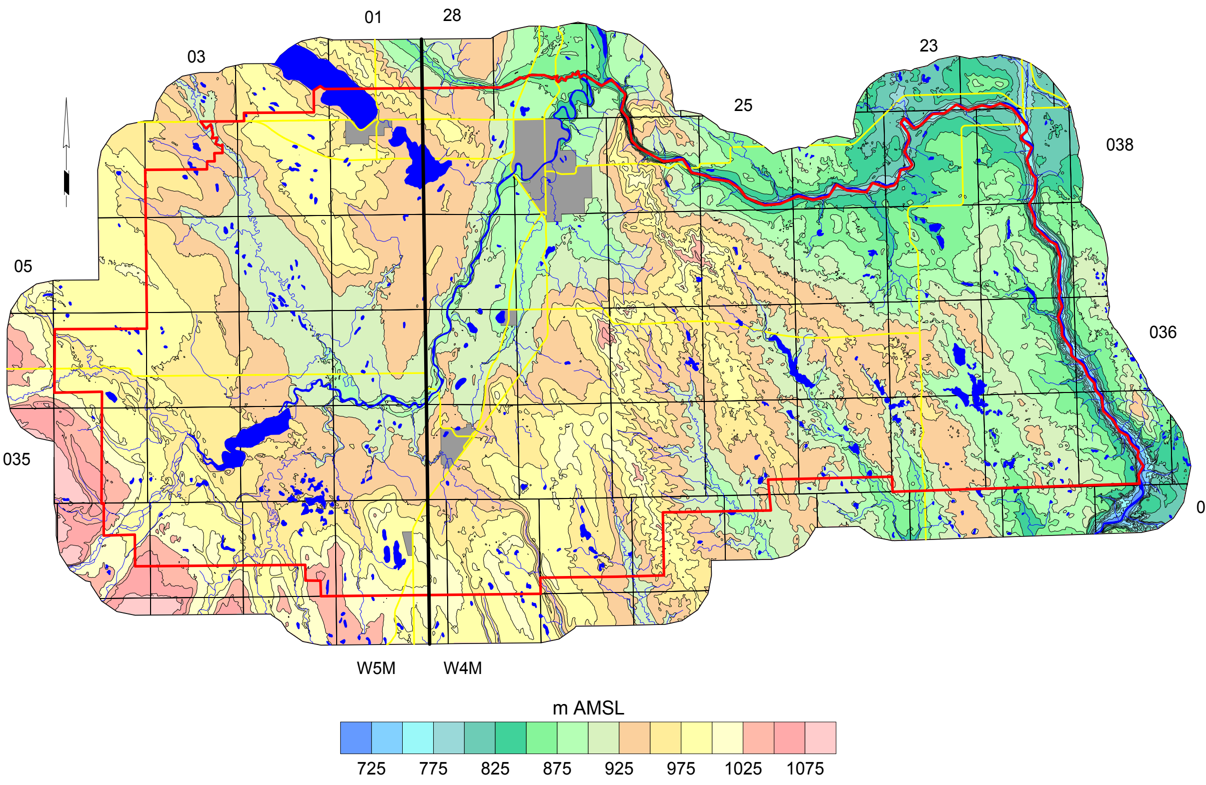
Appendix A

HYDROGEOLOGICAL MAPS AND FIGURES

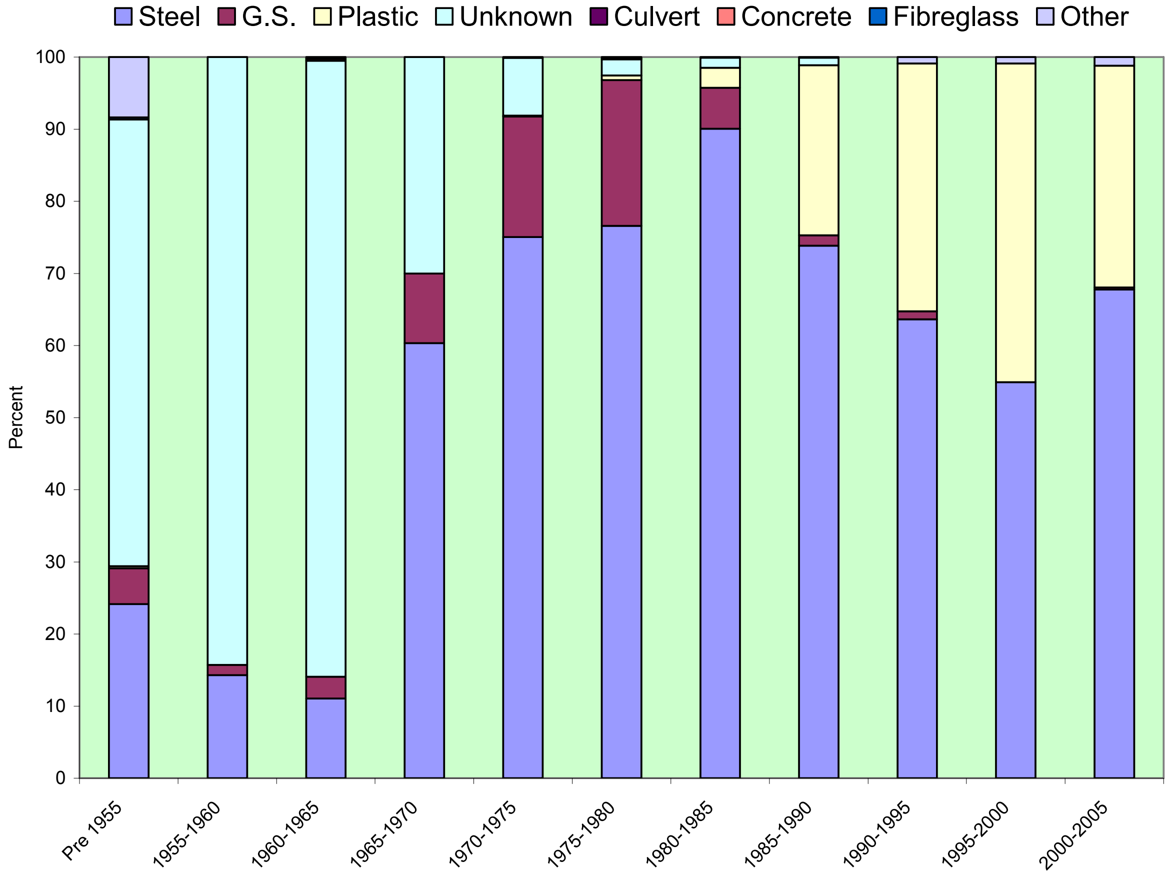
Index Map


Edmonton
16
Beaverhill Lake
14
River
Saskatchewan
North
Leduc
39
Pigeon Lake
Camrose
2
Wetaskiwin
20
21
22
Rimbey
53
Ponoka
Gull Lake
12
Sylvan Lake
Lacombe
Buffalo Lake
Stettler
Deer
Red Deer
Rocky Mountain House
56
Red
21
River
Olds
2
22
Airdrie
Drumheller
Cochrane
Canmore
Calgary
1
Bow River

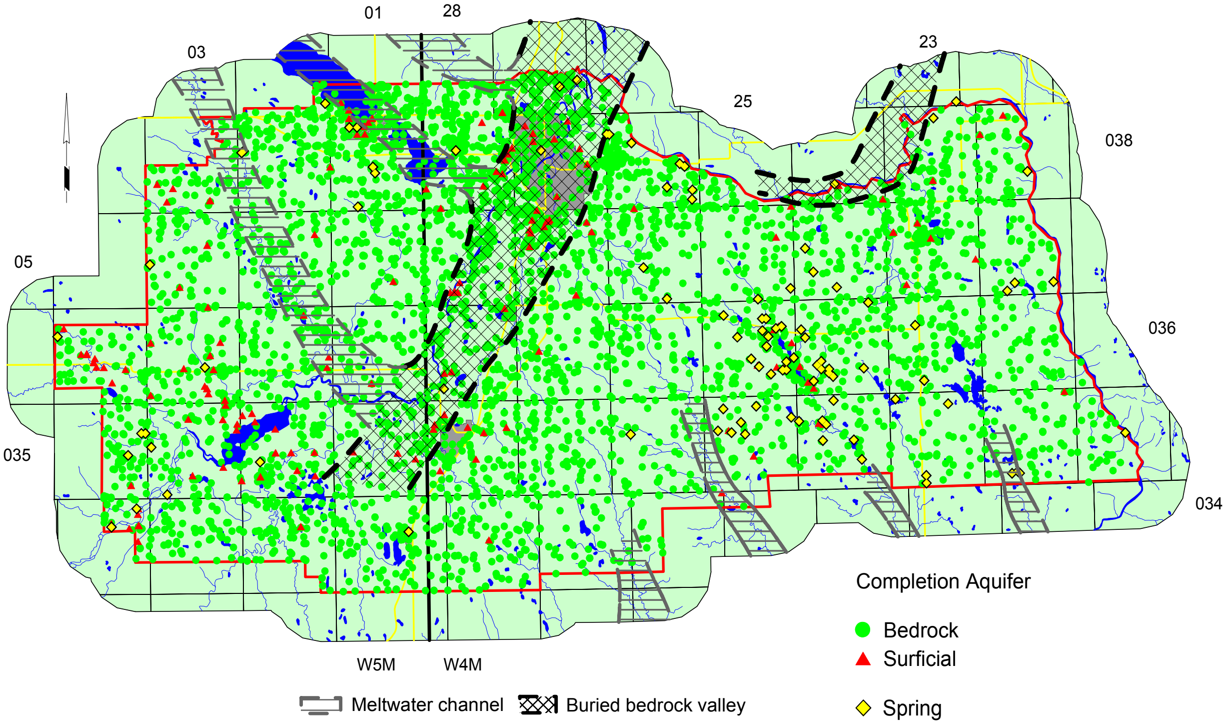
Surface Topography



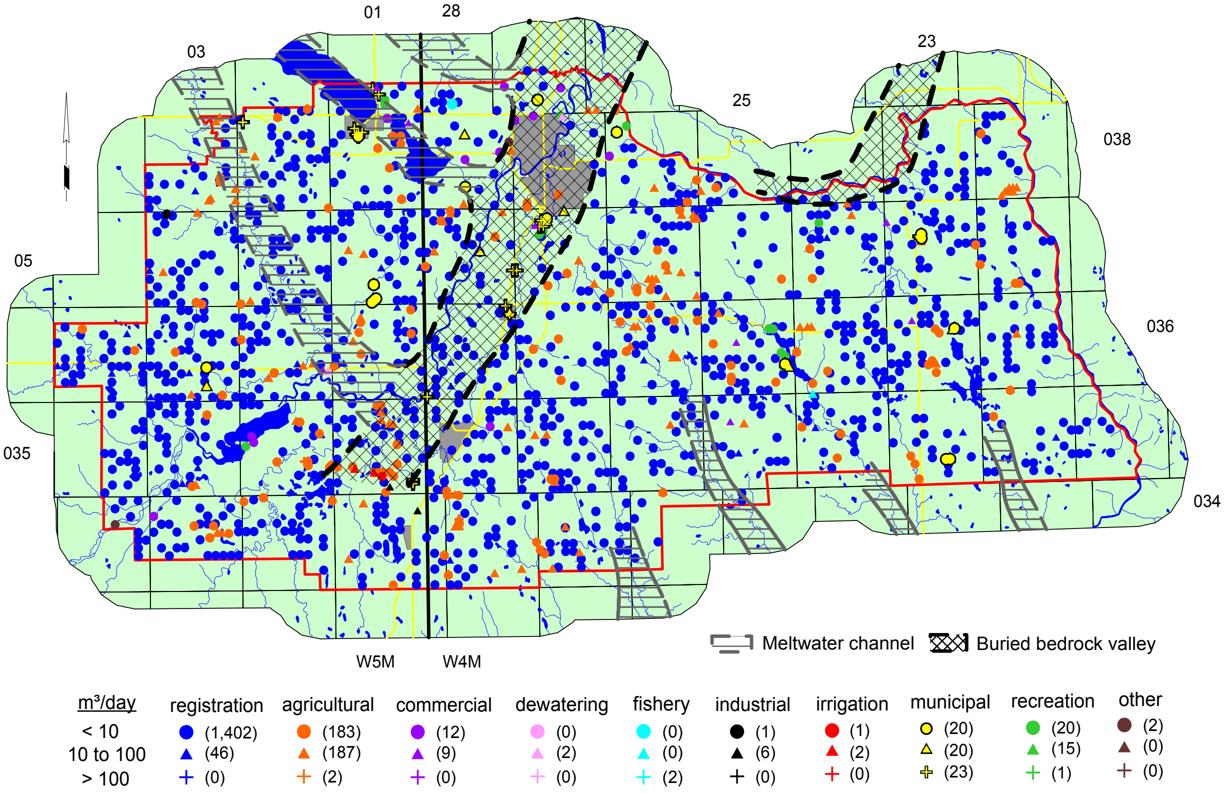
Surface Casing Types Used in Drilled Water Wells



Location of Water Wells and Springs

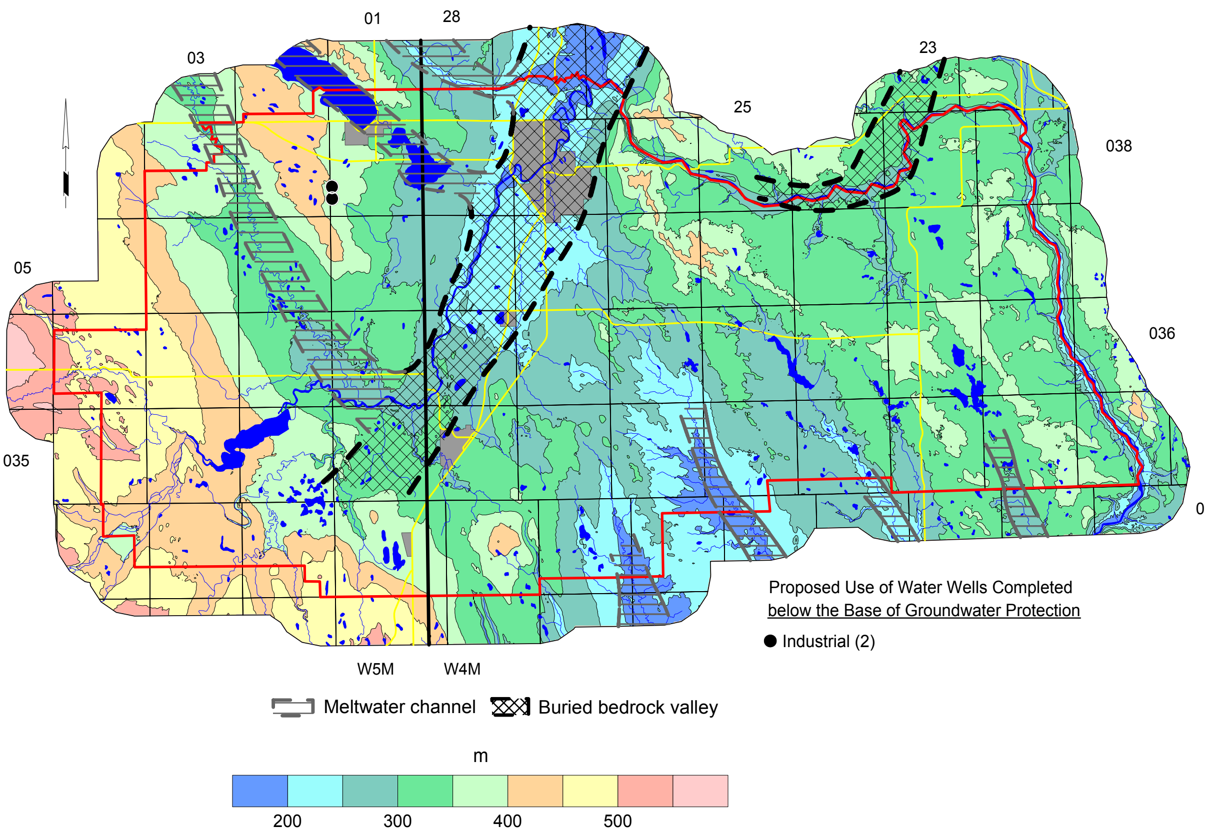


Licensed and/or Registered Groundwater Water Wells



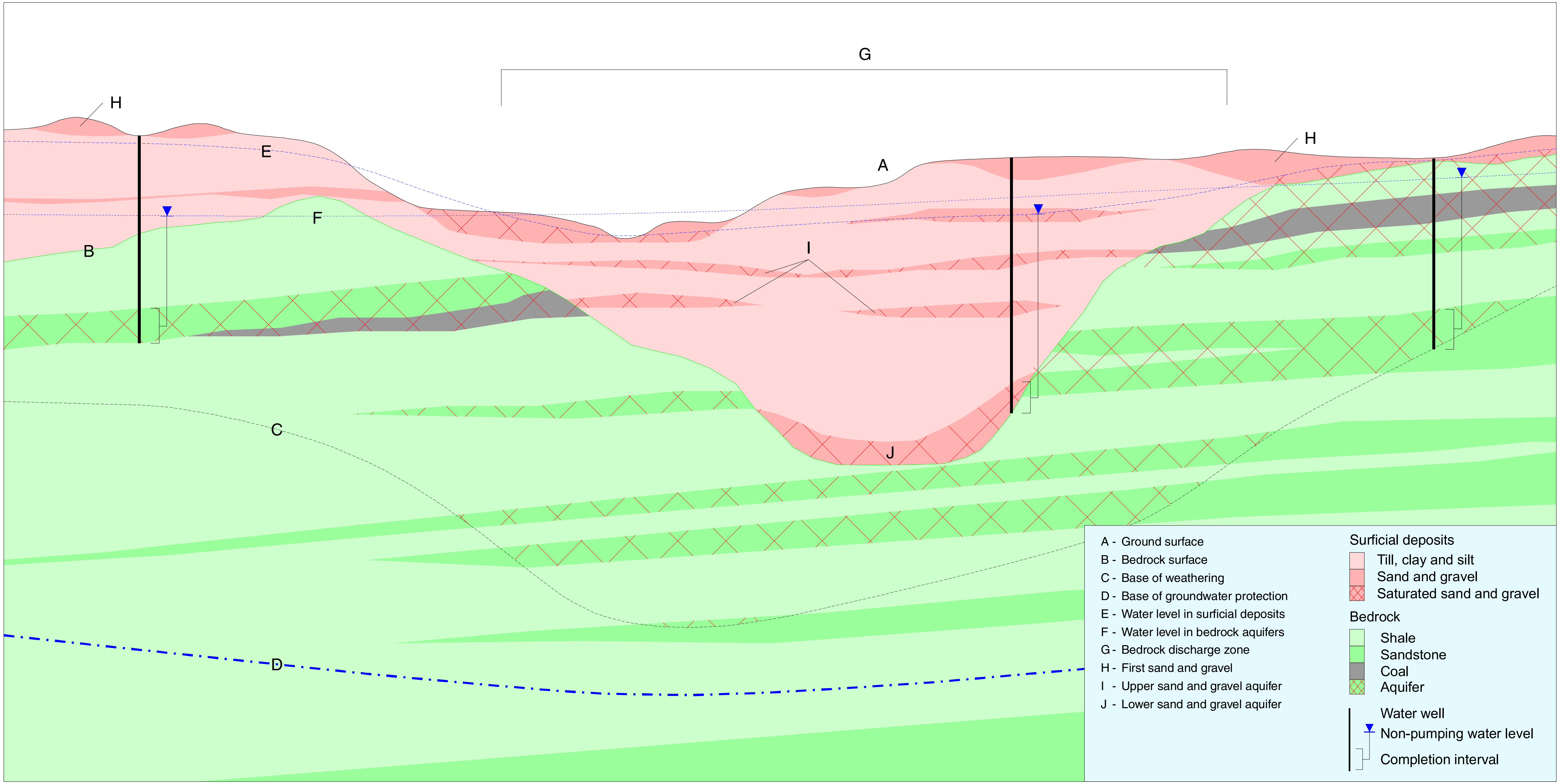
Depth to Base of Groundwater Protection

(modified after EUB, 1995)

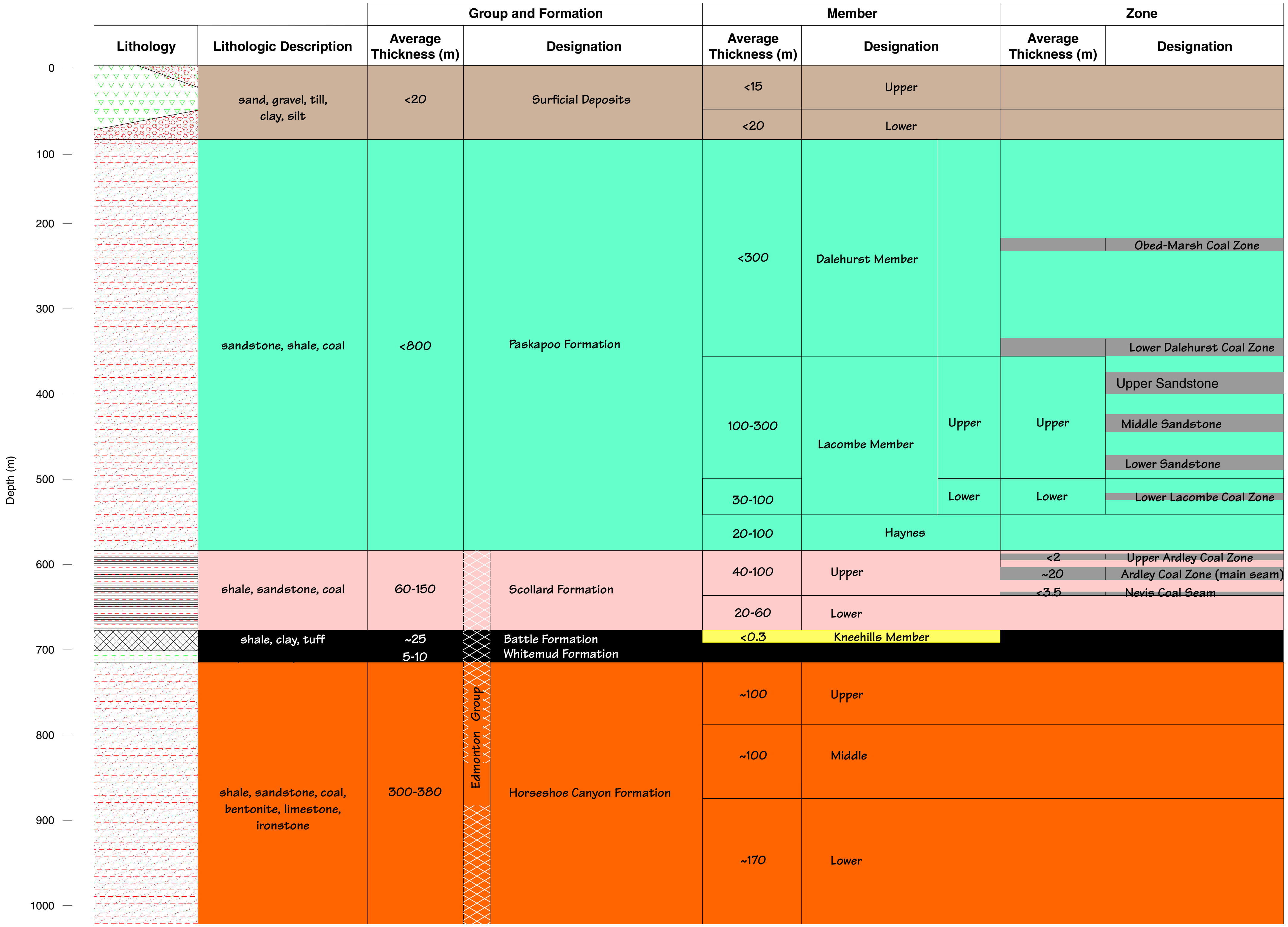


Generalized Cross-Section

(for terminology only)

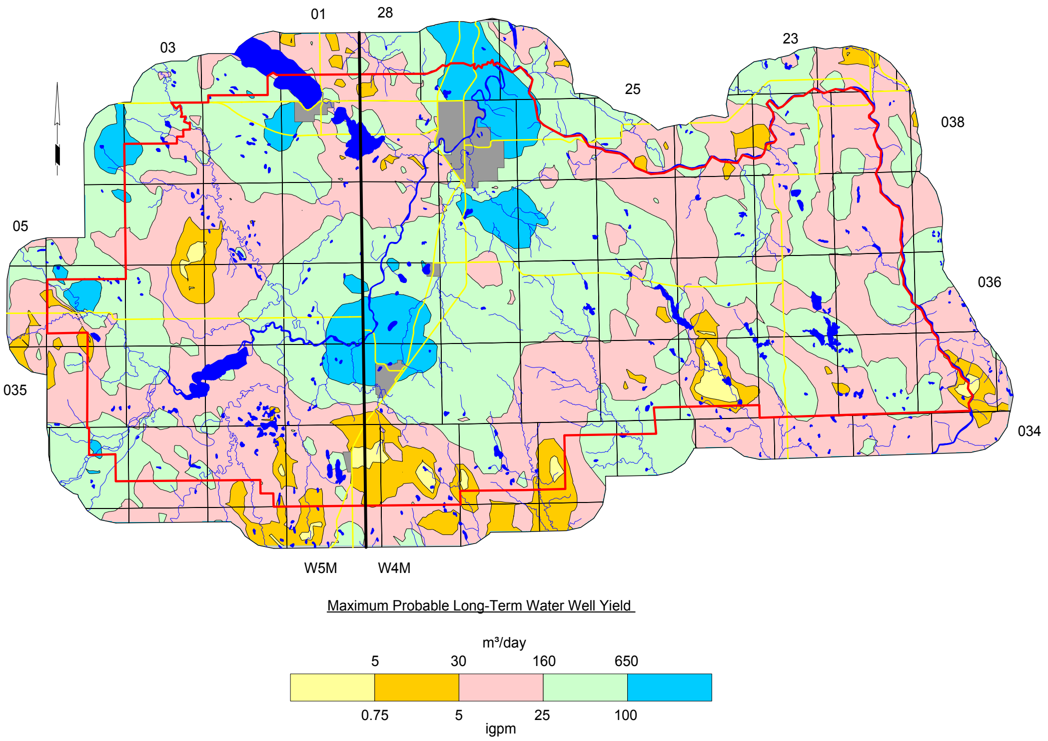


Geologic Column

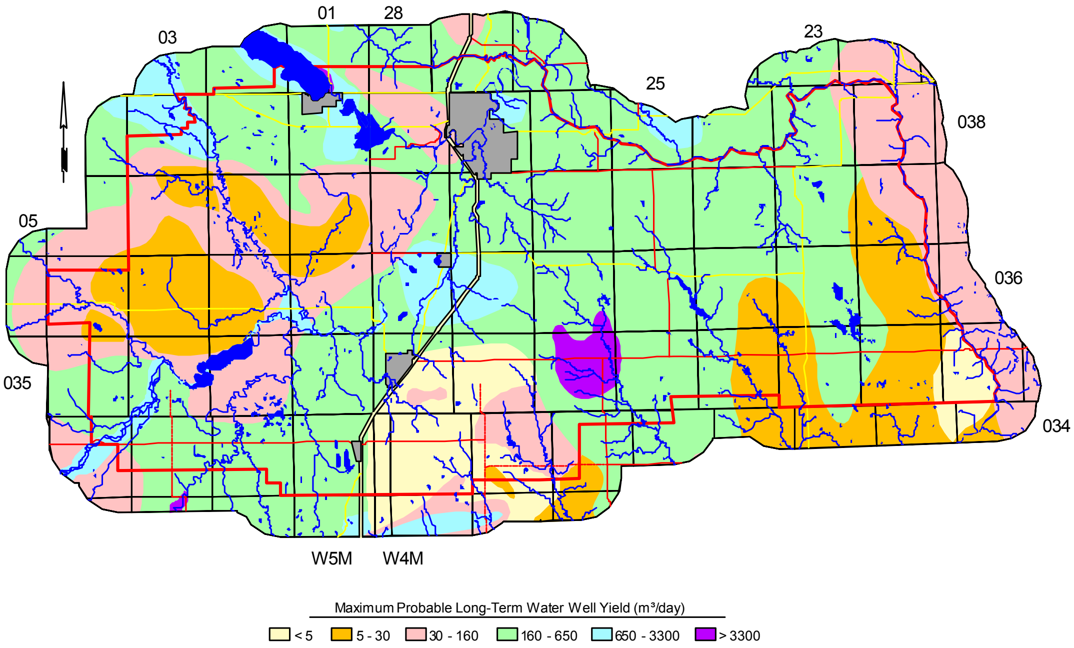


Lithologic Description	Group and Formation			Member			Zone	
	Average Thickness (m)		Designation	Average Thickness (m)	Designation		Average Thickness (m)	Designation
sand, gravel, till, clay, silt	<20		Surficial Deposits	<15	Upper			
				<20	Lower			
sandstone, shale, coal	<800		Paskapoo Formation	<300	Dalehurst Member			Obed-Marsh Coal Zone
								Lower Dalehurst Coal Zone
				100-300	Lacombe Member	Upper	Upper	Upper Sandstone Middle Sandstone Lower Sandstone
				30-100		Lower	Lower	Lower Lacombe Coal Zone
				20-100	Haynes			
shale, sandstone, coal	60-150	Edmonton Group	Scollard Formation	40-100	Upper		<2 ~20 <3.5	Upper Ardley Coal Zone Ardley Coal Zone (main seam) Nevis Coal Seam
				20-60	Lower			
shale, clay, tuff	~25 5-10		Battle Formation Whitemud Formation	<0.3	Kneehills Member			
shale, sandstone, coal, bentonite, limestone, ironstone	300-380		Horseshoe Canyon Formation	~100	Upper			
				~100	Middle			
				~170	Lower			

Hydrogeological Maps

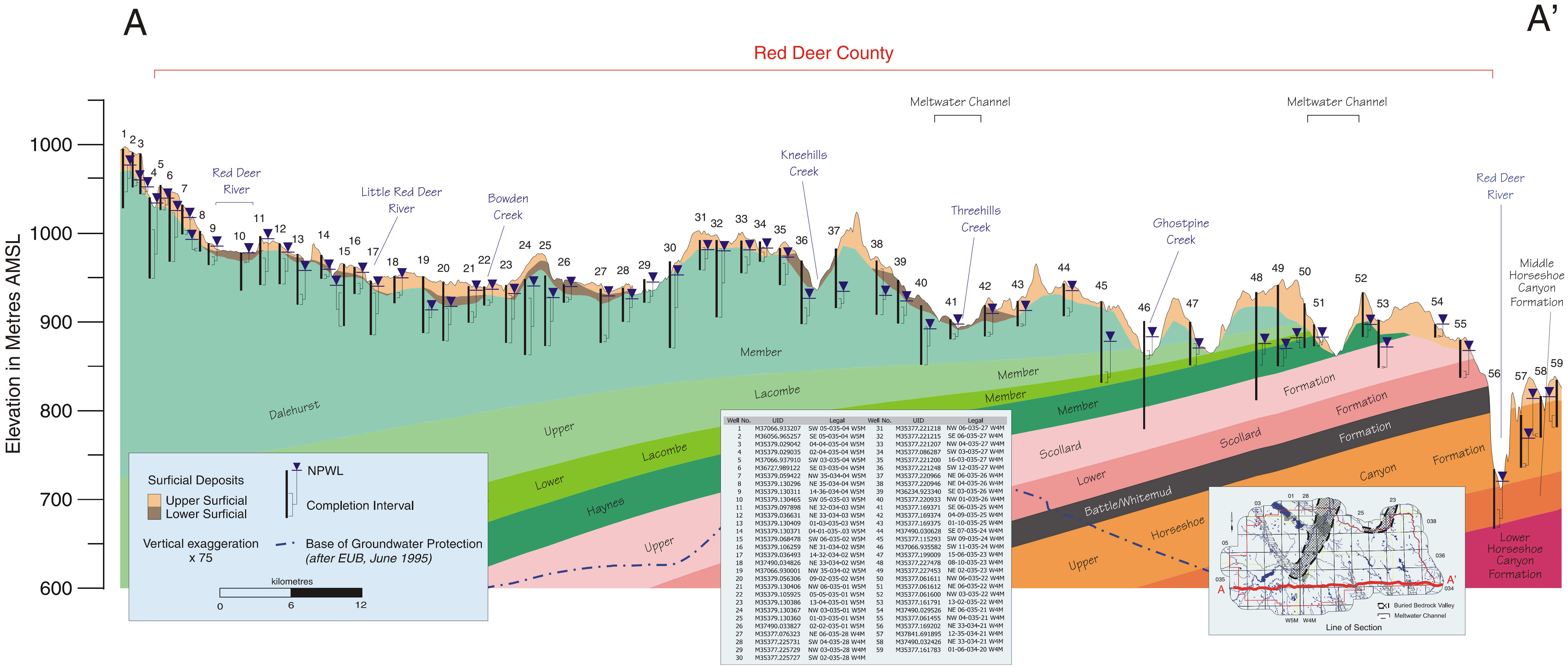


2004 HCL



1971 Alberta Research Council

Cross-Section A - A'



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3	M35379.029042	04-04-035-04 W5M	33	M35377.221207	NW 04-035-27 W4M
4	M35379.029035	02-04-035-04 W5M	34	M35377.086287	SW 03-035-27 W4M
5	M37066.937910	SW 03-035-04 W5M	35	M35377.221200	16-03-035-27 W4M
6	M36727.989122	SE 03-035-04 W5M	36	M35377.221248	SW 12-035-27 W4M
7	M35379.059422	NW 35-034-04 W5M	37	M35377.220966	NE 06-035-26 W4M
8	M35379.130296	NE 35-034-04 W5M	38	M35377.220946	NE 04-035-26 W4M
9	M35379.130311	14-36-034-04 W5M	39	M36234.923340	SE 03-035-26 W4M
10	M35379.130465	SW 05-035-03 W5M	40	M35377.220933	NW 01-035-26 W4M
11	M35379.097898	NE 32-034-03 W5M	41	M35377.169371	SE 06-035-25 W4M
12	M35379.036631	NE 33-034-03 W5M	42	M35377.169374	04-09-035-25 W4M
13	M35379.130409	01-03-035-03 W5M	43	M35377.169375	01-10-035-25 W4M
14	M35379.130371	04-01-035-.03 W5M	44	M37490.030628	SE 07-035-24 W4M
15	M35379.068478	SW 06-035-02 W5M	45	M35377.115293	SW 09-035-24 W4M
16	M35379.106259	NE 31-034-02 W5M	46	M37066.935582	SW 11-035-24 W4M
17	M35379.036493	14-32-034-02 W5M	47	M35377.199009	15-06-035-23 W4M
18	M37490.034826	NE 33-034-02 W5M	48	M35377.227478	08-10-035-23 W4M
19	M37066.930001	NW 35-034-02 W5M	49	M35377.227453	NE 02-035-23 W4M
20	M35379.056306	09-02-035-02 W5M	50	M35377.061611	NW 06-035-22 W4M
21	M35379.130406	NW 06-035-01 W5M	51	M35377.061612	NE 06-035-22 W4M
22	M35379.105925	05-05-035-01 W5M	52	M35377.061600	NW 03-035-22 W4M
23	M35379.130386	13-04-035-01 W5M	53	M35377.161791	13-02-035-22 W4M
24	M35379.130367	NW 03-035-01 W5M	54	M37490.029526	NE 06-035-21 W4M
25	M35379.130360	01-03-035-01 W5M	55	M35377.061455	NW 04-035-21 W4M
26	M37490.033827	02-02-035-01 W5M	56	M35377.169202	NE 33-034-21 W4M
27	M35377.076323	NE 06-035-28 W4M	57	M37841.691895	12-35-034-21 W4M
28	M35377.225731	SW 04-035-28 W4M	58	M37490.032426	NE 33-034-21 W4M
29	M35377.225729	NW 03-035-28 W4M	59	M35377.161783	01-06-034-20 W4M
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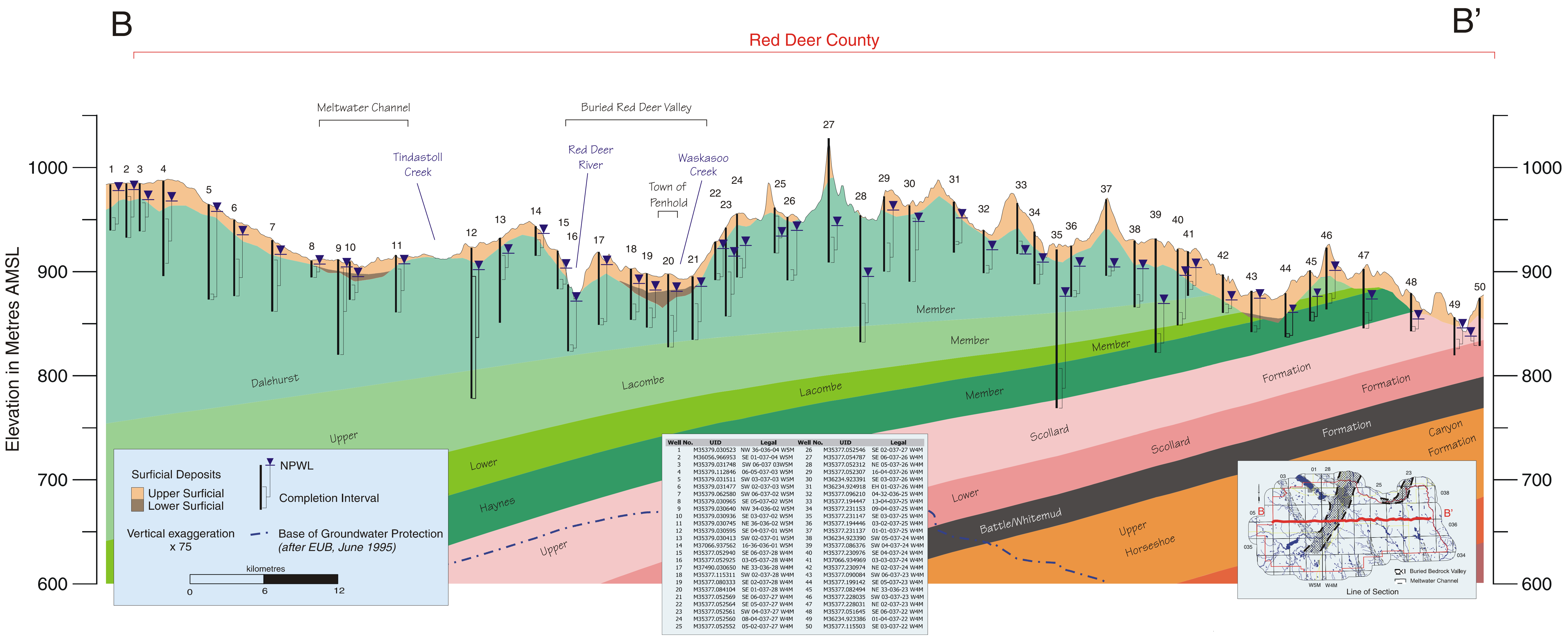
Cross-Section B - B'



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2	M36056.966953	SE 01-037-04 W5M	27	M35377.054787	SE 06-037-26 W4M
3	M35379.031748	SW 06-037 03W5M	28	M35377.052312	NE 05-037-26 W4M
4	M35379.112846	06-05-037-03 W5M	29	M35377.052307	16-04-037-26 W4M
5	M35379.031511	SW 03-037-03 W5M	30	M36234.923391	SE 03-037-26 W4M
6	M35379.031477	SW 02-037-03 W5M	31	M36234.924918	EH 01-037-26 W4M
7	M35379.062580	SW 06-037-02 W5M	32	M35377.096210	04-32-036-25 W4M
8	M35379.030965	SE 05-037-02 W5M	33	M35377.194447	13-04-037-25 W4M
9	M35379.030640	NW 34-036-02 W5M	34	M35377.231153	09-04-037-25 W4M
10	M35379.030936	SE 03-037-02 W5M	35	M35377.231147	SE 03-037-25 W4M
11	M35379.030745	NE 36-036-02 W5M	36	M35377.194446	03-02-037-25 W4M
12	M35379.030595	SE 04-037-01 W5M	37	M35377.231137	01-01-037-25 W4M
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14	M37066.937562	16-36-036-01 W5M	39	M35377.086376	SW 04-037-24 W4M
15	M35377.052940	SE 06-037-28 W4M	40	M35377.230976	SE 04-037-24 W4M
16	M35377.052925	03-05-037-28 W4M	41	M37066.934969	03-03-037-24 W4M
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19	M35377.080333	SE 02-037-28 W4M	44	M35377.199142	SE 05-037-23 W4M
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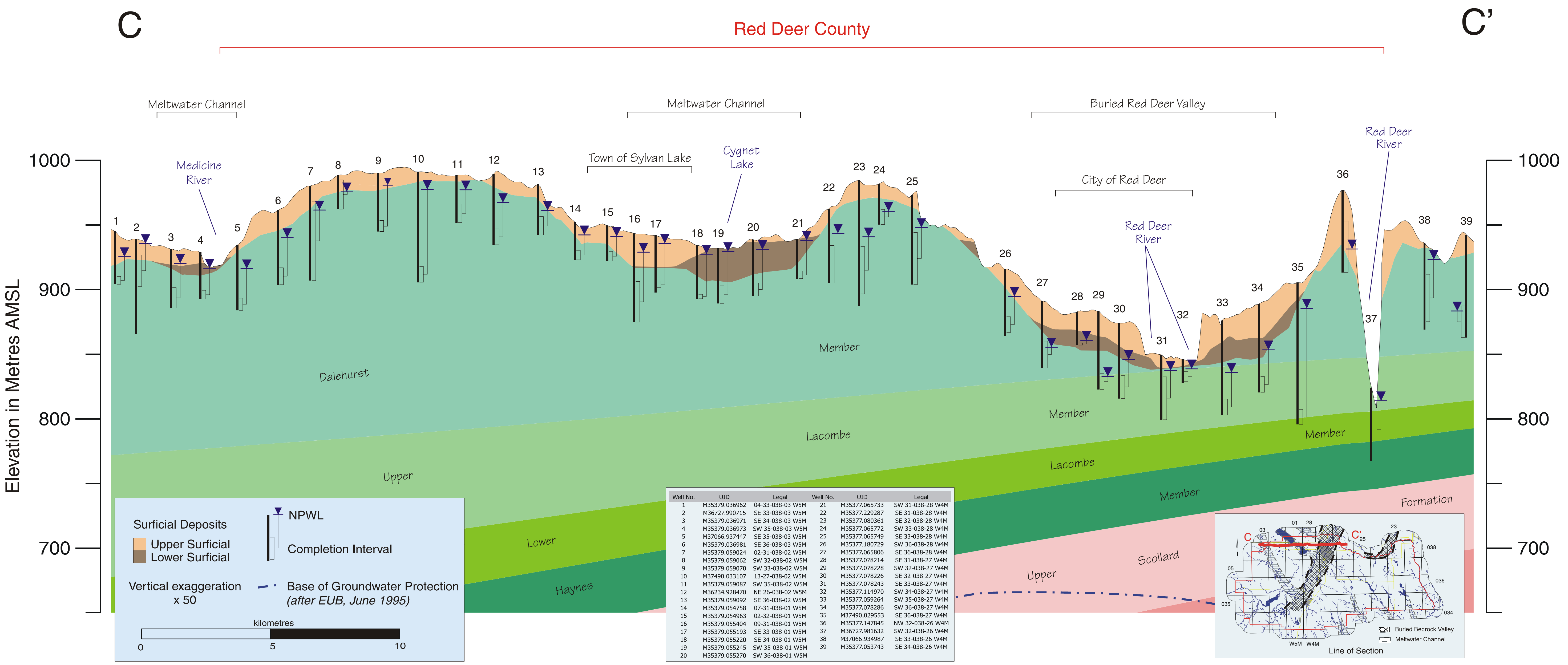
21	M35377.052569	SE 06-037-27 W4M	46	M35377.228035	SW 03-037-23 W4M
22	M35377.052564	SE 05-037-27 W4M	47	M35377.228031	NE 02-037-23 W4M
23	M35377.052561	SW 04-037-27 W4M	48	M35377.051645	SE 06-037-22 W4M
24	M35377.052560	08-04-037-27 W4M	49	M36234.923386	01-04-037-22 W4M
25	M35377.052552	05-02-037-27 W4M	50	M35377.115503	SE 03-037-22 W4M

Cross-Section C - C'



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3	M35379.036971	SE 34-038-03 W5M	23	M35377.080361	SE 32-038-28 W4M
4	M35379.036973	SW 35-038-03 W5M	24	M35377.065772	SW 33-038-28 W4M
5	M37066.937447	SE 35-038-03 W5M	25	M35377.065749	SE 33-038-28 W4M
6	M35379.036981	SE 36-038-03 W5M	26	M35377.180729	SW 36-038-28 W4M
7	M35379.059024	02-31-038-02 W5M	27	M35377.065806	SE 36-038-28 W4M
8	M35379.059062	SW 32-038-02 W5M	28	M35377.078214	SE 31-038-27 W4M
9	M35379.059070	SW 33-038-02 W5M	29	M35377.078228	SW 32-038-27 W4M
10	M37490.033107	13-27-038-02 W5M	30	M35377.078226	SE 32-038-27 W4M
11	M35379.059087	SW 35-038-02 W5M	31	M35377.078243	SE 33-038-27 W4M
12	M36234.928470	NE 26-038-02 W5M	32	M35377.114970	SW 34-038-27 W4M
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16	M35379.055404	09-31-038-01 W5M	36	M35377.147845	NW 32-038-26 W4M
17	M35379.055193	SE 33-038-01 W5M	37	M36727.981632	SW 32-038-26 W4M
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19	M35379.055245	SW 35-038-01 W5M	39	M35377.053743	SE 34-038-26 W4M
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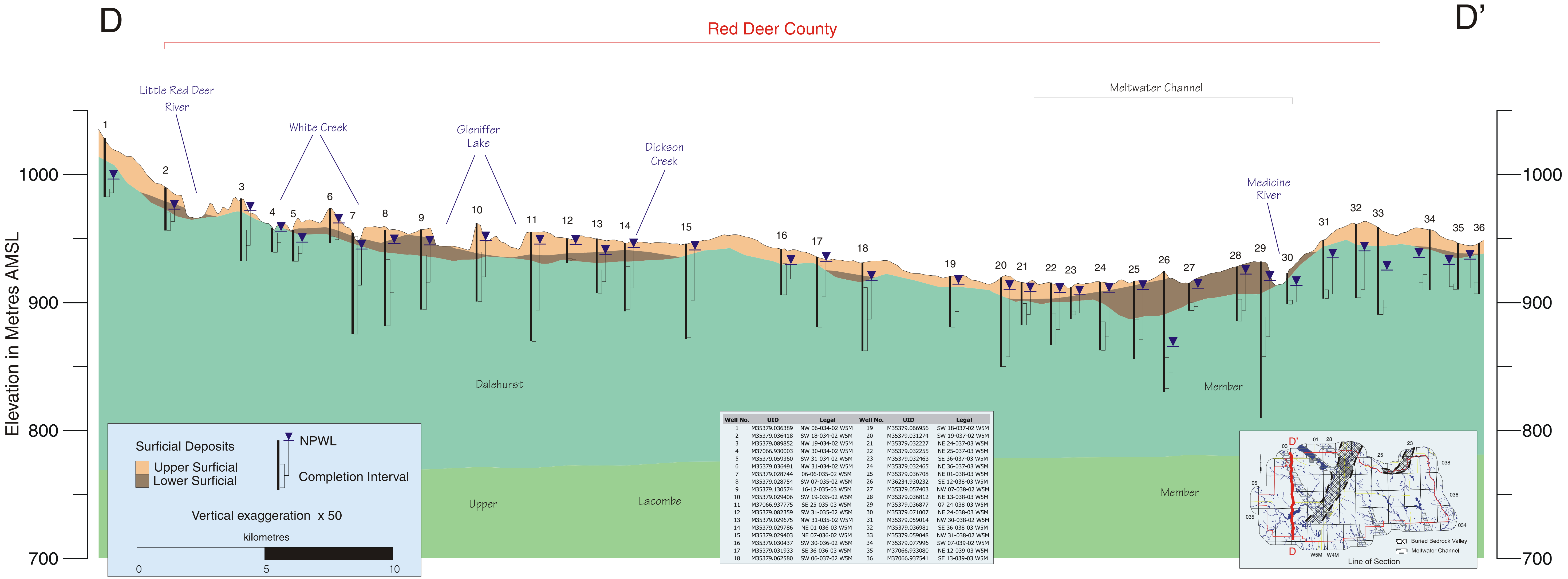
Cross-Section D - D'



