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
6) chemical analyses for some groundwaters
7) location of some flowing shot holes
8) location of some 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 within 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 based on the NAD27 datum. This means that a record for the NW ¼ of section 01, township 070, range 11, W4M, would have a horizontal coordinate with an Easting of 221,235 metres and a Northing of 6,101,516 metres, the centre of the quarter section. If the water well has been repositioned by AAFC-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); 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.

Where sufficient information is available, individual records are assigned to specific geological units in both the bedrock and the surficial deposits; the minimum information required is a value for the depth to bedrock and a value for depth to top and bottom of the completion intervals[7].

Also, where sufficient information is available, values for apparent transmissivity[8] and apparent yield[9] 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 map covering most of the County was published in 1980 (Ozoray, Wallick and Lytviak), 1980), 490 values for apparent transmissivity and 300 values for apparent yield have been added to the groundwater database. With the addition of the apparent yield values, including a 0.1 - m³/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 8). 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 hydrogeological maps.

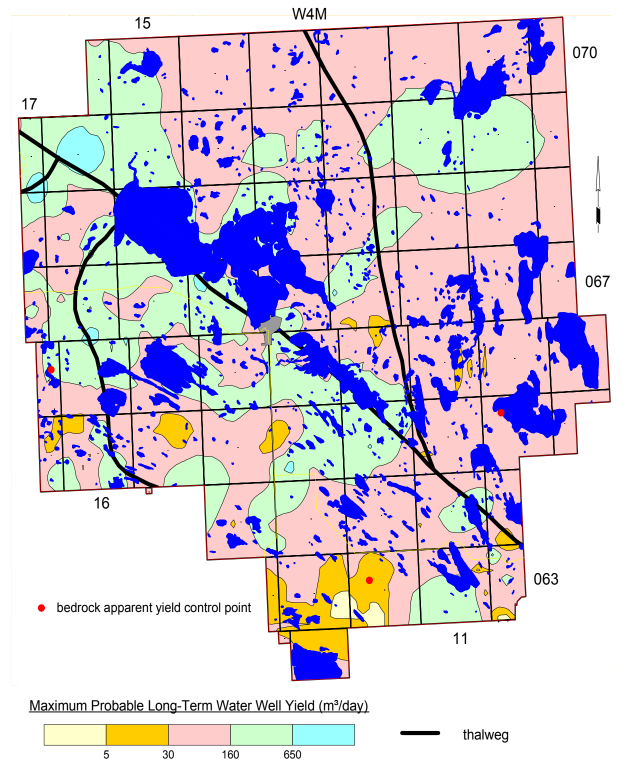

Figure 8. Hydrogeological Map

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 groundwater database. The reference section of this report lists the available reports. 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. Digital data of the Cold Lake stratigraphy were received from L. D. Andriashek (Andriashek and Fenton, 1989).

---

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

4.2 Spatial Distribution of Aquifers

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

1) Quaternary geologic formation picks provided by L. D. Andriashek
2) published structure contour maps
3) lithologs provided by the water well drillers
4) geophysical logs from structure test holes
5) geophysical logs for wells drilled by the oil and gas industry
6) 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 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, and apparent water well yield. The total dissolved solids, sulfate, nitrate + nitrite (as N), chloride and total hardness concentrations from the chemical analysis of the groundwater are also assigned to applicable aquifers. **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. The representative data set included using the available data from townships 062 to 070, ranges 09 to 17, W4M, plus a buffer area of at least one township. 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.

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 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. 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 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. Six cross-sections are presented in Appendix A of this report and as poster-size drawings forwarded with this report; only two (B-B' and D-D') 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 4.0
- ArcView 3.2
- AutoCAD 2000
- CorelDraw! 10.0
- Microsoft Office XP
- Surfer 7.0

5. Aquifers

5.1 Background

An aquifer is a permeable rock that is saturated. In this context, rock refers to subsurface materials, such as sand, gravel, sandstone and coal. If the non-pumping water level is above the top of the rock, this type of aquifer is an artesian aquifer. If the rock is not entirely saturated and the water level is below the top of the rock, this type of aquifer is a water-table aquifer. These types of aquifers occur in one of two general geological settings in the County. The first geological setting 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.

5.1.1 Surficial Aquifers

Surficial deposits in the County are mainly less than 100 metres thick, except in areas of linear bedrock lows where the thickness of the surficial deposits can exceed 150 metres. The Buried Helena and Imperial Mills valleys are the main linear bedrock lows in the County (see Figure 11). A linear bedrock low that is not well defined in the County is the Buried Kikino Valley. The west-east cross-section D-D', Figure 9 shown below, passes across both the Buried Helena and Buried Beverly valleys and shows the surficial deposits being in the order of 100 metres thick across the Buried Imperial Mills Valley.

