The following table shows a breakdown of the 409 licensed groundwater allocations by the aquifer in which the water well is completed. The largest total licensed allocations are in the Haynes and Upper Lacombe aquifers; the majority of the groundwater is used for municipal and agricultural purposes.

	No. of	Licensed Groundwater Users* (m³/day)									
Aquifer **	Diversions	Agricultural	Commerical	Industrial	Municipal	Recreation	Fishery	Exploration	Dewatering	Total	Percentage
Upper Sand and Gravel	3	62	0	0	0	0	44	0	0	106	1
Lower Sand and Gravel	14	27	248	0	372	0	0	0	615	1,262	7
Dalehurst	48	407	61	46	608	0	0	0	0	1,122	7
Upper Lacombe	158	2,274	141	895	352	53	0	8	0	3,723	22
Lower Lacombe	33	493	132	0	34	0	0	0	0	659	4
Haynes	63	577	162	0	5,307	3	0	0	0	6,049	36
Upper Scollard	28	412	0	0	1,244	3	0	278	0	1,937	11
Lower Scollard	9	74	0	0	18	0	98	0	0	190	1
Upper Horseshoe Canyon	22	197	34	0	446	0	0	0	0	677	4
Bedrock	17	138	186	0	187	0	5	152	0	668	4
Unknown	14	171	0	389	10	0	0	0	0	570	3
Total	409	4,832	964	1,330	8,578	59	147	438	615	16,963	100
Percentage		28	6	8	50	0	1	3	4	100	

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

Table 1. Licensed Groundwater Diversions

Based on the 1996 Agriculture Census, the calculated water requirement for livestock for the County is in the order of 15,258 m³/day. Of the 15,258 m³/day average calculated livestock use, AENV has licensed a groundwater diversion of 4,832 m³/day (32%) and a licensed surface-water diversion of 1,334 m³/day (9%). The remaining 59% of the calculated livestock use would have to be mainly from unlicensed sources.

5) Groundwater Chemistry and Base of Groundwater Protection

Groundwaters from the surficial deposits can be expected to be chemically hard with a high dissolved iron content. High nitrate and nitrite (as N) were not evident in the available chemical data for the surficial or upper bedrock aquifer(s); a plot of nitrate and nitrite (as N) in surficial aquifers is on the accompanying CD-ROM. The TDS concentrations in the groundwaters from the upper bedrock in the County are generally less than 1,000 mg/L, and in the Eckville, Blackfalds and Lacombe areas groundwaters generally have less than 500 mg/L of TDS (page A-29). Groundwaters from the bedrock aquifers frequently are chemically soft with generally low concentrations of dissolved iron. The chemically soft groundwater is high in sodium concentration. Nearly 15% of the chemical analyses indicate a fluoride concentration above 1.5 mg/L, with most of the exceedances occurring in the south-central part of the County (see CD-ROM).

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

Constituent	Range for County in mg/L Minimum	Maximum	Average	Recommended Maximum Concentration GCDWQ
Total Dissolved Solids	64	2917	745	500
Sodium	0	925	230	200
Sulfate	0	1275	140	500
Chloride	<1	1050	9	250
Fluoride	0	8.6	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)

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

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

Alberta Environment defines the Base of Groundwater Protection as the elevation below which the groundwater is expected to have more than 4,000 mg/L of total dissolved solids. By using the ground elevation, and the elevation of the Base of Groundwater Protection provided by the Alberta Energy and Utilities Board (EUB), a depth to the Base of Groundwater Protection can be determined. These values are gridded using the Kriging[6] method to prepare a depth to the Base of Groundwater Protection surface. This depth, for the most part, would be the maximum drilling depth for a water well for agricultural purposes or for a potable water supply. If a water well has total dissolved solids exceeding 4,000 mg/L, the groundwater use does not require licensing by AENV. In the County, the depth to Base of Groundwater Protection ranges from less than 100 metres to more than 500 metres below ground level, as shown on Figure 4 and on each cross-section, where present.