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3	M35379.089852	NW 19-034-02 W5M	21	M35379.032227	NE 24-037-03 W5M
4	M37066.930003	NW 30-034-02 W5M	22	M35379.032255	NE 25-037-03 W5M
5	M35379.059360	SW 31-034-02 W5M	23	M35379.032463	SE 36-037-03 W5M
6	M35379.036491	NW 31-034-02 W5M	24	M35379.032465	NE 36-037-03 W5M
7	M35379.028744	06-06-035-02 W5M	25	M35379.036708	NE 01-038-03 W5M
8	M35379.028754	SW 07-035-02 W5M	26	M36234.930232	SE 12-038-03 W5M
9	M35379.130574	16-12-035-03 W5M	27	M35379.057403	NW 07-038-02 W5M
10	M35379.029406	SW 19-035-02 W5M	28	M35379.036812	NE 13-038-03 W5M
11	M37066.937775	SE 25-035-03 W5M	29	M35379.036877	07-24-038-03 W5M
12	M35379.082359	SW 31-035-02 W5M	30	M35379.071007	NE 24-038-03 W5M
13	M35379.029675	NW 31-035-02 W5M	31	M35379.059014	NW 30-038-02 W5M
14	M35379.029786	NE 01-036-03 W5M	32	M35379.036981	SE 36-038-03 W5M
15	M35379.029403	NE 07-036-02 W5M	33	M35379.059048	NW 31-038-02 W5M
16	M35379.030437	SW 30-036-02 W5M	34	M35379.077996	SW 07-039-02 W5M
17	M35379.031933	SE 36-036-03 W5M	35	M37066.933080	NE 12-039-03 W5M
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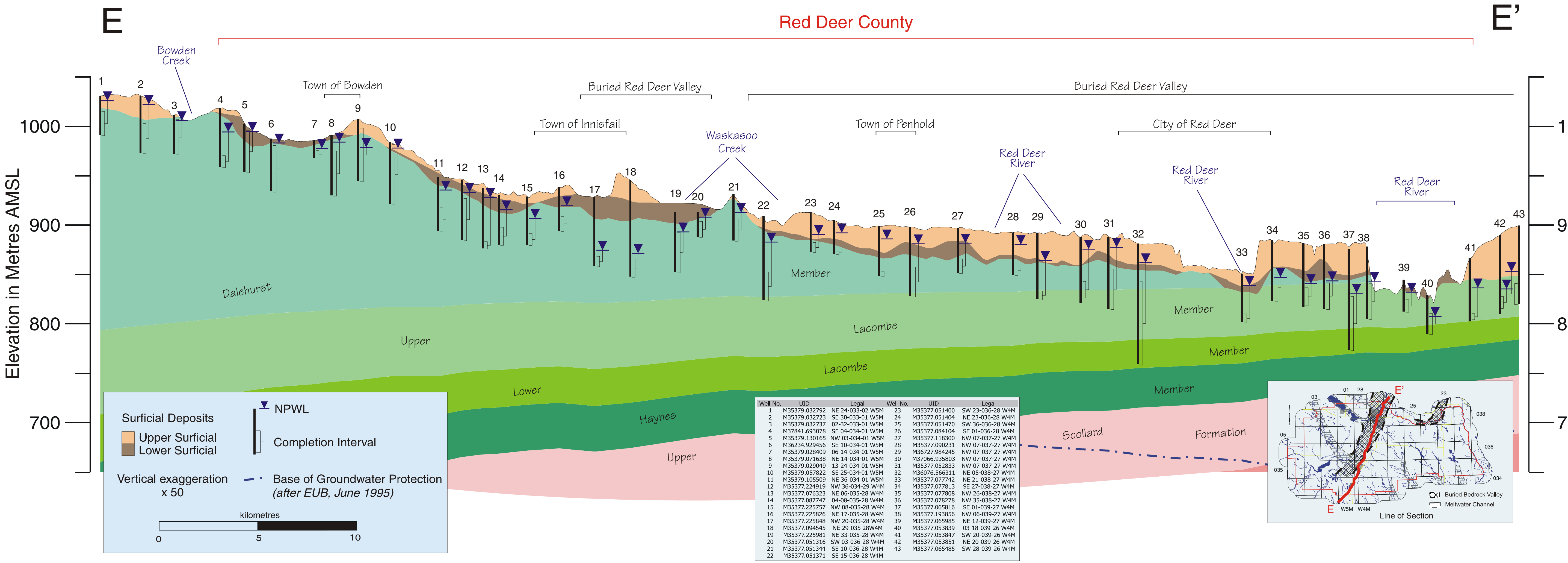
Cross-Section E - E'



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3	M35379.032737	02-32-033-01 W5M	25	M35377.051470	SW 36-036-28 W4M
4	M37841.693078	SE 04-034-01 W5M	26	M35377.084104	SE 01-036-28 W4M
5	M35379.130165	NW 03-034-01 W5M	27	M35377.118300	NW 07-037-27 W4M
6	M36234.929456	SE 10-034-01 W5M	28	M35377.090231	NW 07-037-27 W4M
7	M35379.028409	06-14-034-01 W5M	29	M36727.984245	NW 07-037-27 W4M
8	M35379.071638	NE 14-034-01 W5M	30	M37066.935803	NW 07-037-27 W4M
9	M35379.029049	13-24-034-01 W5M	31	M35377.052833	NW 07-037-27 W4M
10	M35379.057822	SE 25-034-01 W5M	32	M36076.566311	NE 05-038-27 W4M
11	M35379.105509	NE 36-034-01 W5M	33	M35377.077742	NE 21-038-27 W4M
12	M35377.224919	NW 36-034-29 W4M	34	M35377.077813	SE 27-038-27 W4M
13	M35377.076323	NE 06-035-28 W4M	35	M35377.077808	NW 26-038-27 W4M
14	M35377.087747	04-08-035-28 W4M	36	M35377.078278	NW 35-038-27 W4M
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16	M35377.225826	NE 17-035-28 W4M	38	M35377.193856	NW 06-039-27 W4M
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19	M35377.225981	NE 33-035-28 W4M	41	M35377.053847	SW 20-039-26 W4M
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21	M35377.051344	SE 10-036-28 W4M	43	M35377.065485	SW 28-039-26 W4M
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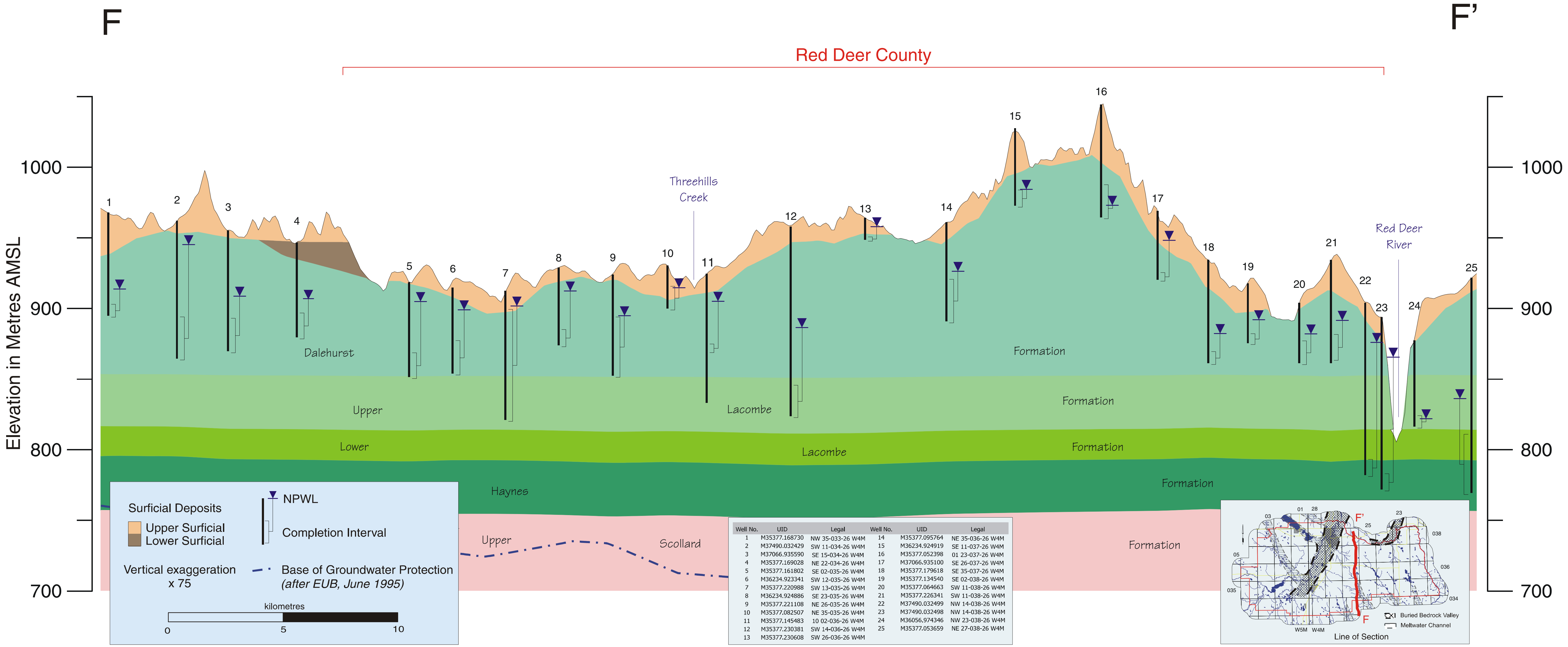
Cross-Section F - F'



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5	M35377.161802	SE 02-035-26 W4M	18	M35377.179618	SE 35-037-26 W4M
6	M36234.923341	SW 12-035-26 W4M	19	M35377.134540	SE 02-038-26 W4M
7	M35377.220988	SW 13-035-26 W4M	20	M35377.064663	SW 11-038-26 W4M
8	M36234.924886	SE 23-035-26 W4M	21	M35377.226341	SW 11-038-26 W4M
9	M35377.221108	NE 26-035-26 W4M	22	M37490.032499	NW 14-038-26 W4M
10	M35377.082507	NE 35-035-26 W4M	23	M37490.032498	NW 14-038-26 W4M
11	M35377.145483	10 02-036-26 W4M	24	M36056.974346	NW 23-038-26 W4M
12	M35377.230381	SW 14-036-26 W4M	25	M35377.053659	NE 27-038-26 W4M
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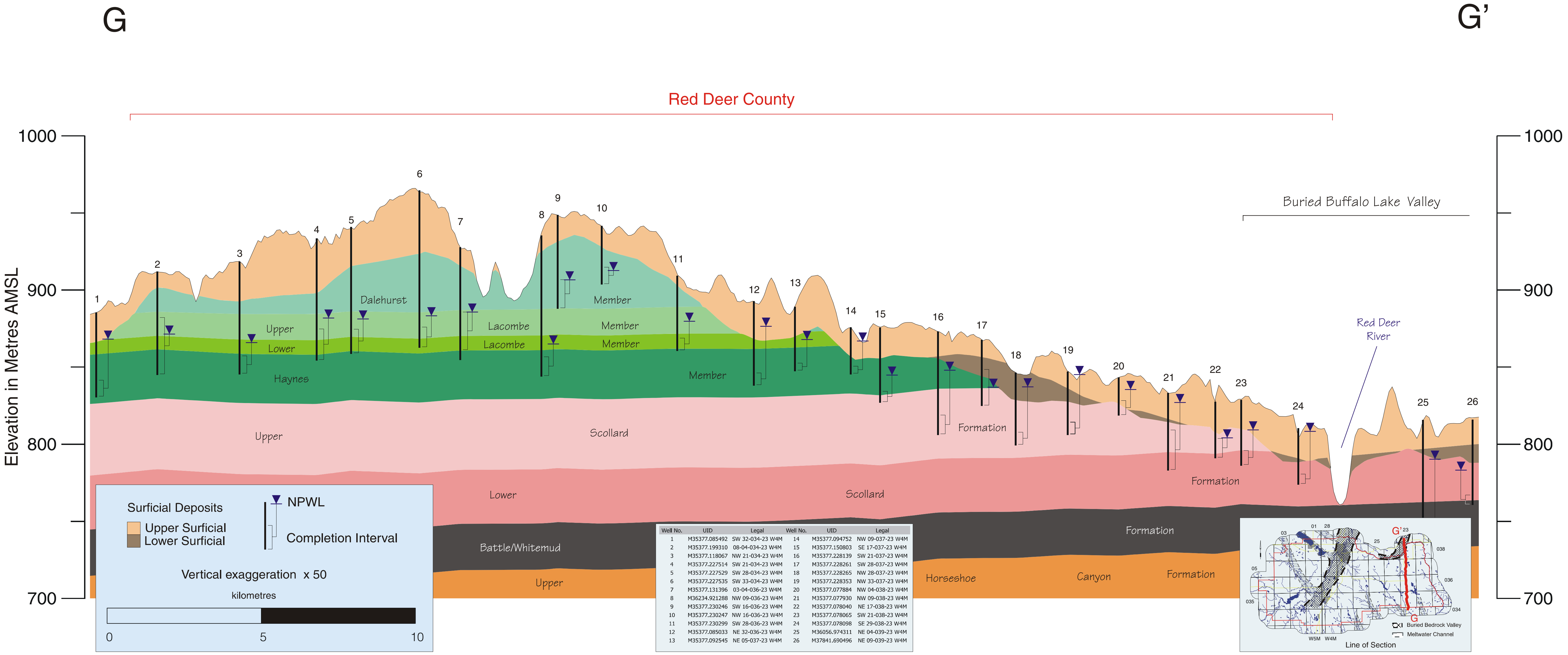
Cross-Section G -G'



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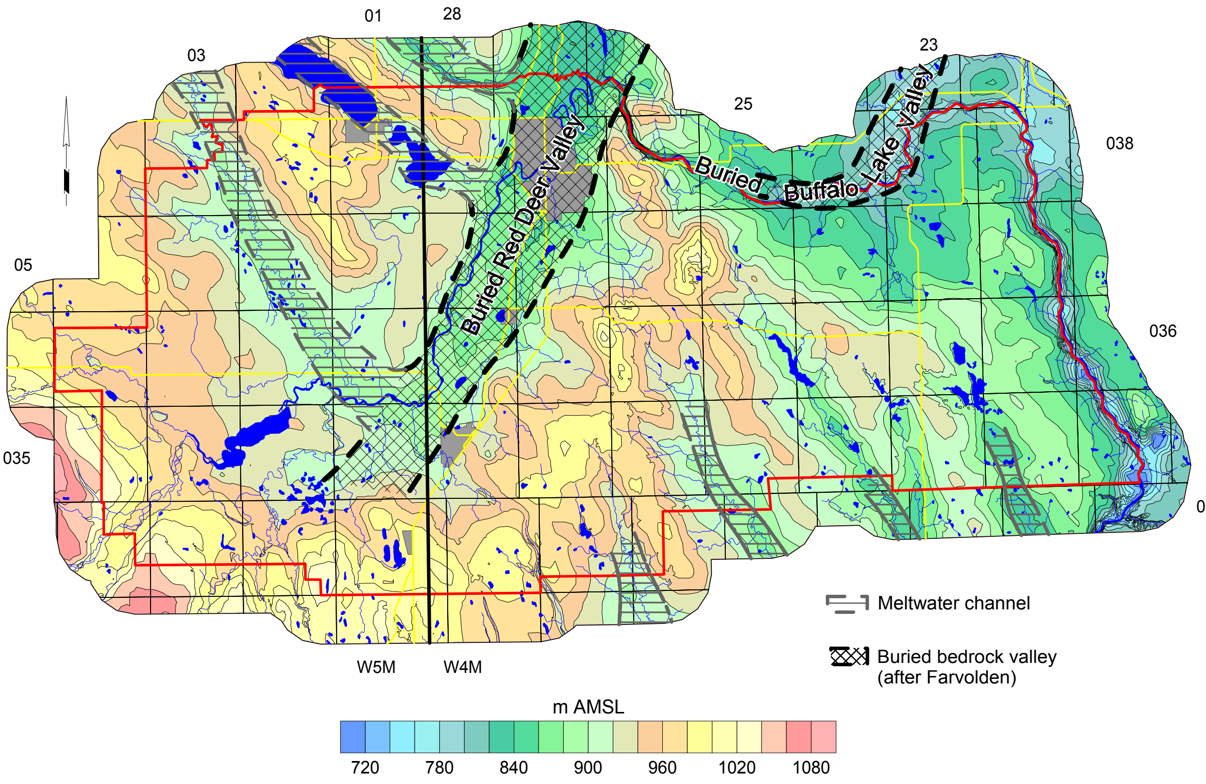
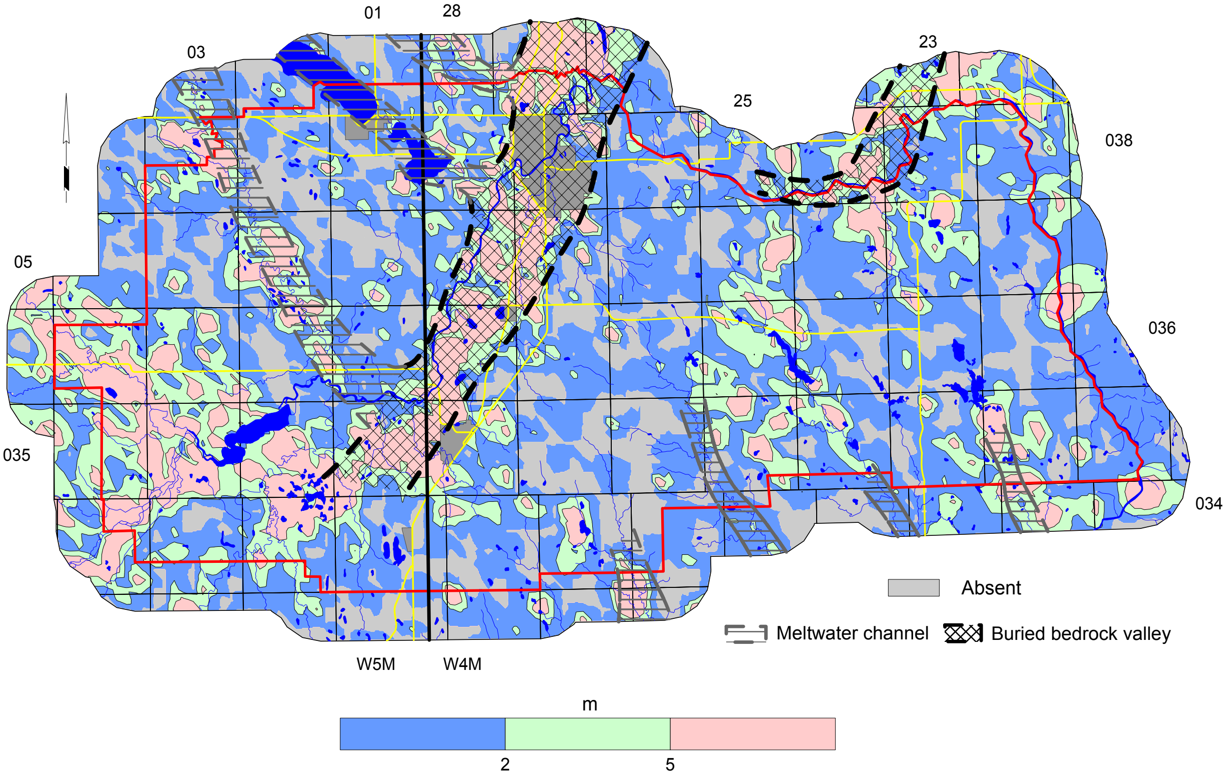
4	M35377.227514	SW 21-034-23 W4M	17	M35377.228261	SW 28-037-23 W4M
5	M35377.227529	SW 28-034-23 W4M	18	M35377.228265	NW 28-037-23 W4M
6	M35377.227535	SW 33-034-23 W4M	19	M35377.228353	NW 33-037-23 W4M
7	M35377.131396	03-04-036-23 W4M	20	M35377.077884	NW 04-038-23 W4M
8	M36234.921288	NW 09-036-23 W4M	21	M35377.077930	NW 09-038-23 W4M
9	M35377.230246	SW 16-036-23 W4M	22	M35377.078040	NE 17-038-23 W4M
10	M35377.230247	NW 16-036-23 W4M	23	M35377.078065	SW 21-038-23 W4M
11	M35377.230299	SW 28-036-23 W4M	24	M35377.078098	SE 29-038-23 W4M
12	M35377.085033	NE 32-036-23 W4M	25	M36056.974311	NE 04-039-23 W4M
13	M35377.092545	NE 05-037-23 W4M	26	M37841.690496	NE 09-039-23 W4M

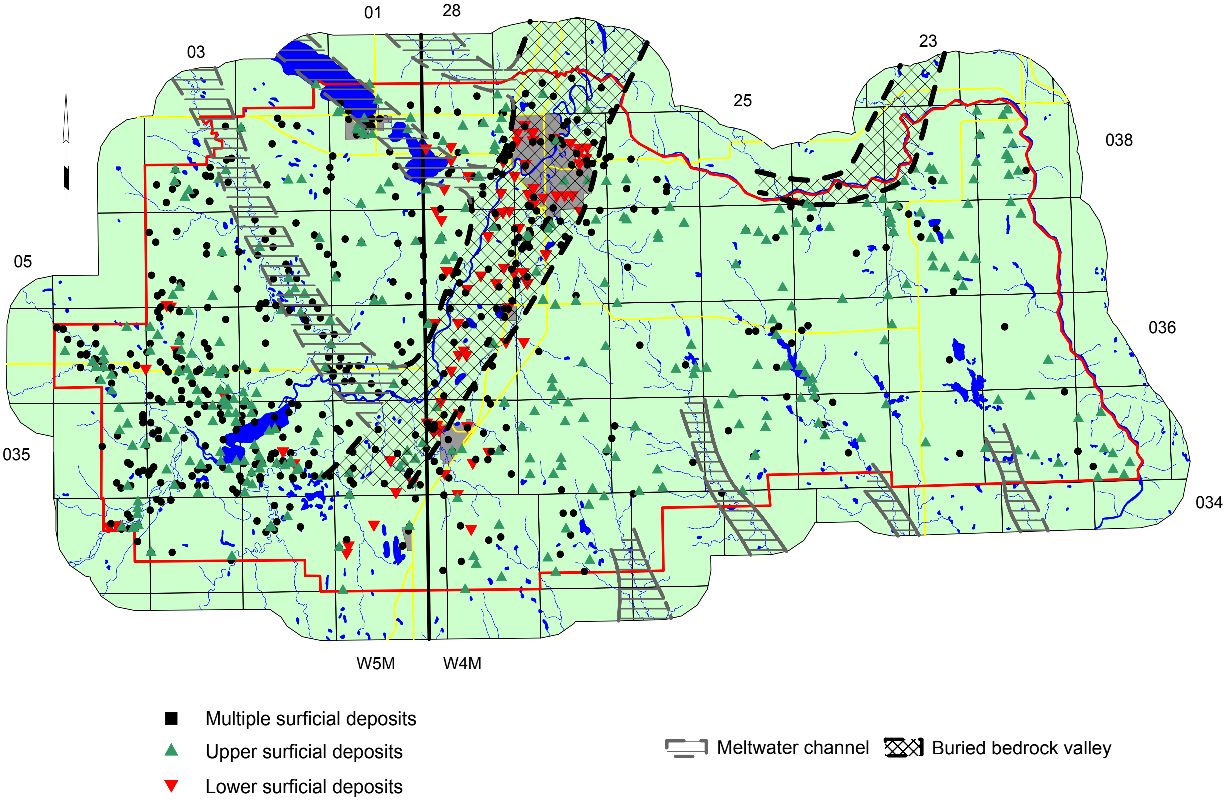
Bedrock Topography



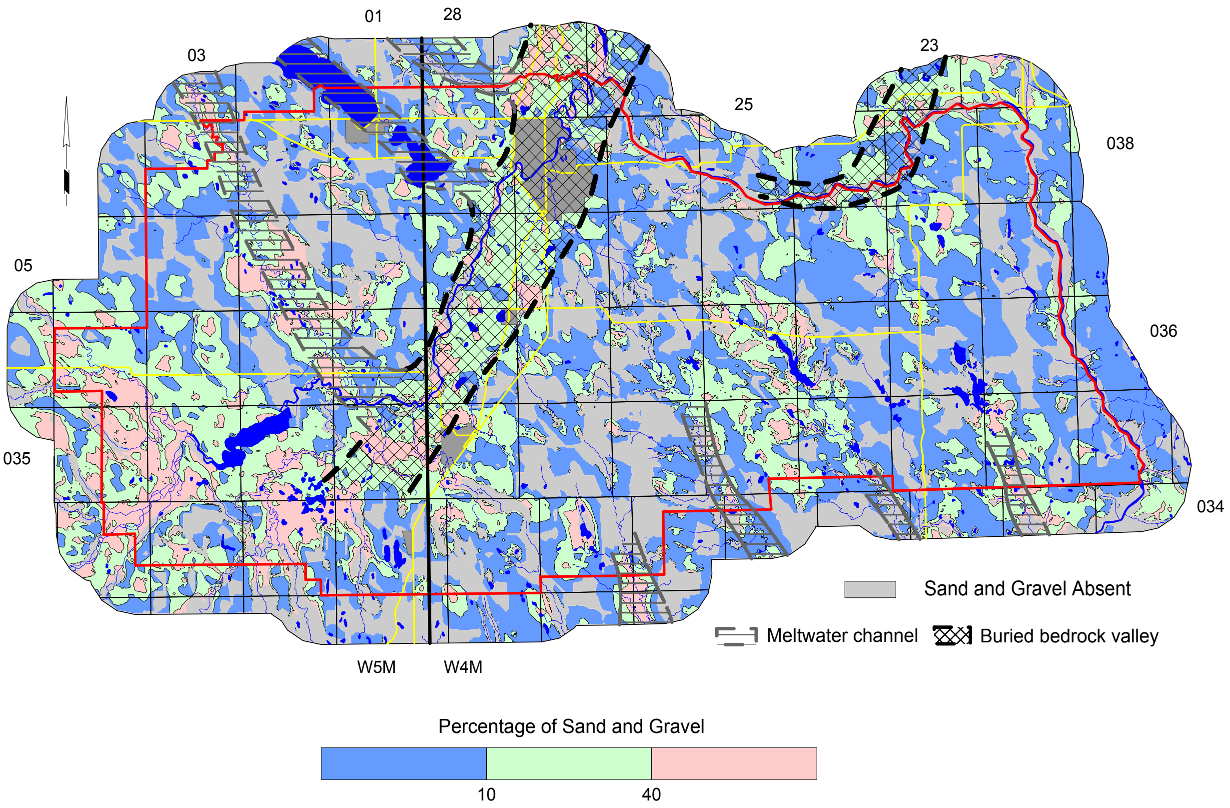
Thickness of Sand and Gravel Deposits



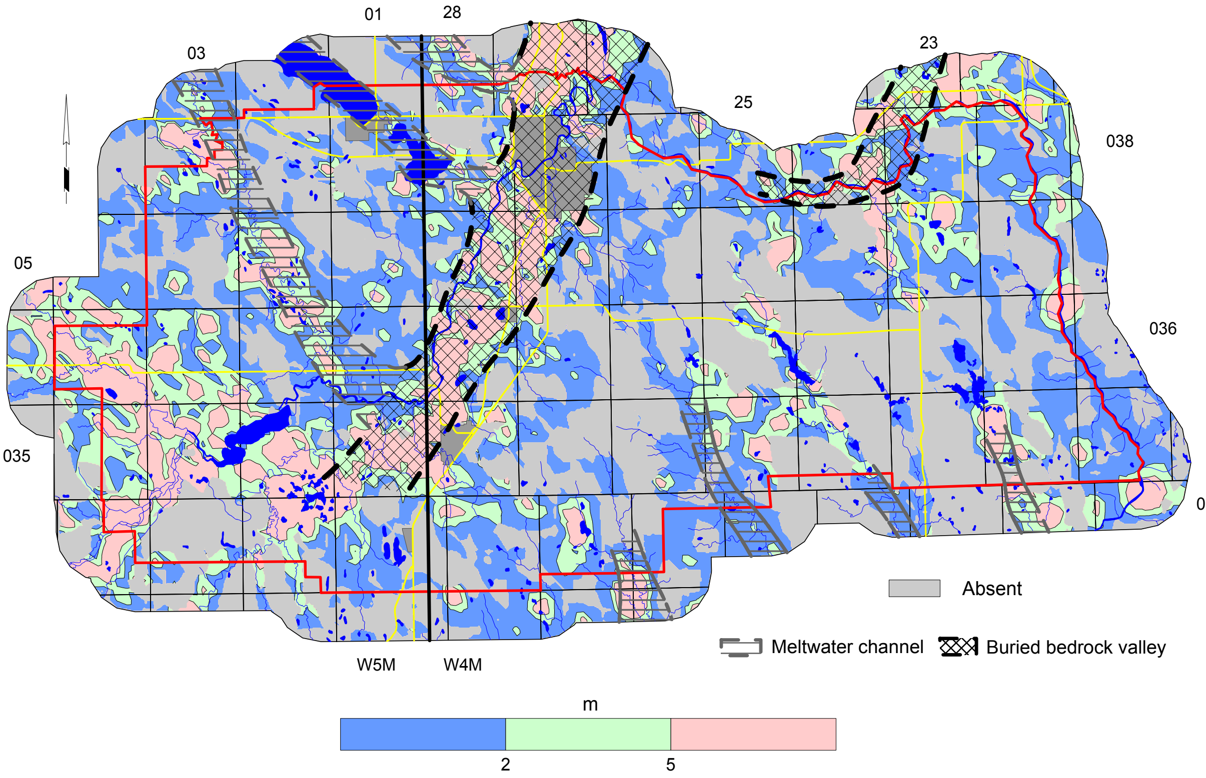
Water Wells Completed in Surficial Deposits



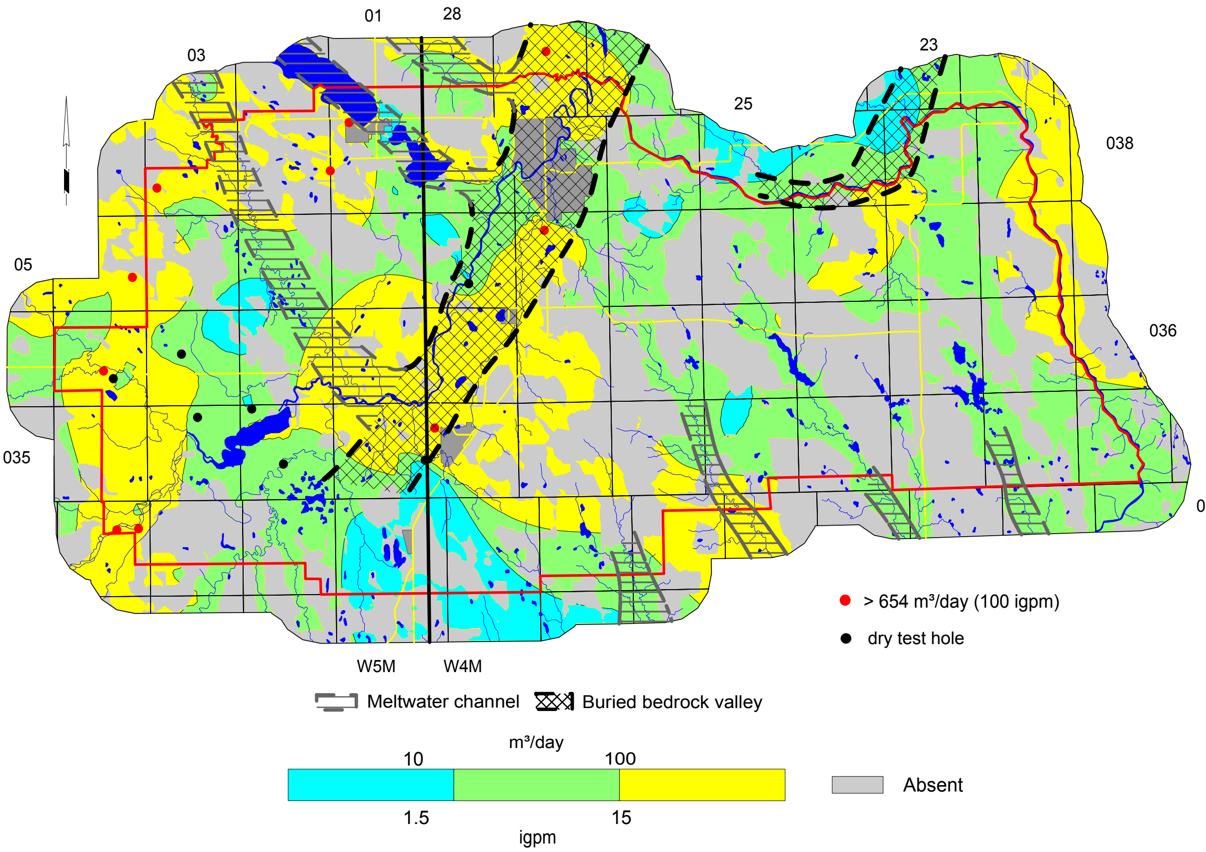
Amount of Sand and Gravel in Surficial Deposits



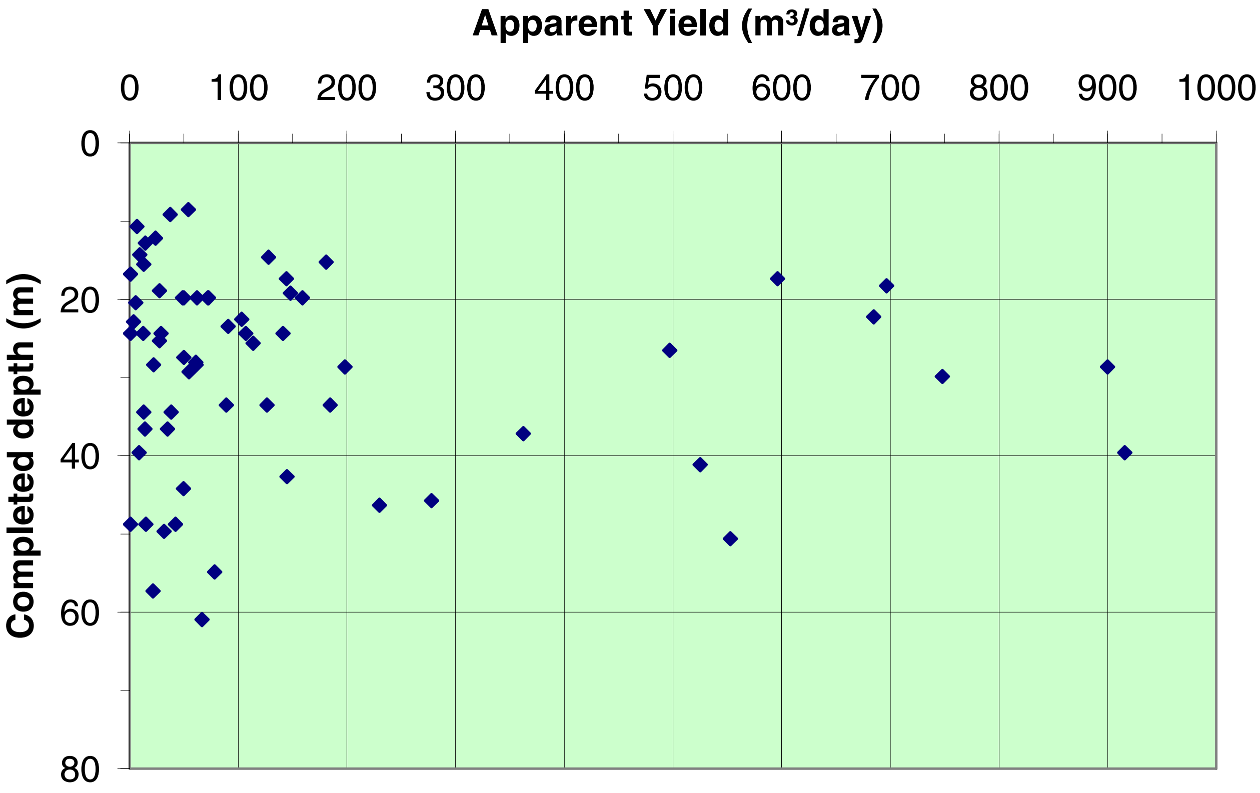
Thickness of Sand and Gravel Aquifer(s)



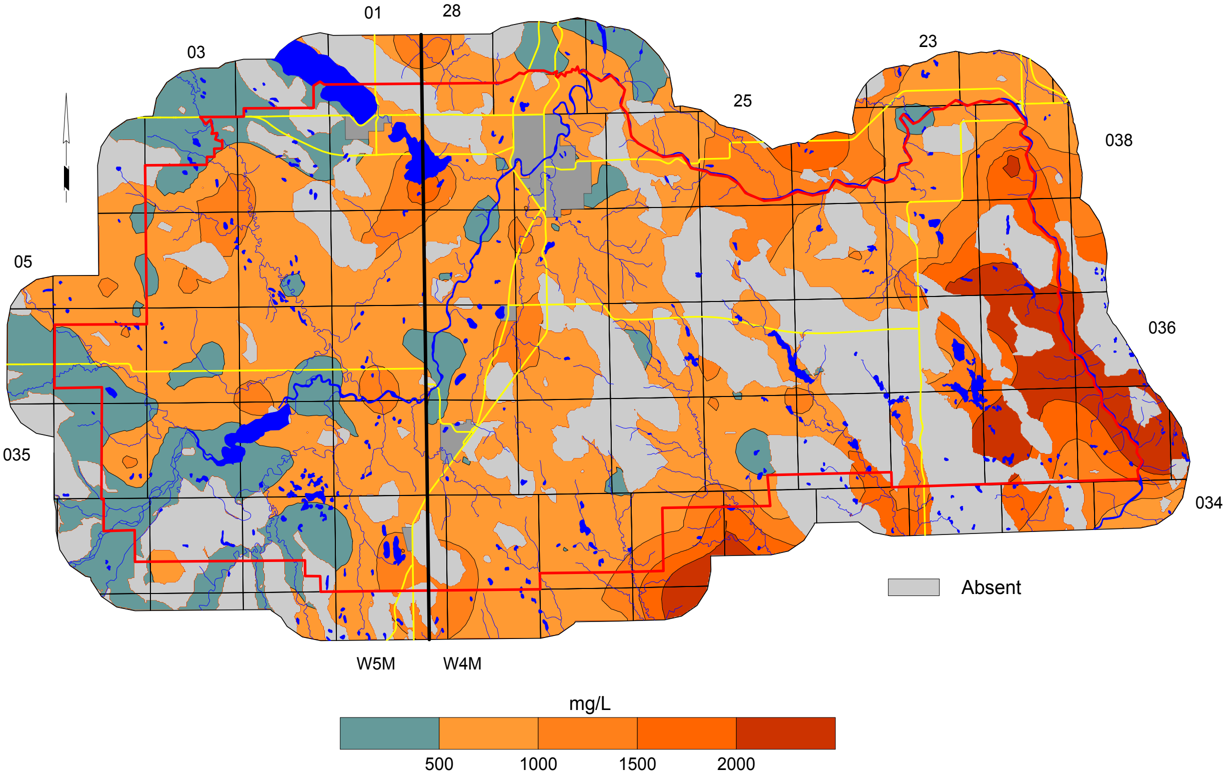
Apparent Yield for Water Wells Completed in Sand and Gravel Aquifer(s)



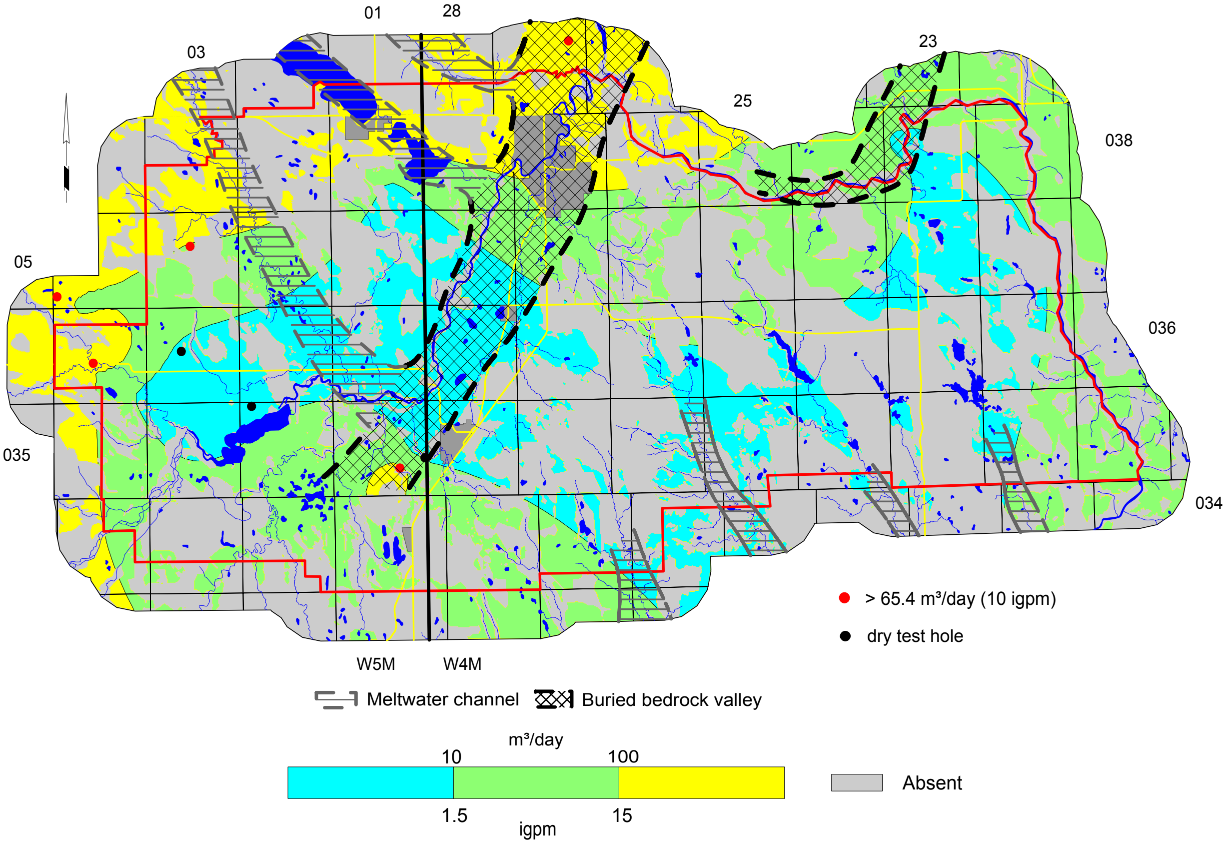
Sand and Gravel Water Well Yields vs Completed Depth



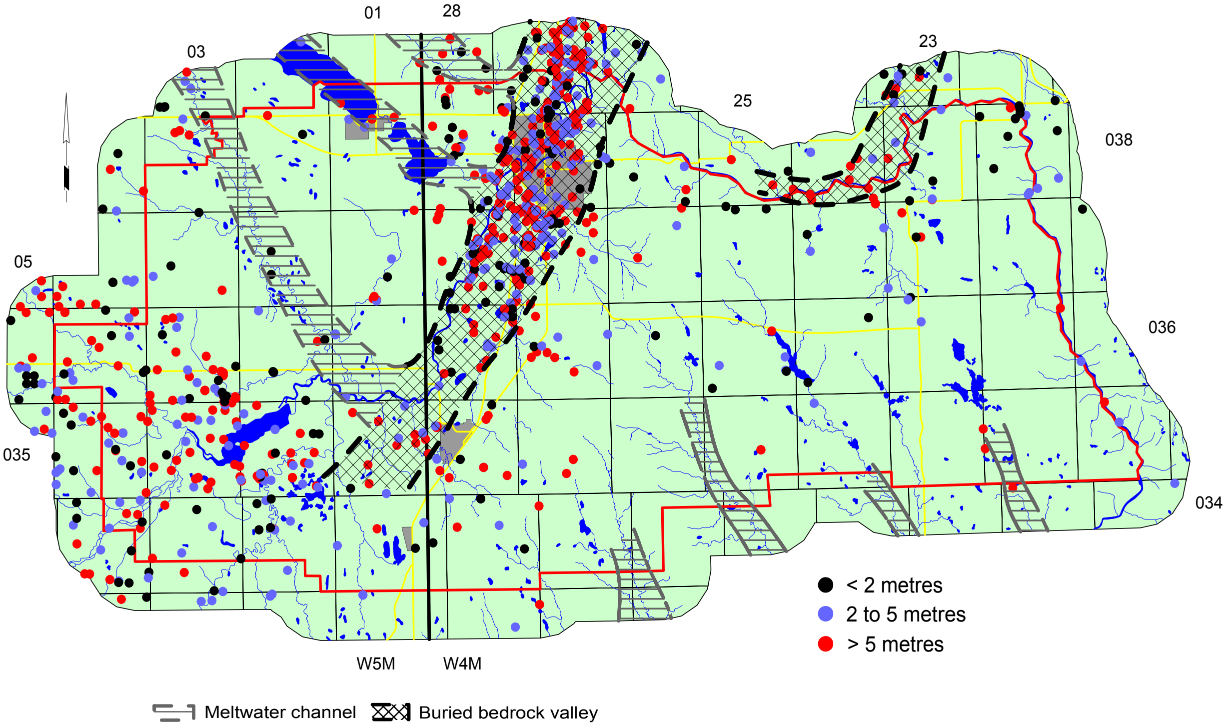
Total Dissolved Solids in Groundwater from Surficial Deposits



