2.3 Background Information

2.3.1 Number, Type and Depth of Water Wells

There are currently records for 6,469 water wells in the groundwater database for the County. Of the 6,469 water wells, 5,798 are for domestic/stock purposes. The remaining 671 water wells were completed for a variety of uses, including industrial, municipal, observation, injection, irrigation, investigation and dewatering. Based on a rural population of 15,945 (Phinney, 2001), there are 1.4 domestic/stock water wells per family of four. It is unknown how many of these water wells may still be active. The domestic or stock water wells vary in depth from 1.2 to 198 metres below ground level. Details for lithology[5] are available for 3,335 water wells.

2.3.2 Number of Water Wells in Surficial and Bedrock Aquifers

There are 2,426 water well records 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 2,426 water wells for which aquifers could be defined, 549 are completed in surficial aquifers, with 75% having a completion depth of more than 20 metres below ground level. The adjacent map shows that the water wells completed in the surficial deposits occur throughout the County, but mainly in the vicinity of linear bedrock lows.

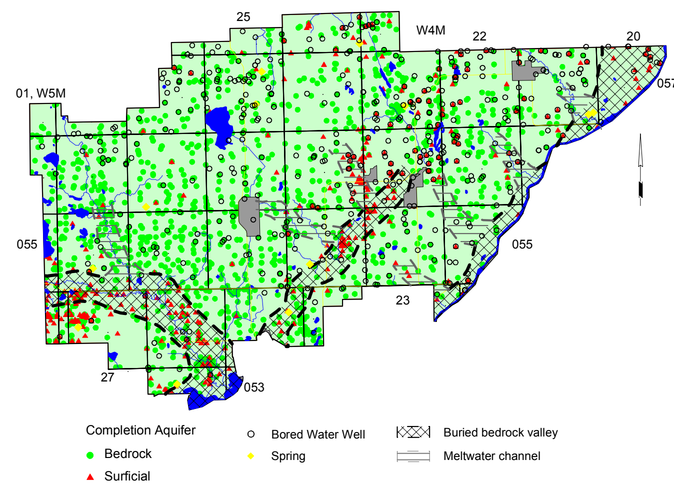

Figure 2. Location of Water Wells and Springs

The 1,877 water wells that have the top of their completion interval deeper than the top of the bedrock are referred to as bedrock water wells. From Figure 2, it can be seen that water wells completed in bedrock aquifers occur throughout the County.

There are currently records for 12 springs in the groundwater database for which there are only two available chemical analyses. The chemical values for springs indicate the groundwaters have total hardness concentrations of less than 200 milligrams per litre (mg/L) and total dissolved solids (TDS) concentrations ranging from 934 to 3,650 mg/L.

2.3.3 Casing Diameter and Type

Data for casing diameters are available for 2,936 water wells, with 2,449 (83%) indicated as having a diameter of less than 275 mm and 487 water wells having a surface-casing 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 drilled water wells. The locations of the 487 water wells with large-diameter casings are shown on Figure 2 as bored water wells. Bored water wells are generally completed in surficial deposits. Figure 2 shows that bored water wells occur throughout the County but mainly in groupings in the northern half of the County.

5 See glossary

Until the mid-1950s, the percentage of bored water wells nearly equaled the number of drilled water wells completed in the County. From 1960 to 1990, the percentage of bored water wells decreased to an average of 19%, and since the mid-1990s has decreased to only 2%.

In the County, steel, galvanized steel and plastic surface casing materials have been used in 99% of the drilled water wells over the last 40 years. Until 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 two percent of the water wells being drilled in the County in the late-1990s.

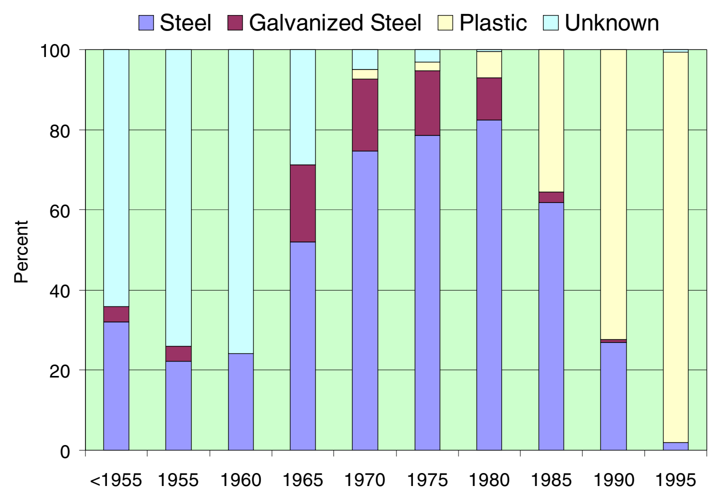

Figure 3. Surface Casing Types Used in Drilled Water Wells

Galvanized steel surface casing was used in a maximum of 19% of the drilled water wells from the early 1960s to the early 1990s. Galvanized steel was last used in December 1992. Plastic casing was first used in December 1971. The percentage of water wells with plastic casing has increased and in the late-1990s, plastic casing was used in 97% of the drilled water wells in the County.