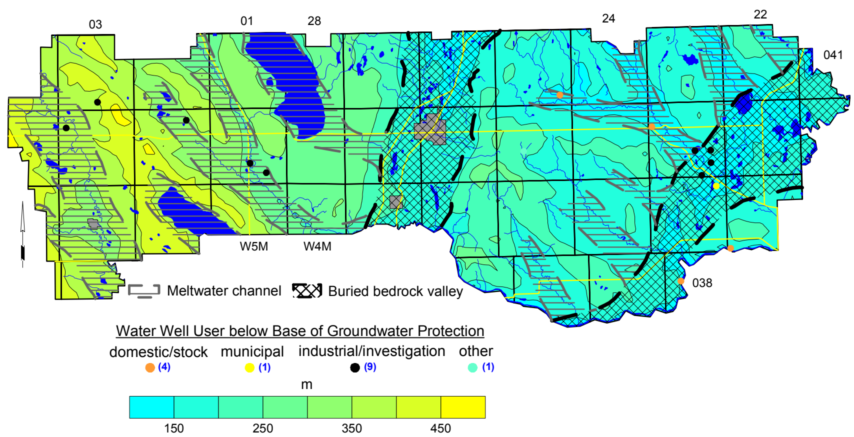

Figure 4. Depth to Base of Groundwater Protection (after EUB, 1995)

Of the 6,998 water wells with completed depth data, 15 are completed below the Base of Groundwater Protection. Most of these water wells are located in buried bedrock valleys or meltwater channels and in other areas where the depth to Base of Groundwater Protection is less than 150 metres. The five water wells located west of Range 28, W4M that are completed below the Base of Groundwater Protection are used for industrial or investigation purposes. Chemistry data are available for two water wells, which provide groundwaters with TDS concentrations of less than 1,000 mg/L.

Proper management of the groundwater resource requires water-level data. These data are often collected from observation water wells. At the present time, there are two AENV-operated observation water wells within the County. Additional data can be obtained from some of the licensed groundwater diversions. In the past, the data for licensed diversions have been difficult to obtain from AENV, in part because of the failure of the licensee to provide the data.

However, even with the available sources of data, the number of water-level data points relative to the size of the County is too few to provide a reliable groundwater budget (see section 6.0 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.

6 See glossary

III. Terms

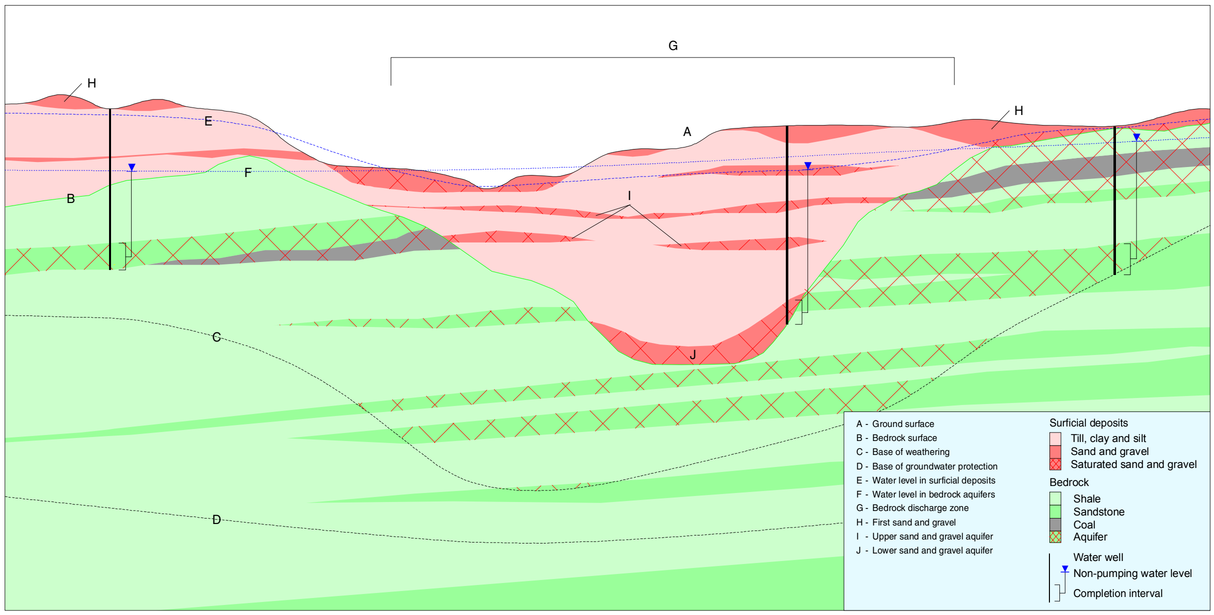

Figure 5. Generalized Cross-Section (for terminology only)