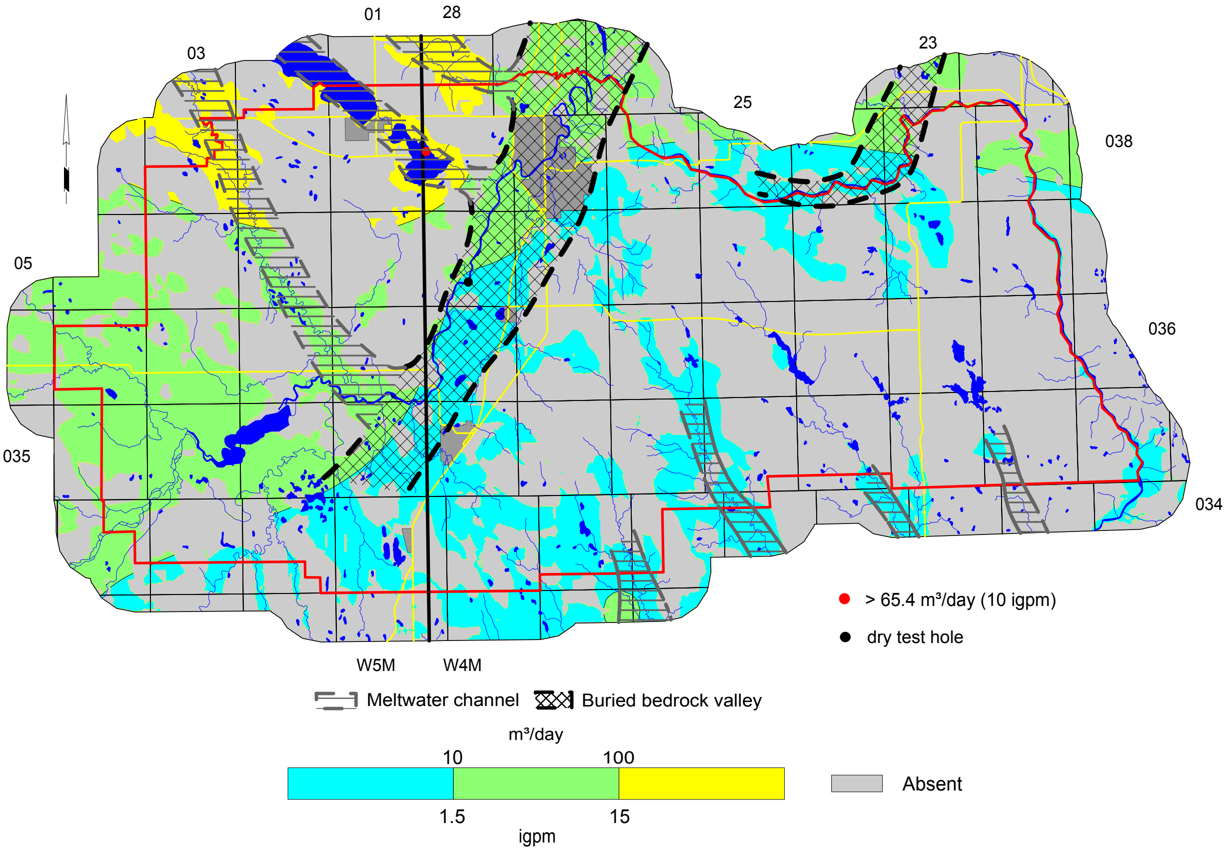
Apparent Yield for Water Wells Completed through Upper Sand and Gravel Aquifer



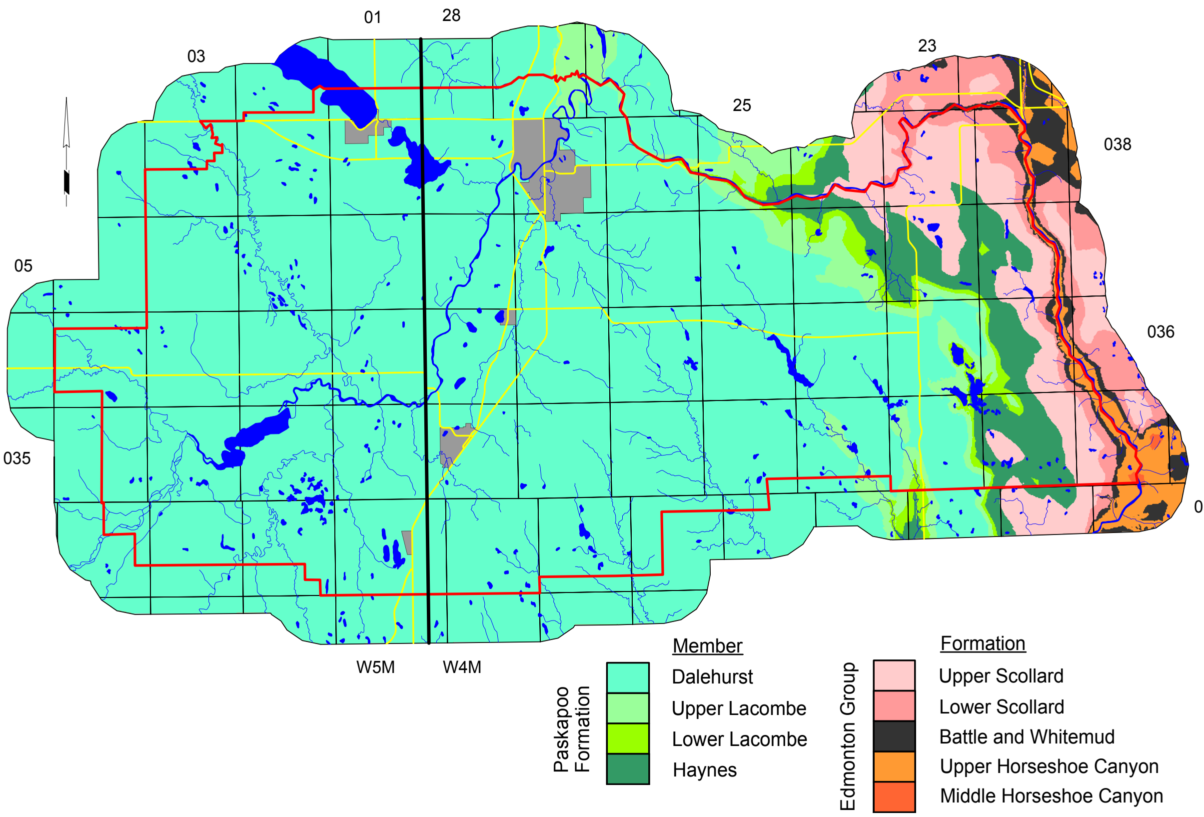
Thickness of Sand and Gravel Deposits that Directly Overlie the Bedrock Surface



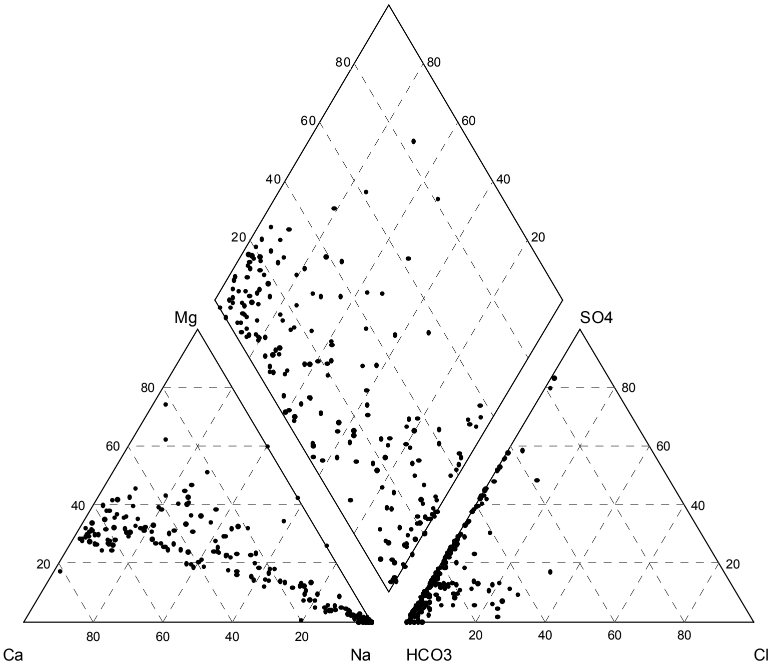
Apparent Yield for Water Wells Completed through Lower Sand and Gravel Aquifer



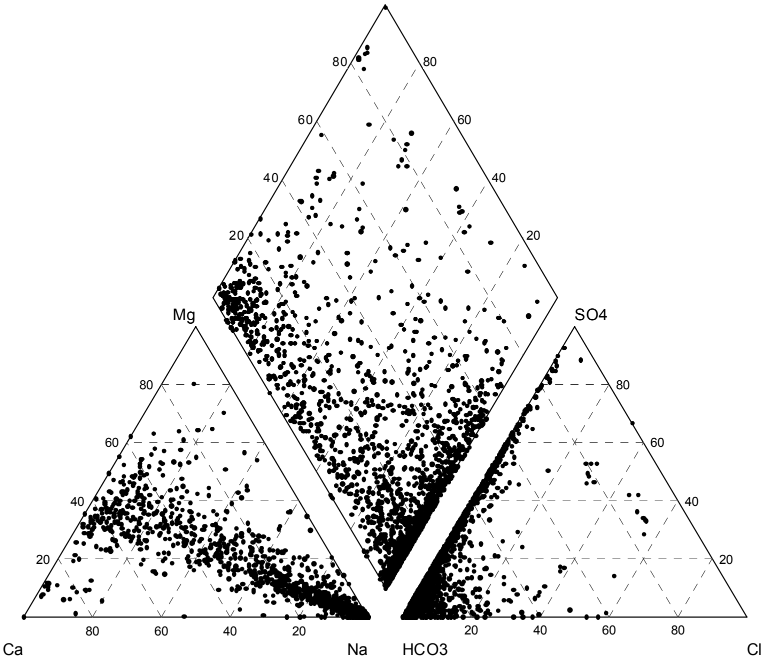
Bedrock Geology



Piper Diagrams

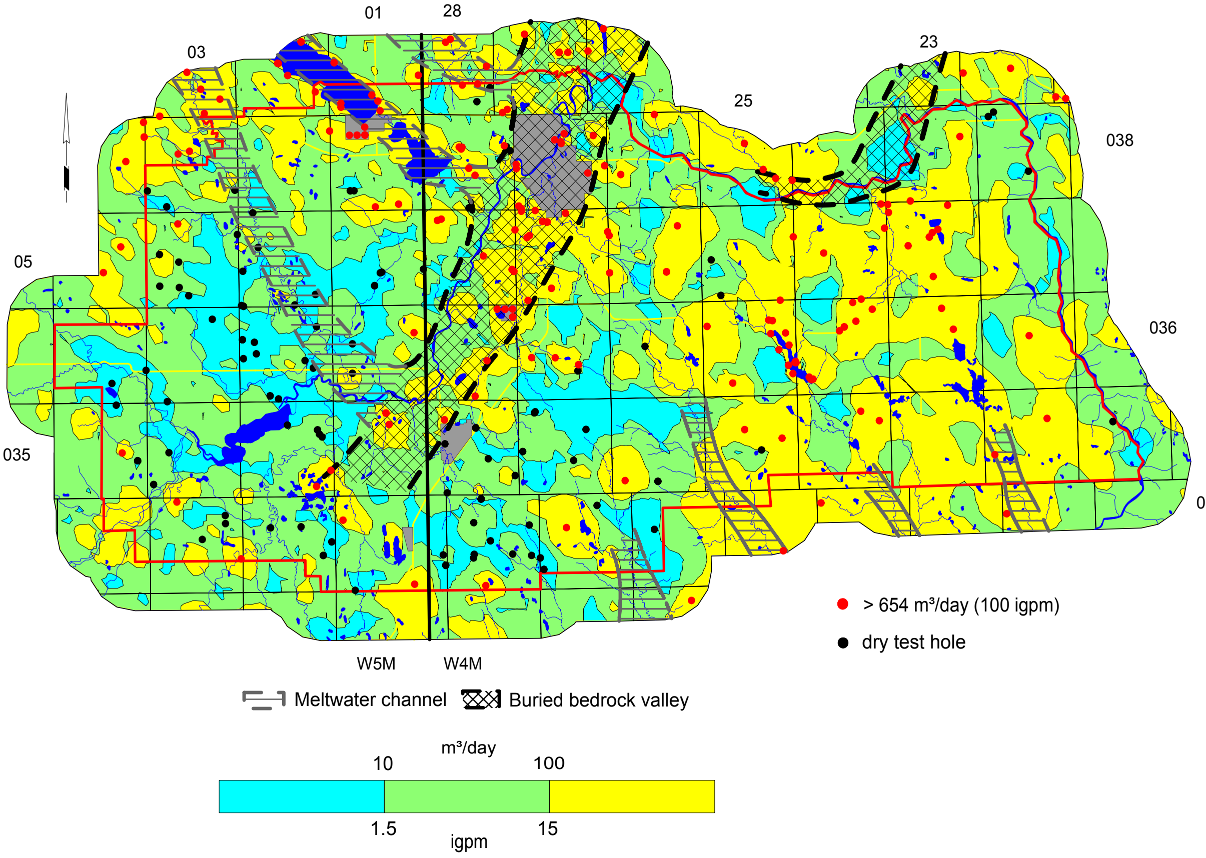


Surficial Deposits

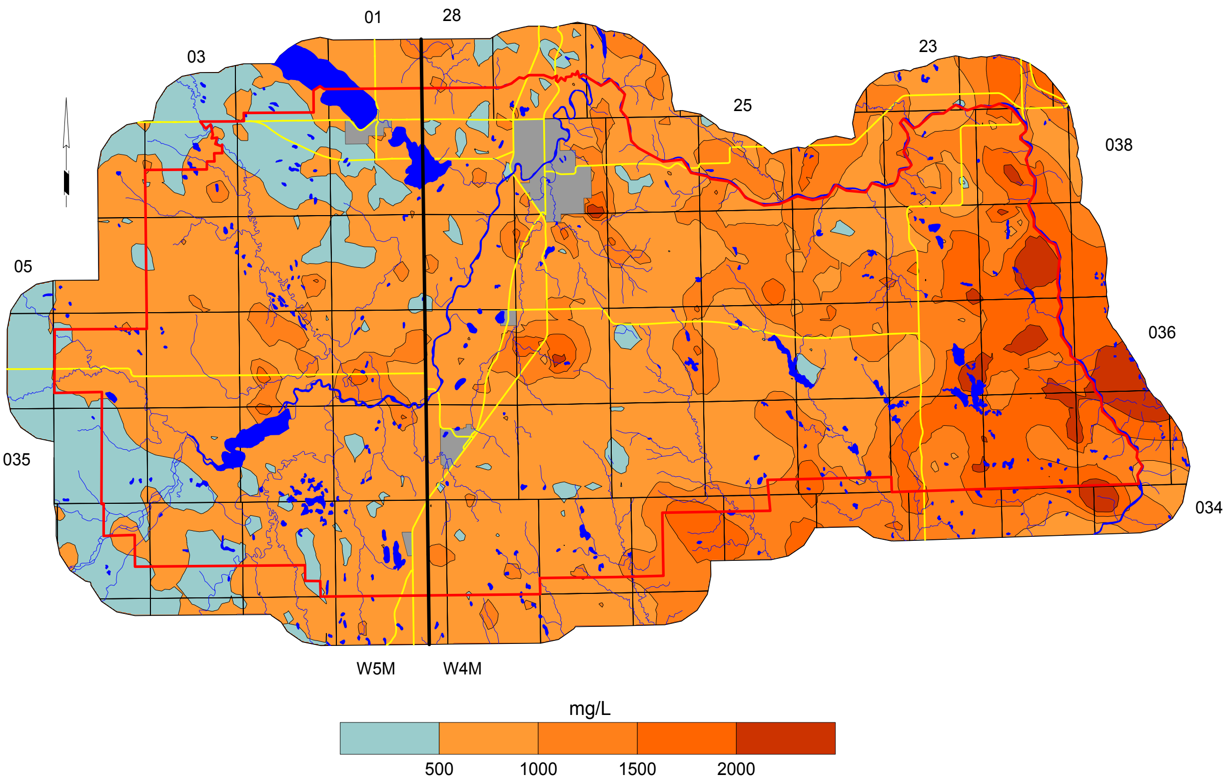


Bedrock Aquifers

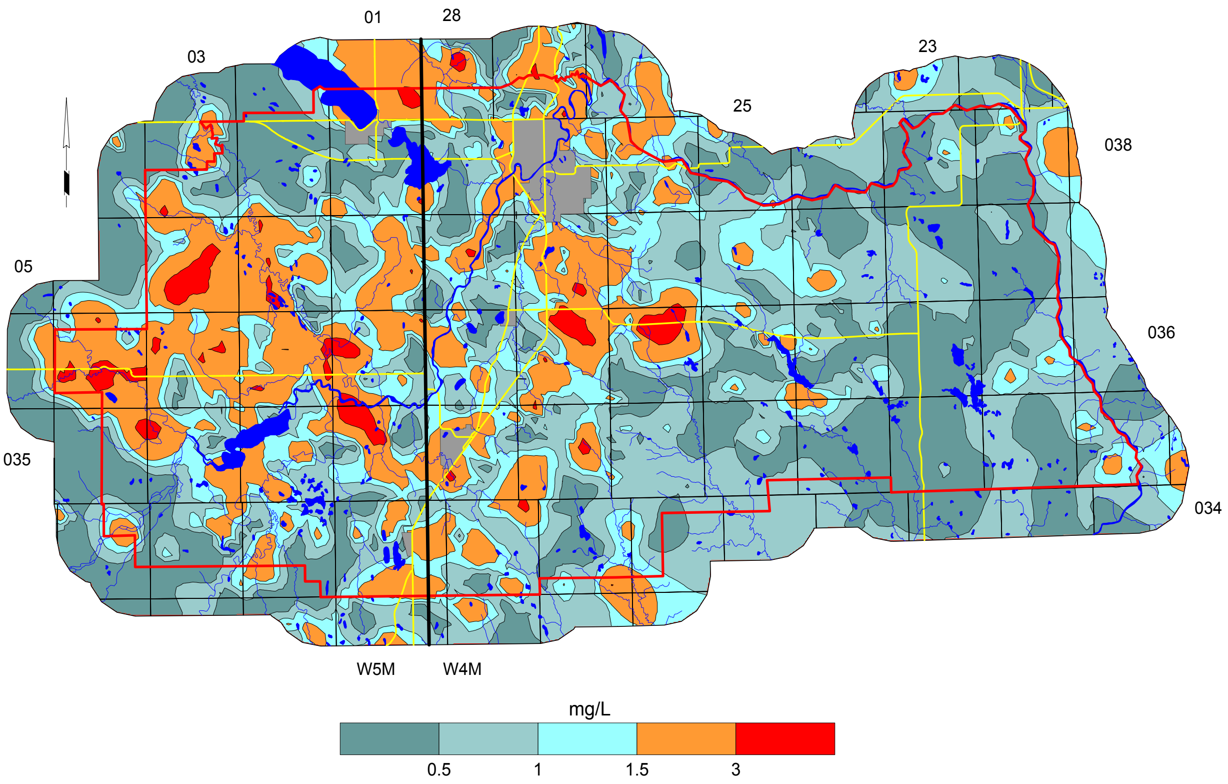
Apparent Yield for Water Wells Completed in Upper Bedrock Aquifer(s)



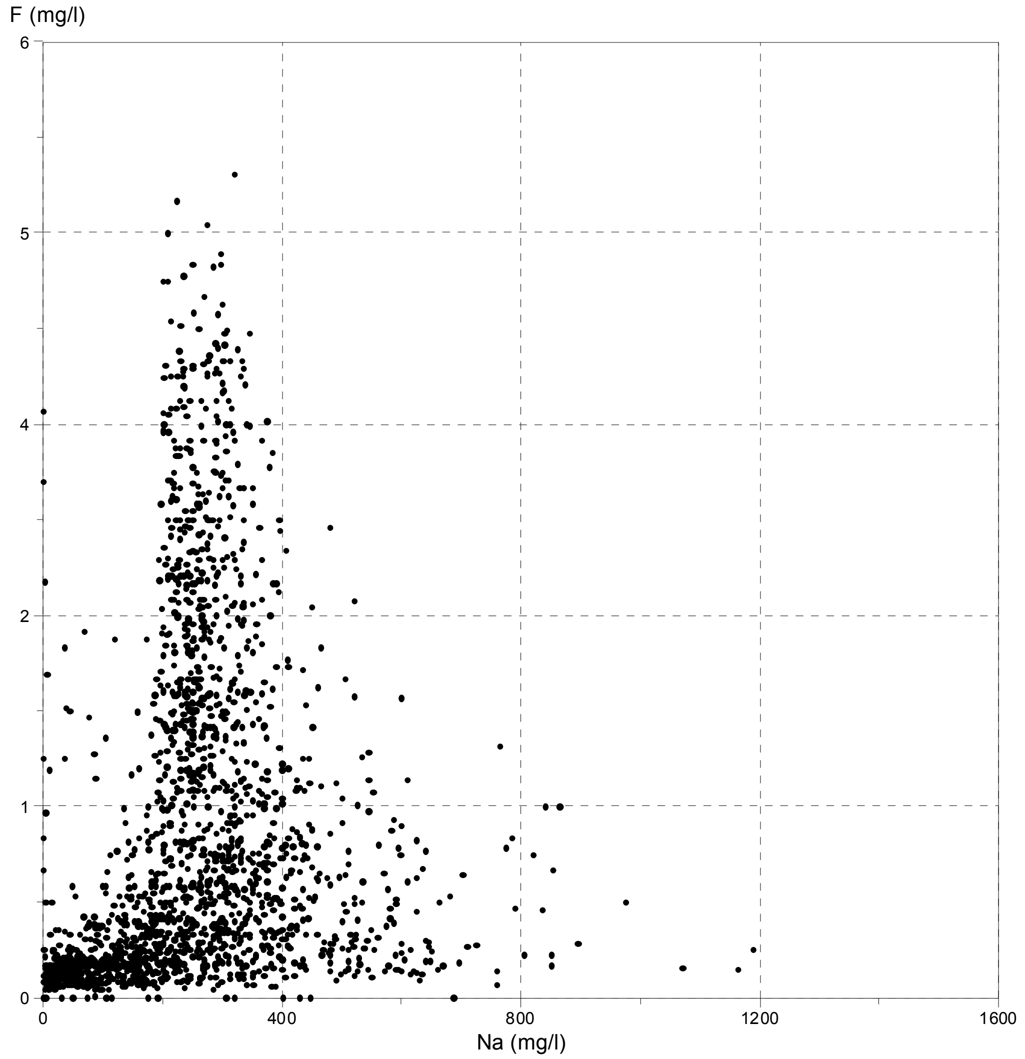
Total Dissolved Solids in Groundwater from Upper Bedrock Aquifer(s)



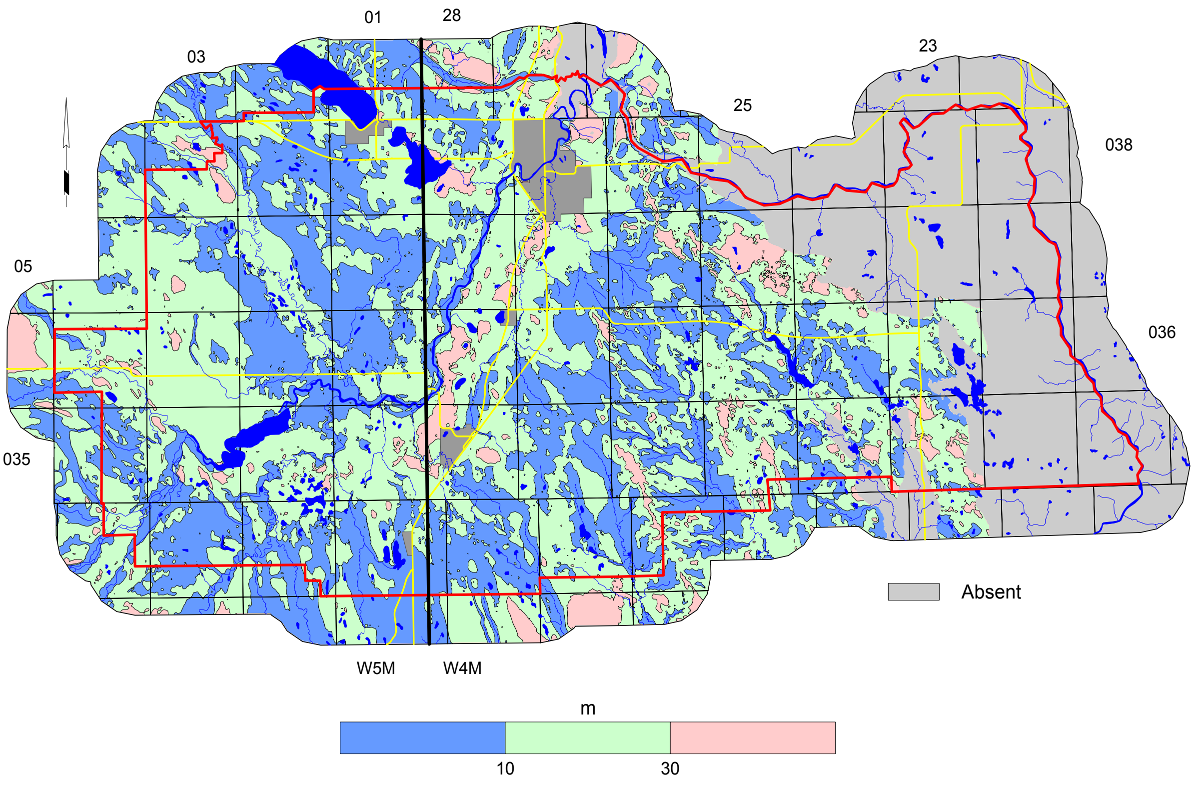
Fluoride in Groundwater from Upper Bedrock Aquifer(s)



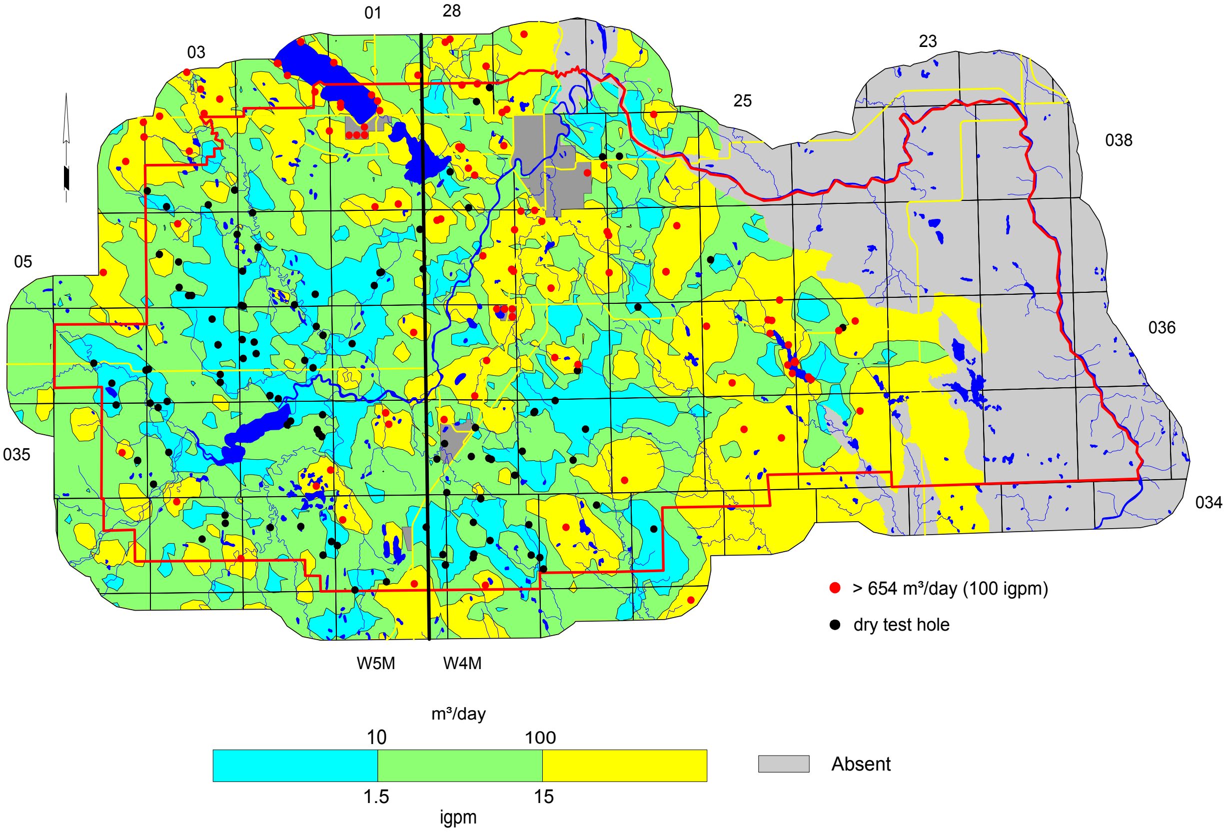
Fluoride vs Sodium Concentrations in Groundwater from Upper Bedrock Aquifer(s)



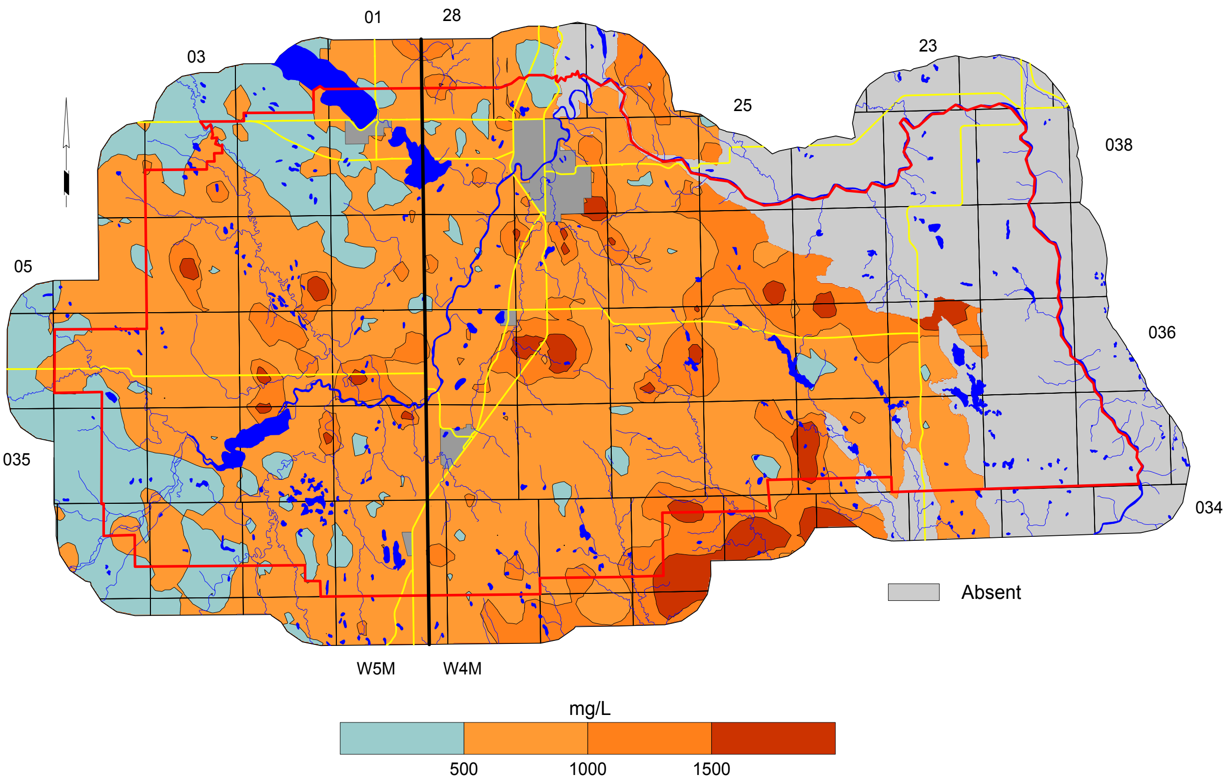
Depth to Top of Dalehurst Member



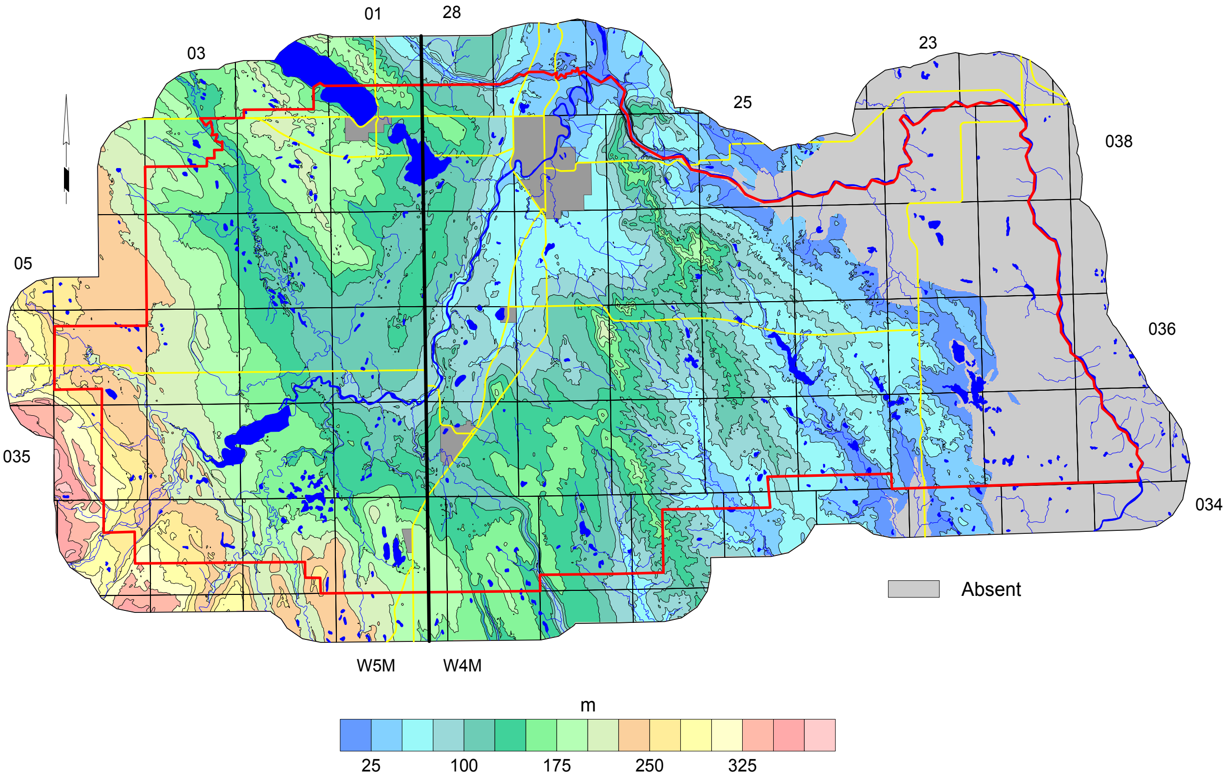
Apparent Yield for Water Wells Completed through Dalehurst Aquifer



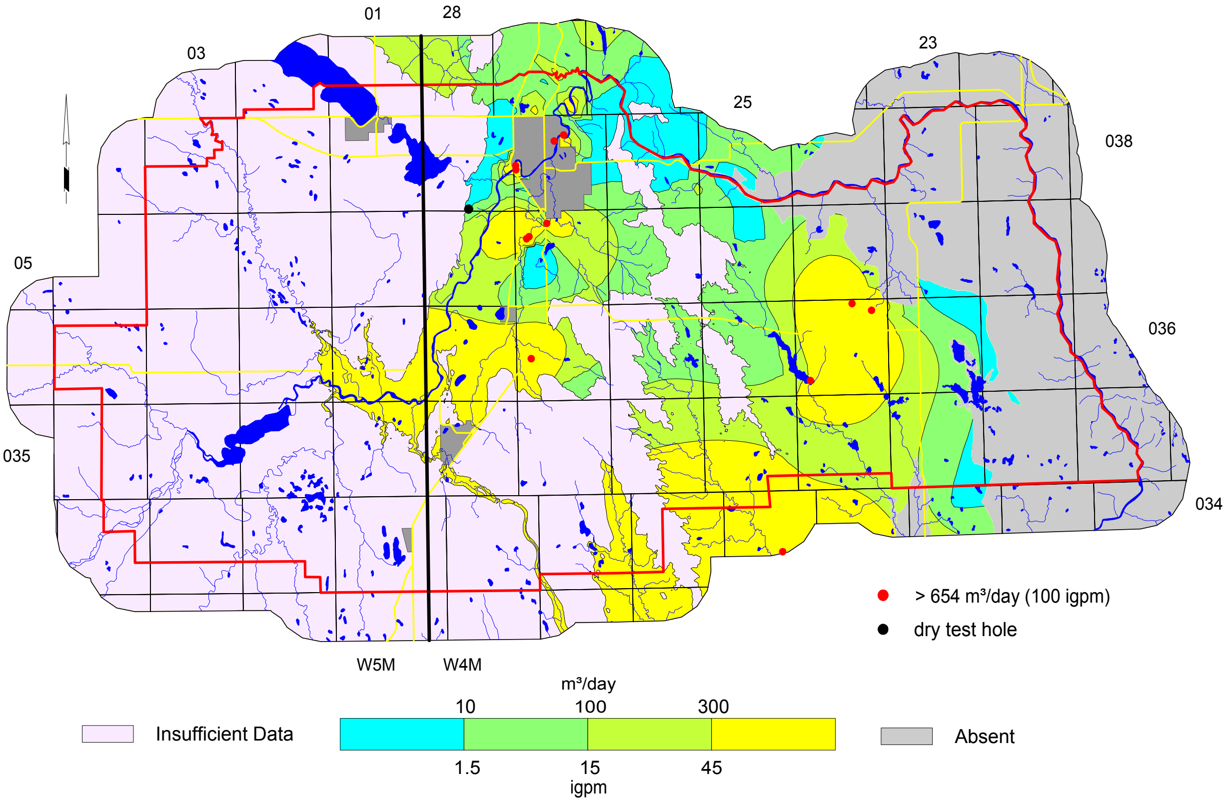
Total Dissolved Solids in Groundwater from Dalehurst Aquifer



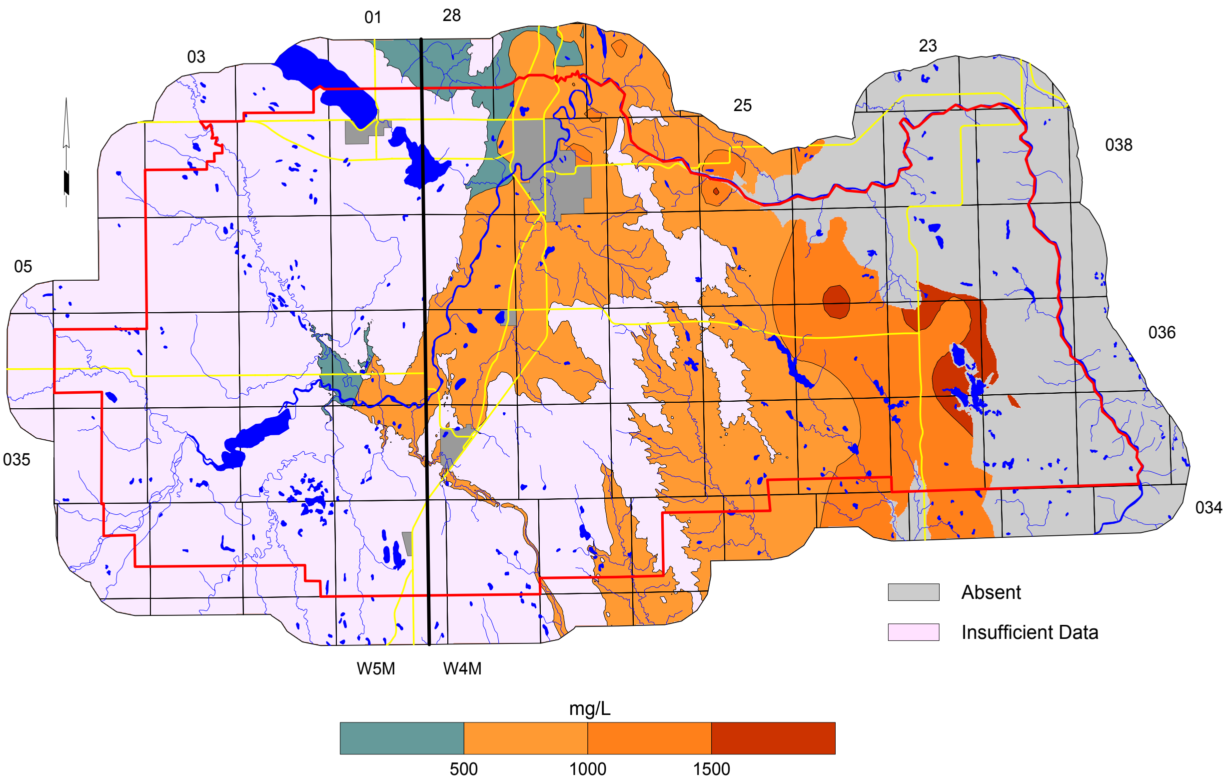
Depth to Top of Upper Lacombe Member



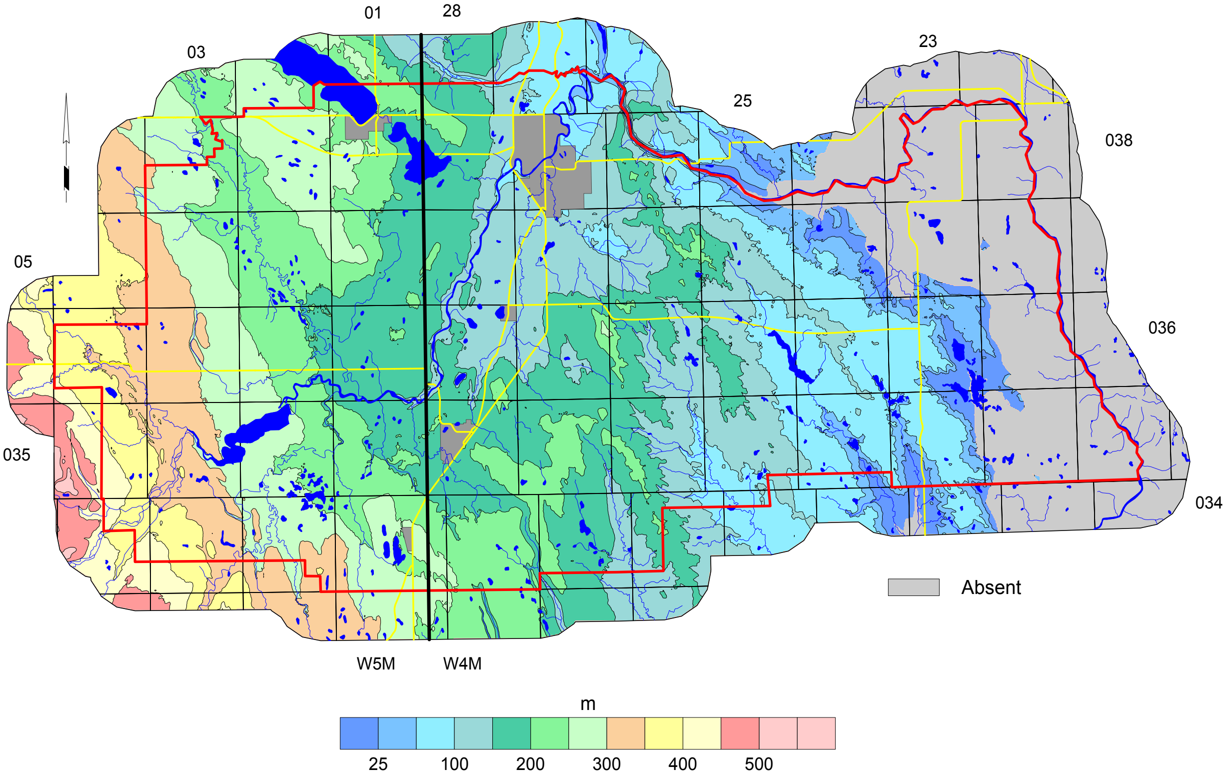
Apparent Yield for Water Wells Completed through Upper Lacombe Aquifer



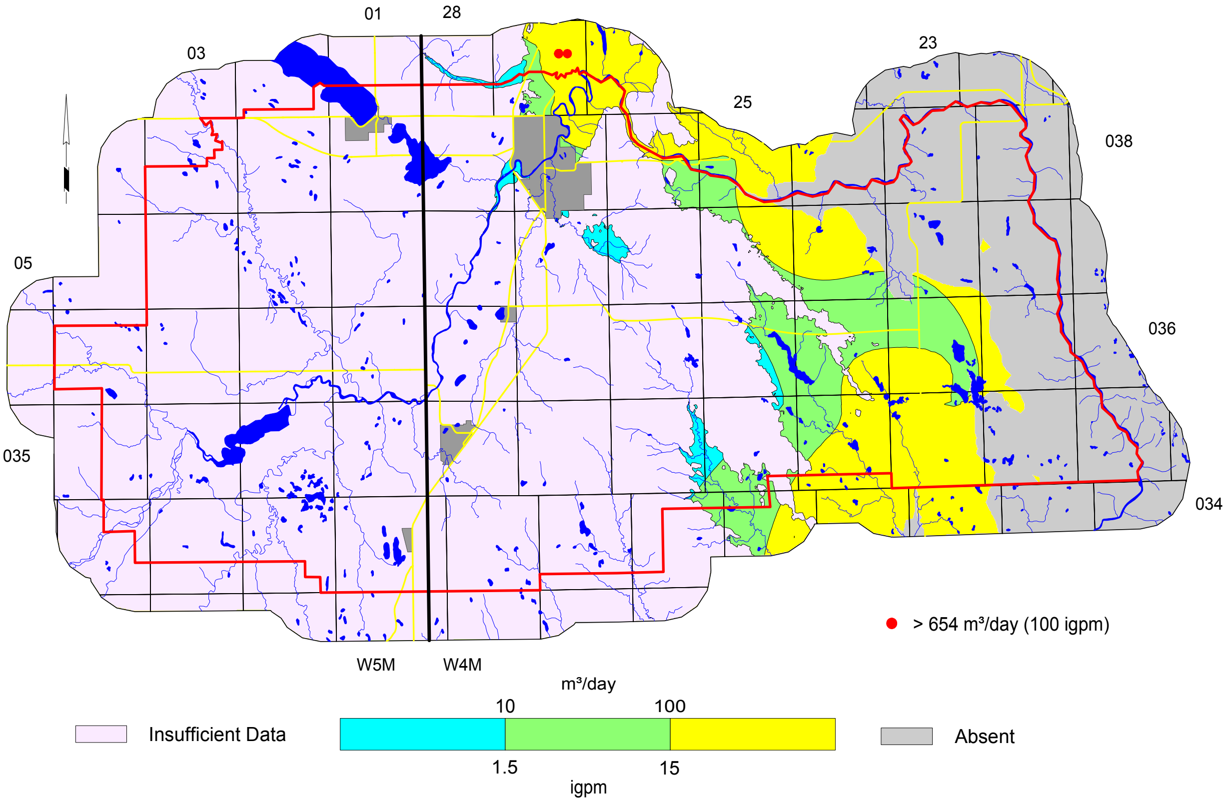
Total Dissolved Solids in Groundwater from Upper Lacombe Aquifer