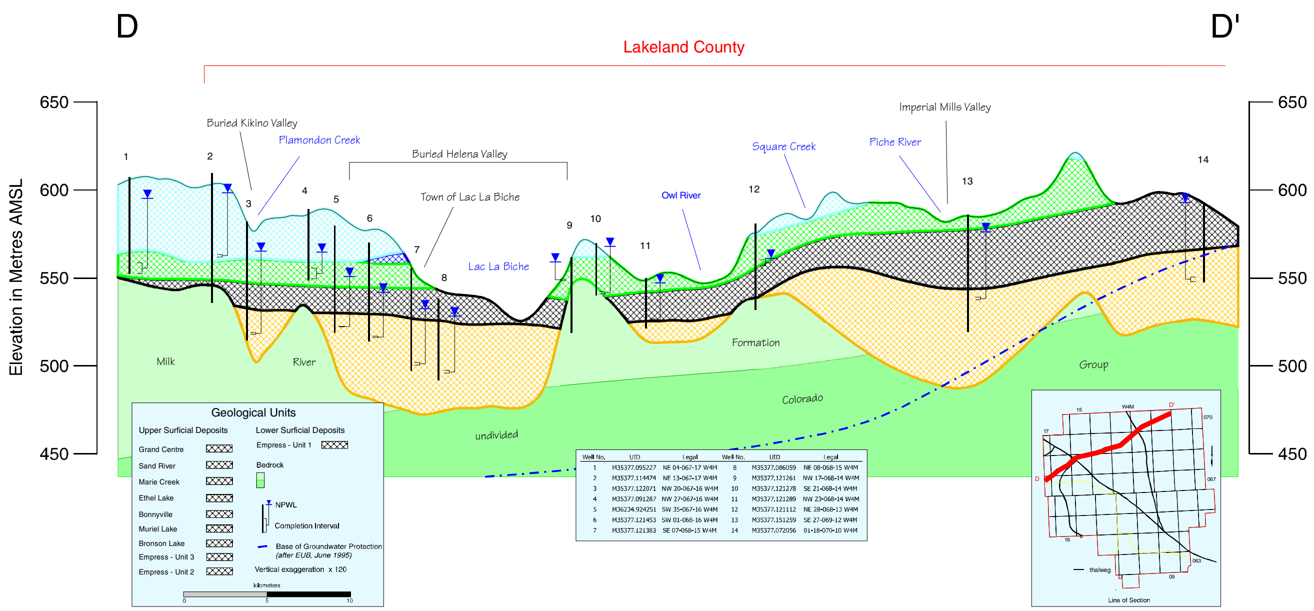

Figure 9. Cross-Section D - D'

In the County, the Base of Groundwater Protection extends below the bedrock surface but can extend into the Empress Formation, as shown on Figure 10 on the following page. A map showing the depth to the Base of Groundwater Protection is given on Page 7 of this report, in Appendix A, and on the CD-ROM.

The south-north cross-section B-B’, Figure 10 shown below, passes across the Buried Helena Valley and shows the surficial deposits being in the order of 50 metres thick but can be more than 100 metres thick across the Buried Helena Valley.

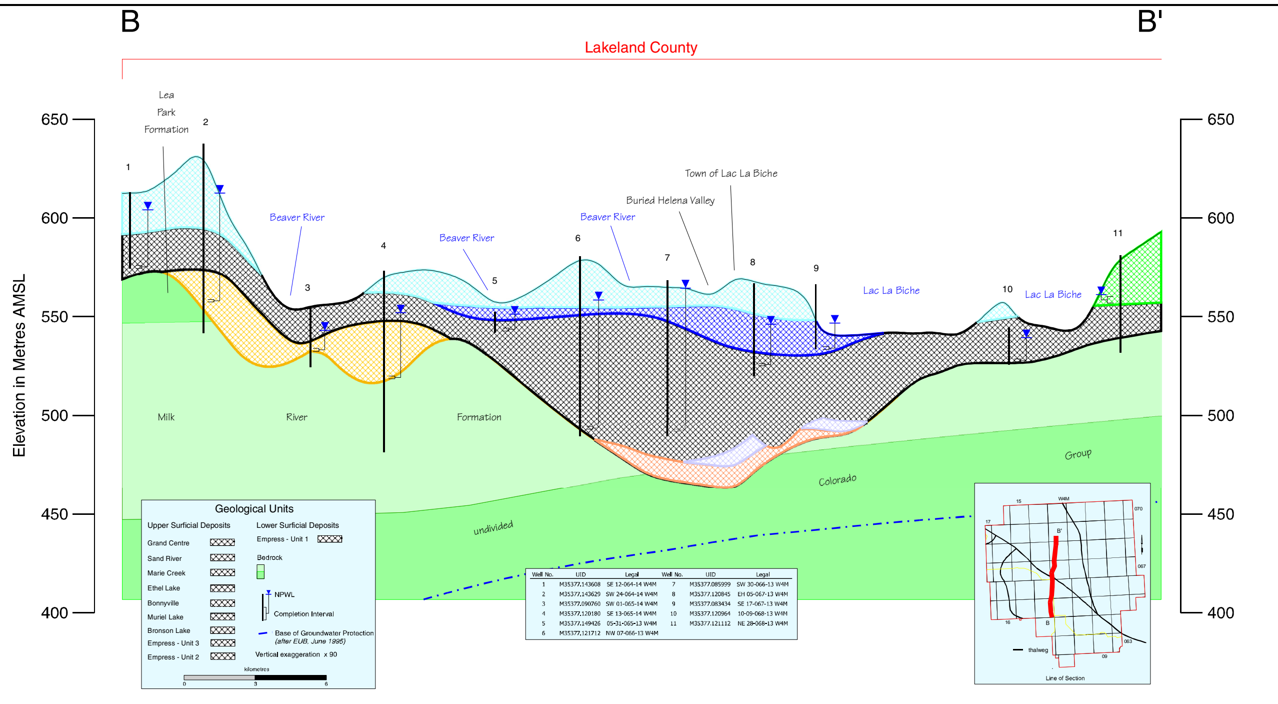

Figure 10. Cross-Section B - B'

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.