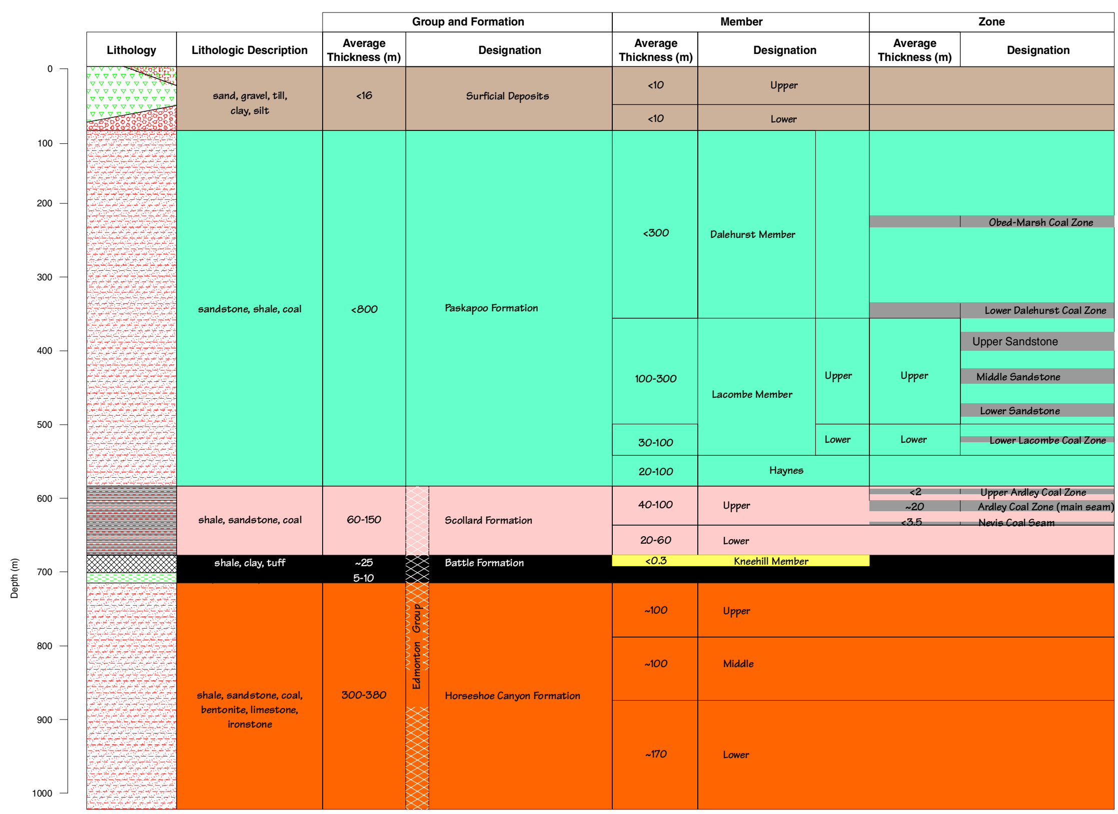

Figure 6. Geologic Column

IV. Methodology

A. 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) water well locations determined during water well surveys
6) chemical analyses for some groundwaters
7) location of flowing shot holes
8) location of structure test holes
9) a variety of data related to the groundwater resource.

The main disadvantage to the database is the absence of quality control. Very little can be done to overcome this lack of quality control in the data collection, other than to assess the usefulness of control points relative to other data during the interpretation. Another disadvantage to the database is the lack of adequate spatial information. Any duplicate water wells that have been identified for the County have been removed from the database used in this regional groundwater assessment.

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

The present project uses the 10TM coordinate system. This means that a record for the NW ¼ of section 26, township 039, range 22, W4M, would have a horizontal coordinate with an Easting of 131,135 metres and a Northing of 5,802,929 metres, the centre of the quarter section. If the water well has been repositioned by PFRA using orthorectified aerial photos, 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); the Resource Data Division of AENV 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.