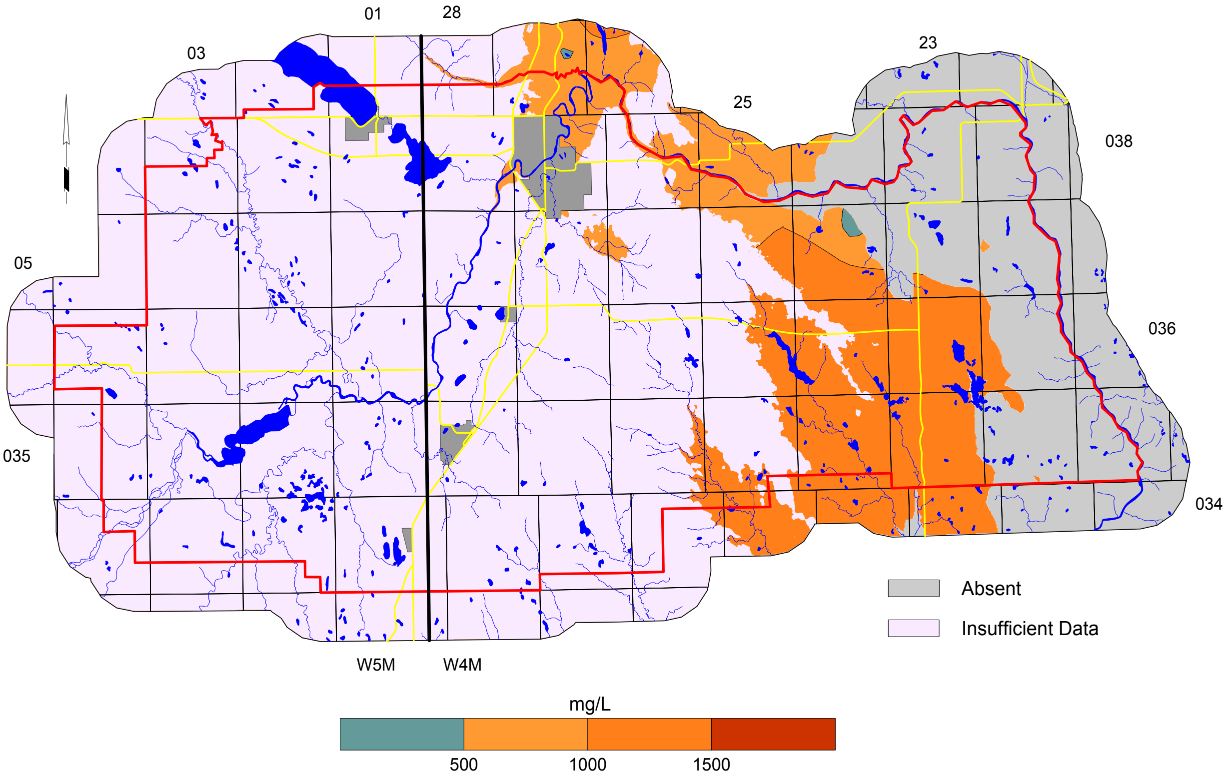
Depth to Top of Lower Lacombe Member



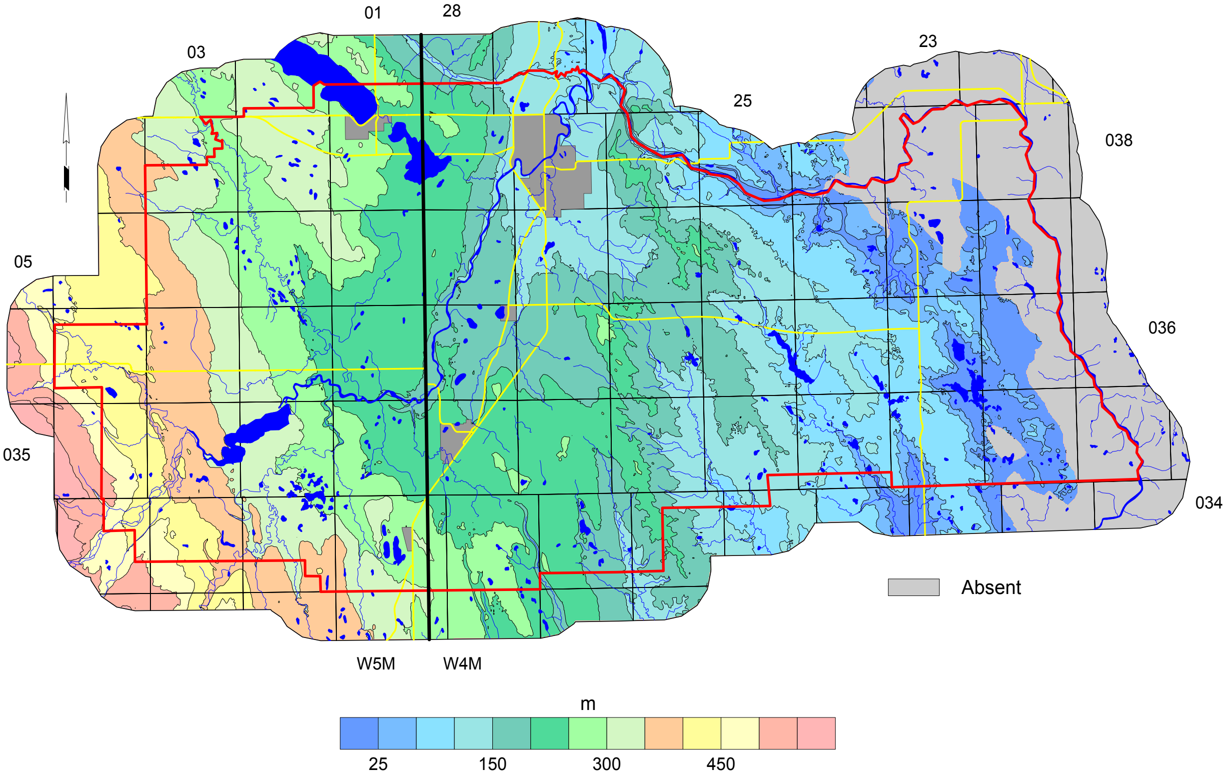
Apparent Yield for Water Wells Completed through Lower Lacombe Aquifer



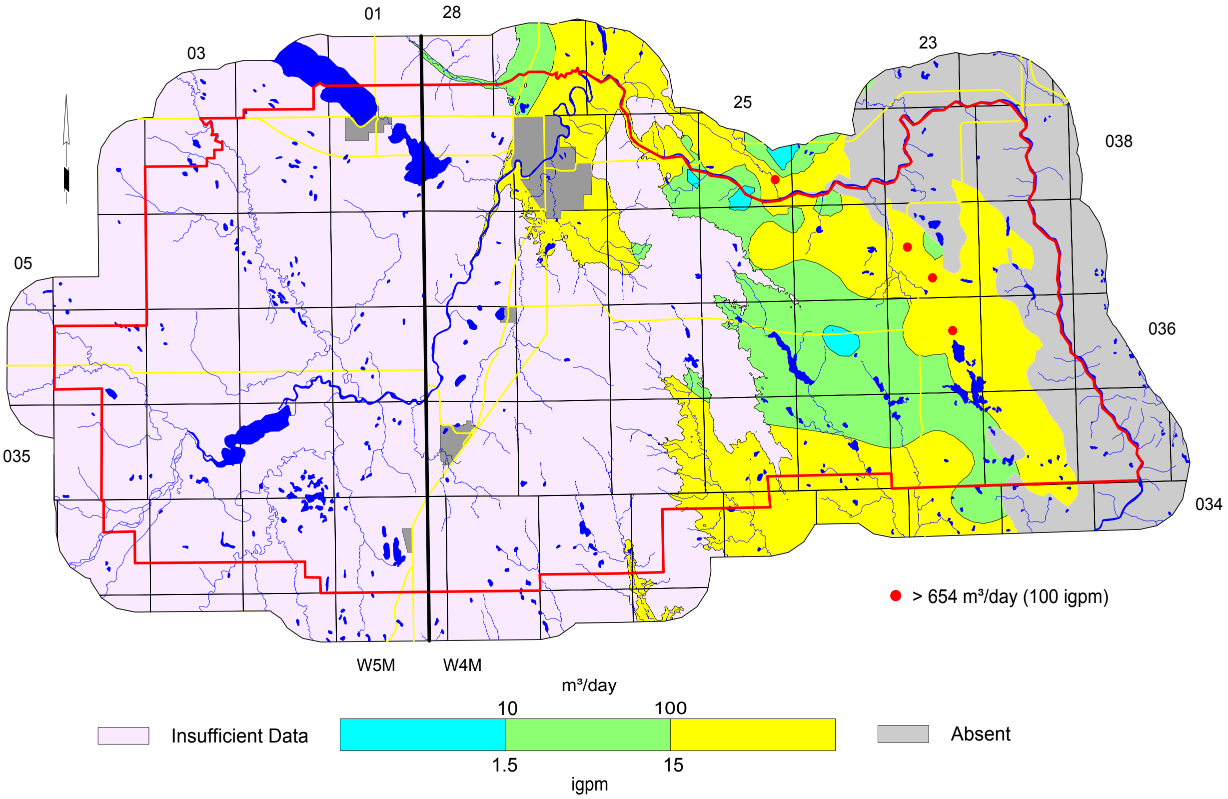
Total Dissolved Solids in Groundwater from Lower Lacombe Aquifer



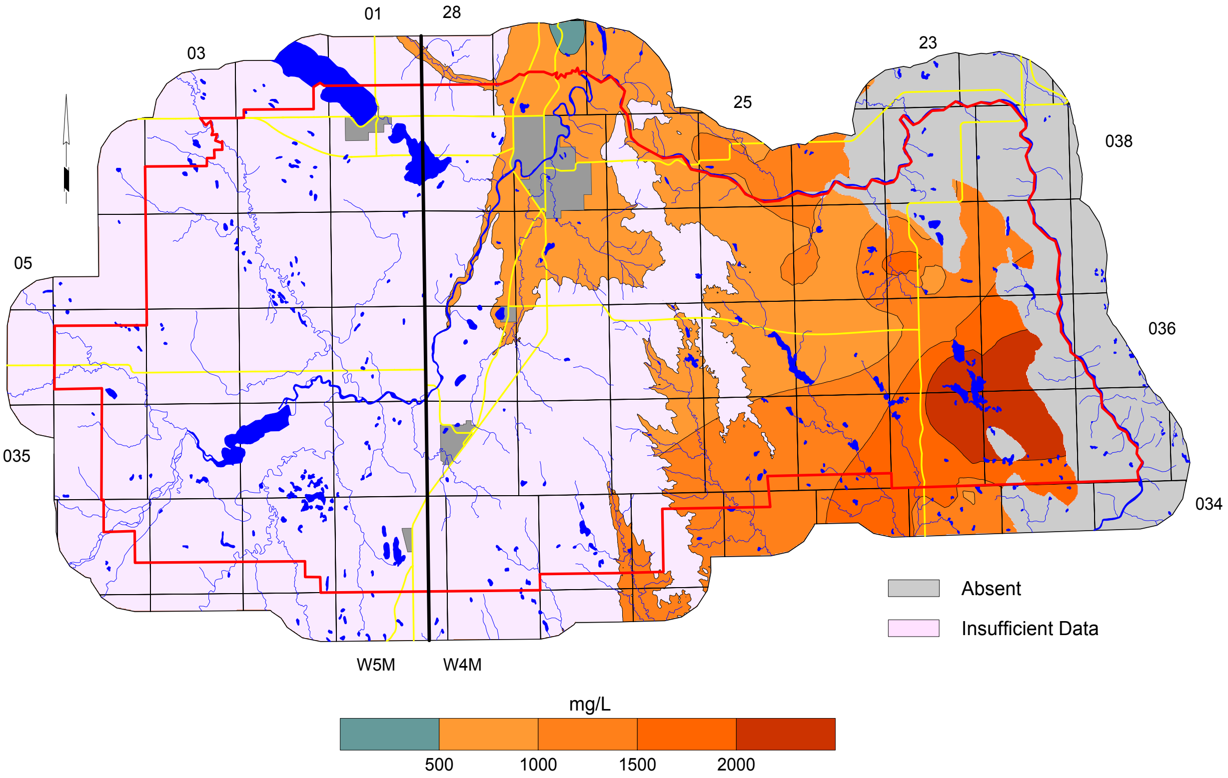
Depth to Top of Haynes Member



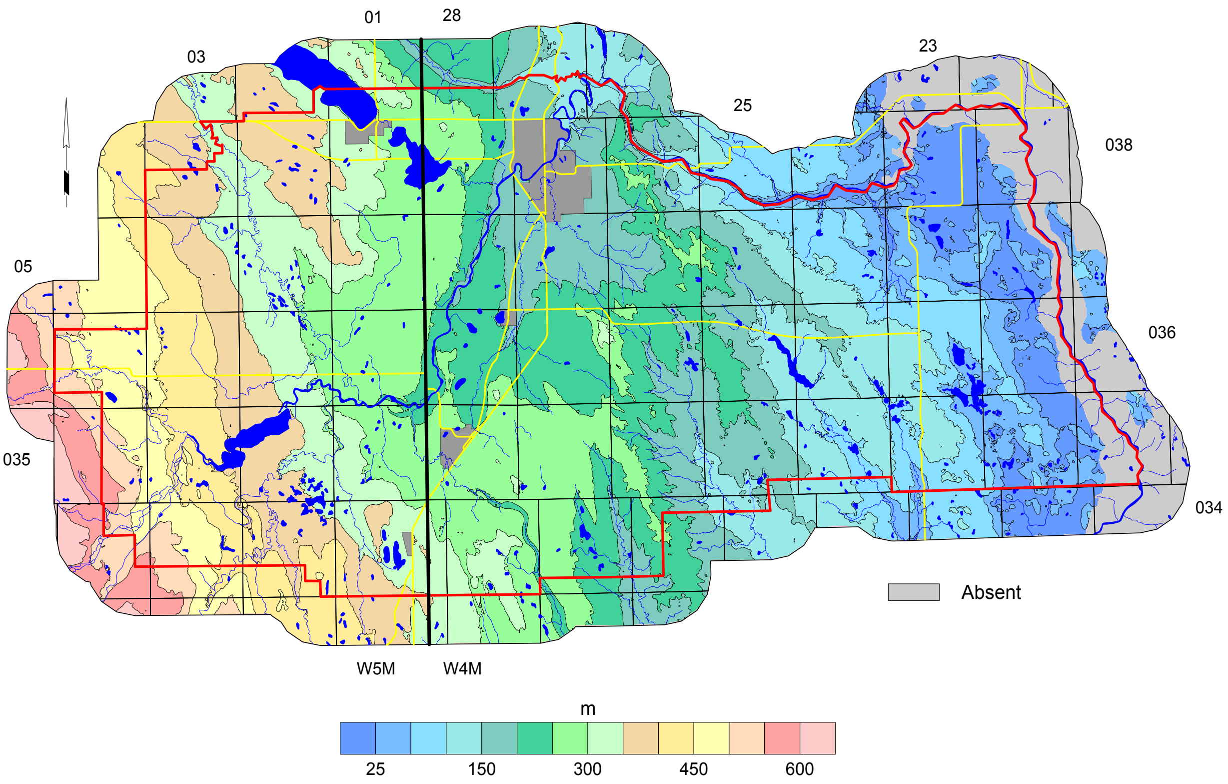
Apparent Yield for Water Wells Completed through Haynes Aquifer



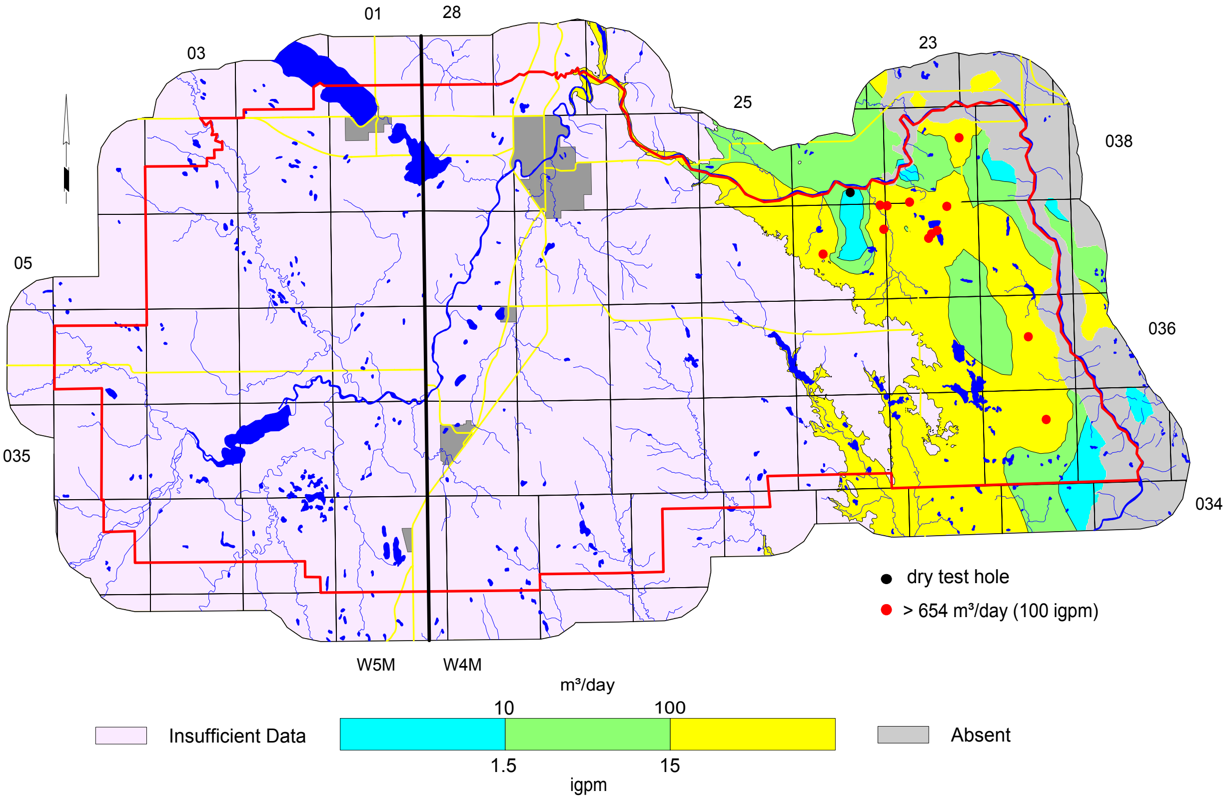
Total Dissolved Solids in Groundwater from Haynes Aquifer



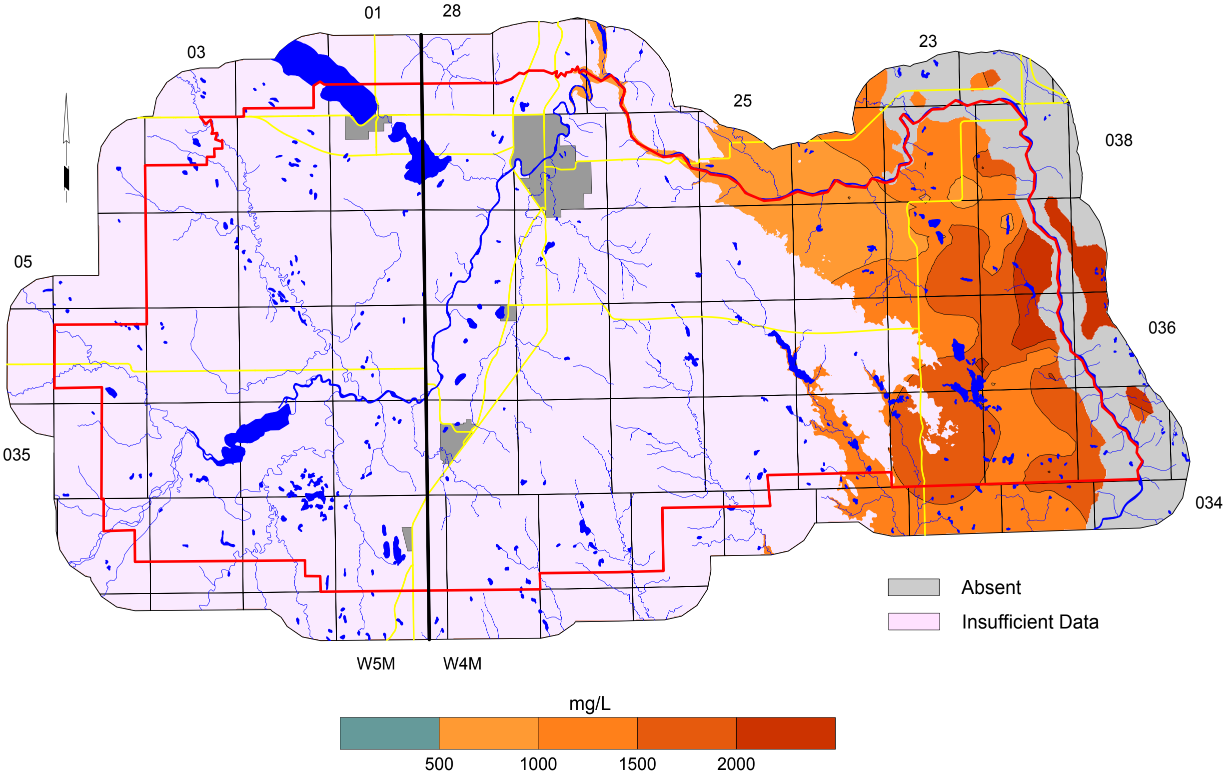
Depth to Top of Upper Scollard Formation



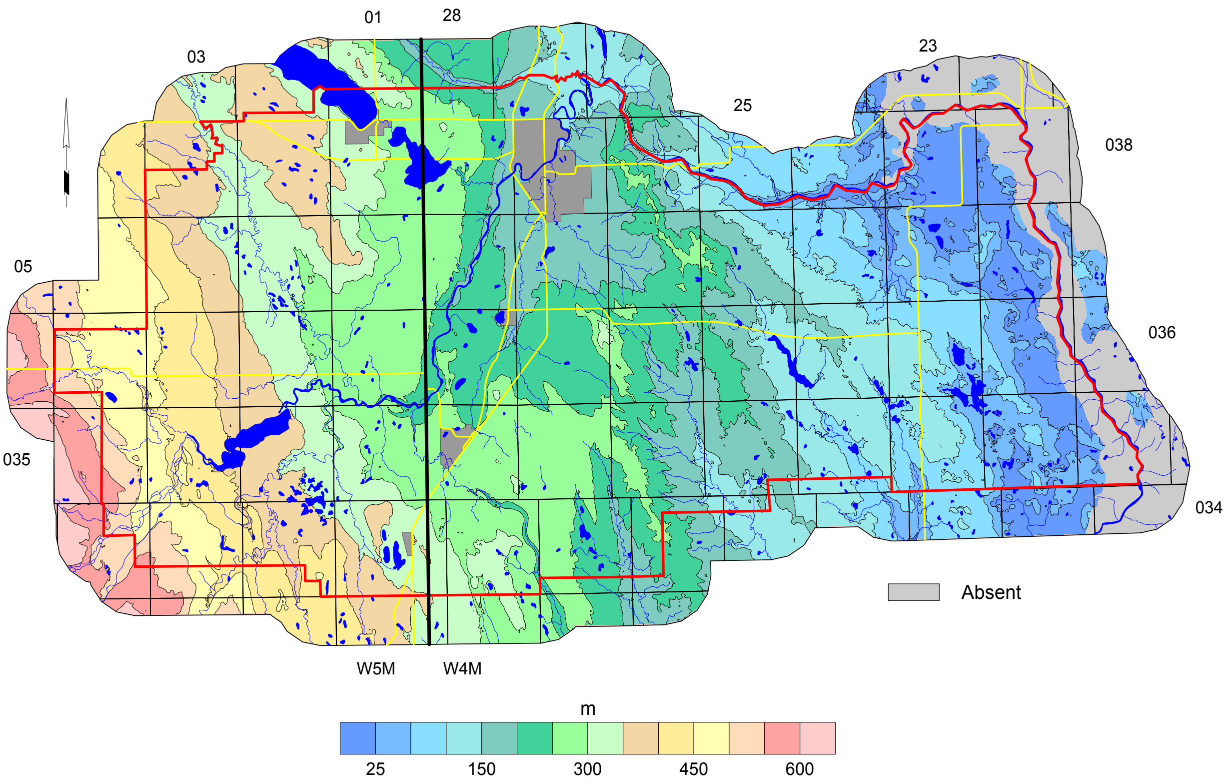
Apparent Yield for Water Wells Completed through Upper Scollard Aquifer



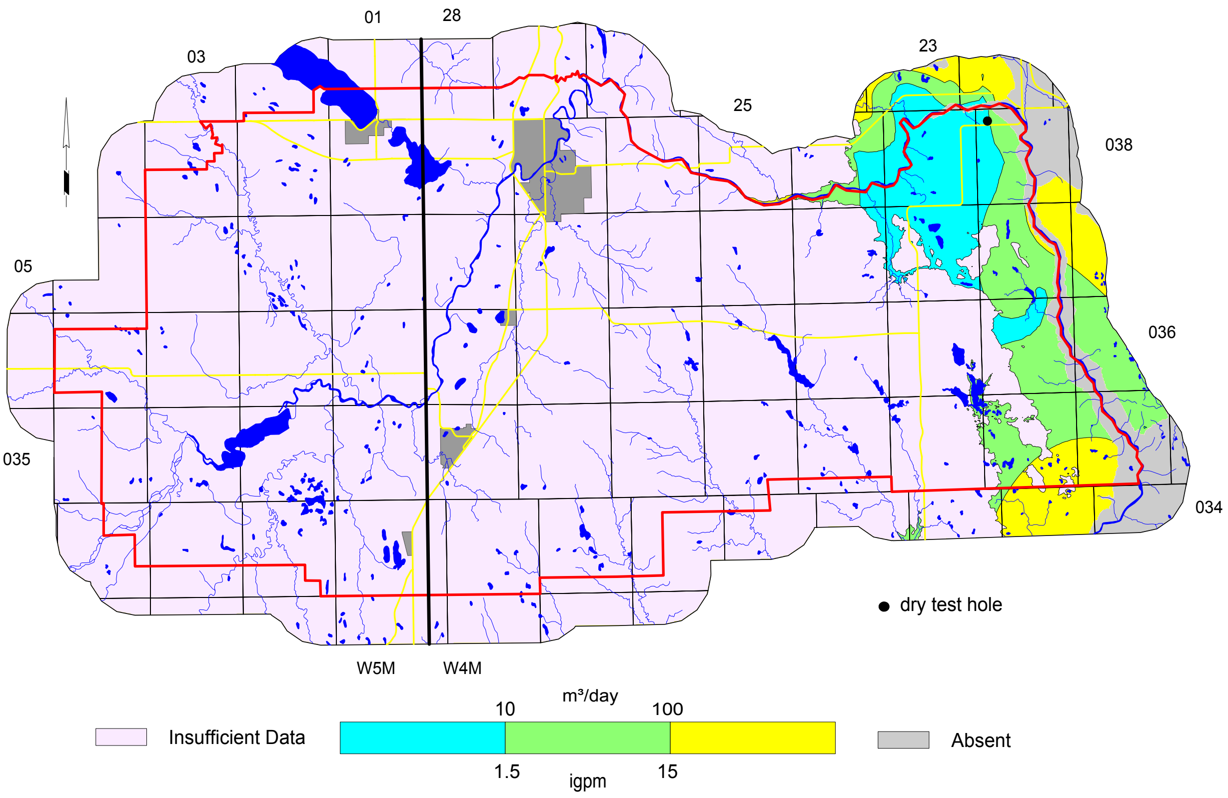
Total Dissolved Solids in Groundwater from Upper Scollard Aquifer



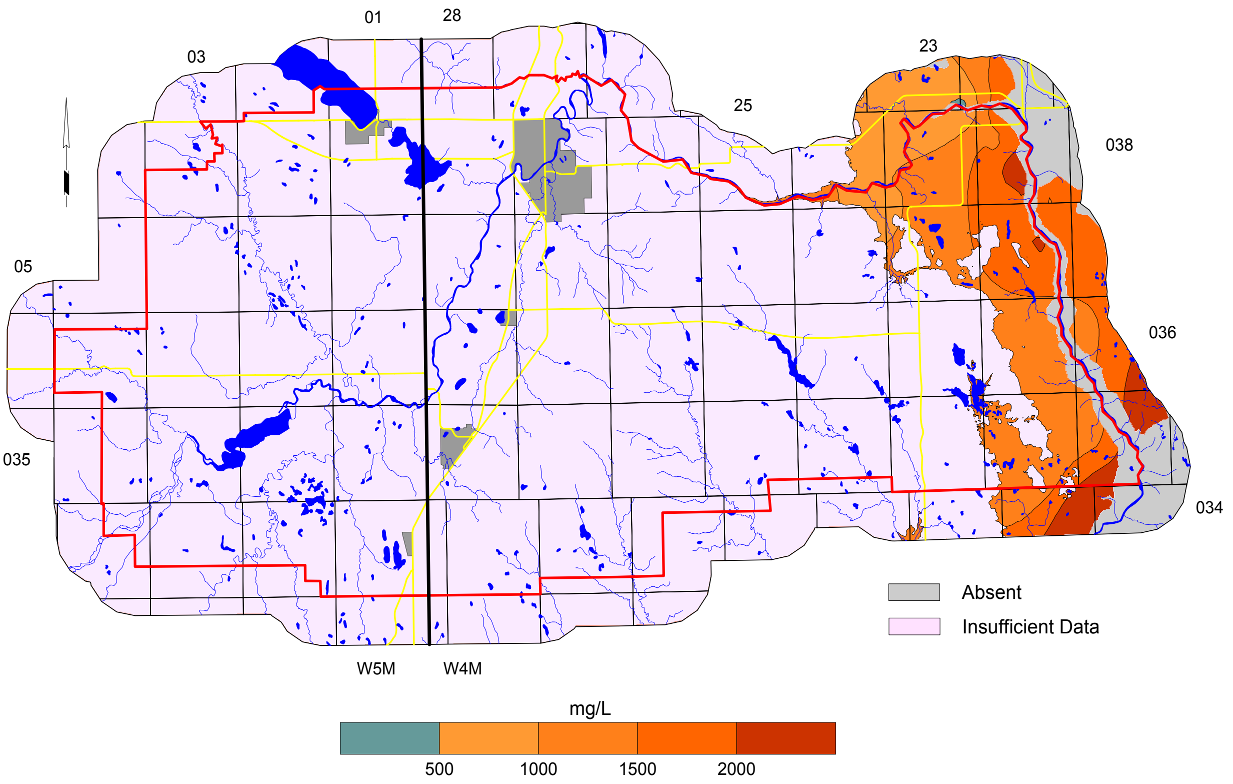
Depth to Top of Lower Scollard Formation



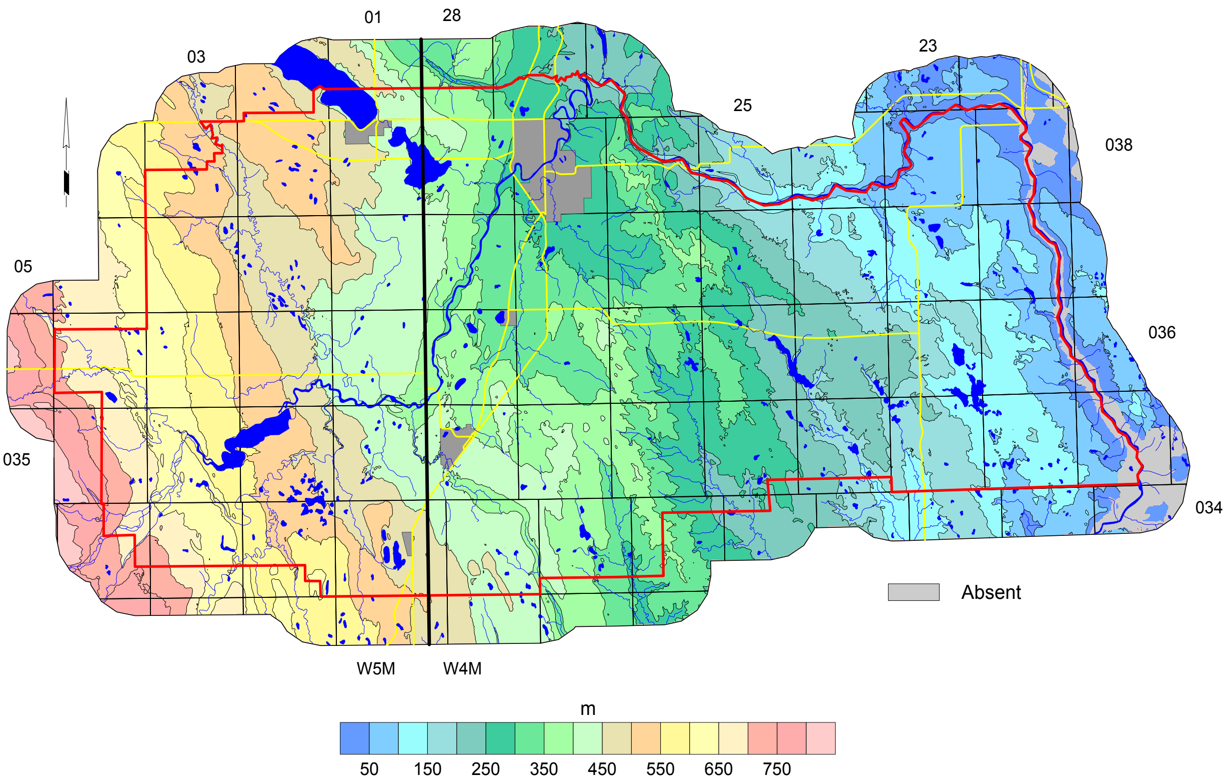
Apparent Yield for Water Wells Completed through Lower Scollard Aquifer



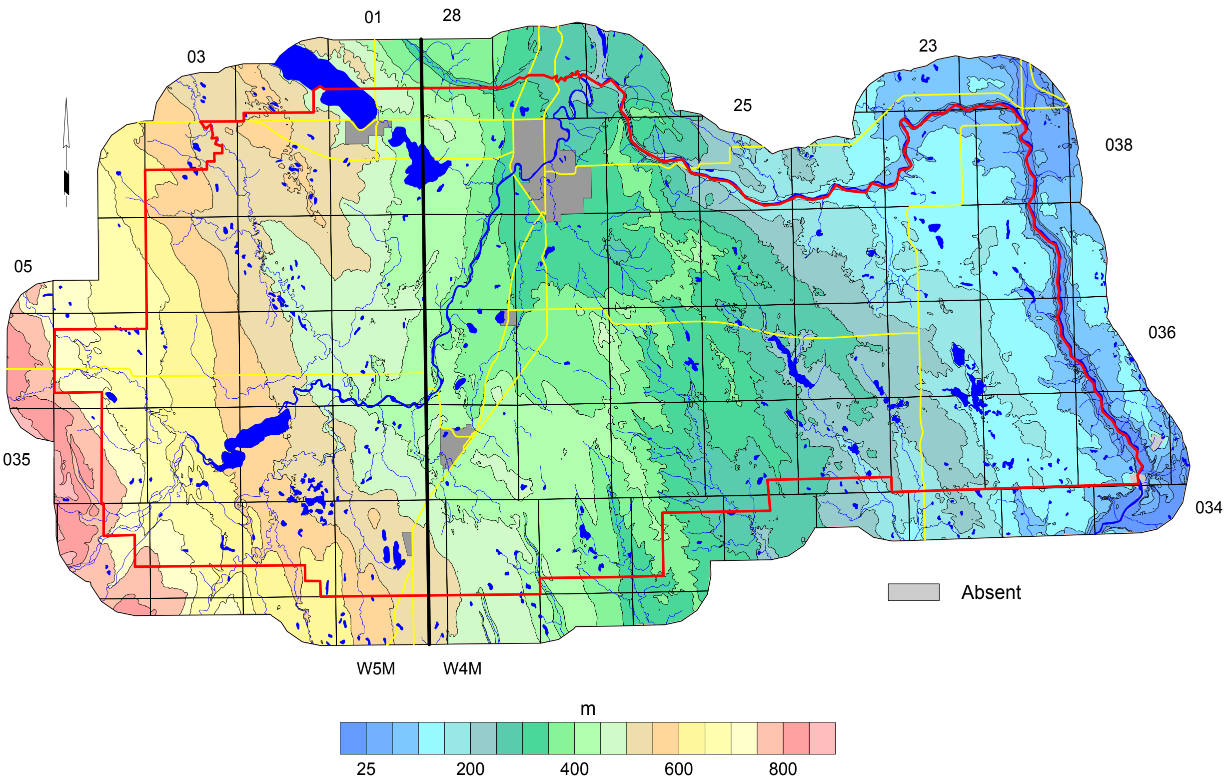
Total Dissolved Solids in Groundwater from Lower Scollard Aquifer



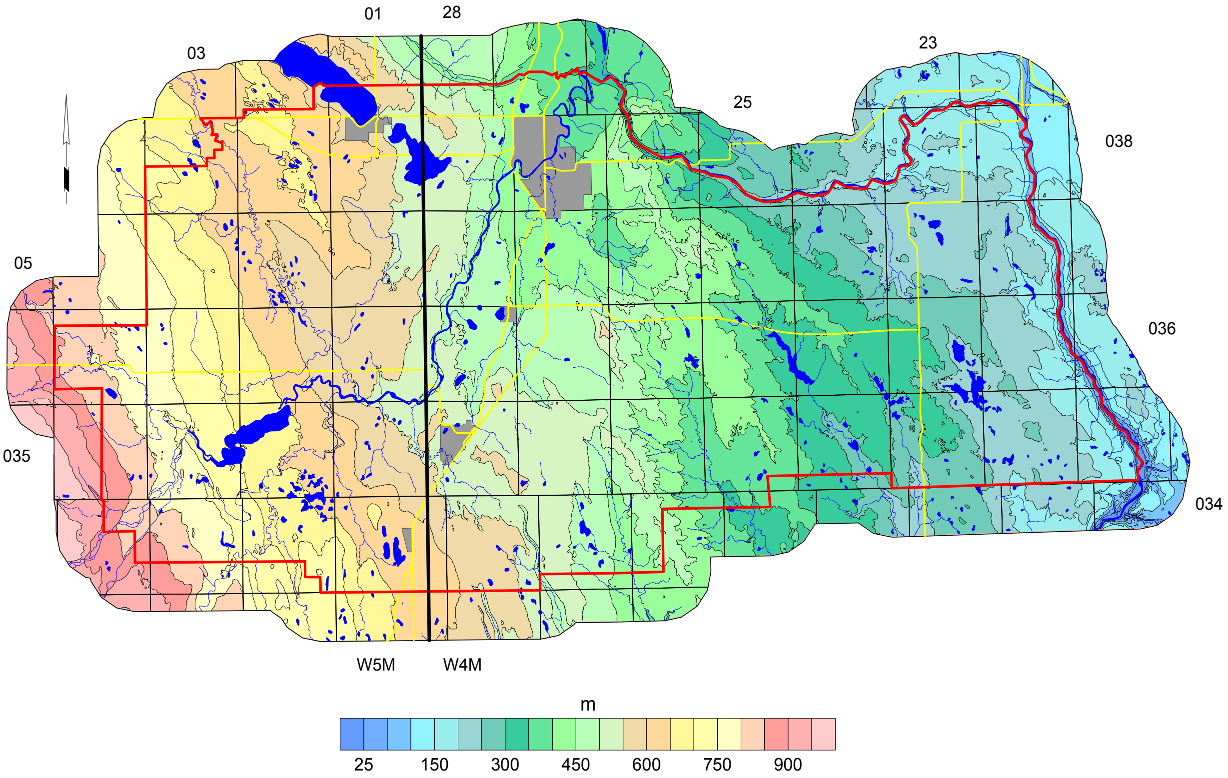
Depth to Top of Battle Formation



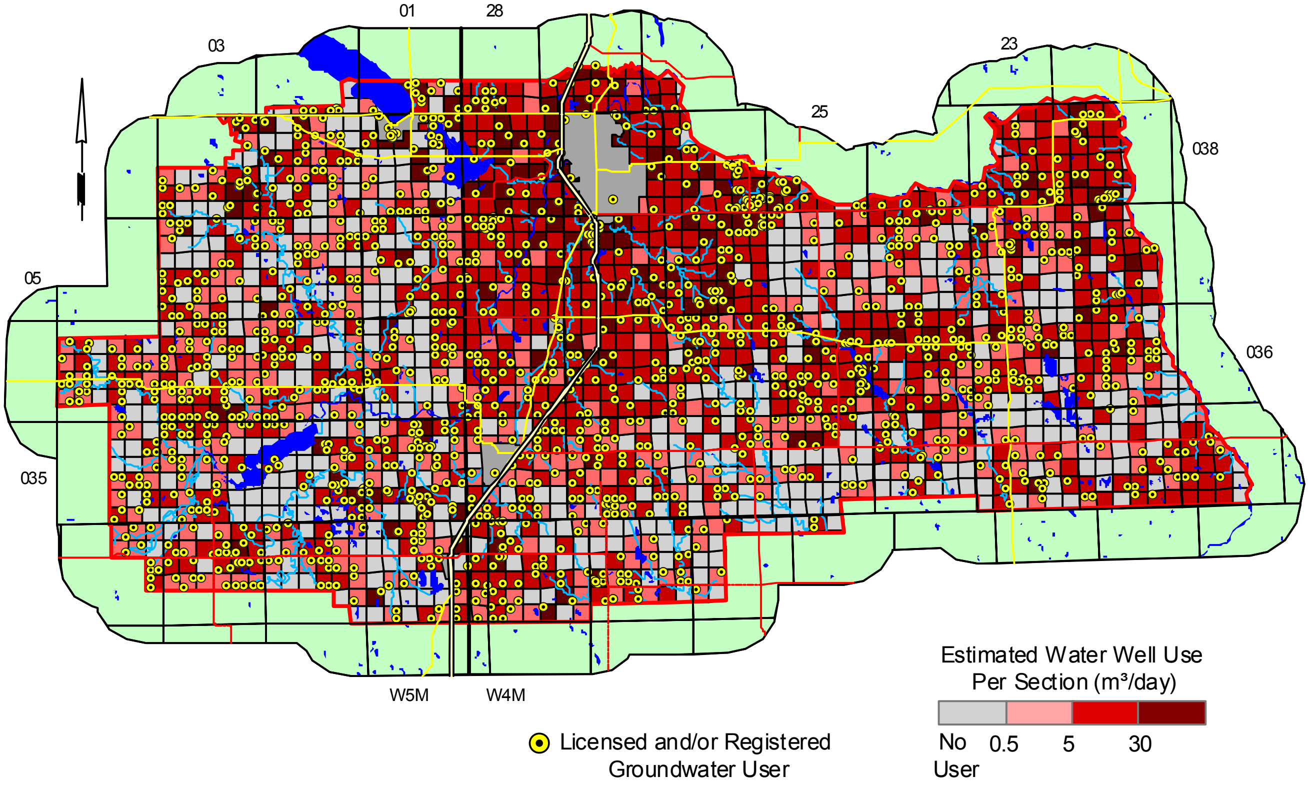
Depth to Top of Upper Horseshoe Canyon Formation



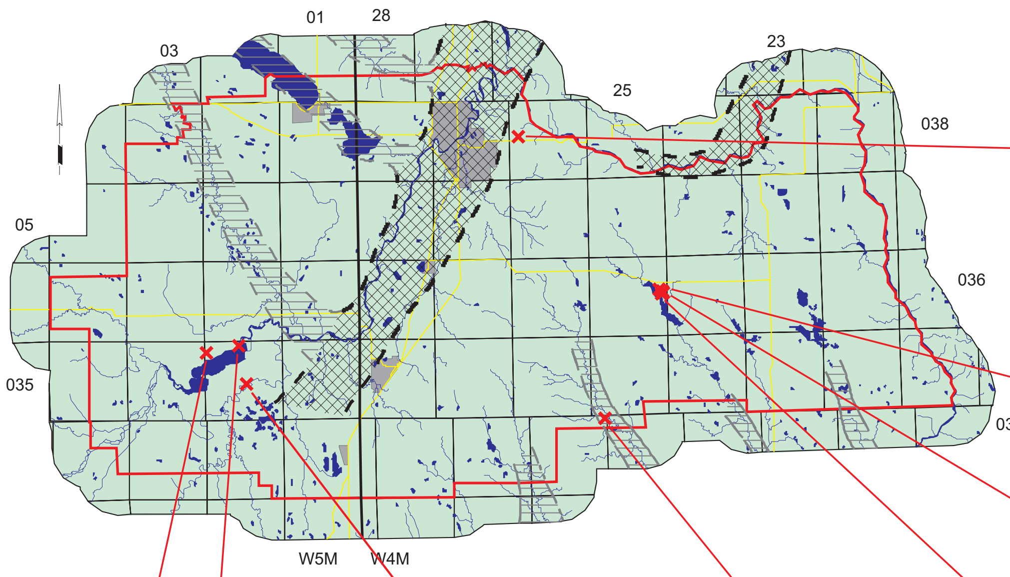
Depth to Top of Middle Horseshoe Canyon Formation



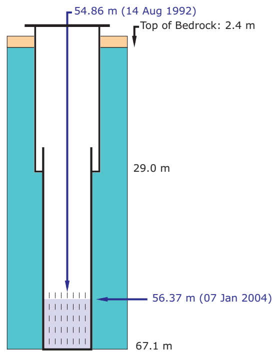
Estimated Water Well Use per Section

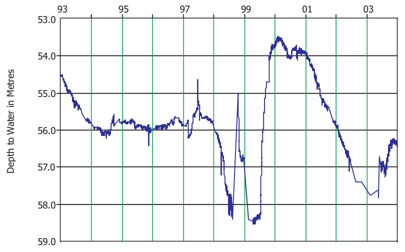


Hydrographs

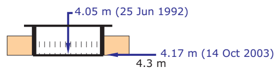


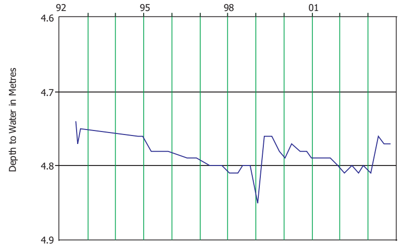
🟧 Upper Surficial
🟫 Lower Surficial
🟦 Dalehurst Member



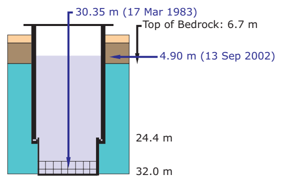


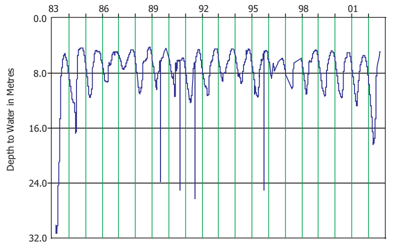
M36076.564445 - AENV Meadowglen Obs WW
— Water-Level Measurement



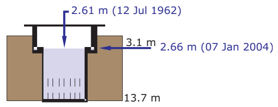


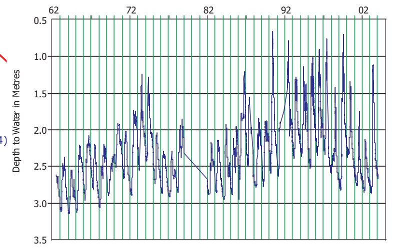
M35377.115302 - AENV Pine Lake Obs WW No. 2677E
— Water-Level Measurement



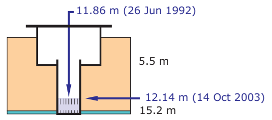


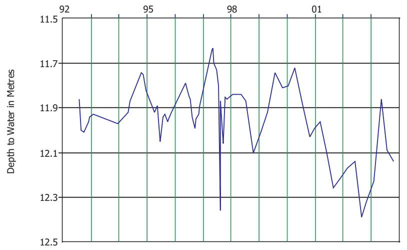
M35379.095565 - AENV Dickson Dam Obs WW No. 82-1
— Water-Level Measurement



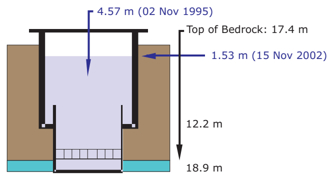


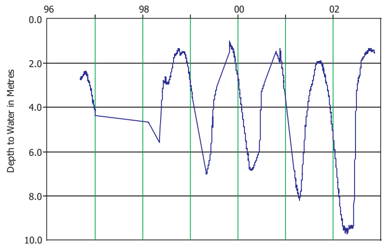
M37267.767255 - AENV Elnora Obs WW No. 5
— Water-Level Measurement



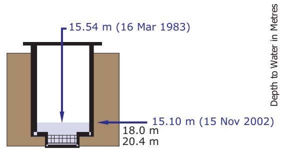


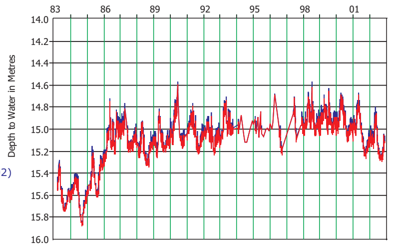
M35377.115303 - AENV Pine Lake Obs WW No. 2678E
— Water-Level Measurement



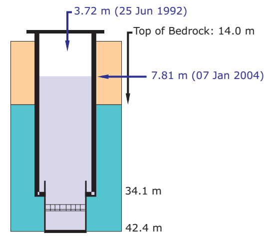


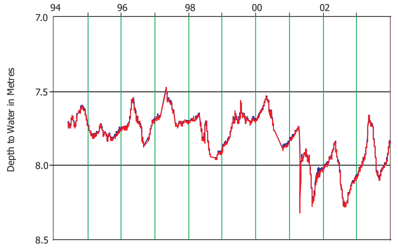
M37267.767254 - AENV Dickson Dam Obs WW No. 4031R
— Water-Level Measurement