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. The groundwater from an aquifer in the surficial deposits usually has a chemical hardness of at least a few hundred mg/L and a dissolved iron concentration such that the groundwater must be treated before being used for domestic needs. Within the County, casing-diameter information is available for 585 of the 614 water wells completed in the surficial deposits; 95 (16%) of the 585 water wells have a casing diameter of more than 275 millimetres, and are assumed to be bored or dug water wells.

5.1.2 Bedrock Aquifers

In the County, the upper bedrock includes the Foremost, Lea Park and Milk River formations, and the *undivided* Colorado Group, as shown above in Figure 10. Some of this bedrock contains saturated rocks that are permeable enough to transmit groundwater for a specific need. In the County, the upper bedrock aquifer(s) are of minor importance and there are only a few water wells completed in the upper bedrock.

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[10] and lacustrine[11] deposits. The lacustrine deposits include clay, silt and fine-grained sand. The *upper surficial deposits* include the more traditional glacial deposits of till[12], meltwater deposits, and ice contact. Pre-glacial materials are expected to be mainly present in association with the buried bedrock valleys.

5.2.1 Geological Characteristics of Surficial Deposits

While the surficial deposits are treated as one hydrogeologic unit, they consist of three hydraulic parts. The first unit is the sand and gravel deposits of the lower surficial deposits, when present. These deposits are usually 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. For a graphical depiction of the above description, please refer to Figure 6, Page 7. While the unsaturated deposits are not technically an aquifer, they are significant as they provide a pathway for liquid 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 the adjacent map. There are four linear bedrock lows shown on the bedrock topography map. The lowest elevation of the linear bedrock low is the thalweg; the thalwegs for the linear bedrock lows in the present report are named as per Gold, Andriashek and Fenton, 1983.

Over the majority of the County, the surficial deposits are less than 100 metres thick (Page A-19). The exceptions are mainly in association with areas where buried bedrock valleys are present, where the deposits can have a maximum thickness of more than 150 metres. The main linear bedrock lows in the County are northwest-southeast-trending, are designated as the Buried Helena Valley and the Buried Imperial Mills Valley. The bedrock surface is at its lowest elevation of less than 440 metres AMSL within the Buried Helena Valley near Lac La Biche. The lowest elevation of the bedrock surface within the Buried Imperial Mills Valley is less than 480 metres AMSL.

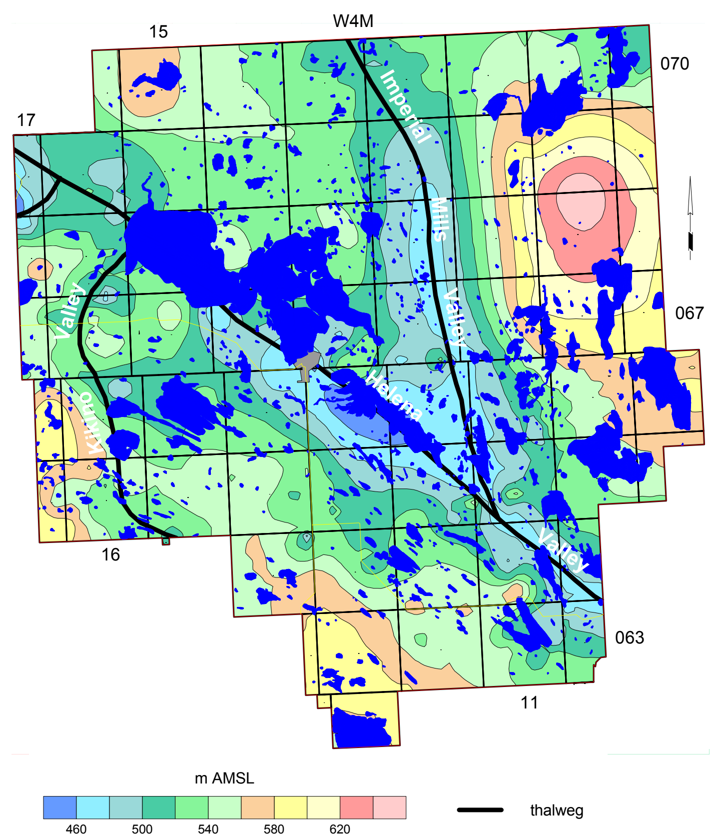

Figure 11. Bedrock Topography

10 See glossary
11 See glossary
12 See glossary