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

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

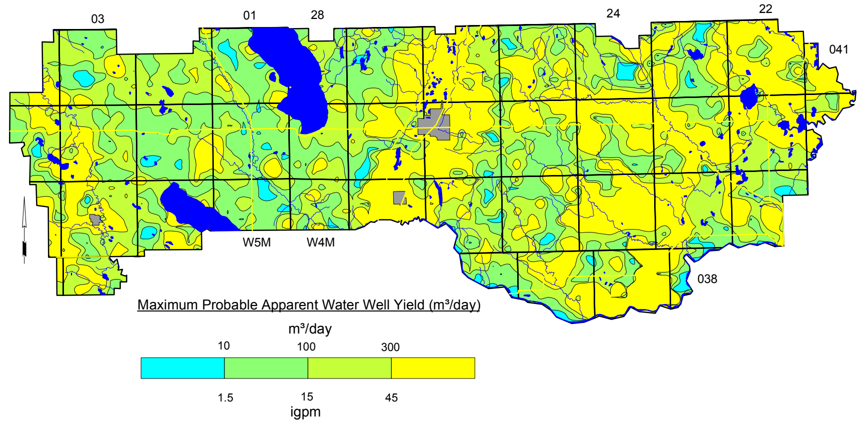

Figure 7. Hydrogeological Map

Also, where sufficient information is available, values for apparent transmissivity[7] and apparent yield[8] 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 hydrogeology map was published in 1971 (Tokarsky, 1971 and LeBreton, 1971), 2,800 values for apparent transmissivity and 2,485 values for apparent yield have been added to the groundwater database. With the addition of the apparent yield values, a hydrogeological map has been prepared to help illustrate the general groundwater availability across the County. The anticipated groundwater apparent yield is based on the expected yield of a single water well obtaining water from the total accessible stratigraphic section.

The EUB well database includes records for all of the wells drilled by the oil and gas industry. The information from this source includes:

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

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

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

7 For definitions of Transmissivity, see glossary
8 For definitions of Yield, see glossary

B. Spatial Distribution of Aquifers

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

1) lithologs provided by the water well drillers
2) geophysical logs from structure test holes
3) wells drilled by the oil and gas industry
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.

C. Hydrogeological Parameters

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

After the water wells are assigned to a specific aquifer, the parameters from the water well records are assigned to the individual aquifers. The parameters include non-pumping (static) water level (NPWL), apparent transmissivity if neither aquifer nor effective volumes are available, and apparent water well yield. The total dissolved solids, sulfate and chloride concentrations from the chemical analysis of the groundwater 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). Since 1986, Alberta Health and Wellness has restricted access to chemical analysis data, and hence the database includes only limited amounts of chemical data since 1986.

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. 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.

D. 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 an upper 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. The areal extent of individual parameters is outlined by “masks” to delineate individual aquifers. For the upper bedrock aquifer(s) where areas of no data are available from the groundwater database, maps prepared have been masked with a solid brown color to indicate this area. These brown masks have been added to the Lower Lacombe, Haynes, Upper and Lower Scollard, and the Upper Horseshoe Canyon aquifers. For the Dalehurst and Upper Lacombe aquifers, control points have been added to the maps to show the extent of the available data. Appendix A includes page-size maps from the text, plus additional page-size maps and figures that support the discussion in the text. A list of maps and figures that are included on the CD-ROM is given in Appendix B.

Cross-sections are prepared by first choosing control points from the database along preferred lines of section. Data from these control points are then obtained from the database and placed in an AutoCAD drawing with an appropriate vertical exaggeration. The data placed in the AutoCAD drawing include the geo-referenced lithology, completion intervals and NPWLs. Data from individual 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. Five cross-sections are presented in this report and as poster-size drawings forwarded with this report. The cross-sections also are in Appendix A, and are included on the CD-ROM; page-size maps of the poster-size cross-sections are included in Appendix D of this report.

E. Software

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

- Acrobat 4.0
- ArcView 3.1
- AutoCAD 14.01
- CorelDRAW! 8.0
- Microsoft Professional Office 2000
- Surfer 6.04