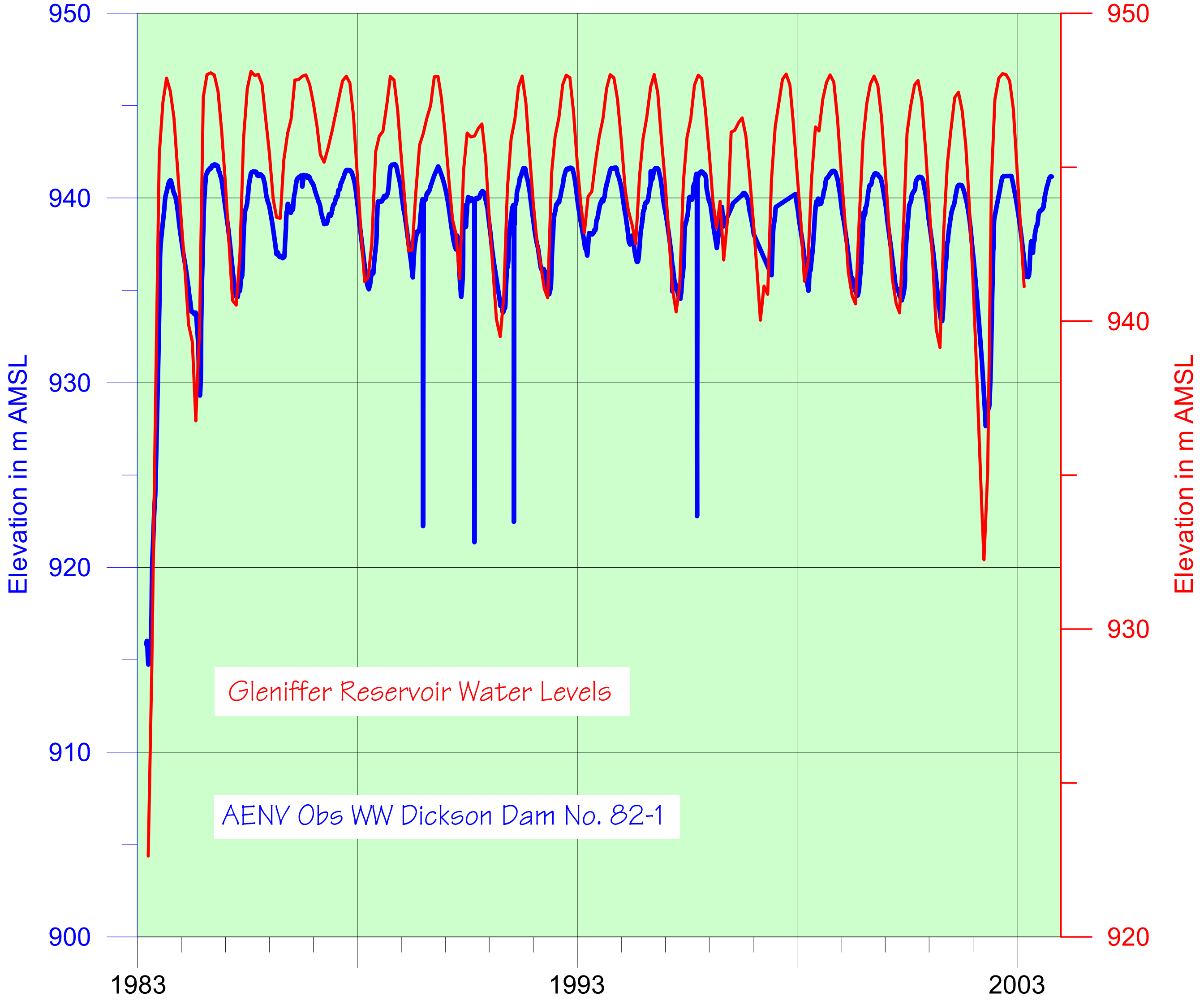
M35379.071687 - AENV Dickson Dam Obs WW No. 4015A
— Highest Water-Level Measurement — Lowest Water-Level Measurement



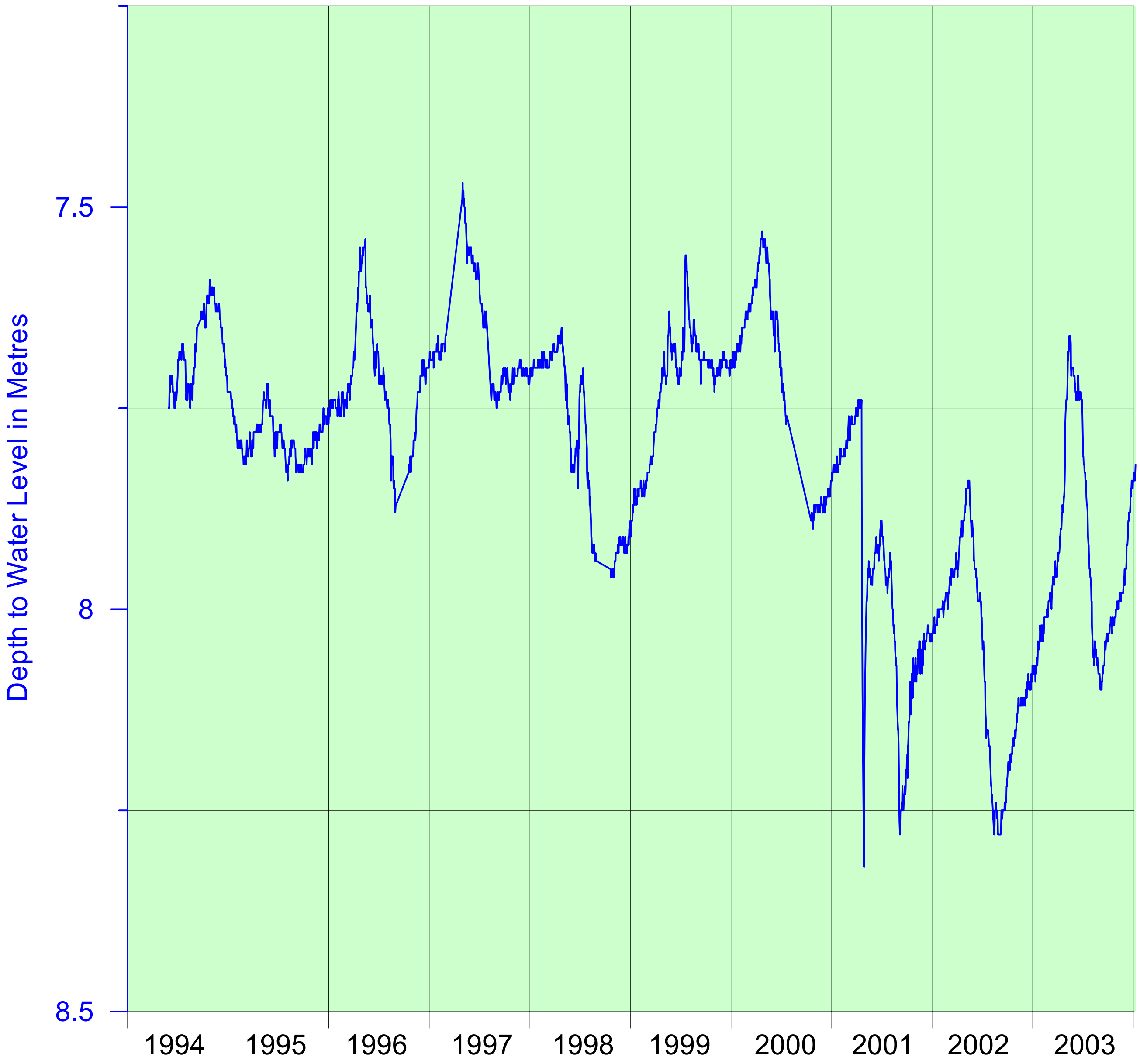


M35377.115301 - AENV Pine Lake Obs WW No. 2676E
— Highest Water-Level Measurement — Lowest Water-Level Measurement

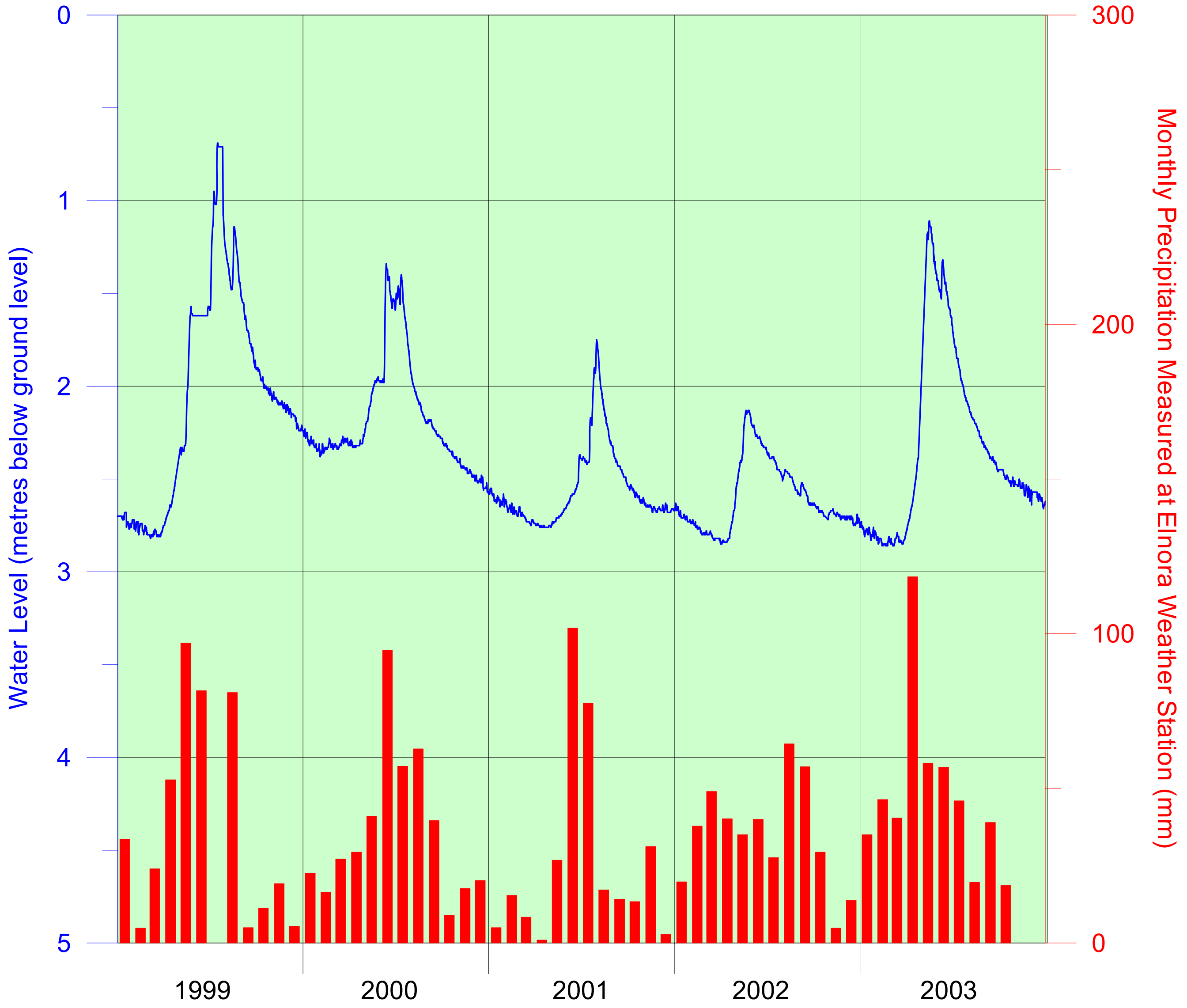
Comparison of Water Levels in AENV Dickson Dam Obs WW No. 82-1 and Gleniffer Reservoir



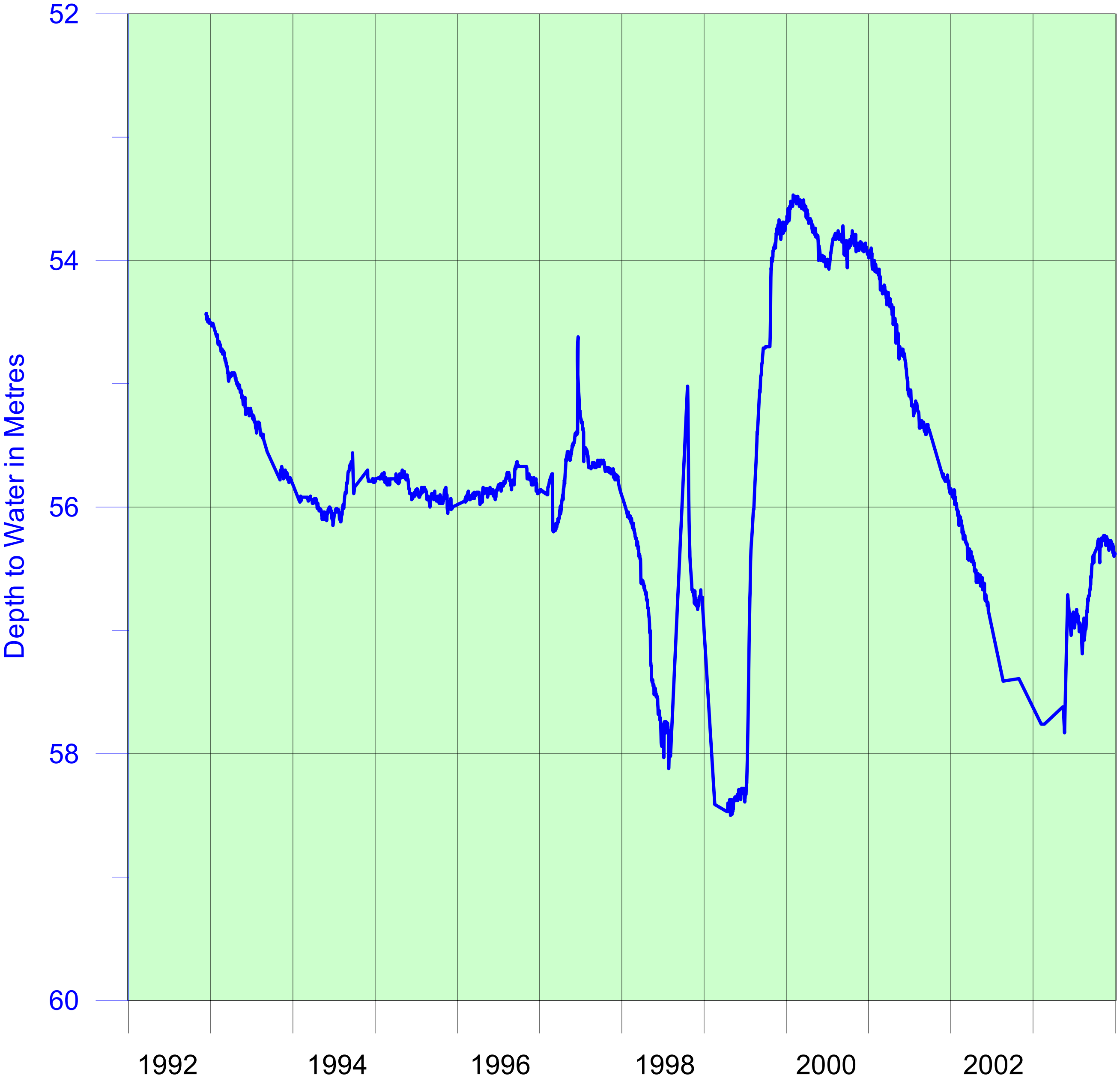
Water Levels in AENV Pine Lake Obs WW No. 2676E



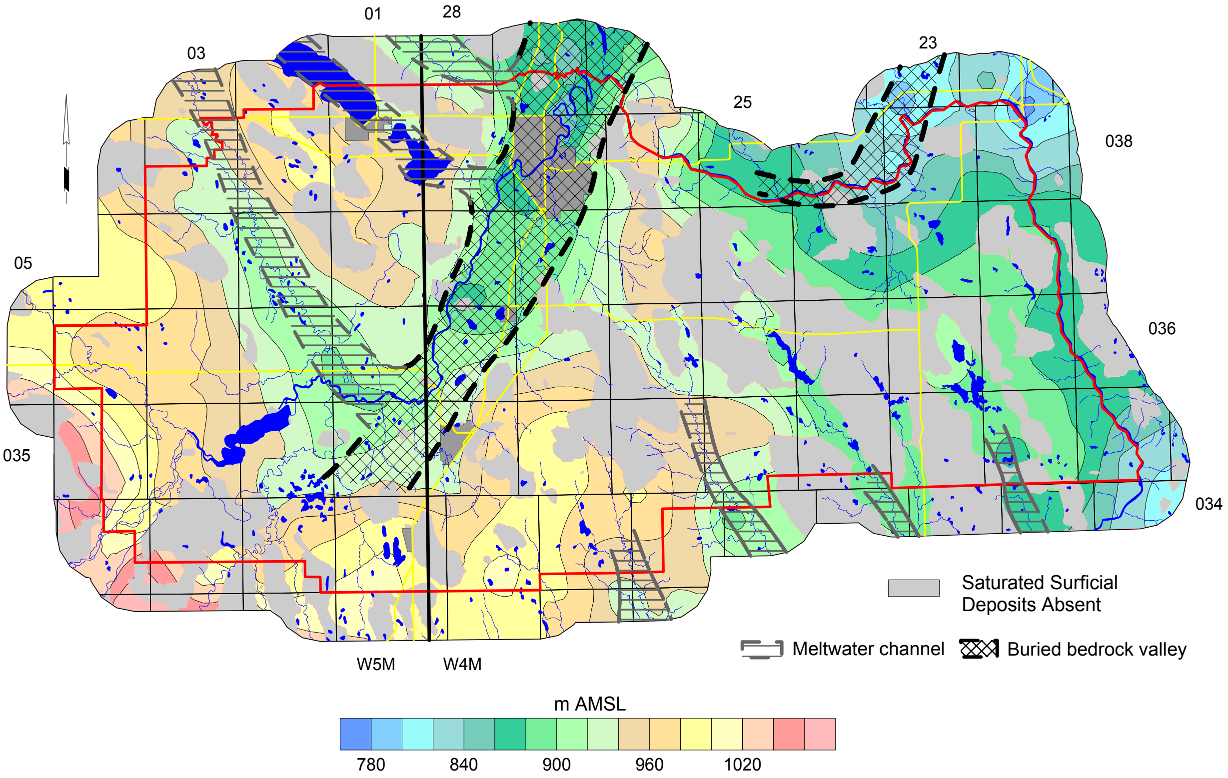
Monthly Precipitation and Water Levels in AENV Elnora Obs WW No. 5



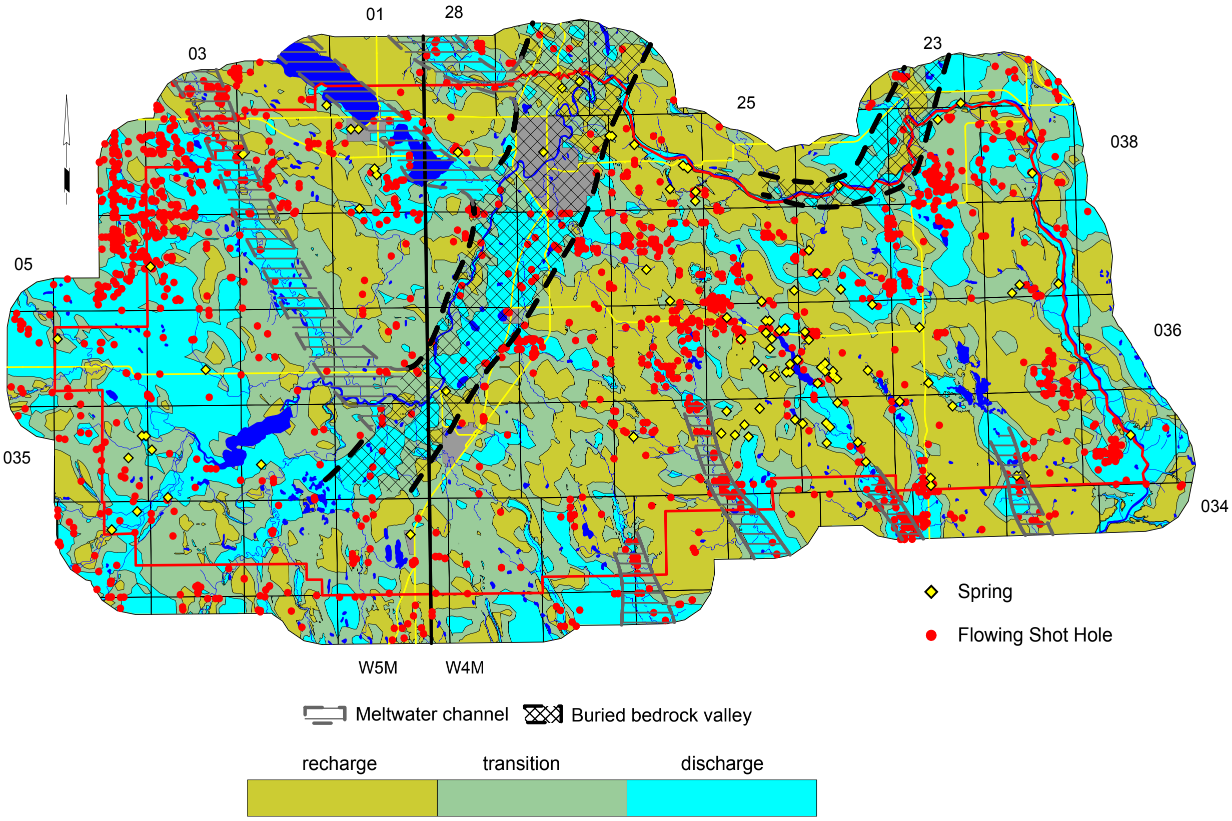
Water Levels in AENV Meadowglen Obs WW



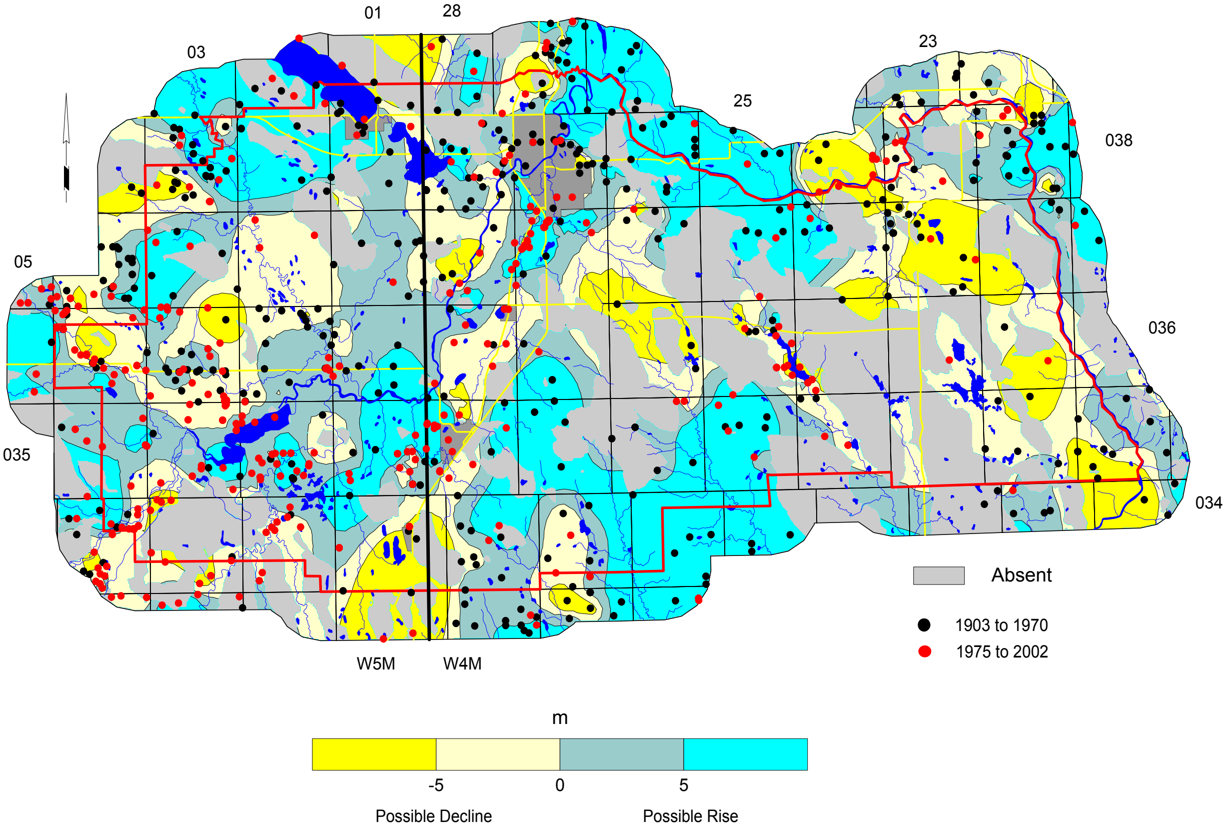
Non-Pumping Water-Level Surface in Surficial Deposits Based on Water Wells Less than 20 Metres Deep



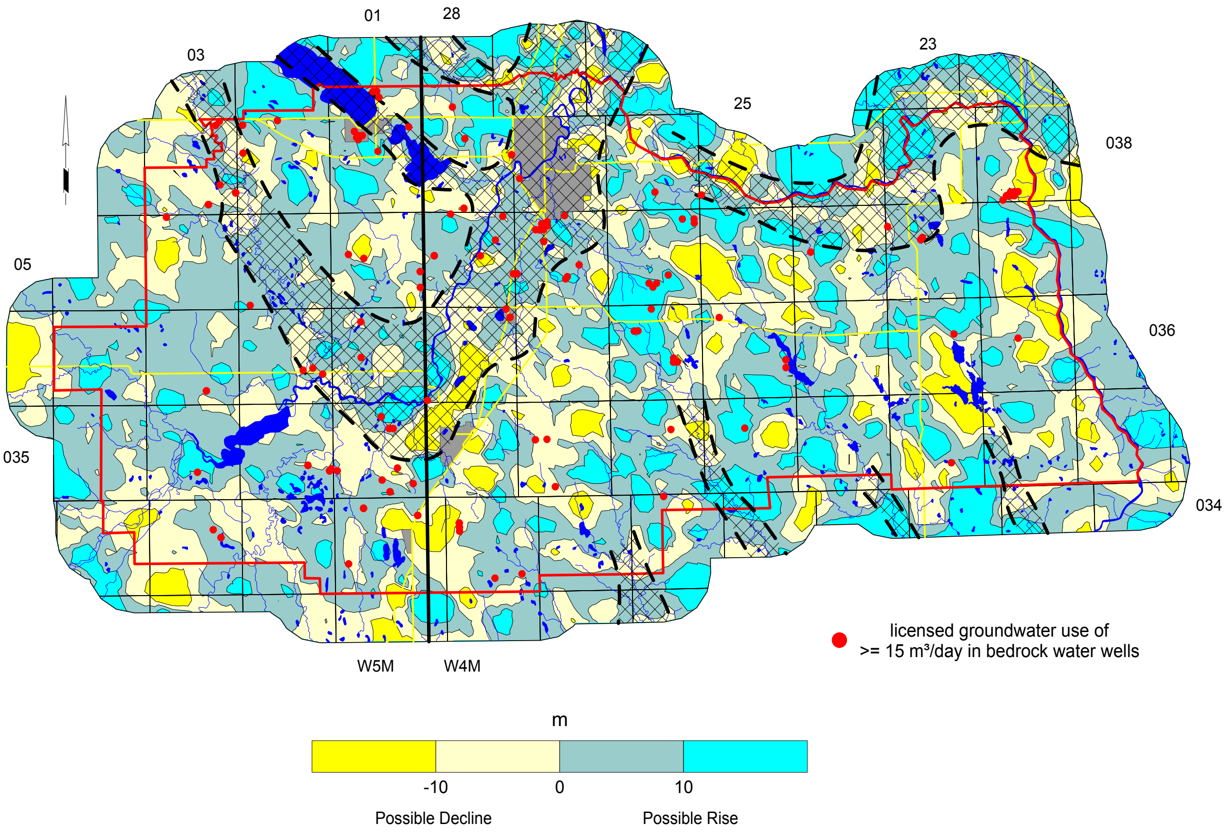
Bedrock Recharge/Discharge Areas



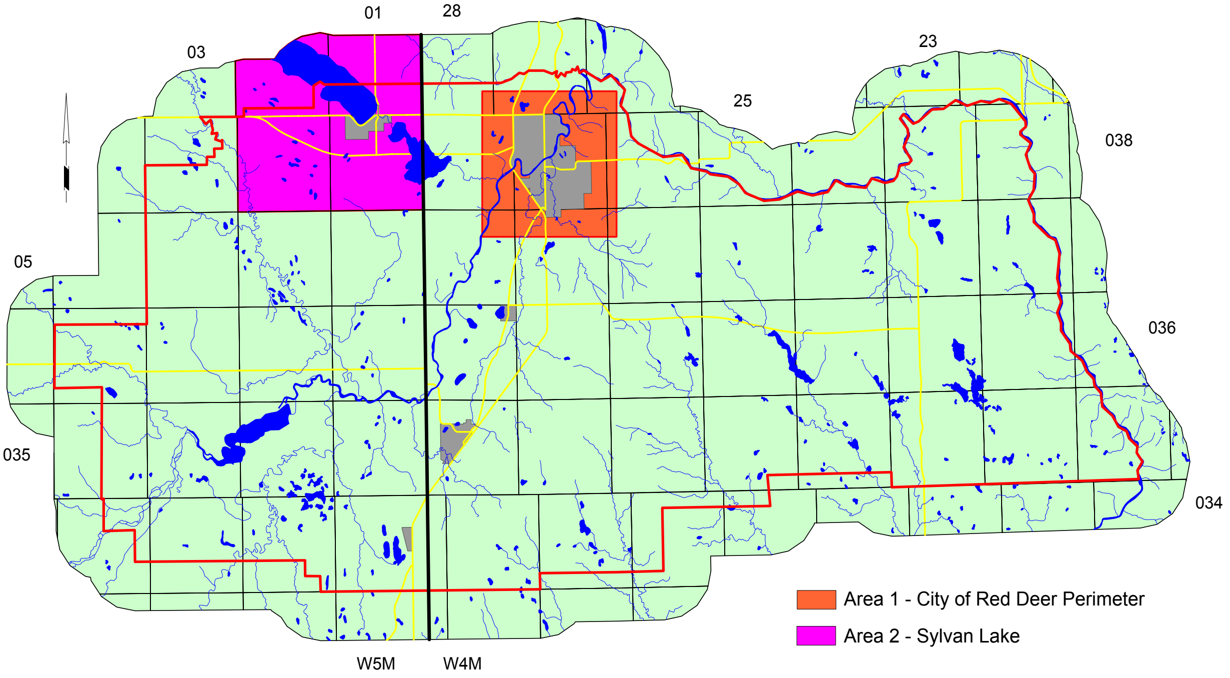
Changes in Water Levels in Surficial Deposits



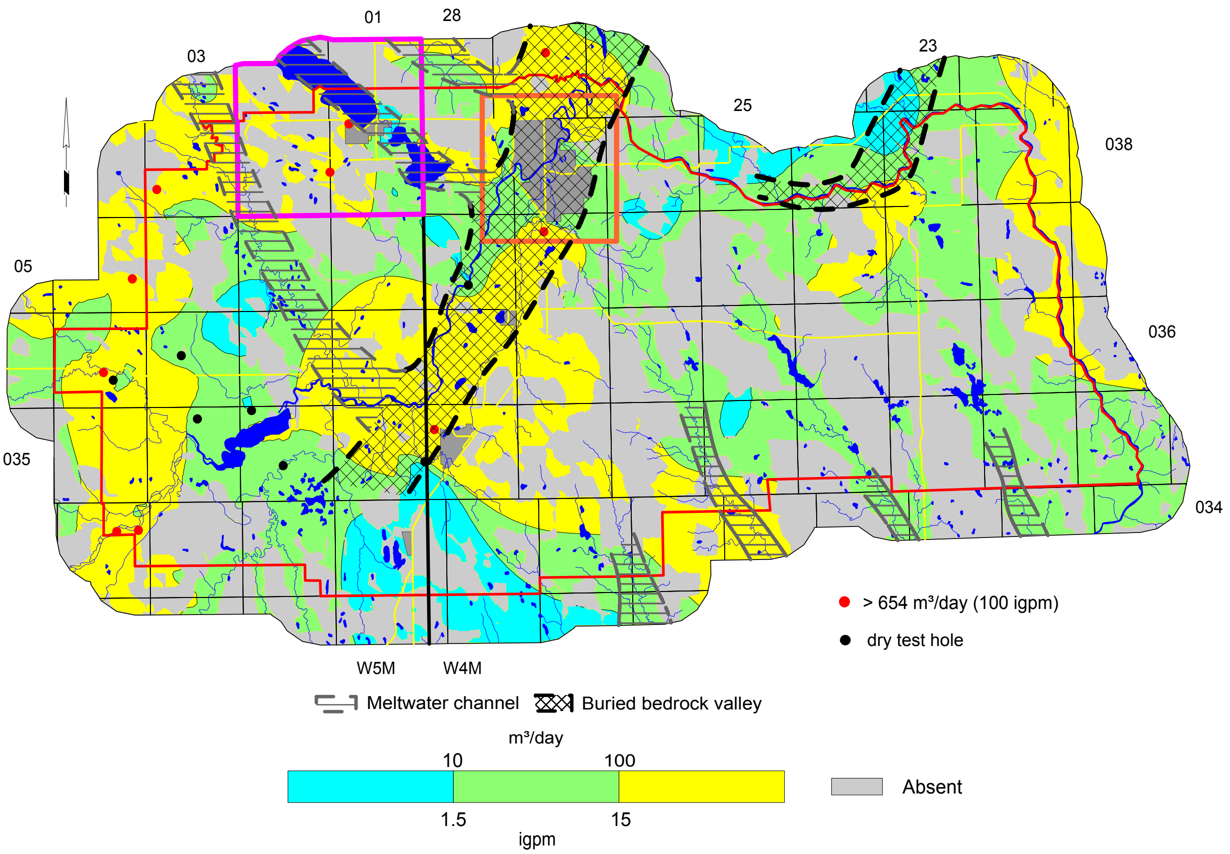
Areas of Potential Groundwater Depletion - Upper Bedrock Aquifer(s)



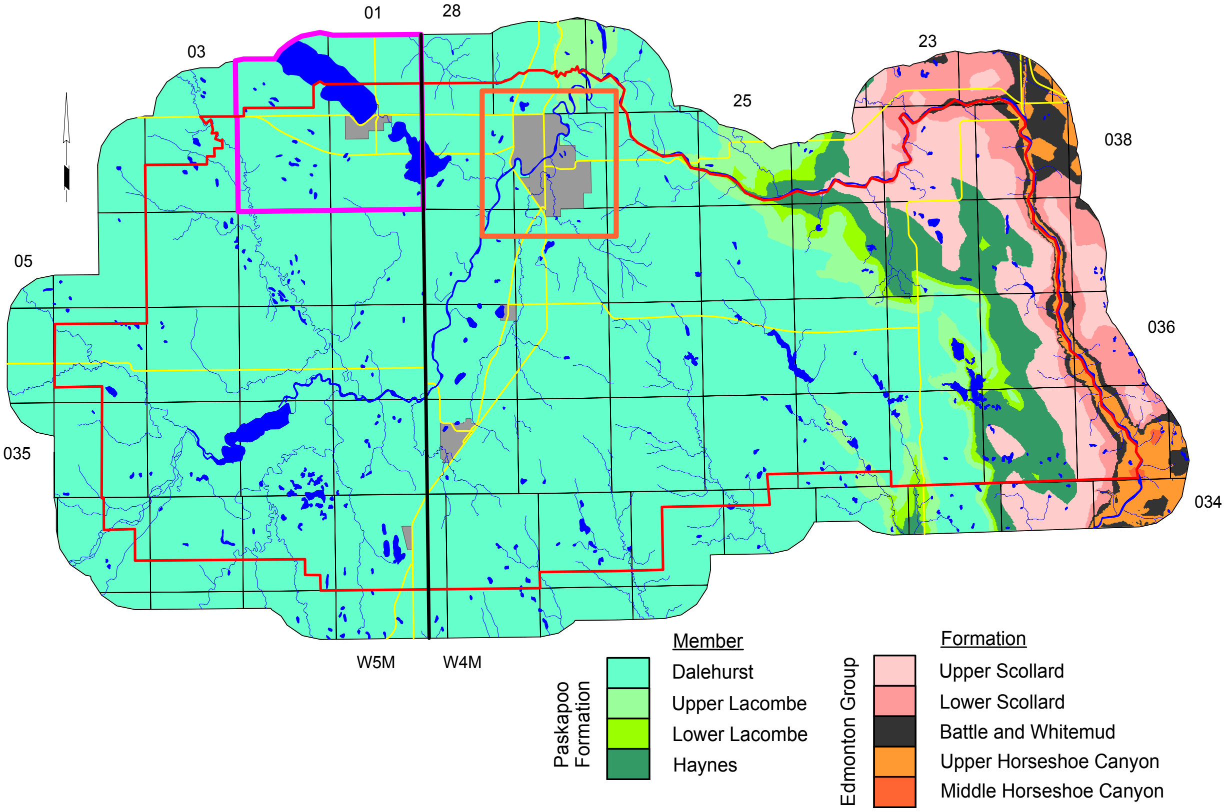
Location of Specific Study Areas



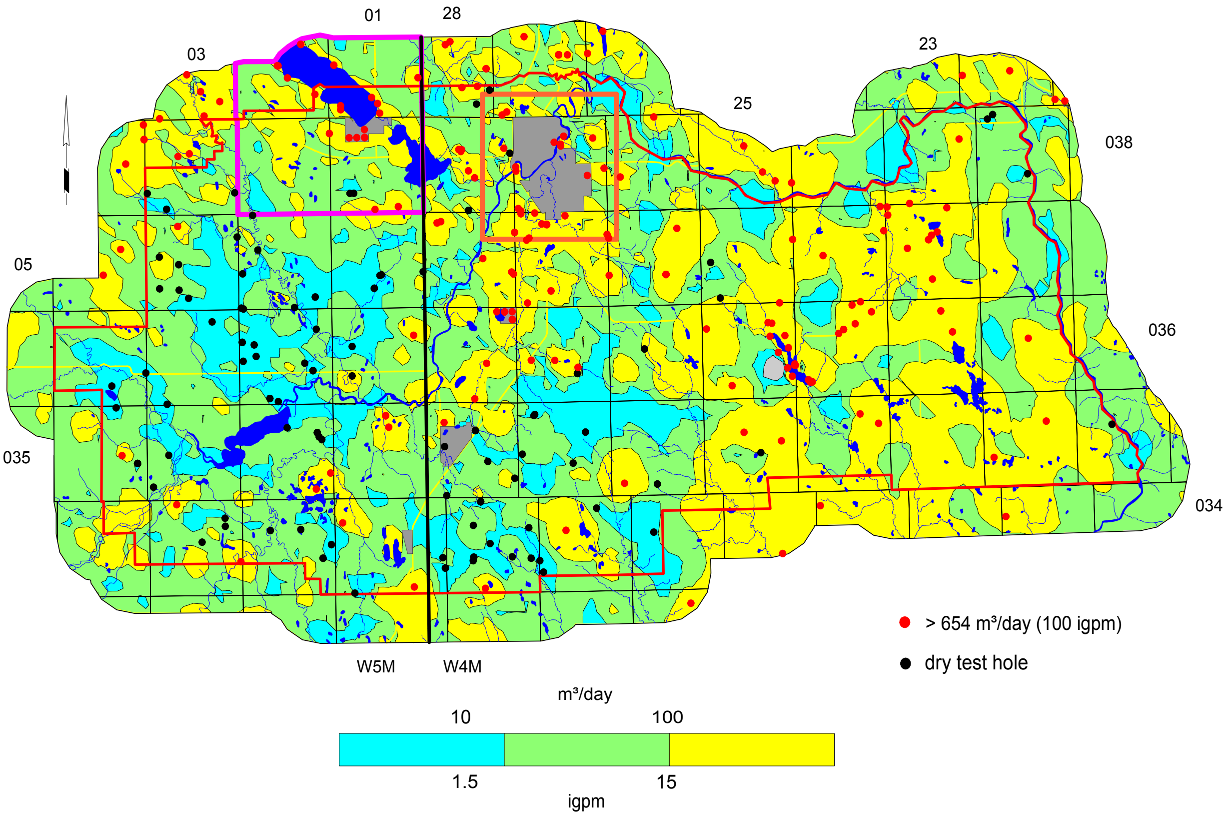
Apparent Yield for Water Wells Completed in Sand and Gravel Aquifer(s) - Specific Study Areas



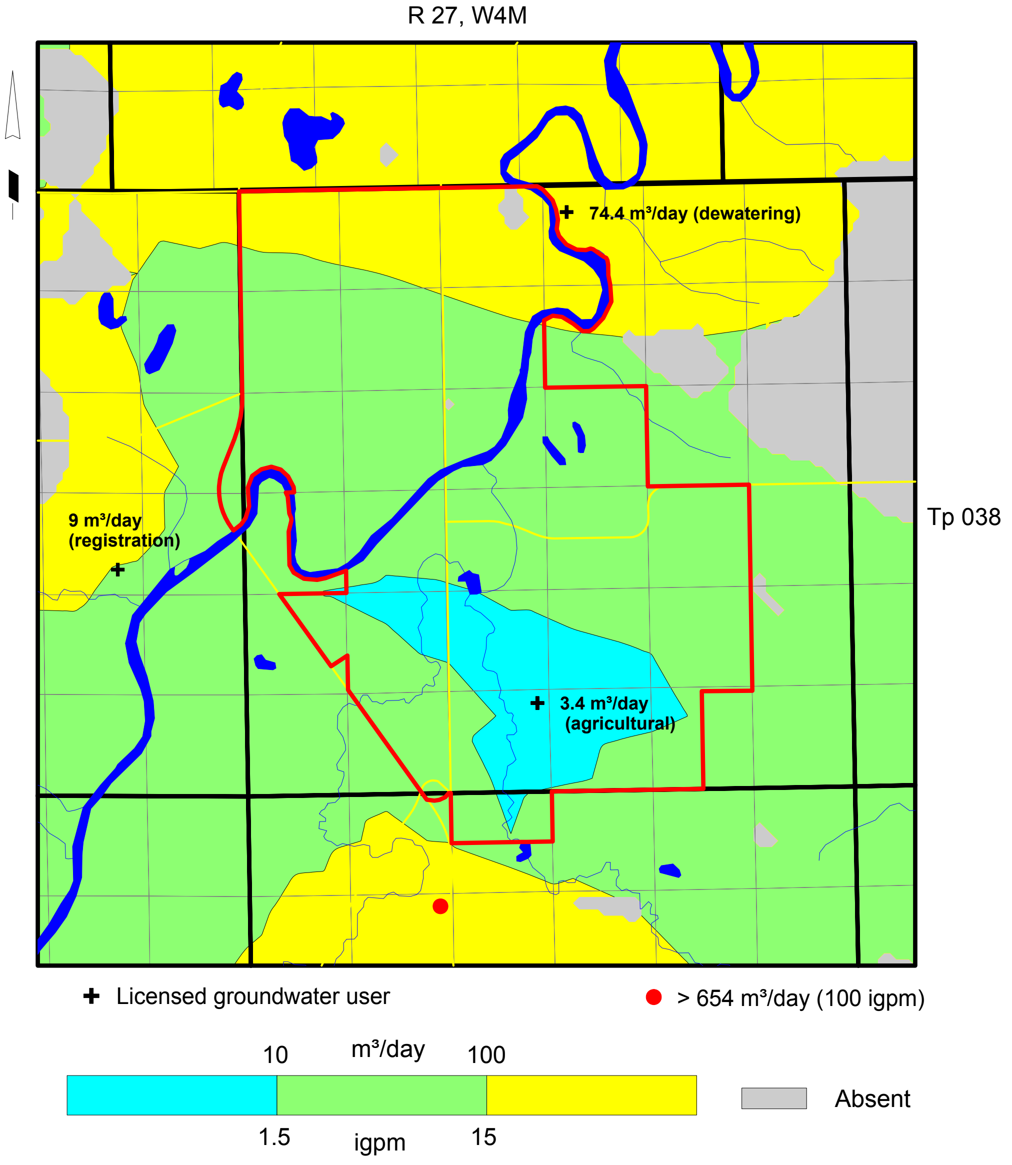
Bedrock Geology of Specific Study Areas



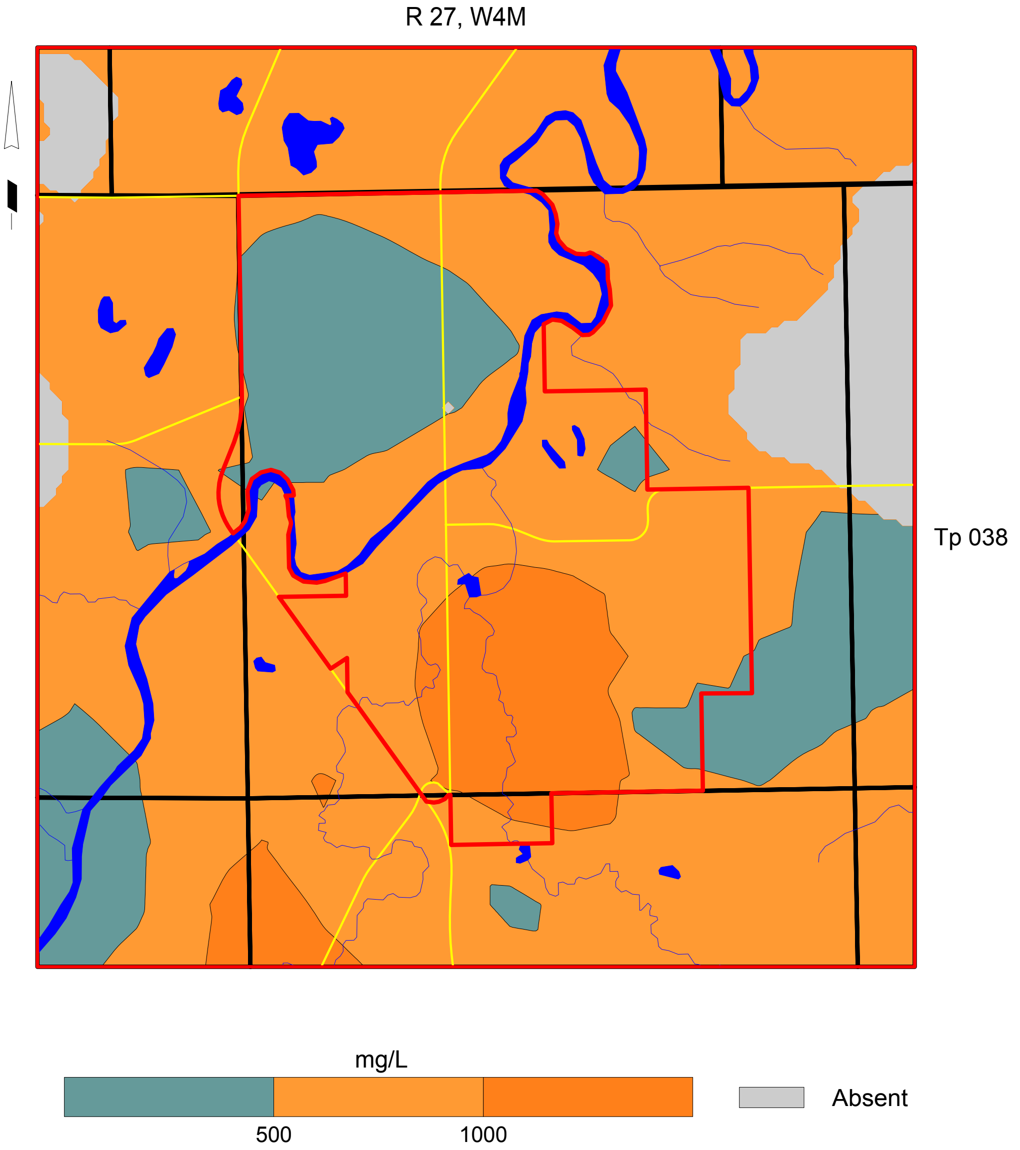
Apparent Yield for Water Wells Completed in Upper Bedrock Aquifer(s) - Specific Study Areas



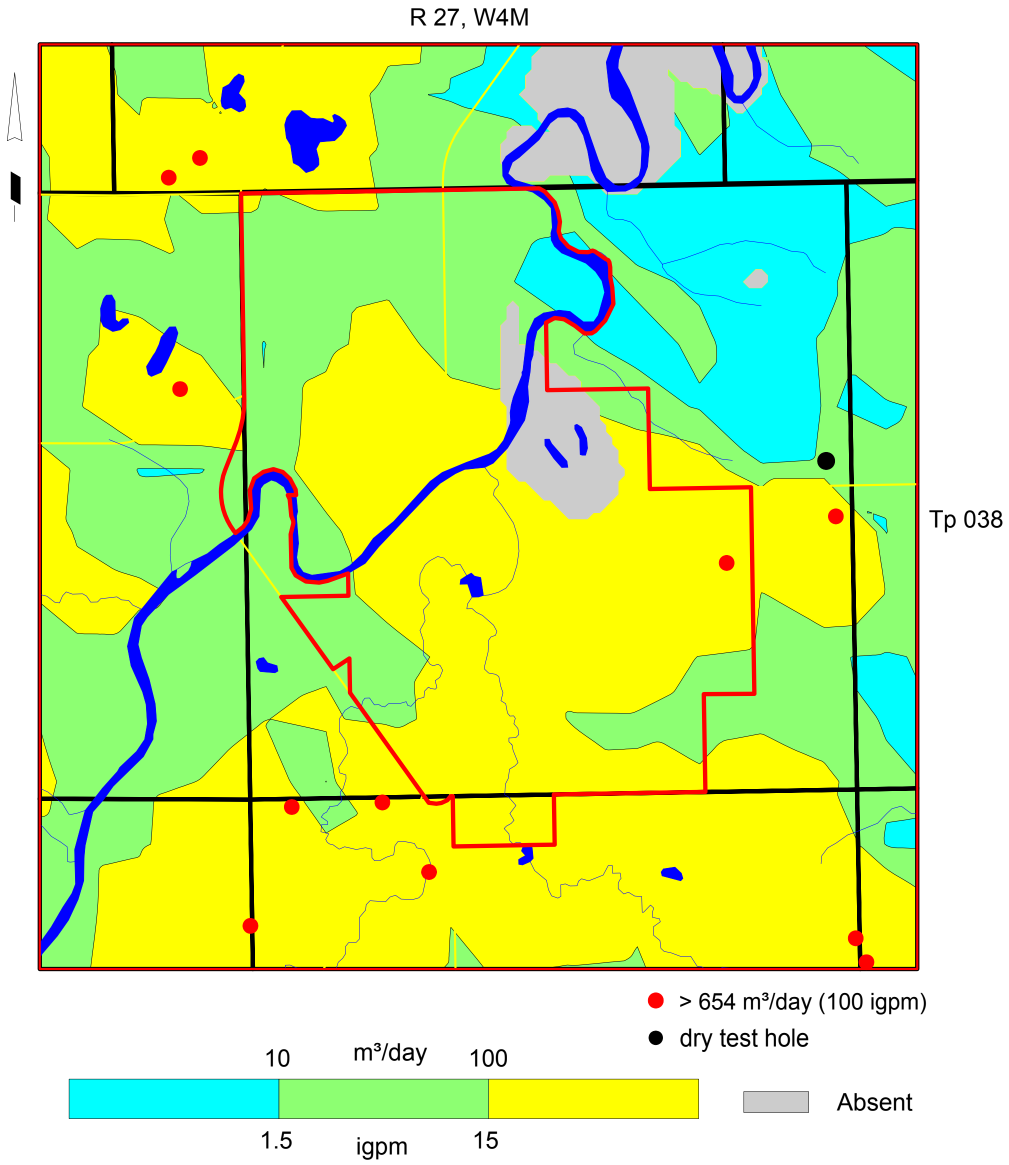
Apparent Yield for Water Wells Completed in Sand and Gravel Aquifer(s) - Area 1



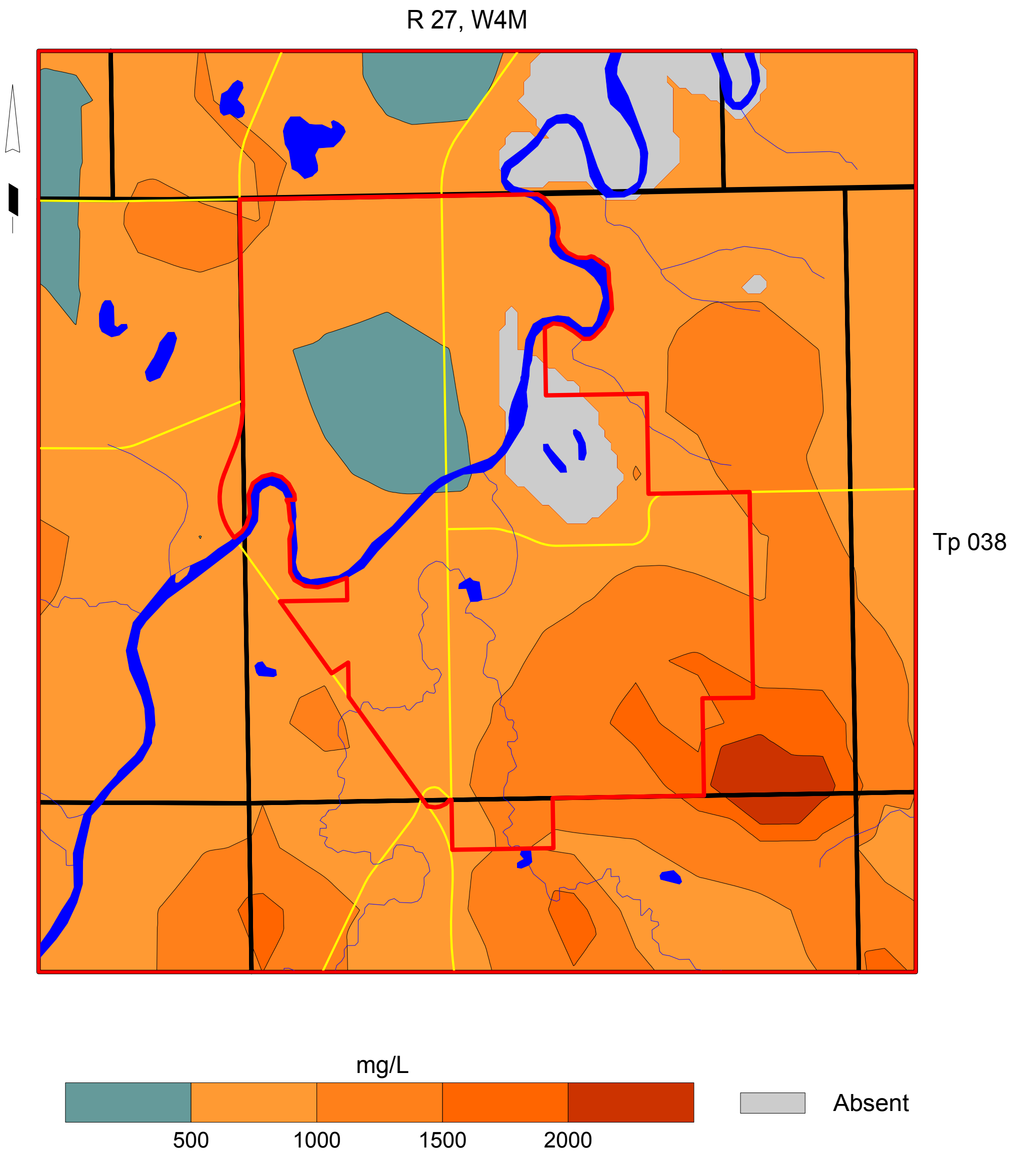
Total Dissolved Solids in Groundwater from Surficial Deposits - Area 1



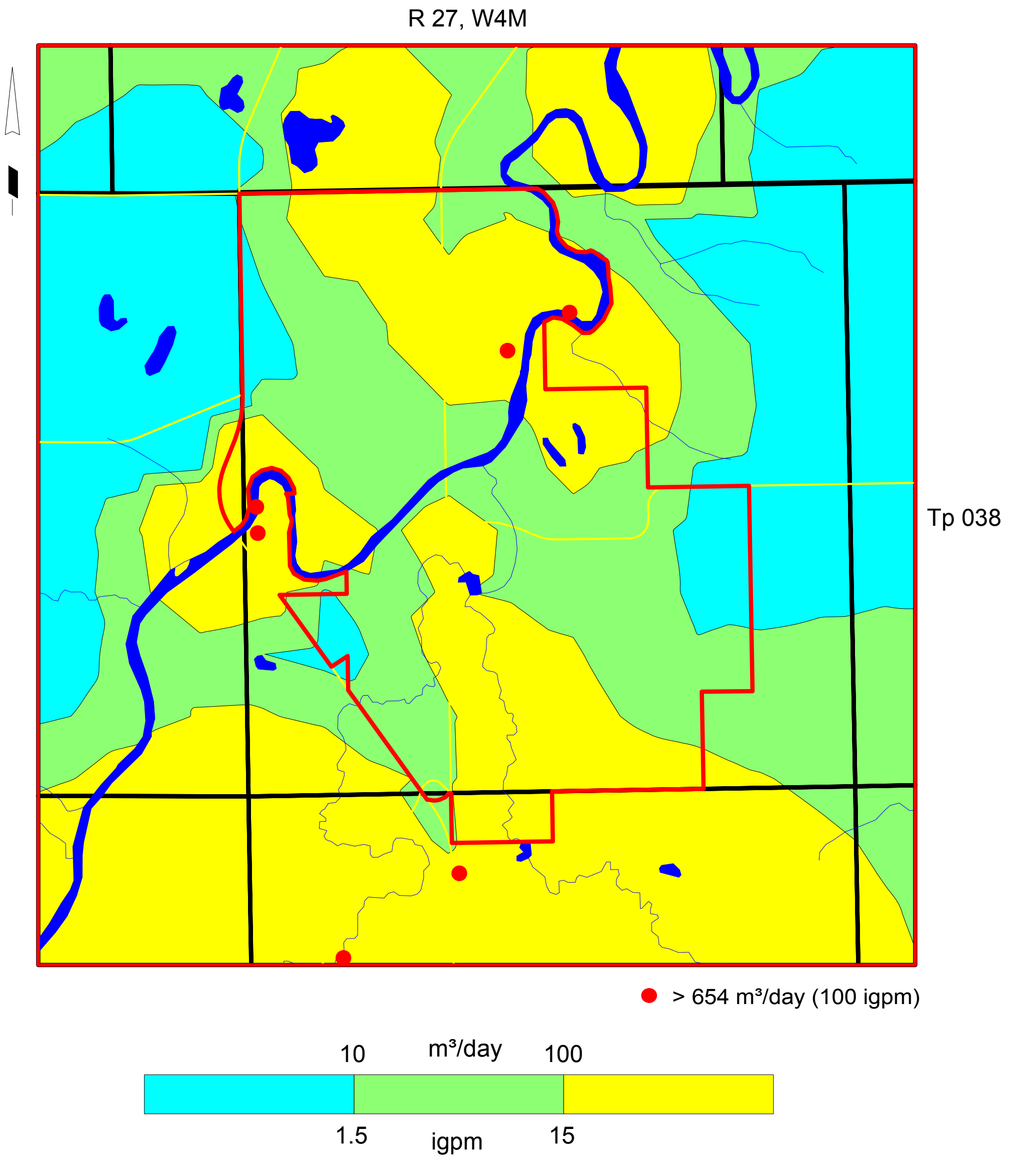
Apparent Yield for Water Wells Completed through Dalehurst Aquifer – Area 1



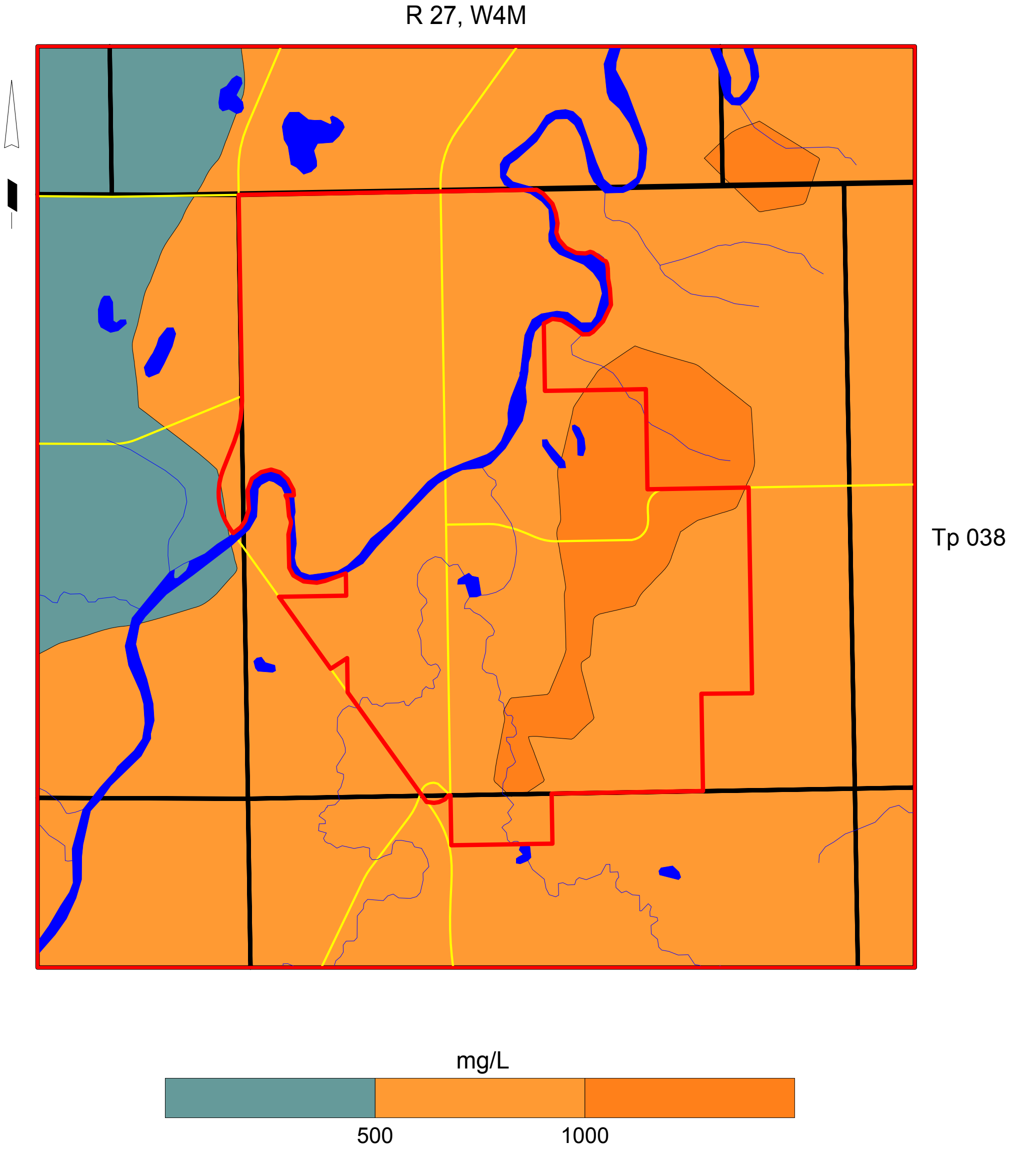
Total Dissolved Solids in Groundwater from Dalehurst Aquifer – Area 1



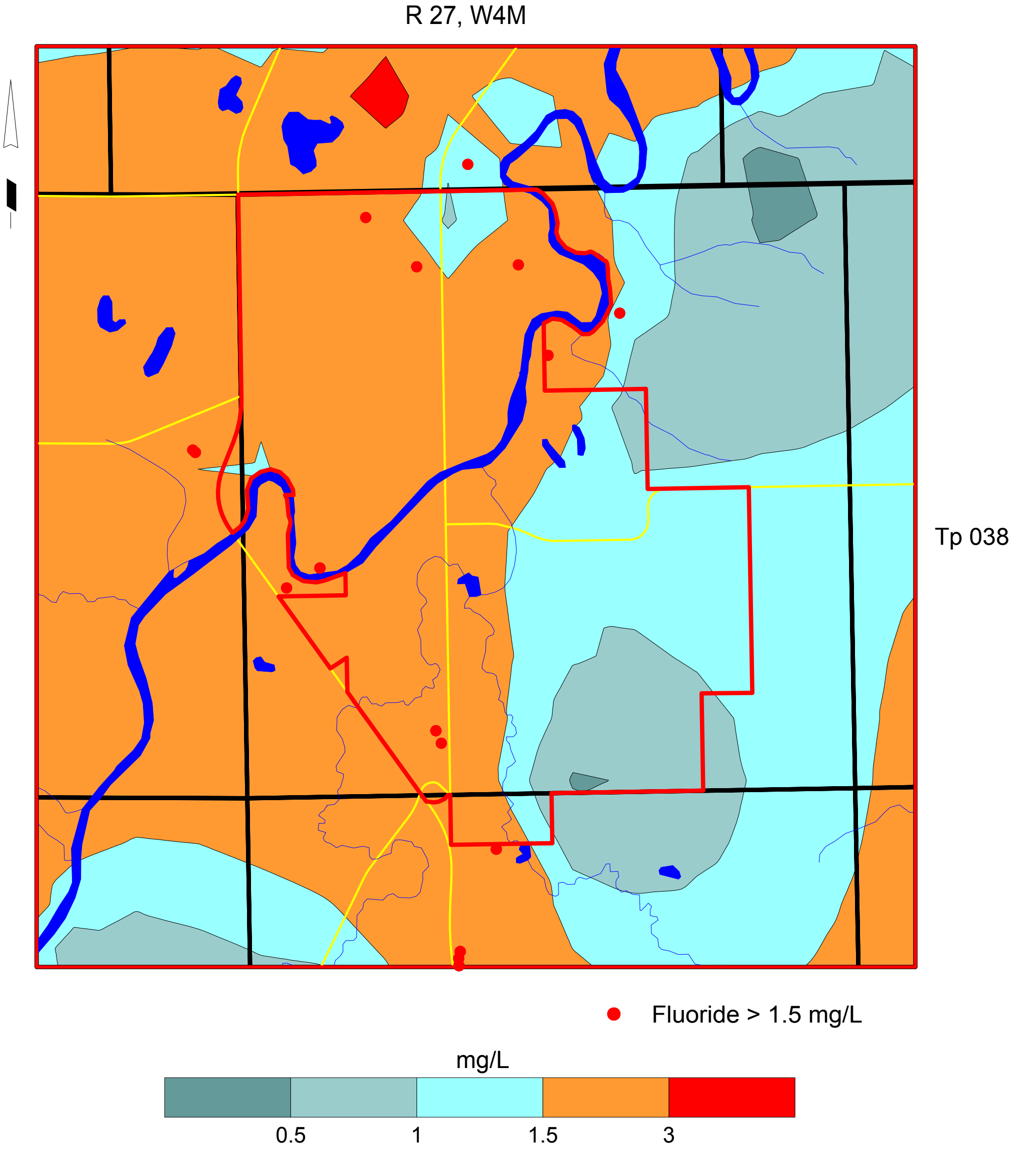
Apparent Yield for Water Wells Completed through Upper Lacombe Aquifer – Area 1



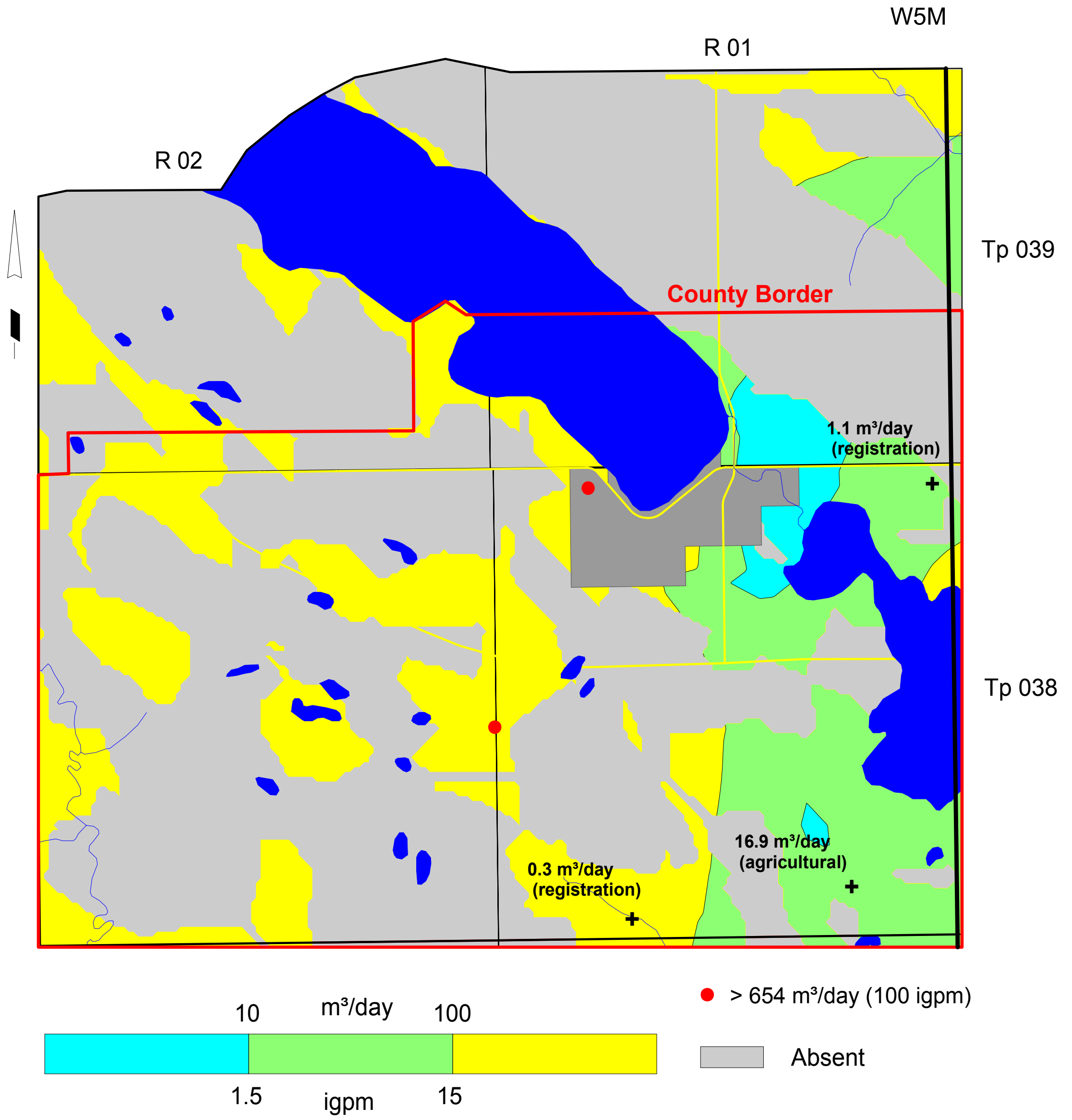
Total Dissolved Solids in Groundwater from Upper Lacombe Aquifer – Area 1



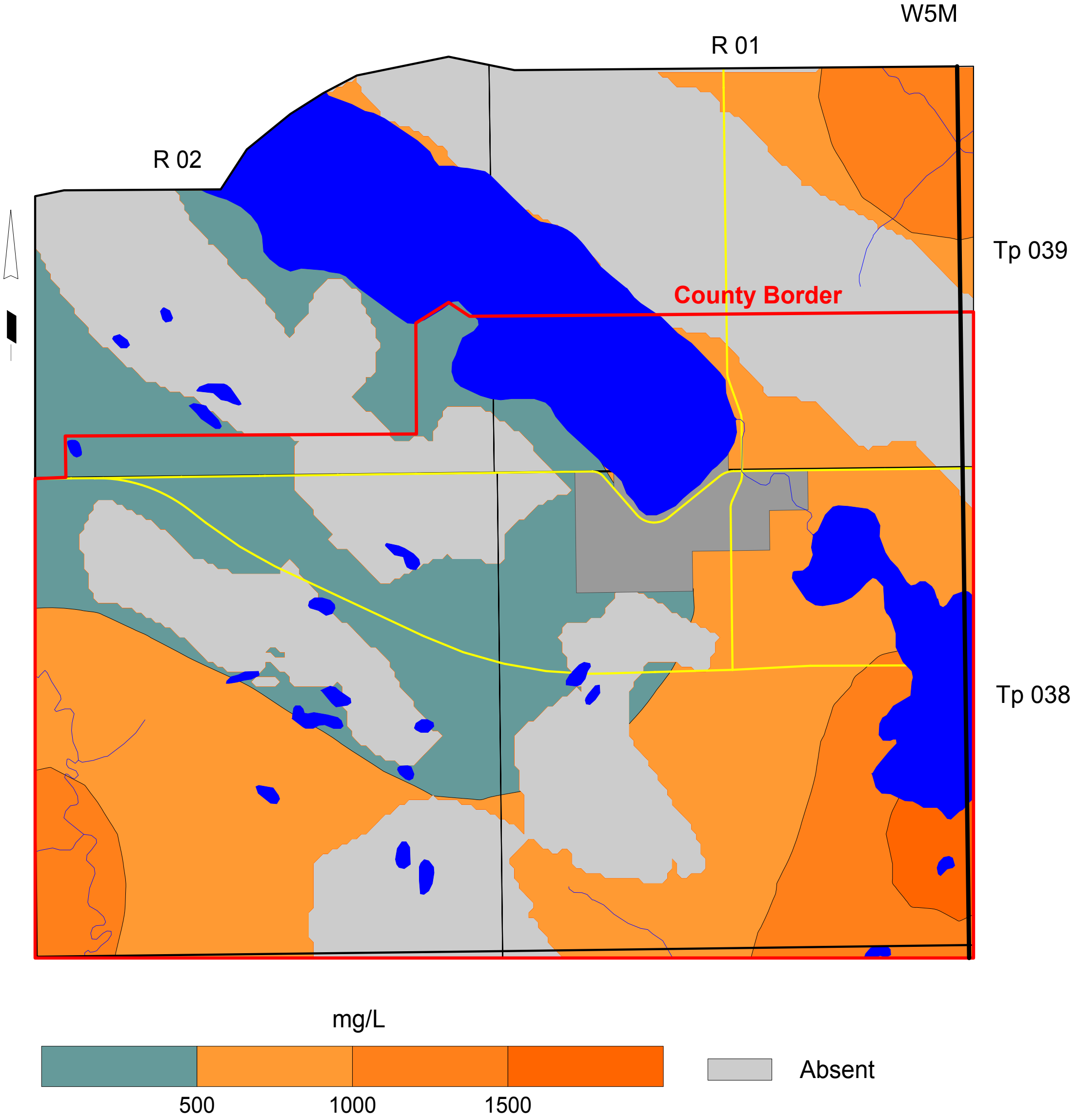
Fluoride in Groundwater from Upper Lacombe Aquifer – Area 1



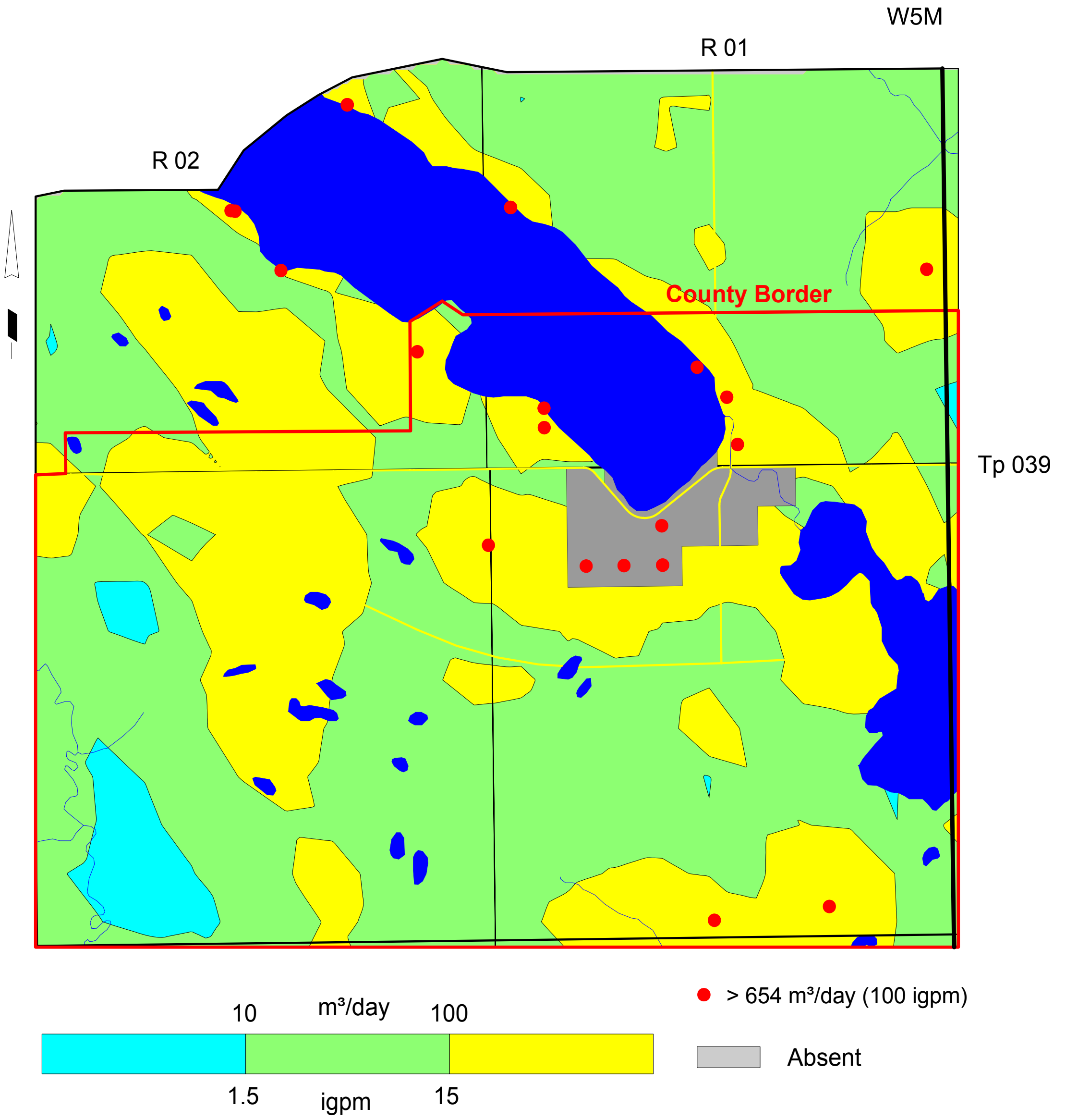
Apparent Yield for Water Wells Completed in Sand and Gravel Aquifer(s) – Area 2



Total Dissolved Solids in Groundwater from Surficial Deposits – Area 2



Apparent Yield for Water Wells Completed through Dalehurst Aquifer – Area 2



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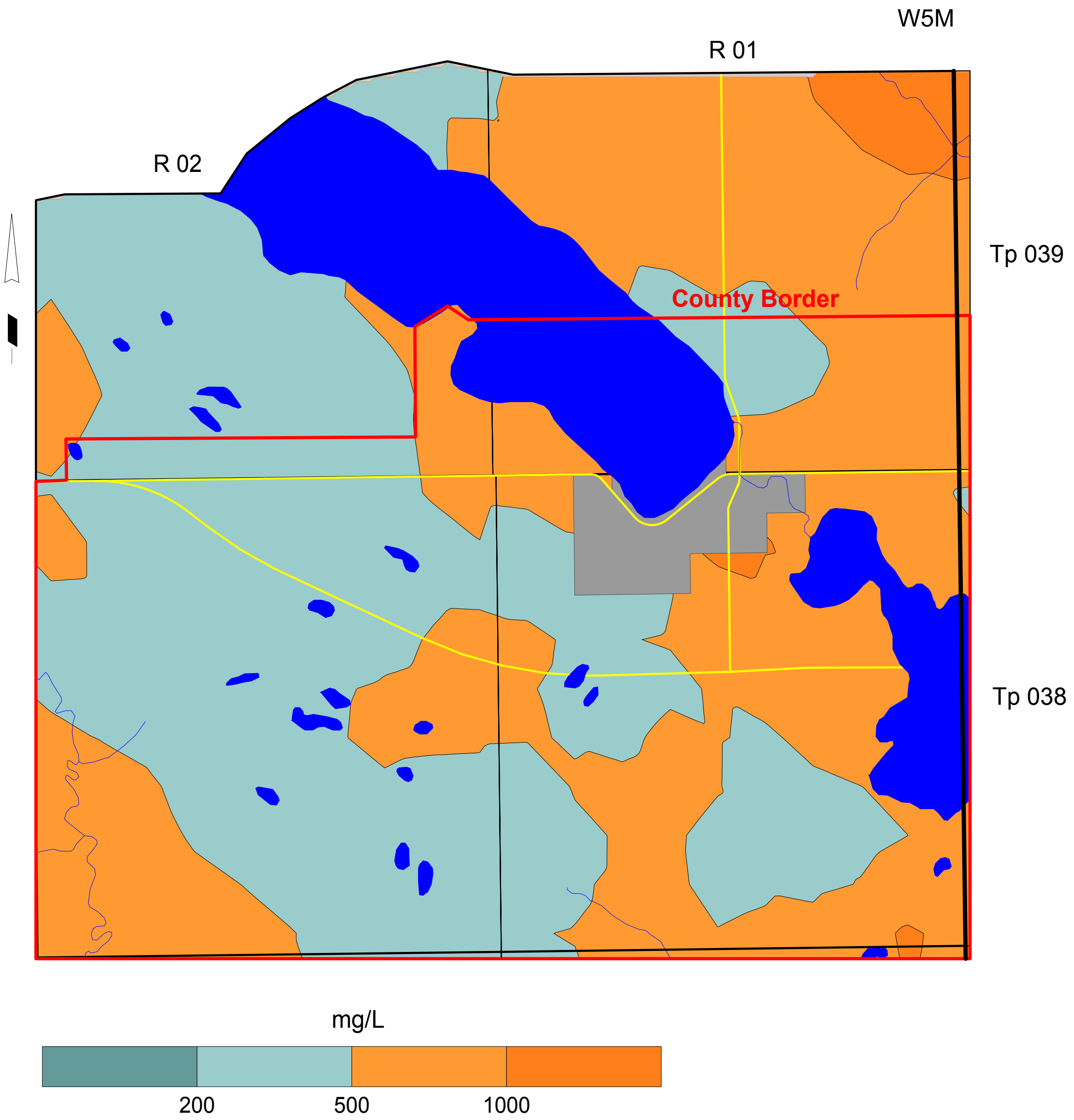
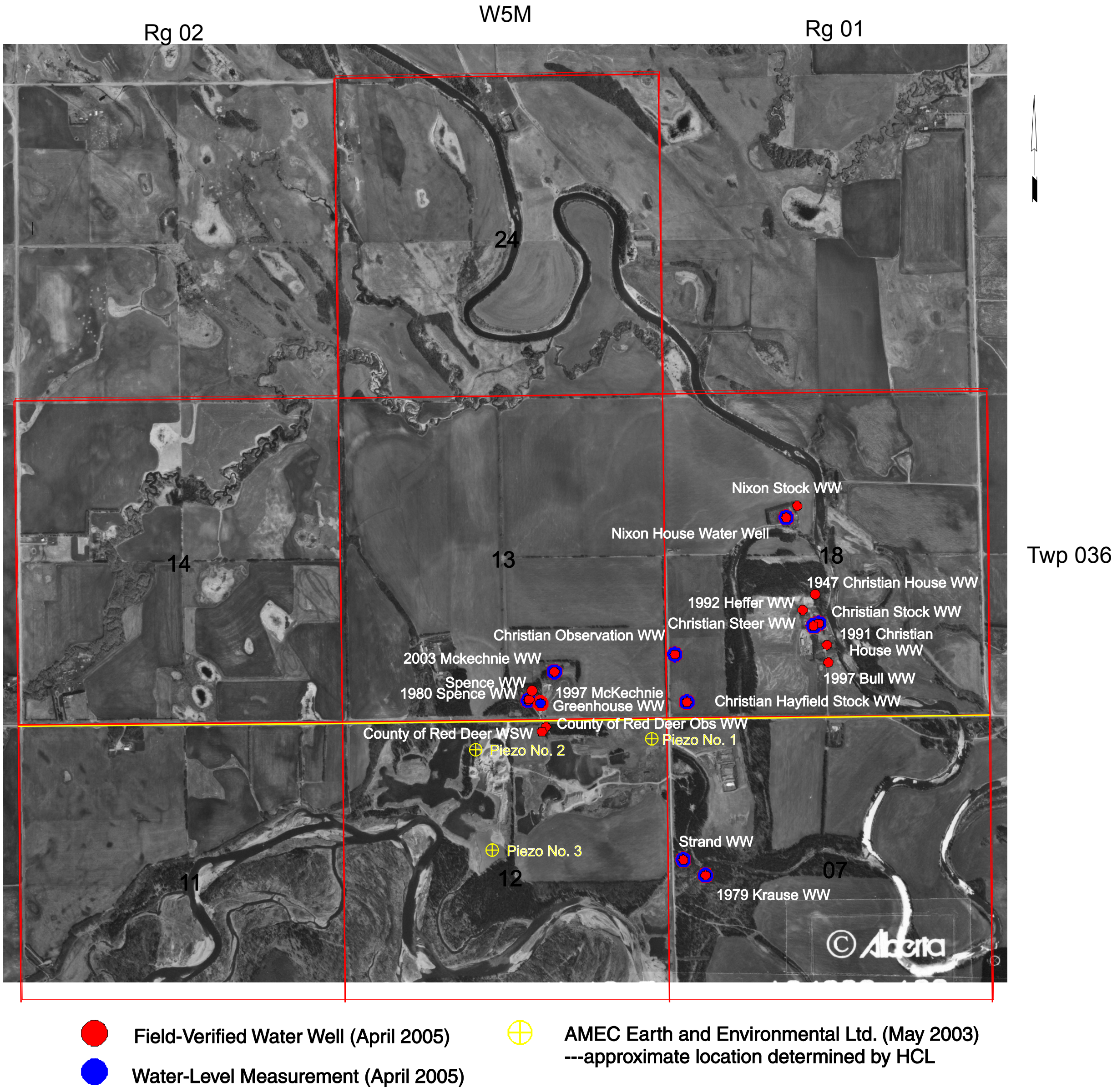
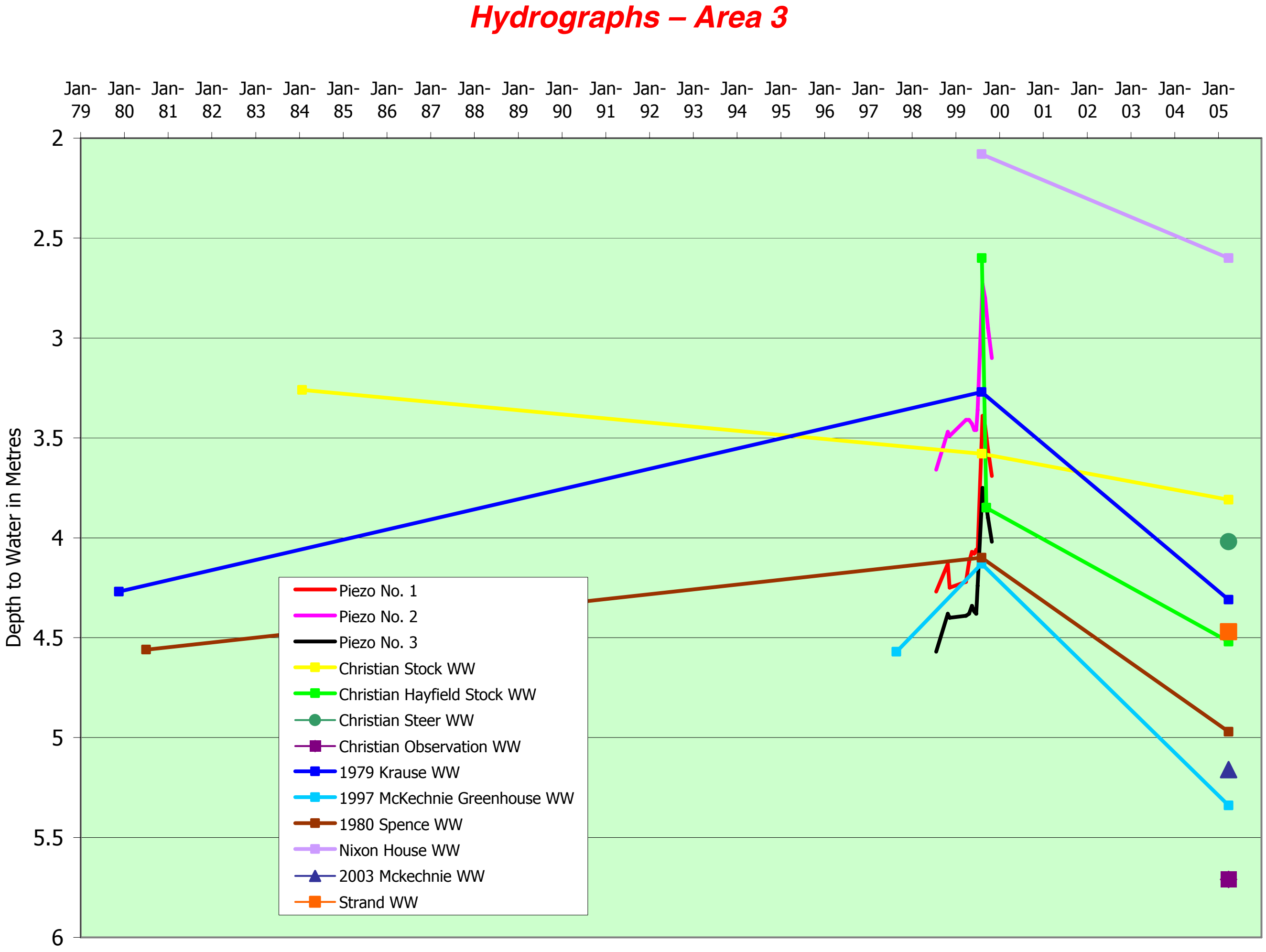


April 2005 Field-Verified Water Wells – Area 3

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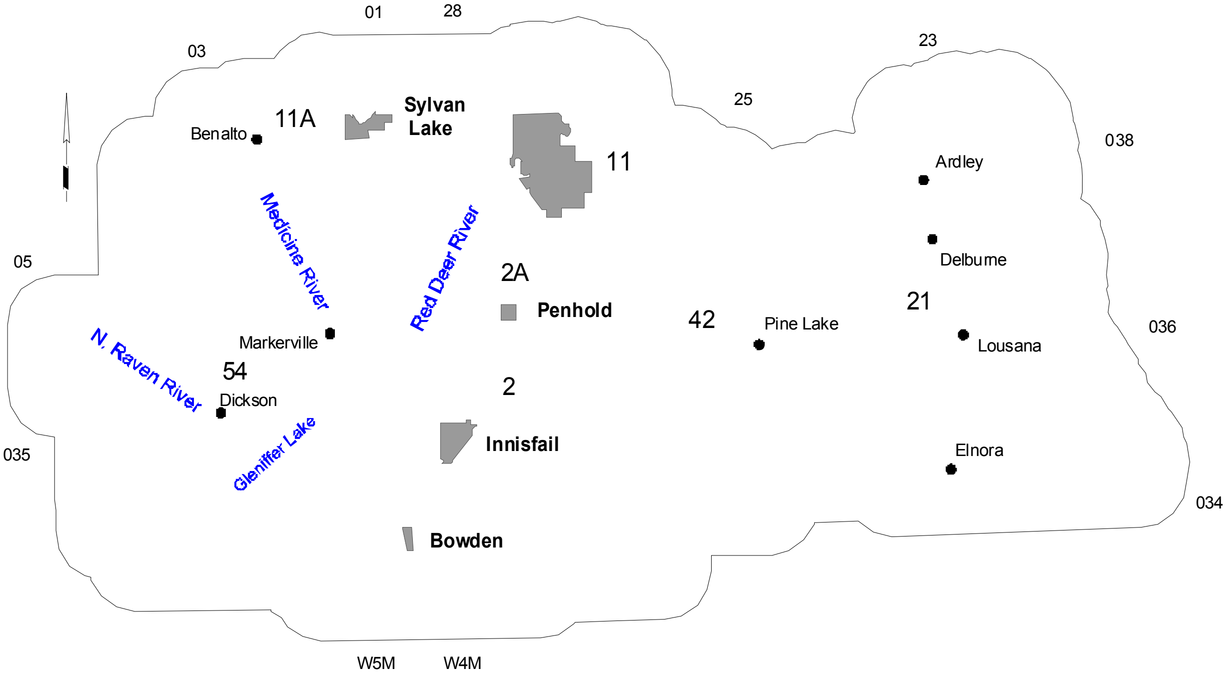
Depth to Water in Metres
Piezo No. 1
Piezo No. 2
Piezo No. 3
Christian Stock WW
Christian Hayfield Stock WW
Christian Steer WW
Christian Observation WW
1979 Krause WW
1997 McKechnie Greenhouse WW
1980 Spence WW
Nixon House WW
2003 Mckechnie WW
Strand WW

Overlay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W4M
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Ardley
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Bowden

RED DEER COUNTY

Appendix B

Maps and Figures on CD-ROM

MAPS AND FIGURES ON CD-ROM

RED DEER COUNTY

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.

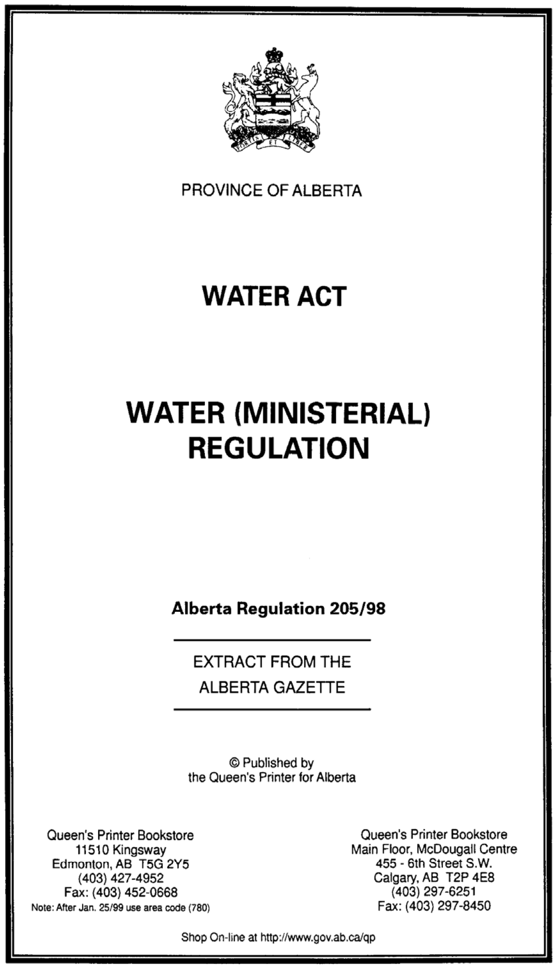
Discharge Measurements

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.

Water Act - Water (Ministerial) Regulation



PROVINCE OF ALBERTA

WATER ACT

WATER (MINISTERIAL) REGULATION

Alberta Regulation 205/98

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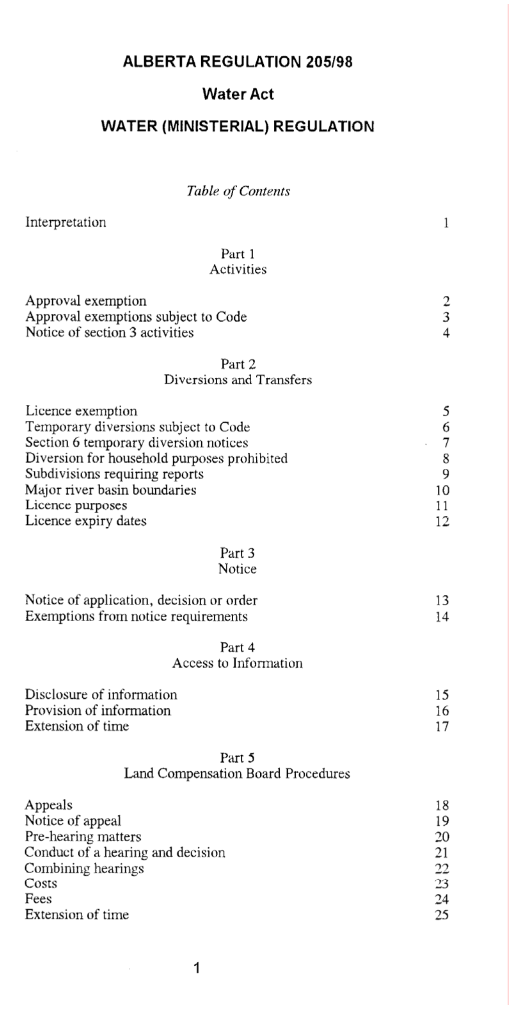

ALBERTA REGULATION 205/98

Water Act

WATER (MINISTERIAL) REGULATION

Table of Contents

1

Chemical Analysis of Farm Water Supplies

Adapted from Agdex 716 (D04) Published April 1991

A routine chemical analysis tests the water for 15 chemical parameters. It will reveal the hardness and iron concentration as well as the presence of other chemicals such as chlorides, sulphates, nitrates and nitrites. Chemicals, other than those listed below, can be tested but arrangements should be made with the lab before the sample is submitted. These special requests' must be clearly specified on the request form. Your farm water supply should be analyzed whenever a new water source is constructed, or when a change in water quality is noticed.

Your local health unit can provide you with the necessary water sample containers. Water samples specifically for human consumption must be submitted to the health unit.

The water sample you take should be representative. Choose an outlet as close to the source as possible. For most domestic samples, allow the water to run through the faucet for about five minutes and then fill the sample container.

Once you have obtained a good water sample, take it to your local health unit for forwarding to the appropriate laboratory. After the laboratory analysis is completed, the health inspector or technologist will receive a copy of the analysis and will be able to help you interpret the results.

Water Quality Criteria

It is not essential for private supplies to meet these guidelines. People have different reactions and tolerances to different minerals. If any chemical in your water exceeds drinking water limits consult you family doctor or local health unit.

All levels listed below (except pH) are listed in parts per million (ppm). Many labs report results in milligrams/Litre (mg/L), which is equivalent to ppm.

Sodium

Sodium is not considered a toxic metal, and 5,000 to 10,000 milligrams per day are consumed by normal adults without adverse effects. The average intake of sodium from water is only a small fraction of that consumed in a normal diet.

Persons suffering from certain medical conditions such as hypertension may require a sodium restricted diet, in which case the intake of sodium from drinking water could become significant. Sodium levels as low as 20 ppm are sometimes a concern to them. A maximum level of 300 (200*) ppm sodium has traditionally been used as a guideline but the "Guidelines for Canadian Drinking Water Quality" list no maximum acceptable concentration.

Sodium is a significant factor in assessing water for irrigation and plant watering. High sodium levels affect soil structure and a plant's ability to take up water.

Potassium

Potassium is usually only found in quantities of a few ppm in water. There is no recommended limit for potassium but levels over 2,000 ppm may be harmful to human nervous systems. Alberta water supplies rarely contain more than 20 ppm.

Calcium
Calcium is one cause of "hardness" in water. Calcium is not a hazard to health but is undesirable because it may be detrimental for domestic uses such as washing, bathing and laundering. It also tends to cause encrustations in kettles, coffee makers and water heaters. 200 ppm is often considered an acceptable limit.

Magnesium
Magnesium is another constituent causing "hardness" in water. A suggested limit of 150 ppm is used because of taste considerations.

Iron
Iron levels as low as 0.2 to 0.3 ppm will usually cause the staining of laundry and plumbing fixtures. The presence of iron bacteria in water supplies will often cause these symptoms at even lower levels. Iron gives water a metallic taste that may be objectionable to some persons at one to two ppm. Most water contains less that five ppm iron but occasionally levels over 30 ppm are found. Iron and iron bacteria are not considered a health concern.

Sulphate (SO4)
Sulphate concentrations over 500 ppm can be laxative to some humans and livestock. Sulphate levels over 500 ppm may be a concern for livestock on marginal intakes of certain trace minerals. Very high levels of sulphates have been associated with some brain disorders in cattle and pigs.

Chloride
Due to taste considerations the suggested maximum level for chloride is 250 ppm. Most water in Alberta contains less than 20 ppm chloride, although chloride in the 2,000 ppm range can be found.

NO2 Nitrogen (Nitrite)
Due to its toxicity, the maximum acceptable concentration of nitrite in drinking water is one ppm. Nitrite is usually an indicator of very direct contamination by sewage or manure because nitrites are unstable and quickly become nitrates.

The concentration in livestock water should not exceed 10 ppm.

NO3 Nitrogen (Nitrate)
Nitrates are also an indicator of contamination by human or livestock wastes, excessive fertilization or seepage from dump sites. The maximum acceptable concentration in drinking water is 10 ppm. The figure is based on the potential for the nitrate poisoning of infants. Adults can tolerate higher levels but high nitrate levels may cause irritation of the stomach and bladder. The suggested maximum for livestock use is 1,000 ppm.

Fluoride
Fluorides occur naturally in most well waters and are desirable since they help prevent dental cavities. Between one and 1.5 ppm is desirable. As fluoride levels increase above this amount there is an increase in the tendency to cause tooth mottling.

Fluoride levels less than four ppm are not considered a problem for livestock.

TDS Inorganic (Total Dissolved Solids)
This is a measure of the inorganic minerals dissolved in the water. As a general rule less than 1,000 (500*) ppm TDS is considered satisfactory. Levels higher than this are not necessarily a problem; it depends on the specific minerals present.

The suitability for livestock deteriorates as TDS exceeds the 2,000 to 3,000 ppm range.

Conductivity

Conductivity is measured in micro Siemens per centimetre. It can be used to estimate the total dissolved solids in the water. Multiplying the conductivity by 0.65 will give a good approximation of the total dissolved solids. Conductivity tests are often used to assess water suitability for irrigation.

pH

pH is a measure of how acidic or basic the water is. The pH scale goes from zero (acidic) to 14 (basic) with seven being neutral. The generally accepted range for pH is 6.5 to 8.5 with an upper limit of 9.5.

Hardness

The harder the water is the greater its ability to neutralize soap suds. Hardness is caused primarily by calcium and magnesium, but is expressed as ppm equivalent of calcium carbonate. Hard water causes soap curd which makes bathroom fixtures difficult to keep clean and causes greying of laundry.

Hard water will also tend to form scale in hot water tanks, kettles, piping systems, etc.

Type of Water	**Amount of Hardness**	
	ppm	**grains per gallon**
Soft	0- 50	0-3
Moderately Soft	50 - 100	3-6
Moderately Hard	100 - 200	6-12
Hard	200 - 400	12- 23
Very Hard	400 - 600	23 - 35
Extremely Hard	Over 600	Over 35

Alkalinity

Alkalinity is not a specific substance but rather a combined effect of several substances. It is a measure of the resistance of a water to a change in pH. The alkalinity of most Alberta waters is in the range of 100 - 500 ppm, which is considered acceptable. Water with higher levels is often used. Alkalinity is a factor in corrosion or scale deposition and may affect some livestock when over 1,000 ppm.

Water Treatment

Water treatment equipment can often improve water quality significantly. Each type of water treatment equipment has its limitations and thus should be selected carefully. For more information on water treatment please refer to the Agdex 71 6 D series of fact sheets.

Helpful Conversions

1 ppm (part per million) = 1 mg/L (milligram per litre)
1 gpg (grain per gallon) = 17.1 ppm (parts per million)

References

Guidelines for Canadian Drinking Water Quality (1987) Health and Welfare Canada

*Federal-Provincial Subcommittee on Drinking Water of the Federal-Provincial-Territorial Committee on Environment and Occupational Health. March 2001. Summary of Guidelines for Canadian Drinking Water Quality.

Additional Information

VIDEOS

Will the Well Go Dry Tomorrow? (Mow-Tech Ltd.: 1-800 GEO WELL)
Water Wells that Last (PFRA – Edmonton Office: 780-495-3307)
Ground Water and the Rural Community (Ontario Ground Water Association)

BOOKLET

Water Wells that Last (PFRA – Edmonton Office: 780-495-3307);
http://www.agric.gov.ab.ca/water/wells/index.html
Quality Farm Dugouts - http://www.agric.gov.ab.ca/esb/dugout.html

ALBERTA ENVIRONMENT

WATER - http://www3.gov.ab.ca/env/water.cfm

GROUNDWATER INFORMATION SYSTEM - http://www.telusgeomatics.com/tgpub/ag_water/

WATER WELL INSPECTORS
Jennifer McPherson (Edmonton: 780-427-6429)

WATER WELL LICENSING
Alan Hingston (Edmonton: 780-427-6429)

GEOPHYSICAL INSPECTION SERVICE
Edmonton: 780-427-3932

COMPLAINT INVESTIGATIONS
Jerry Riddell (Edmonton: 780-422-4851)

UNIVERSITY OF ALBERTA – Department of Earth and Atmospheric Sciences - Hydrogeology
Carl Mendoza (Edmonton: 780-492-2664)

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

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Dean Lien (Edmonton: 780-427-2433)

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Terry Dash (Calgary: 403-292-5719) -dasht@agr.gc.ca

WILDROSE COUNTRY GROUND WATER MONITORING ASSOCIATION
Dave Andrews (Irricana: 403-935-4478)

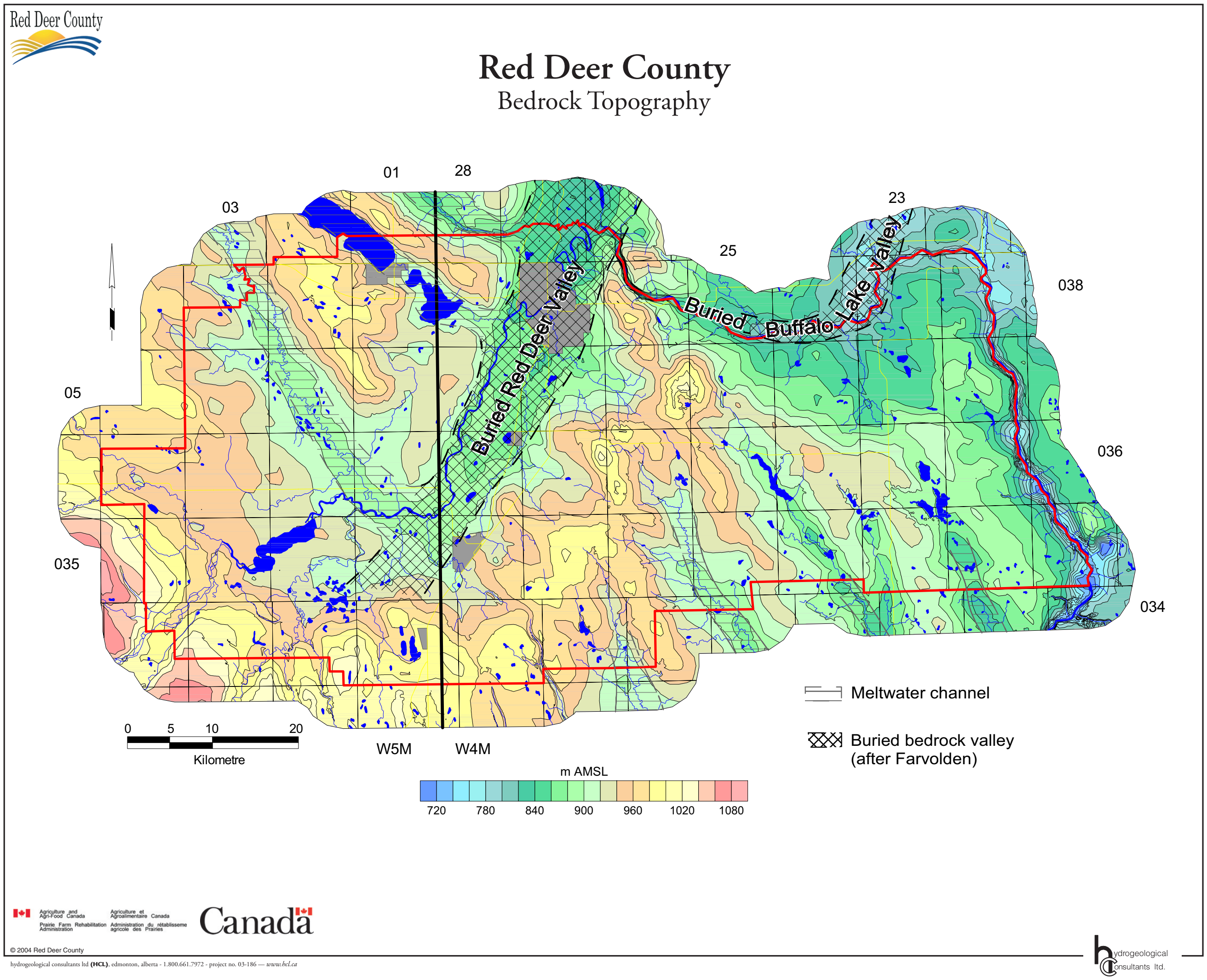
LOCAL HEALTH DEPARTMENTS

RED DEER COUNTY

Appendix D

Maps and Figures Included as Large Plots

Bedrock Topography



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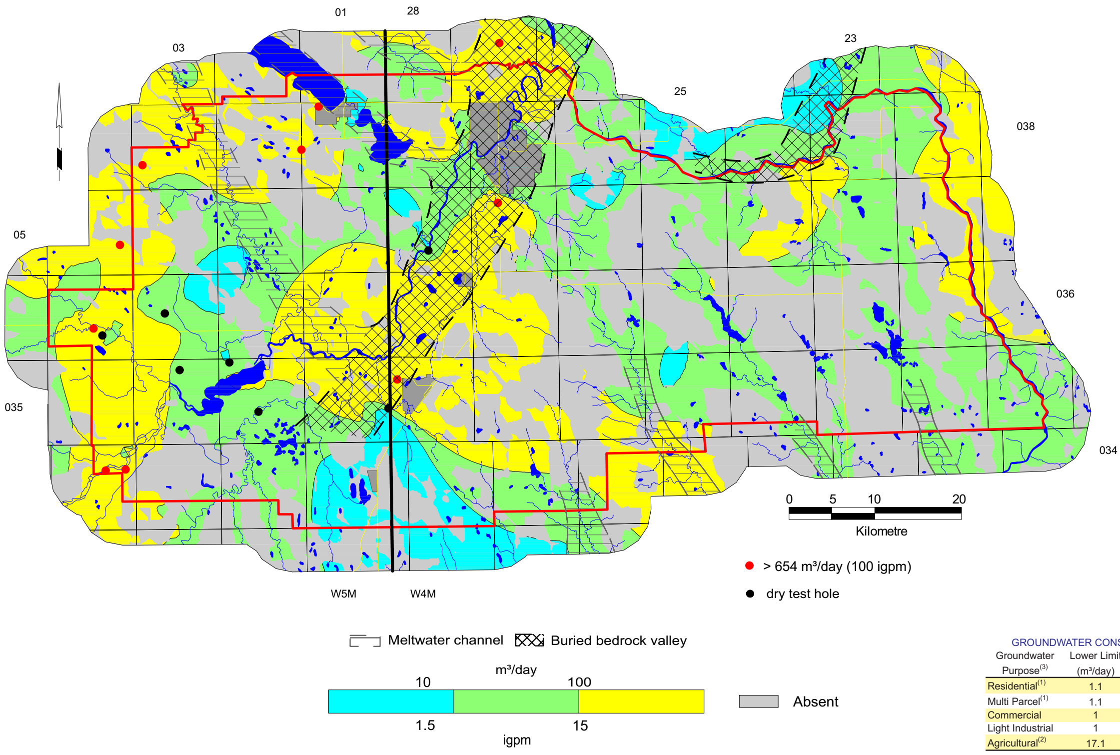
Apparent Yield for Water Wells Completed in Sand and Gravel Aquifer(s)

Red Deer County

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



GROUNDWATER CONSUMPTION

Groundwater Purpose(3)	Lower Limit (m³/day)	Upper Limit (m³/day)
Residential(1)	1.1	3.4
Multi Parcel(1)	1.1	3.4
Commercial	1	max. available
Light Industrial	1	max. available
Agricultural(2)	17.1	max. available

(1) per household
(2) traditional agricultural use as defined in the Water Act
(3) all non-household groundwater use must be licensed

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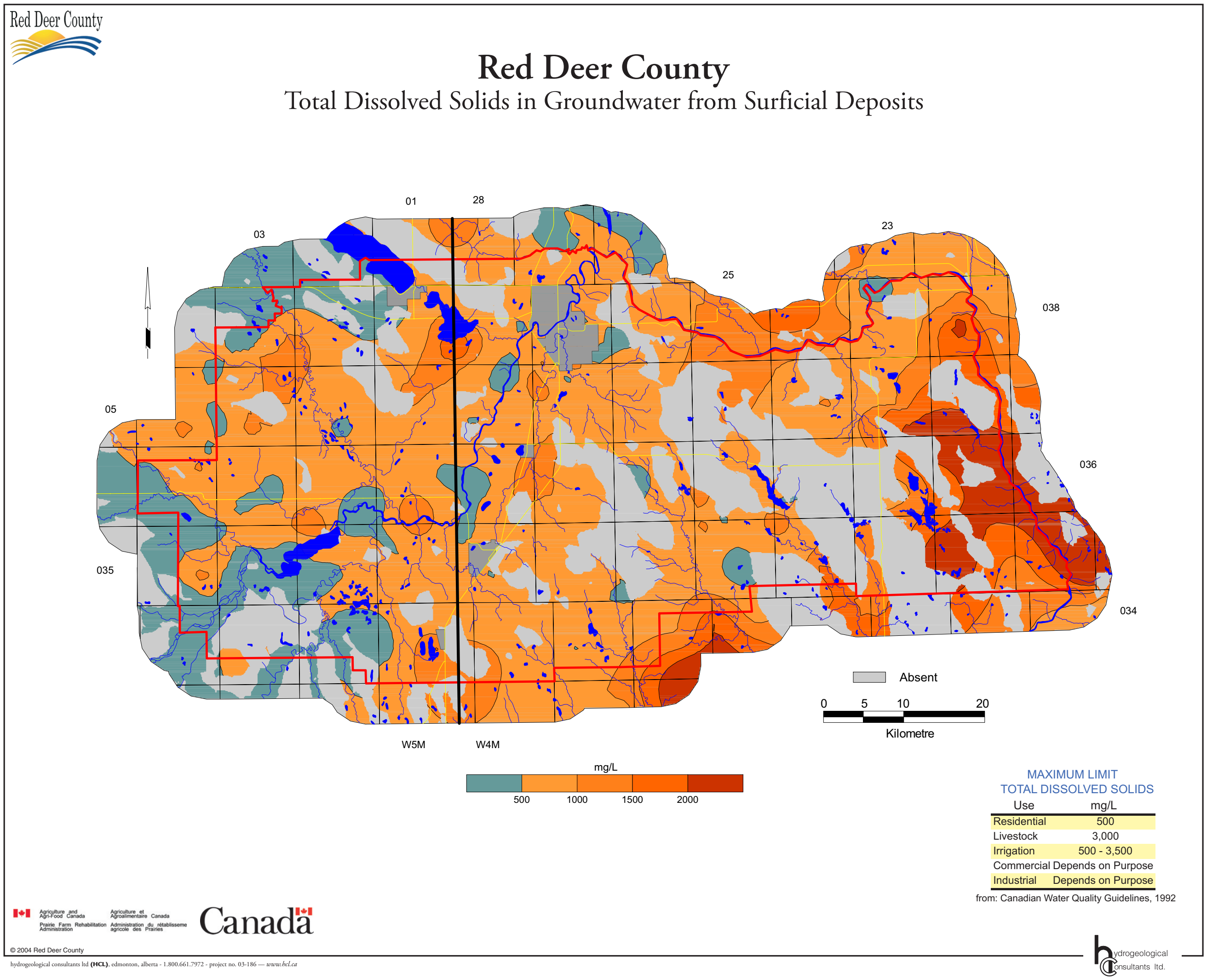
Total Dissolved Solids in Groundwater from Surficial Deposits



MAXIMUM LIMIT
TOTAL DISSOLVED SOLIDS

Use	mg/L
Residential	500
Livestock	3,000
Irrigation	500 - 3,500
Commercial	Depends on Purpose
Industrial	Depends on Purpose

from: Canadian Water Quality Guidelines, 1992

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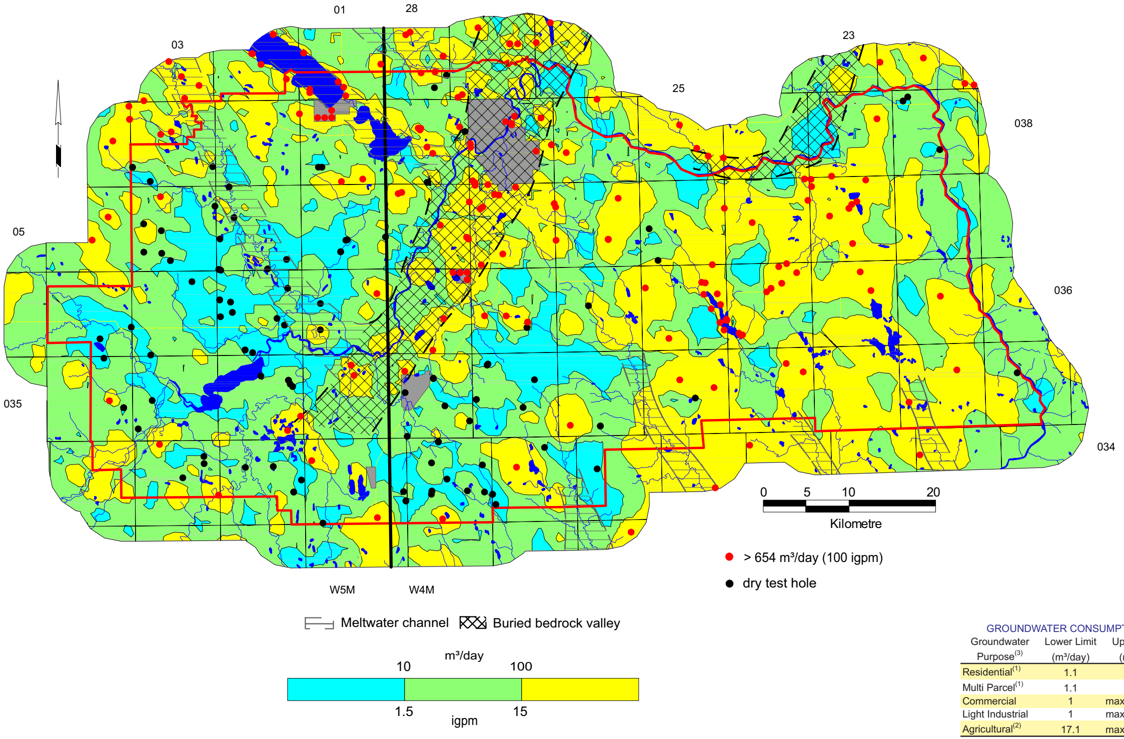
Apparent Yield for Water Wells Completed in Upper Bedrock Aquifer(s)

Red Deer County

Red Deer County

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



GROUNDWATER CONSUMPTION

Groundwater Purpose[3]	Lower Limit (m³/day)	Upper Limit (m³/day)
Residential[1]	1.1	3.4
Multi Parcel[1]	1.1	3.4
Commercial	1	max. available
Light Industrial	1	max. available
Agricultural[2]	17.1	max. available

(1) per household
(2) traditional agricultural use as defined in the Water Act
(3) all non-household groundwater use must be licensed

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Agriculture et Agroalimentaire Canada
Prairie Farm Rehabilitation Administration
Administration du rétablisseme agricole des Prairies
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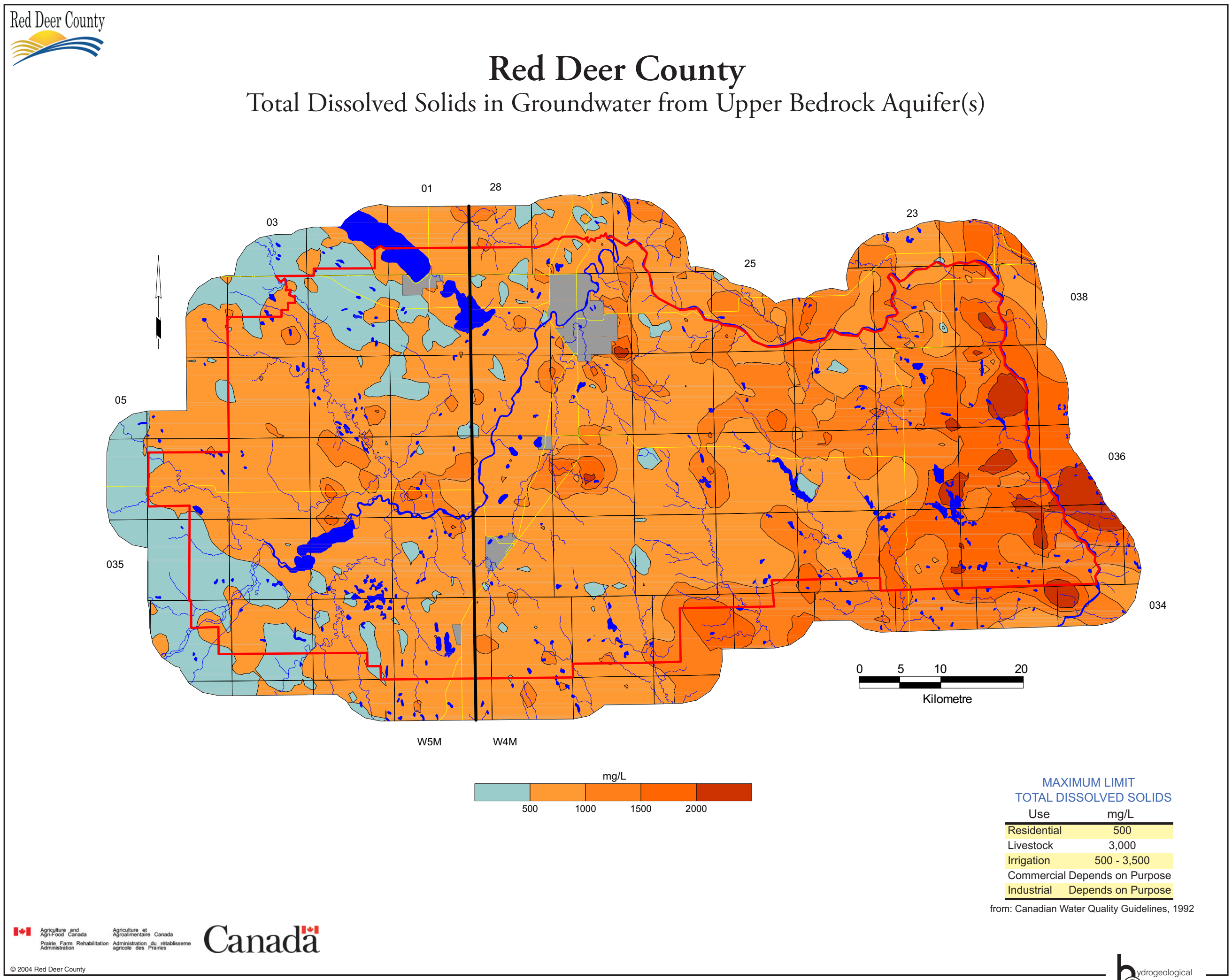
Total Dissolved Solids in Groundwater from Upper Bedrock Aquifer(s)



MAXIMUM LIMIT
TOTAL DISSOLVED SOLIDS

Use	mg/L
Residential	500
Livestock	3,000
Irrigation	500 - 3,500
Commercial	Depends on Purpose
Industrial	Depends on Purpose

from: Canadian Water Quality Guidelines, 1992

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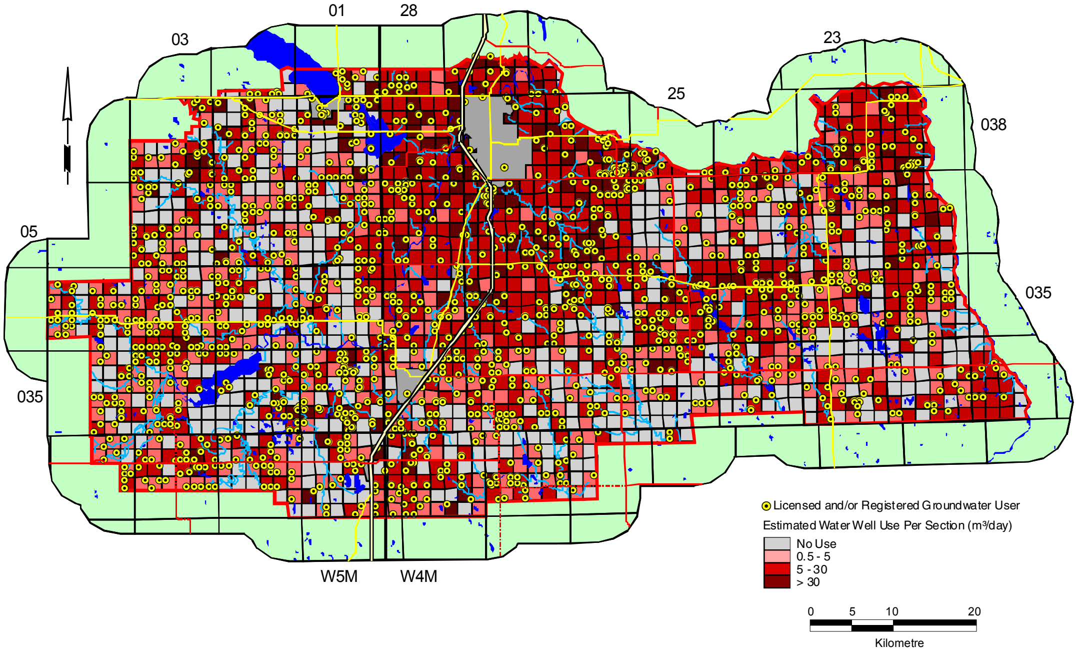
Estimated Water Well Use Per Section

Red Deer County

Red Deer County

Estimated Water Well Use Per Section



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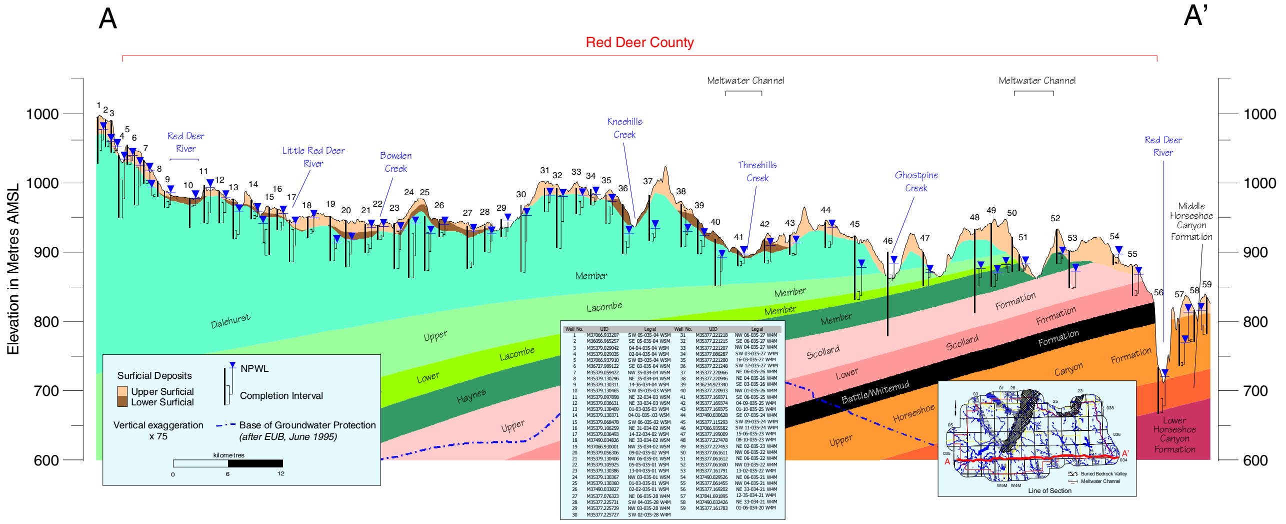
Cross-Section A - A’

Red Deer County

Red Deer County

Cross-Section A - A'



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3	M35379.029042	04-04-035-04 W5M	33	M35377.221207	NW 04-035-27 W4M
4	M35379.029035	02-04-035-04 W5M	34	M35377.086287	SW 03-035-27 W4M
5	M37066.937910	SW 03-035-04 W5M	35	M35377.221200	16-03-035-27 W4M
6	M36727.989122	SE 03-035-04 W5M	36	M35377.221248	SW 12-035-27 W4M
7	M35379.059422	NW 35-034-04 W5M	37	M35377.220966	NE 06-035-26 W4M
8	M35379.130296	NE 35-034-04 W5M	38	M35377.220946	NE 04-035-26 W4M
9	M35379.130311	14-36-034-04 W5M	39	M36234.923340	SE 03-035-26 W4M
10	M35379.130465	SW 05-035-03 W5M	40	M35377.220933	NW 01-035-26 W4M
11	M35379.097898	NE 32-034-03 W5M	41	M35377.169371	SE 06-035-25 W4M
12	M35379.036631	NE 33-034-03 W5M	42	M35377.169374	04-09-035-25 W4M
13	M35379.130409	01-03-035-03 W5M	43	M35377.169375	01-10-035-25 W4M
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19	M37066.930001	NW 35-034-02 W5M	49	M35377.227453	NE 02-035-23 W4M
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21	M35379.130406	NW 06-035-01 W5M	51	M35377.061612	NE 06-035-22 W4M
22	M35379.105925	05-05-035-01 W5M	52	M35377.061600	NW 03-035-22 W4M
23	M35379.130386	13-04-035-01 W5M	53	M35377.161791	13-02-035-22 W4M
24	M35379.130367	NW 03-035-01 W5M	54	M37490.029526	NE 06-035-21 W4M
25	M35379.130360	01-03-035-01 W5M	55	M35377.061455	NW 04-035-21 W4M
26	M37490.033827	02-02-035-01 W5M	56	M35377.169202	NE 33-034-21 W4M
27	M35377.076323	NE 06-035-28 W4M	57	M37841.691895	12-35-034-21 W4M
28	M35377.225731	SW 04-035-28 W4M	58	M37490.032426	NE 33-034-21 W4M
29	M35377.225729	NW 03-035-28 W4M	59	M35377.161783	01-06-034-20 W4M
30	M35377.225727	SW 02-035-28 W4M			

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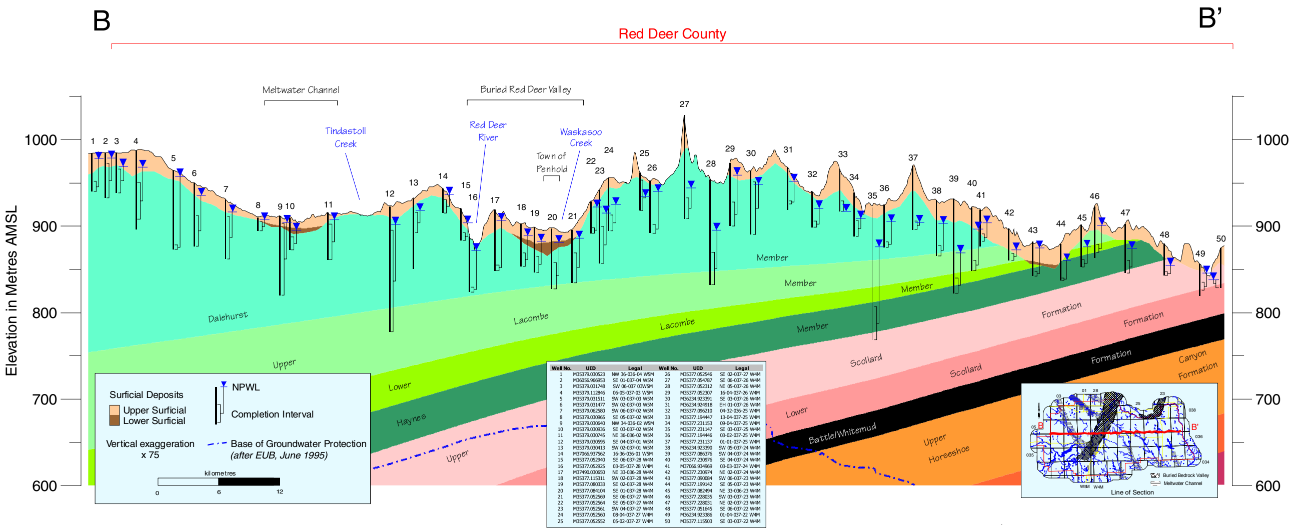
Cross-Section B - B'

Red Deer County

Red Deer County

Cross-Section B - B'



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4	M35379.112846	06-05-037-03 W5M	29	M35377.052307	16-04-037-26 W4M
5	M35379.031511	SW 03-037-03 W5M	30	M36234.923391	SE 03-037-26 W4M
6	M35379.031477	SW 02-037-03 W5M	31	M36234.924918	EH 01-037-26 W4M
7	M35379.062580	SW 06-037-02 W5M	32	M35377.096210	04-32-036-25 W4M
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9	M35379.030640	NW 34-036-02 W5M	34	M35377.231153	09-04-037-25 W4M
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22	M35377.052564	SE 05-037-27 W4M	47	M35377.228031	NE 02-037-23 W4M
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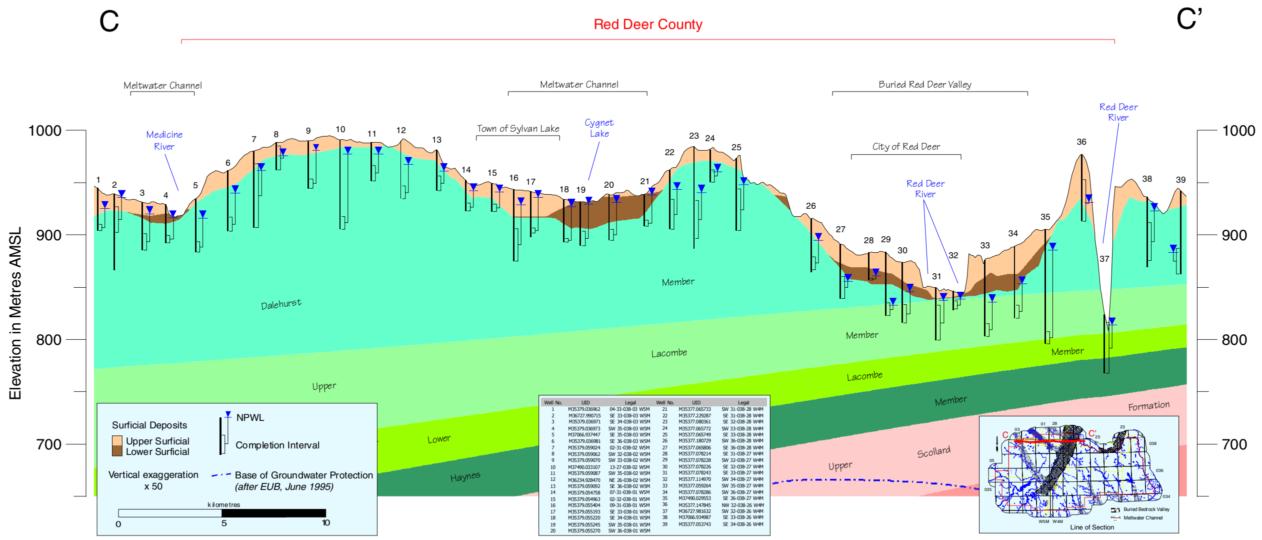
Cross-Section C - C'

Red Deer County

Red Deer County
Cross-Section C - C'



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11	M35379.059087	SW 35-038-02 W5M	31	M35377.078243	SE 33-038-27 W4M
12	M36234.928470	NE 26-038-02 W5M	32	M35377.114970	SW 34-038-27 W4M
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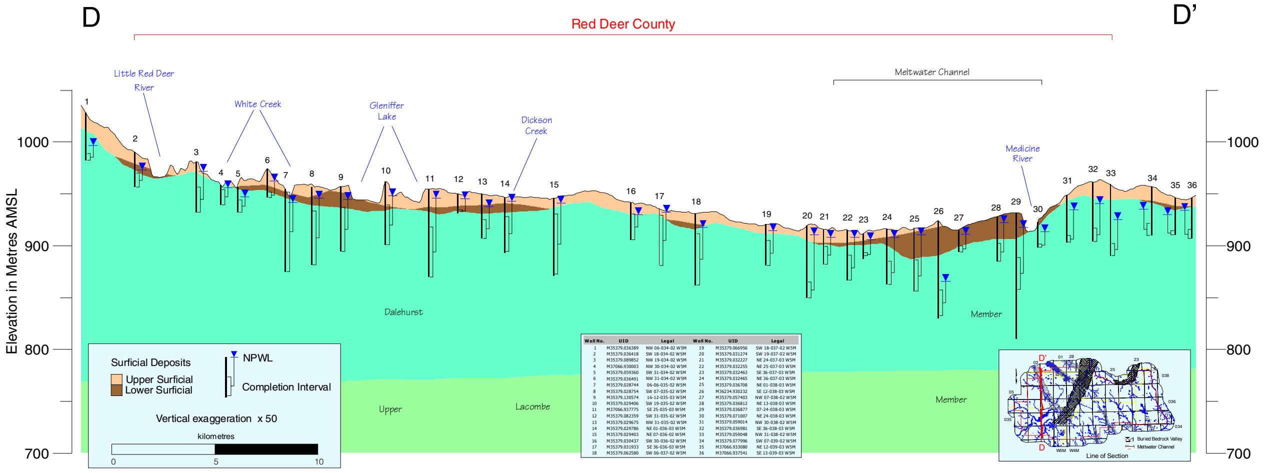
Cross-Section D - D'

Red Deer County

Red Deer County

Cross-Section D - D'



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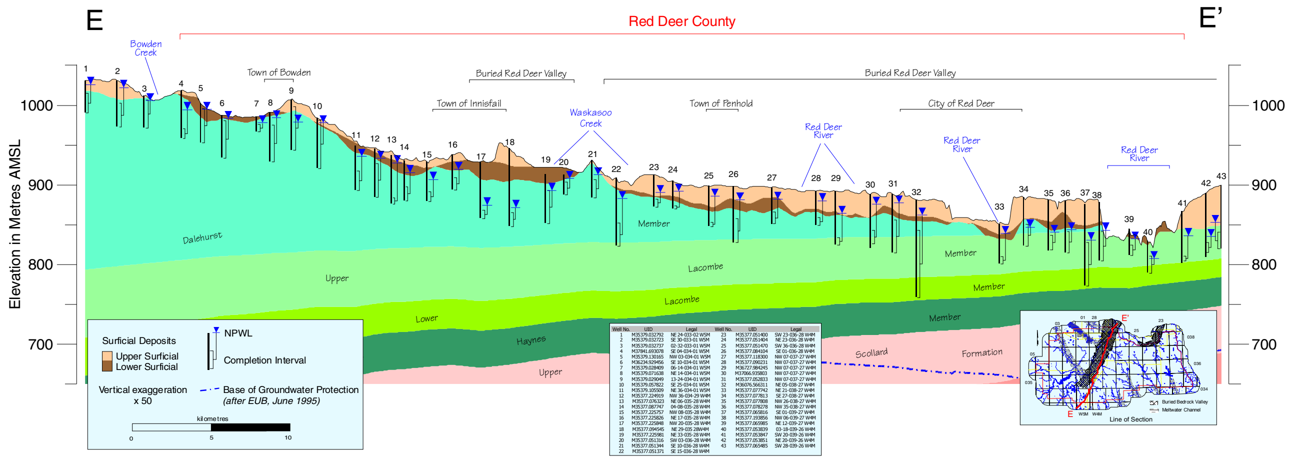
Cross-Section E - E'

Red Deer County

Cross-Section E - E'



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6	M36234.929456	SE 10-034-01 W5M	28	M35377.090231	NW 07-037-27 W4M
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14	M35377.087747	04-08-035-28 W4M	36	M35377.078278	NW 35-038-27 W4M
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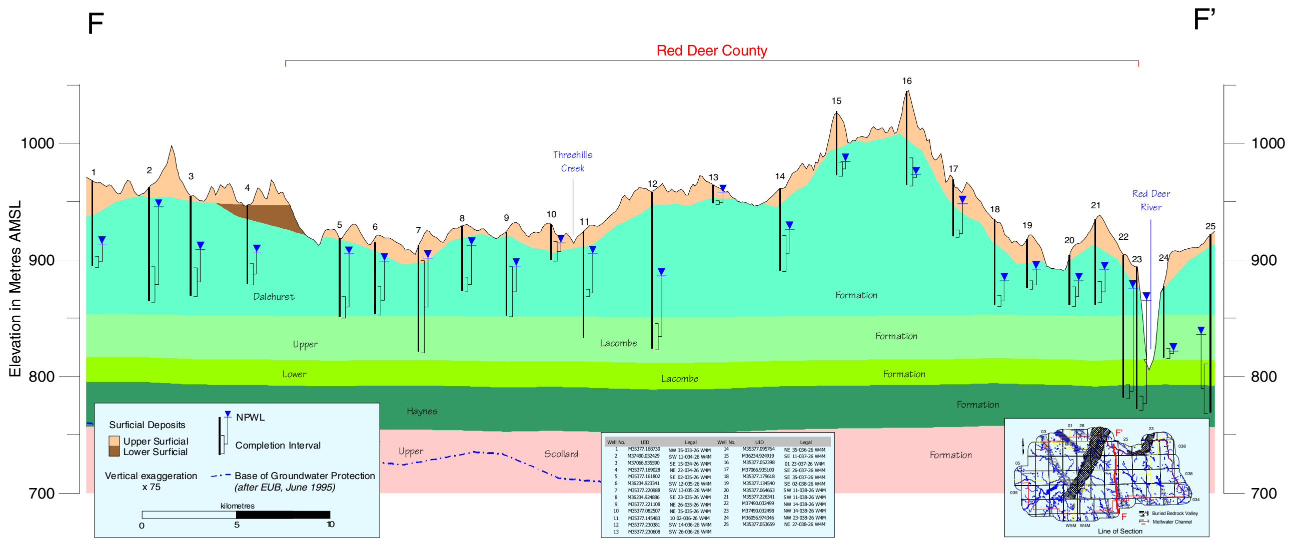
Cross-Section F - F'

Red Deer County

Red Deer County

Cross-Section F - F'



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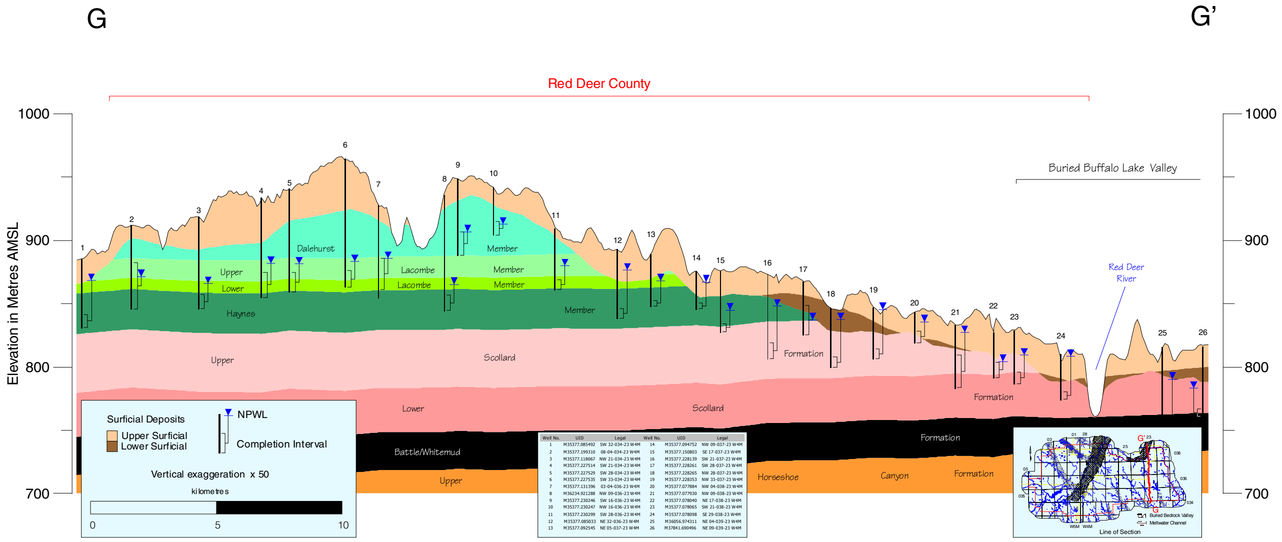
Cross-Section G - G'

Red Deer County

Red Deer County

Cross-Section G - G'



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9	M35377.230246	SW 16-036-23 W4M	22	M35377.078040	NE 17-038-23 W4M
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RED DEER COUNTY

Appendix E

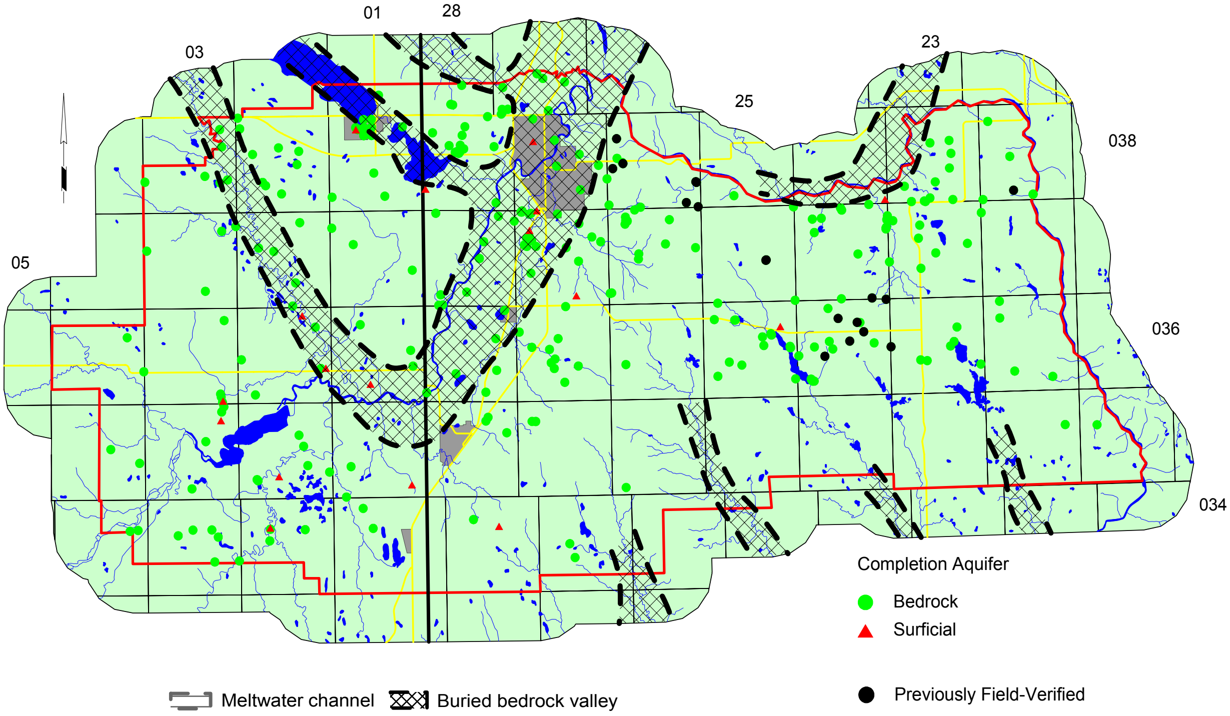
Water Wells That Are Recommended for Field-Verification

including

County-Operated Water Wells

Water Wells That Are Recommended For Field-Verification

(details on following pages)



WATER WELLS RECOMMENDED FOR FIELD-VERIFICATION THAT MEET CRITERIA

		Aquifer	Date Water	Completed Depth		NPWL		
Owner	Location	Name	Well Drilled	Metres	Feet	Metres	Feet	UID
Ademsonn, Frank	NE 26-036-02 W5M	Dalehurst Member	29-Jul-75	15.85	52.0	6.4	21.0	M37066.937576
Agricultural Services Building Ltd.	NE 33-037-27 W4M	Dalehurst Member	01-Sep-78	42.67	140.0	3.54	11.6	M35377.090089
Alberta Environment	16-26-035-03 W5M	Surficial	02-Oct-80	19.81	65.0	3.75	12.3	M35379.071693
Alberta Environment	09-02-036-03 W5M	Dalehurst Member	18-May-77	28.95	95.0	4.57	15.0	M35379.029842
Alberta Housing Corporation Ltd.	SE 29-034-02 W5M	Upper Surficial	01-Sep-75	15.54	51.0	3.05	10.0	M35379.036472
Albrecht, Dennis & Cathy	SW 32-037-26 W4M	Dalehurst Member	30-Aug-79	35.05	115.0	20.73	68.0	M35377.052470
Allison, Allon	NE 30-038-22 W4M	Battle	01-Jun-71	43.58	143.0	33.53	110.0	M35377.077481
Anderson, Chris	08-15-038-03 W5M	Dalehurst Member	23-May-63	29.26	96.0	7.62	25.0	M35379.036819
Anderson, Gloria	SE 28-034-01 W5M	Dalehurst Member	01-Jul-70	54.86	180.0	39.62	130.0	M35379.029446
Anderson, Roy	SW 01-036-03 W5M	Surficial	17-Apr-76	17.68	58.0	2.74	9.0	M35379.029693
Baxter, Doug	SW 20-036-24 W4M	Dalehurst Member	12-Jun-80	42.67	140.0	21.06	69.1	M35377.095804
Beaudry, Rene	NW 33-038-01 W5M	Dalehurst Member	13-Jun-79	39.62	130.0	7.01	23.0	M35379.055456
Becker Const	NE 28-038-01 W5M	Dalehurst Member	26-Jun-78	24.38	80.0	4.27	14.0	M35379.054539
Becker Const	NE 28-038-01 W5M	Dalehurst Member	26-Jun-78	24.38	80.0	4.57	15.0	M35379.054534
Bell, Duke	NW 06-038-01 W5M	Dalehurst Member	31-Oct-64	30.48	100.0	18.59	61.0	M35379.054028
Benalto Elks	SW 31-038-02 W5M	Dalehurst Member	07-Oct-76	47.24	155.0	24.38	80.0	M35379.059025
Bergmann, Karl	SE 09-035-02 W5M	Surficial	14-Mar-89	48.77	160.0	12.19	40.0	M35379.029029
Bickford, K.	15-32-037-26 W4M	Dalehurst Member	06-Nov-59	36.57	120.0	21.33	70.0	M35377.079721
Blair, David	NE 20-037-23 W4M	Upper Scollard	17-Jun-77	54.86	180.0	35.17	115.4	M35377.228118
Bloss, P.	04-14-034-03 W5M	Dalehurst Member	24-Nov-78	41.45	136.0	16.46	54.0	M35379.036557
Bodwell, Gordon	NW 24-037-27 W4M	Dalehurst Member		33.53	110.0	7.62	25.0	M35377.052719
Boibe, Carl	NW 24-035-22 W4M	Upper Scollard	23-May-74	45.72	150.0	30.48	100.0	M35377.227393
Bootes Brothers	NW 28-036-25 W4M	Dalehurst Member	31-Jan-84	30.48	100.0	18.29	60.0	M35377.096066
Bourne, Gary	16-21-036-27 W4M	Dalehurst Member	15-Jun-91	32.61	107.0	16.76	55.0	M35377.090160
Bowden Istitute	NW 01-035-01 W5M	Upper Surficial	01-Sep-77	17.07	56.0	9.75	32.0	M35379.130187
Bowie, Lee	SE 19-036-27 W4M	Dalehurst Member	10-May-73	27.43	90.0	0.91	3.0	M35377.051189
Braatz, A.	SW 32-037-26 W4M	Dalehurst Member	03-Mar-77	36.57	120.0	21.33	70.0	M35377.052463
Brown, Norman	12-26-036-24 W4M	Dalehurst Member	30-Oct-75	33.53	110.0	18.9	62.0	M35377.095906
Burnett, Jerry	NW 32-037-27 W4M	Surficial	11-Aug-86	22.55	74.0	9.14	30.0	M35377.052835
Burren, Doug	SE 05-038-23 W4M	Upper Scollard	22-Aug-83	42.67	140.0	13.87	45.5	M35377.077892
Bye, Virgil	NE 35-037-24 W4M	Upper Scollard	01-Sep-73	45.72	150.0	22.86	75.0	M35377.231126
Bystrom, H.S.	NW 30-037-01 W5M	Dalehurst Member	11-Feb-74	51.81	170.0	35.05	115.0	M35379.031232
Camp Little Red	NE 20-034-02 W5M	Dalehurst Member	17-Jun-83	16.76	55.0	2.43	8.0	M37066.930013
Campbell, T.J.	NW 33-038-01 W5M	Dalehurst Member	07-Sep-76	36.57	120.0	9.14	30.0	M35379.055434
Cannady, Kent	NW 23-036-25 W4M	Dalehurst Member	23-Oct-89	22.86	75.0	9.75	32.0	M35377.096195
Catholic Church	01-32-038-01 W5M	Dalehurst Member	01-Oct-64	25.91	85.0	5.49	18.0	M35379.054960
Cedars Drive In Resturant	NE 33-038-01 W5M	Dalehurst Member	26-Apr-77	51.81	170.0	5.79	19.0	M35379.056569
City of Red Deer	07-28-038-27 W4M	Upper Lacombe Member	11-Mar-61	25.91	85.0	7.92	26.0	M35377.077848
Colban, Murry	SW 33-036-24 W4M	Dalehurst Member	31-May-83	39.01	128.0	29.87	98.0	M35377.095959
Coleman, Carl	01-22-035-04 W5M	Dalehurst Member	30-Mar-81	19.81	65.0	4.88	16.0	M35379.029337
Comis, Erwin	NE 03-038-01 W5M	Dalehurst Member	02-Dec-82	35.05	115.0	8.53	28.0	M35379.053990
Conn, Lyle	04-09-036-01 W5M	Surficial	21-Jul-70	11.89	39.0	3.05	10.0	M35379.029110
Corbett, Bud	SE 28-034-03 W5M	Dalehurst Member		30.48	100.0	17.37	57.0	M35379.036607
Corrigan, C.D.	13-35-038-28 W4M	Dalehurst Member	02-Jun-61	38.4	126.0	14.32	47.0	M35377.065799
Cox, E L	13-25-037-03 W5M	Dalehurst Member	01-May-74	32.92	108.0	12.19	40.0	M35379.032242
Crawford, Ron	SE 02-036-03 W5M	Dalehurst Member	24-Oct-86	54.86	180.0	1.83	6.0	M35379.029799
Daines, Jim	NE 23-036-28 W4M	Dalehurst Member	22-May-73	34.14	112.0	12.19	40.0	M35377.051404
Deboon, Arie	SE 32-038-01 W5M	Dalehurst Member	08-Dec-80	35.96	118.0	5.79	19.0	M35379.054949
Degraff, Dave	NW 28-038-01 W5M	Dalehurst Member	29-Sep-76	33.53	110.0	3.05	10.0	M35379.054433
Dentoom's Greenhouses	SW 29-038-27 W4M	Lower Surficial	20-Oct-76	28.35	93.0	24.69	81.0	M35377.078176
Department of National Defence	SE 24-037-26 W4M	Dalehurst Member	01-Feb-72	62.48	205.0	56.39	185.0	M35377.052399
Dersch, Dexter	08-06-035-26 W4M	Dalehurst Member	28-Mar-78	36.57	120.0	32	105.0	M35377.220962
Dietrick, E	SW 33-038-01 W5M	Dalehurst Member	05-Nov-66	39.62	130.0	9.14	30.0	M35379.055195

WATER WELLS RECOMMENDED FOR FIELD-VERIFICATION THAT MEET CRITERIA

		Aquifer	Date Water	Completed Depth		NPWL		
Owner	Location	Name	Well Drilled	Metres	Feet	Metres	Feet	UID
Dionne, Joe	SE 01-038-24 W4M	Surficial	09-Apr-60	43.89	144.0	24.38	80.0	M35377.079598
Dolinsky, E.V.	SE 30-037-27 W4M	Upper Lacombe Member	14-Aug-71	57.91	190.0	7.01	23.0	M35377.052771
Don's Trailer Park	SE 35-038-01 W5M	Dalehurst Member	08-Jul-75	35.05	115.0	10.67	35.0	M35379.055229
Dorin, E.A.	12-06-036-28 W4M	Dalehurst Member	26-Oct-81	22.86	75.0	14.32	47.0	M35377.143648
Duffin, Lawrence	SW 32-037-26 W4M	Dalehurst Member	15-May-81	73.15	240.0	61.57	202.0	M35377.052482
Duffin, Steve	SE 25-037-24 W4M	Upper Scollard	06-Nov-85	36.57	120.0	-0.3	-1.0	M35377.231063
Dufresne, L	SE 36-037-03 W5M	Dalehurst Member	19-Oct-85	21.33	70.0	5.49	18.0	M35379.032463
Durrant, Basil	SW 23-038-27 W4M	Dalehurst Member	25-Mar-83	45.72	150.0	33.53	110.0	M35377.077768
Durward, H	SE 09-038-02 W5M	Dalehurst Member	30-Jul-74	22.86	75.0	12.8	42.0	M35379.057418
Edgar, B.	NW 08-035-01 W5M	Dalehurst Member	14-Sep-74	50.29	165.0	18.29	60.0	M35379.130427
Edgar, Bill	SE 26-038-28 W4M	Dalehurst Member	04-Nov-61	43.89	144.0	20.97	68.8	M35377.065626
Emerich, Bill	NE 29-034-28 W4M	Dalehurst Member	01-Mar-71	33.53	110.0	22.86	75.0	M35377.224791
Engineered Homes Ltd.	NW 28-038-01 W5M	Dalehurst Member	23-Sep-76	22.86	75.0	4.27	14.0	M35379.054382
Engineered Homes Ltd.	NW 28-038-01 W5M	Dalehurst Member	24-Aug-76	22.86	75.0	4.27	14.0	M35379.054415
Engineered Homes Ltd.	NW 28-038-01 W5M	Dalehurst Member	23-Aug-76	32	105.0	6.1	20.0	M35379.054423
Fabris, Gary	NE 03-037-27 W4M	Surficial	10-Oct-73	24.38	80.0	7.62	25.0	M35377.052556
Fetch, Norman	NE 22-035-03 W5M	Dalehurst Member	19-Sep-74	45.72	150.0	21.03	69.0	M35379.028474
Feth, Rick	NE 33-038-01 W5M	Dalehurst Member	04-May-78	48.77	160.0	5.49	18.0	M35379.056556
Finlay, Jack	NE 31-037-27 W4M	Dalehurst Member	07-Jun-72	44.19	145.0	9.14	30.0	M35377.052794
Fitch, Laura	SW 35-037-02 W5M	Dalehurst Member	23-Jul-75	19.81	65.0	9.75	32.0	M35379.031584
Fokkens, W	NW 18-036-02 W5M	Dalehurst Member	06-Jul-73	26.21	86.0	12.8	42.0	M35379.030005
Foothills Sda Camp	01-13-034-03 W5M	Dalehurst Member	11-Apr-75	39.62	130.0	13.11	43.0	M35379.036551
Foss, Roy	SE 18-037-27 W4M	Dalehurst Member	09-Dec-77	42.67	140.0	15.24	50.0	M35377.052642
Fox, Harold	16-36-037-25 W4M	Haynes Member	17-Jun-76	42.67	140.0	33.53	110.0	M35377.231283
Fraser, Lonnie	SE 25-037-24 W4M	Upper Scollard	20-Oct-80	33.53	110.0	-0.3	-1.0	M35377.231060
Freeman, Mr. F.	01-12-036-25 W4M	Dalehurst Member		21.64	71.0	10.36	34.0	M35377.096136
Gaetz, William	NE 33-038-01 W5M	Dalehurst Member	30-Jun-73	53.34	175.0	5.49	18.0	M35379.056579
Glenn, C W	SE 10-037-03 W5M	Dalehurst Member	17-Apr-76	45.41	149.0	39.01	128.0	M35379.031860
Glover, Don	NW 04-038-25 W4M	Upper Lacombe Member	27-Aug-76	18.29	60.0	9.88	32.4	M35377.053234
Godbout, Ron	03-05-037-28 W4M	Dalehurst Member	09-Sep-80	64	210.0	15.54	51.0	M35377.052925
Goruk, George	NW 20-037-02 W5M	Dalehurst Member	25-Jul-85	27.43	90.0	18.29	60.0	M35379.031291
Graham, M.	NW 29-036-22 W4M	Upper Scollard	04-Nov-80	67.05	220.0	20.66	67.8	M35377.079987
Gross, Don	NE 03-036-28 W4M	Dalehurst Member	12-Nov-82	27.43	90.0	12.19	40.0	M35377.051319
Grumette, Lorne	16-21-038-28 W4M	Dalehurst Member	26-May-84	24.38	80.0	3.96	13.0	M35377.065570
Gummow, Stan	NE 17-037-26 W4M	Dalehurst Member	23-Sep-63	21.33	70.0	12.19	40.0	M35377.052351
Hansen, Wilfred	01-26-036-04 W5M	Dalehurst Member	10-Sep-74	56.39	185.0	5.48	18.0	M37066.937325
Hanson, R.C	SE 16-038-01 W5M	Dalehurst Member	23-Nov-72	33.53	110.0	12.19	40.0	M35379.054207
Hartrich, P.	13-31-037-27 W4M	Dalehurst Member	01-Dec-58	42.06	138.0	8.53	28.0	M35377.052789
Harvey, Ross	SE 29-038-28 W4M	Dalehurst Member	12-Sep-73	39.62	130.0	12.5	41.0	M35377.080331
Herbey, N.	NW 02-036-22 W4M	Upper Scollard	01-Apr-72	29.87	98.0	20.73	68.0	M35377.079960
Herman, Gary	01-36-037-24 W4M	Upper Scollard	12-May-76	44.19	145.0	4.75	15.6	M35377.231127
Heywood, Ken	SW 32-037-26 W4M	Dalehurst Member	28-Jun-79	60.96	200.0	30.48	100.0	M35377.052473
Hillman, Earl	NW 20-037-01 W5M	Dalehurst Member	11-Jul-78	30.48	100.0	12.19	40.0	M35379.030865
Hodgson, Harry R.	SW 21-036-27 W4M	Dalehurst Member	23-Oct-61	63.7	209.0	15.24	50.0	M35377.051223
Hollings, B.	NE 06-036-24 W4M	Dalehurst Member	09-May-74	21.64	71.0	12.5	41.0	M35377.095848
Holt, Ron	SE 26-036-25 W4M	Surficial	16-Sep-78	25.6	84.0	13.72	45.0	M35377.096231
Hough, Mel	SE 27-037-28 W4M	Upper Lacombe Member	28-Aug-74	48.77	160.0	9.14	30.0	M35377.053064
Hovey, Adolph	SE 08-036-22 W4M	Upper Scollard	23-May-86	54.86	180.0	29.32	96.2	M35377.080472
J.E.M. Farm	NE 12-036-23 W4M	Upper Scollard	01-Jan-66	58.21	191.0	21.03	69.0	M35377.230238
Jackson, Elsie	SW 18-037-23 W4M	Upper Scollard	21-Nov-64	41.15	135.0	5.18	17.0	M35377.228105
Jaremcio, Brian	NW 09-037-23 W4M	Haynes Member	20-Nov-91	30.48	100.0	9.14	30.0	M35377.094752
Johannson, J H	SW 35-036-02 W5M	Surficial	03-Jul-68	32	105.0	12.19	40.0	M35379.030674
Johannson, Stan & Helen	SW 13-036-02 W5M	Dalehurst Member	13-Nov-68	27.43	90.0	9.14	30.0	M35379.029749
Jones, Percy	SW 23-038-23 W4M	Upper Scollard	23-Apr-79	36.57	120.0	7.92	26.0	M35377.078072
Jones, Percy	NE 21-038-23 W4M	Upper Scollard	25-Oct-73	36.57	120.0	23.47	77.0	M35377.078067
Jorden, G.	SW 23-035-02 W5M	Dalehurst Member	16-Jun-75	50.29	165.0	25.91	85.0	M35379.029431
Jost, Paul	SE 06-039-27 W4M	Dalehurst Member	24-Aug-68	32	105.0	12.59	41.3	M35377.228483
Kelly, Lynn	SW 14-035-02 W5M	Dalehurst Member	09-Apr-76	42.97	141.0	15.85	52.0	M35379.029199
Kerr, Doug	01-07-036-24 W4M	Dalehurst Member	02-Jun-82	30.48	100.0	10.73	35.2	M35377.095878
Kinzel, Ernest	SE 06-039-27 W4M	Dalehurst Member	11-Jan-73	47.24	155.0	14.63	48.0	M35377.065872

WATER WELLS RECOMMENDED FOR FIELD-VERIFICATION THAT MEET CRITERIA

		Aquifer	Date Water	Completed Depth		NPWL		
Owner	Location	Name	Well Drilled	Metres	Feet	Metres	Feet	UID
Klepper, Danny	03-16-036-25 W4M	Dalehurst Member	01-Oct-74	19.2	63.0	11.28	37.0	M35377.096055
Knowles, P.J. & J.W.	NW 31-038-02 W5M	Dalehurst Member	01-Oct-72	33.53	110.0	27.43	90.0	M35379.059045
Krogmon, Dick	NE 07-039-27 W4M	Dalehurst Member	14-Nov-74	36.57	120.0	22.86	75.0	M35377.065944
Lachorite, Bill	13-31-037-27 W4M	Dalehurst Member		47.24	155.0	10.67	35.0	M35377.079686
Lagrange, D.	08-34-037-26 W4M	Dalehurst Member	22-Apr-68	27.43	90.0	9.75	32.0	M35377.079722
Lakes End Resort	NW 23-036-25 W4M	Dalehurst Member	26-May-75	24.38	80.0	4.27	14.0	M35377.096181
Lalar, Jim	NW 29-035-27 W4M	Dalehurst Member	09-Jun-77	18.29	60.0	6.61	21.7	M35377.225682
Lalor, Bill	NE 30-035-27 W4M	Dalehurst Member	05-Oct-79	16.76	55.0	7.31	24.0	M35377.225687
Landgrebe, Otto	NE 20-034-03 W5M	Dalehurst Member	21-Apr-80	24.38	80.0	11.89	39.0	M35379.036575
Lawrence, Art	SE 24-036-25 W4M	Dalehurst Member	10-Sep-70	28.95	95.0	11.582	38.0	M35377.096201
Lawrence, Ed	02-24-036-25 W4M	Dalehurst Member	17-Jun-75	27.43	90.0	6.4	21.0	M35377.096209
Lawrence, Tim	02-24-036-25 W4M	Dalehurst Member	25-Jun-75	18.29	60.0	0.61	2.0	M35377.096207
Leasak, Dave	SE 28-038-28 W4M	Dalehurst Member	12-Oct-79	35.36	116.0	23.16	76.0	M35377.229292
Lebedow, Gerry	NE 33-038-01 W5M	Dalehurst Member	01-Sep-73	36.57	120.0	4.57	15.0	M35379.056710
Lee, Jack	SE 17-036-23 W4M	Dalehurst Member		19.81	65.0	16.15	53.0	M35377.230249
Lehrman, Hans	04-24-036-01 W5M	Dalehurst Member	02-Jan-75	32	105.0	10.97	36.0	M35379.029562
Lougheed, Ralph	SW 31-038-02 W5M	Dalehurst Member	02-Sep-76	45.72	150.0	33.53	110.0	M35379.059027
Lougheed, Robert	SE 20-037-26 W4M	Dalehurst Member	01-Nov-67	35.05	115.0	9.14	30.0	M35377.117286
Lund, Don	SW 29-037-24 W4M	Haynes Member	31-Aug-92	36.57	120.0	27.13	89.0	M35377.150814
Lund, Fred	04-32-037-24 W4M	Haynes Member	22-Mar-78	42.67	140.0	33.34	109.4	M35377.079692
Lund, Oscar	08-32-037-24 W4M	Haynes Member	29-May-62	42.67	140.0	27.43	90.0	M35377.231116
Macbride, Joe	SW 10-036-27 W4M	Dalehurst Member	01-Feb-66	60.96	200.0	21.33	70.0	M35377.080101
Macphee, J.	SW 16-036-27 W4M	Dalehurst Member	15-May-85	24.38	80.0	13.41	44.0	M35377.051162
Macphee, John	NW 16-036-27 W4M	Dalehurst Member	01-May-78	39.62	130.0	16.76	55.0	M35377.080106
Mallett, R.H.	SW 29-037-27 W4M	Dalehurst Member	12-Jul-75	48.77	160.0	9.14	30.0	M35377.052766
Mannerfelt, Rayner	NE 15-038-02 W5M	Dalehurst Member	28-Oct-81	18.29	60.0	6.4	21.0	M35379.057488
Marek, Jim	SW 24-037-23 W4M	Upper Scollard	11-May-83	30.48	100.0	19.81	65.0	M35377.228214
Marshall, J.	04-06-039-27 W4M	Dalehurst Member	25-Jun-62	27.43	90.0	12.19	40.0	M35377.065933
Marshall, Philys	NE 19-037-27 W4M	Dalehurst Member	24-Nov-74	48.77	160.0	9.75	32.0	M35377.052662
Martin, John	NW 21-038-28 W4M	Dalehurst Member	03-Dec-85	33.53	110.0	20.73	68.0	M35377.065547
Martinson, Dale	13-07-038-03 W5M	Dalehurst Member	11-Aug-77	32	105.0	9.14	30.0	M35379.036752
Mccutcheon, J	SW 33-038-01 W5M	Dalehurst Member	07-Apr-77	35.96	118.0	9.45	31.0	M35379.055304
Mckechnie, John & Adele	SE 13-036-02 W5M	Surficial	27-Aug-97	9.14	30.0	4.57	15.0	M36234.930146
McKee, Wayne	SW 11-038-27 W4M	Dalehurst Member	06-May-76	44.19	145.0	16.76	55.0	M35377.077610
McLeod Investment Ltd	SE 32-038-01 W5M	Dalehurst Member	05-Jan-78	31.09	102.0	7.01	23.0	M35379.054938
McLeod, R.J.	SW 25-034-04 W5M	Dalehurst Member	28-Jan-76	12.8	42.0	2.44	8.0	M35379.129893
Mcneil, Lloyd	03-13-038-03 W5M	Dalehurst Member	17-Jan-58	41.45	136.0	6.1	20.0	M35379.036809
McPhedran, Evan	NW 21-038-28 W4M	Dalehurst Member	25-Jul-80	50.29	165.0	11.58	38.0	M35377.065537
Miller, Alice/Laurie	04-35-037-27 W4M	Dalehurst Member	25-Oct-84	34.75	114.0	9.14	30.0	M35377.052888
Miller, Clara	NW 20-035-21 W4M	Lower Scollard	19-Jul-83	42.67	140.0	26.18	85.9	M35377.061551
Miller, Warren	SE 03-037-02 W5M	Dalehurst Member	12-Sep-75	23.77	78.0	8.23	27.0	M35379.030934
Mills, W.S.	01-32-034-01 W5M	Dalehurst Member	08-Sep-69	28.95	95.0	6.1	20.0	M35379.029502
Mooney, A.	SW 08-035-02 W5M	Dalehurst Member	28-May-84	18.29	60.0	2.74	9.0	M35379.028990
Morris, Art	NW 09-036-28 W4M	Dalehurst Member	12-Jun-67	40.23	132.0	22.86	75.0	M35377.051342
Muir, Dave	01-04-037-24 W4M	Dalehurst Member	29-Apr-68	27.43	90.0	18.38	60.3	M35377.230975
Mullen, Bob	SW 16-036-27 W4M	Dalehurst Member	08-Jan-88	24.99	82.0	12.8	42.0	M35377.051164
Munro, Cliff	NE 21-038-28 W4M	Dalehurst Member	16-Feb-83	43.28	142.0	12.19	40.0	M35377.080359
Munroe, M.	SE 04-038-23 W4M	Upper Scollard	15-Apr-60	25.91	85.0	6.1	20.0	M35377.077878
Murdock, Jim	NW 22-037-27 W4M	Dalehurst Member	15-May-75	48.77	160.0	7.62	25.0	M35377.052697
Murray, Malcolm	03-16-036-23 W4M	Dalehurst Member	28-Apr-82	36.57	120.0	26.21	86.0	M35377.230245
Nichols, R. D.	SW 04-038-26 W4M	Dalehurst Member	02-May-74	54.86	180.0	18.29	60.0	M35377.053405
Nickavich, Helen/George	SE 02-038-28 W4M	Dalehurst Member	19-Aug-83	39.62	130.0	-0.03	-0.1	M35377.080390
Nielsen, H	SW 05-036-02 W5M	Dalehurst Member	05-Oct-84	29.87	98.0	9.14	30.0	M35379.029360
Nissen, Margaret	NW 36-035-03 W5M	Dalehurst Member	23-Apr-76	27.43	90.0	4.57	15.0	M35379.028849
Oke, Albert	NW 23-038-23 W4M	Upper Scollard	06-Jun-89	42.67	140.0	20.94	68.7	M35377.078077
Olson, Shelly	NE 19-037-27 W4M	Dalehurst Member	04-Jun-85	54.86	180.0	17.07	56.0	M35377.052671
P.G. Cattle Company Ltd.	SW 03-038-22 W4M	Upper Horseshoe Canyon	30-Jul-98	18.89	62.0	6.42	21.1	M36327.754415
Page, Allen	14-16-036-24 W4M	Dalehurst Member	04-Aug-81	67.05	220.0	40.81	133.9	M35377.095956
Papuschak, A.	SW 02-038-23 W4M	Upper Scollard	30-Oct-81	30.48	100.0	17.56	57.6	M35377.077858
Parker, C.	NW 34-036-27 W4M	Dalehurst Member	23-Oct-78	48.77	160.0	14.02	46.0	M35377.051289

WATER WELLS RECOMMENDED FOR FIELD-VERIFICATION THAT MEET CRITERIA

		Aquifer	Date Water	Completed Depth		NPWL		
Owner	Location	Name	Well Drilled	Metres	Feet	Metres	Feet	UID
Parmeter, George	SW 33-038-01 W5M	Dalehurst Member	05-Sep-75	31.39	9.14	30.0	98.4	M35379.055424
Parsonage, R.	NE 11-036-28 W4M	Dalehurst Member	12-May-59	22.25	10.67	35.0	114.9	M35377.051355
Paylor, W.	SW 32-037-26 W4M	Dalehurst Member	16-Jun-80	60.96	54.5	178.8	586.7	M35377.052475
Pearson, E.C.	SW 07-038-28 W4M	Surficial	18-Jan-58	23.77	9.14	30.0	98.4	M35377.080387
Pearson, Jim	SW 26-034-02 W5M	Dalehurst Member	05-Jun-73	30.48	3.32	10.9	35.7	M35379.107318
Pederson, A.	02-13-035-04 W5M	Dalehurst Member	26-May-76	24.38	9.45	31.0	101.7	M35379.029083
Pengelly, Nigel	SW 04-038-23 W4M	Upper Scollard	06-Jul-87	24.38	6.58	21.6	70.8	M35377.077882
Peterson, Win	NE 10-039-28 W4M	Dalehurst Member	03-May-71	50.59	16.76	55.0	180.4	M35377.066522
Pierce, Charles R.	05-21-036-24 W4M	Dalehurst Member	28-Jun-72	54.86	41.15	135.0	443.0	M35377.095816
Pine Lake Curling Rink	16-22-036-25 W4M	Dalehurst Member	22-Jul-71	28.95	12.19	40.0	131.2	M35377.096149
Pomerleau, Ernie	SW 03-039-27 W4M	Upper Lacombe Member	16-Aug-68	60.96	45.72	150.0	492.2	M35377.065833
Pool, Scott	NE 35-037-28 W4M	Dalehurst Member	07-Feb-86	47.85	13.72	45.0	147.7	M35377.053115
Pope, D.	08-22-036-25 W4M	Dalehurst Member	01-Nov-69	32	20.42	67.0	219.8	M35377.096121
Ramage, A.	NE 15-037-28 W4M	Dalehurst Member	24-May-77	42.67	18.29	60.0	196.9	M35377.053000
Ramsey, Bruce	16-29-036-01 W5M	Dalehurst Member	15-Aug-73	12.8	4.57	15.0	49.2	M35379.029958
Rasmussen, Borge	SE 02-036-03 W5M	Dalehurst Member	20-Feb-74	21.94	4.57	15.0	49.2	M35379.029790
Reberger, Duane	NE 04-035-03 W5M	Dalehurst Member	28-Feb-80	24.38	6.1	20.0	65.7	M35379.130452
Redman, Leslie	NE 17-038-22 W4M	Lower Scollard	14-Apr-60	38.4	9.14	30.0	98.4	M35377.051937
Reeves, Ken	16-04-037-28 W4M	Dalehurst Member	18-Oct-61	40.23	27.43	90.0	295.3	M35377.052919
Richard, Fred	08-07-036-25 W4M	Dalehurst Member	08-Nov-74	35.96	16.76	55.0	180.4	M35377.096023
Ringdahl, Lyle	12-28-037-23 W4M	Upper Scollard	14-Mar-80	36.57	19.93	65.4	214.5	M35377.228264
Robblee, J.S.	SW 08-035-02 W5M	Dalehurst Member	27-Dec-77	11.58	1.68	5.5	18.1	M35379.106399
Robertson, Bob	NW 15-037-23 W4M	Upper Scollard	01-May-71	35.66	28.04	92.0	301.8	M35377.228096
Robidou, Walter	SW 06-038-26 W4M	Dalehurst Member	30-Nov-63	32.92	13.72	45.0	147.7	M35377.053415
Robinson, Edgar & Darlene	10-12-035-02 W5M	Dalehurst Member	11-Jun-68	39.62	5.82	19.1	62.7	M35379.077940
Robinson, J	NW 20-038-02 W5M	Dalehurst Member	14-Aug-62	30.48	27.13	89.0	292.1	M35379.057533
Roland, Percy	SE 36-037-28 W4M	Dalehurst Member	09-Nov-89	70.71	8.53	28.0	91.8	M35377.079689
Rowbotham, Austin	SE 14-039-27 W4M	Upper Lacombe Member	27-Jun-74	54.86	27.43	90.0	295.3	M35377.065993
Rowland, William	NE 19-037-27 W4M	Dalehurst Member	01-Sep-72	48.77	7.62	25.0	82.0	M35377.052660
Schafer, Roy	12-06-037-26 W4M	Dalehurst Member	06-Aug-79	13.72	9.14	30.0	98.4	M35377.052313
Schafer, Roy	12-06-037-26 W4M	Dalehurst Member	28-Apr-61	18.29	12.8	42.0	137.8	M35377.052315
Schielke, Carl	08-26-037-27 W4M	Dalehurst Member	16-Aug-81	46.02	6.71	22.0	72.2	M35377.052726
Schritt, H. G.	NE 30-038-28 W4M	Dalehurst Member	20-Sep-74	30.48	10.67	35.0	114.9	M35377.065727
Schubert, Les	NE 06-036-24 W4M	Dalehurst Member	27-Sep-84	22.25	5.49	18.0	59.1	M35377.095862
Scott Builders	NE 16-038-27 W4M	Dalehurst Member	27-Aug-82	32.61	23.77	78.0	255.9	M35377.077668
Scott, Dave	01-13-036-04 W5M	Dalehurst Member	25-Apr-75	56.39	14.63	48.0	157.5	M35379.030040
Sekura, John	NW 21-037-02 W5M	Dalehurst Member	21-Sep-82	36.57	3.66	12.0	39.4	M35379.031316
Setters, Pat	SE 18-036-26 W4M	Dalehurst Member	11-Jun-80	60.96	51.17	167.9	550.8	M35377.230549
Seventh Day Adventist Church	14-20-037-27 W4M	Dalehurst Member	09-Apr-81	50.29	16.46	54.0	177.2	M35377.090087
Shannon, Dennis	SW 16-034-27 W4M	Dalehurst Member	28-Jul-83	45.72	21.94	72.0	236.2	M35377.169256
Shields, Howard	SW 14-038-23 W4M	Upper Scollard	02-Oct-80	37.79	7.68	25.2	82.7	M35377.078002
Simanton, Robert	04-26-034-03 W5M	Dalehurst Member	20-Aug-85	19.81	10.36	34.0	111.5	M35379.036595
Sinclair, Jim	NW 21-038-28 W4M	Dalehurst Member	30-Jul-80	22.86	10.06	33.0	108.3	M35377.065536
Skog, Don	01-33-038-28 W4M	Dalehurst Member	30-Mar-85	20.73	18.29	60.0	196.9	M35377.065762
Slemko, John	NW 32-038-27 W4M	Upper Lacombe Member	01-Aug-67	54.86	38.1	125.0	410.1	M35377.078232
Smart, Brian	NE 15-036-23 W4M	Haynes Member	12-Aug-76	36.57	7.38	24.2	79.4	M35377.097541
Smith, Bill	09-30-037-27 W4M	Surficial		15.24	9.14	30.0	98.4	M35377.052783
Smith, Dave	12-18-036-24 W4M	Dalehurst Member	01-Jan-71	44.19	25.69	84.3	276.6	M35377.095976
Smith, Tim	SE 35-038-03 W5M	Dalehurst Member	02-May-79	50.59	17.98	59.0	193.6	M37066.937447
Spenceley, John	NW 13-038-27 W4M	Dalehurst Member	14-Sep-84	37.79	10.67	35.0	114.9	M35377.077633
Spyker, James	NW 30-037-23 W4M	Upper Scollard	01-May-73	33.22	13.04	42.8	140.4	M35377.228300
Steele, Norman	15-22-037-26 W4M	Dalehurst Member	15-Jan-58	19.51	4.42	14.5	47.6	M35377.052396
Stephanson, Cecil	NE 10-037-02 W5M	Dalehurst Member	23-Jun-67	24.38	9.14	30.0	98.4	M35379.031042
Stickland, Melvin	NW 05-037-28 W4M	Dalehurst Member	19-Oct-78	25.91	18.29	60.0	196.9	M35377.052929
Stigings, Dwayne	NE 22-035-02 W5M	Dalehurst Member	01-Nov-73	36.57	15.24	50.0	164.1	M35379.029422
Stinn, La Verne	02-28-038-02 W5M	Dalehurst Member	01-Jan-45	15.85	7.62	25.0	82.0	M35379.058930
Stolz, Alvin	NW 28-038-01 W5M	Dalehurst Member	19-Oct-76	30.48	7.31	24.0	78.7	M35379.054383
Stoness, Bill	NW 23-036-25 W4M	Dalehurst Member	24-May-85	21.33	10.82	35.5	116.5	M35377.096193
Strabel, Maurice	NE 16-039-27 W4M	Upper Lacombe Member	10-Aug-72	33.53	11.58	38.0	124.7	M35377.080753
Strachan, D.	SE 15-036-27 W4M	Dalehurst Member	08-Sep-76	32	4.57	15.0	49.2	M35377.051155

WATER WELLS RECOMMENDED FOR FIELD-VERIFICATION THAT MEET CRITERIA

		Aquifer	Date Water	Completed Depth		NPWL		
Owner	Location	Name	Well Drilled	Metres	Feet	Metres	Feet	UID
Strokappe, John	SE 06-039-27 W4M	Dalehurst Member	18-Nov-75	42.67	140.0	11.28	37.0	M35377.065868
Svederus, Bill	SE 17-036-25 W4M	Dalehurst Member	25-Jun-81	48.77	160.0	27.43	90.0	M35377.096078
Tainsh, Ron	NW 14-037-24 W4M	Haynes Member	01-Aug-73	48.77	160.0	22.86	75.0	M35377.231020
Tar-Iffic Developments Ltd	SW 15-039-27 W4M	Upper Lacombe Member	28-May-86	45.72	150.0	10.67	35.0	M35377.066034
Taylor, Allan	NE 23-034-03 W5M	Dalehurst Member	08-May-82	46.33	152.0	9.75	32.0	M37066.937887
Tensen, Clarence	16-18-038-26 W4M	Dalehurst Member	26-Feb-60	50.29	165.0	4.27	14.0	M35377.053571
Thompson, Tim	03-27-034-28 W4M	Upper Surficial	29-Jul-82	12.19	40.0	6.61	21.7	M35377.224778
Tisch, Peter	SW 23-036-23 W4M	Haynes Member	24-Jun-77	36.57	120.0	7.31	24.0	M35377.230272
Tober, Ted	01-26-034-04 W5M	Dalehurst Member	08-Jul-78	33.53	110.0	11.89	39.0	M35379.130044
Todd, Bain	SE 19-038-26 W4M	Dalehurst Member	08-May-62	40.23	132.0	11.582	38.0	M35377.053596
Towle, Jim	SW 25-035-28 W4M	Dalehurst Member	01-Feb-81	50.9	167.0	6.4	21.0	M35377.225898
Turney, Bix	NW 36-036-28 W4M	Dalehurst Member	13-Oct-88	34.14	112.0	0.61	2.0	M35377.051481
Uavigne, C.A.	SW 08-038-23 W4M	Upper Scollard	01-Apr-70	54.86	180.0	23.16	76.0	M35377.077918
Underwood, Ronald	15-30-036-25 W4M	Dalehurst Member	04-Aug-72	11.28	37.0	4.57	15.0	M35377.096151
Urban, Joe	SW 13-036-01 W5M	Dalehurst Member	28-Sep-77	42.67	140.0	16.15	53.0	M35379.029295
Valli, Adrian	NW 23-038-02 W5M	Dalehurst Member	16-Aug-77	27.43	90.0	10.97	36.0	M35379.058900
Van Haren, Peter	NW 21-038-28 W4M	Dalehurst Member	25-Jul-84	30.48	100.0	33.53	110.0	M35377.065551
Van Slyke	NW 03-039-28 W4M	Dalehurst Member	30-Oct-67	24.08	79.0	9.14	30.0	M35377.066489
Van Slyke, Floyd	11-03-039-28 W4M	Dalehurst Member	24-Sep-81	29.56	97.0	27.13	89.0	M35377.066490
Vincent, A.G.	04-32-036-25 W4M	Dalehurst Member	01-Feb-74	41.15	135.0	33.34	109.4	M35377.096210
Vincent, D.	01-01-037-25 W4M	Dalehurst Member	01-Mar-69	73.76	242.0	27.43	90.0	M35377.231137
Volker, Ken	SW 31-037-22 W4M	Upper Scollard	17-Sep-76	48.77	160.0	21.33	70.0	M35377.051701
Wagers, Lester	SW 35-035-28 W4M	Dalehurst Member	06-Jun-75	44.19	145.0	13.41	44.0	M35377.225990
Walker, Leonard	SW 36-036-03 W5M	Dalehurst Member	13-May-83	26.82	88.0	16.76	55.0	M35379.031943
Watson, D.J.	NW 32-036-22 W4M	Upper Scollard	13-Sep-74	36.57	120.0	9.14	30.0	M35377.077081
Watson, Kay	NE 11-038-03 W5M	Dalehurst Member	28-May-82	41.76	137.0	6.4	21.0	M35379.036796
Weir, Norman	NE 17-034-27 W4M	Dalehurst Member	01-Apr-77	25.91	85.0	19.81	65.0	M35377.169258
Wells, Jim	NW 31-037-27 W4M	Dalehurst Member	10-Nov-81	45.72	150.0	12.19	40.0	M35377.052786
Westesa, Teis	NE 31-037-28 W4M	Dalehurst Member	26-Jun-78	32	105.0	9.75	32.0	M35377.053085
Whitehead, Jack	SW 10-039-01 W5M	Dalehurst Member	12-Apr-91	35.66	117.0	20.73	68.0	M35379.057817
Williams, A.	SW 06-038-22 W4M	Upper Scollard	03-May-69	32	105.0	9.14	30.0	M35377.051885
Wilson, Ron	SE 23-036-24 W4M	Dalehurst Member	20-Sep-78	54.86	180.0	9.45	31.0	M35377.095856
Wilson, Sandy	NW 34-037-24 W4M	Haynes Member	14-Jul-77	42.67	140.0	4.57	15.0	M35377.231124
Wong, Yee Wah	NE 12-038-27 W4M	Dalehurst Member	09-Jan-67	22.86	75.0	16.76	55.0	M35377.088149
Woodrow, Allan	NW 14-037-27 W4M	Dalehurst Member	05-Jun-73	54.25	178.0	7.01	23.0	M35377.079726
Woof, Bill	NW 32-037-27 W4M	Dalehurst Member	25-Mar-81	42.06	138.0	2.44	8.0	M35377.052816
Wright, Brian	NE 33-037-24 W4M	Haynes Member	24-Oct-84	42.67	140.0	6.1	20.0	M35377.119126
Young, P.	SE 06-035-01 W5M	Dalehurst Member	31-May-63	17.68	58.0	11.58	38.0	M35379.130403

RED DEER COUNTY-OPERATED WATER WELLS

		Aquifer	Date Water	Completed Depth		NPWL		
Owner	Location	Name	Well Drilled	Metres	Feet	Metres	Feet	UID
County of Red Deer	NW 35-037-27 W4M	19-Jun-92	Dalehurst Member	48.8	160.0	16.22	53.2	M35377.115310
County of Red Deer	SW 10-036-03 W5M	20-Mar-85	Dalehurst Member	21.6	71.0		0.0	M35379.030258
County of Red Deer	SE 33-038-01 W5M	08-Dec-78	Dalehurst Member	40.2	132.0	5.49	18.0	M35379.055193
County of Red Deer No. 23	SE 30-037-27 W4M	31-May-91	Dalehurst Member	40.2	132.0	12.65	41.5	M35377.092336
Red Deer, County Of	SE 09-036-03 W5M	05-Sep-78	Dalehurst Member	54.9	180.0	6.1	20.0	M35379.030217
Red Deer, County Of	NE 29-037-27 W4M	26-Oct-95	Bedrock	59.4	195.0	14.22	46.7	M35377.064641