2.3.4 Requirements for Licensing

Water wells used for household needs in excess of 1,250 cubic metres per year and all other groundwater use must be licensed. The only groundwater uses that do not need licensing are (1) household use of up to 1,250 m³/year and (2) groundwater with total dissolved solids in excess of 4,000 mg/L. At the end of 1999, 107 groundwater allocations were licensed in the County. Of the 107 licensed groundwater users, 71 could be linked to the Alberta Environment (AENV) groundwater database. Of the 107 licensed groundwater users, 66 are for agricultural purposes, and the remaining 41 are for commercial, municipal, recreation, fishery, irrigation or dewatering purposes. The total maximum authorized diversion from the water wells associated with these licences is 13,899 cubic metres per day (m³/day), although actual use could be less. Of the 13,899 m³/day, 10,578 m³/day (76%) is authorized for dewatering purposes from 12 dewatering wells as shown in Table 1 on the following page. Of the remaining 3,322 m³/day, 46% is allotted for commercial use, 28% is allotted for municipal use, 21% is allotted for agricultural use, and the remaining 5% is allotted for recreation, fishery and irrigation use. A figure showing the locations of the licensed users is in Appendix A (page A-5) and on the CD-ROM.

The largest single potable groundwater allocation within the County is for the Cardiff Golf and Country Club, having a diversion of 520 m³/day. This water supply well, used for commercial purposes, is completed in the Upper Sand and Gravel Aquifer.

The table below shows a breakdown of the 107 licensed groundwater allocations by the aquifer in which the water well is completed. The largest total licensed allocations are in the Lower Sand and Gravel Aquifer; the largest total licensed allocations not used for dewatering purposes are in the Upper Sand and Gravel Aquifer.

Aquifer **	Diversions	Agricultural	Commerical	Municipal	Recreation	Fishery	Irrigation	Dewatering	Total	Percentage
Upper Sand and Gravel	19	12	1,021	561	95	0	0	0	1,688	12
Lower Sand and Gravel	23	32	520	247	0	8	0	10,578	11,385	82
Lower Horseshoe Canyon	42	411	0	81	0	20	0	0	512	4
Bearpaw	10	88	0	0	0	0	20	0	108	1
Oldman	12	165	0	0	0	0	0	0	165	1
Unknown	1	0	0	41	0	0	0	0	41	0
Total	107	708	1,541	929	95	29	20	10,578	13,899	100
Percentage		5	11	7	1	0	0	76	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 7,085 m³/day. Of the 7,085 m³/day average calculated livestock use, AENV has licensed a groundwater diversion of 708 m³/day (10%) and a surface-water diversion of 463 m³/day (6%). The remaining 84% of the calculated livestock use would have to be from unlicensed sources.

2.3.5 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 + nitrite (as N) concentrations were evident in 13% of the available chemical data for the surficial aquifers and 2% of the available chemical data for the upper bedrock aquifer(s); a plot of nitrate + 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 range from less than 500 to more than 2,000 mg/L (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 concentrations of sodium. Ten percent of the chemical analyses indicate a fluoride concentration above 1.5 mg/L, with most of the exceedances occurring in the northeastern 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; maximum values of all five constituents exceed the guidelines. Of the 2,271 TDS values from water wells completed in the upper bedrock, 32 have TDS concentrations exceeding 4,000 mg/L.

Constituent	Range for County in mg/L Minimum	Maximum	Average	Recommended Maximum Concentration GCDWQ
Total Dissolved Solids	35	13,965	1424	500
Sodium	0	3,676	366	200
Sulfate	0	9,500	318	500
Chloride	0	4,400	186	250
Fluoride	0	13	0.8	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 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 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 150 metres to more than 270 metres below ground level, as shown on Figure 4 and on each cross-section.

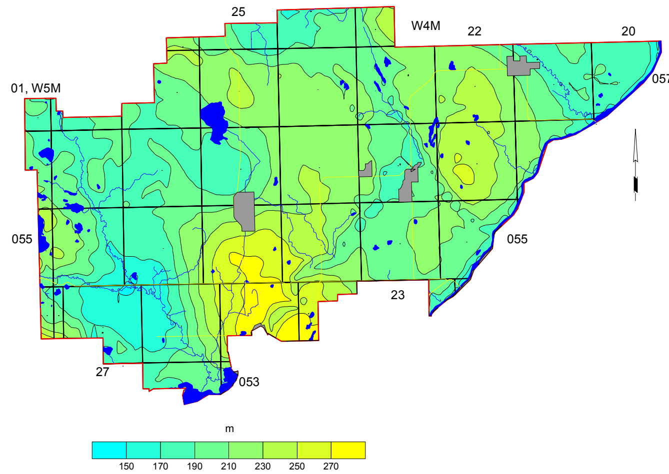

Figure 4. Depth to Base of Groundwater Protection (modified after EUB, 1995)

Of the 6,805 water wells with completed depth data, sixteen are completed below the Base of Groundwater Protection. These sixteen water wells are completed deeper than 1,100 metres below ground level and are used for industrial purposes.

Proper management of the groundwater resource requires water-level data. These data are often collected from observation water wells. At the present time, there are no 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

3. Terms

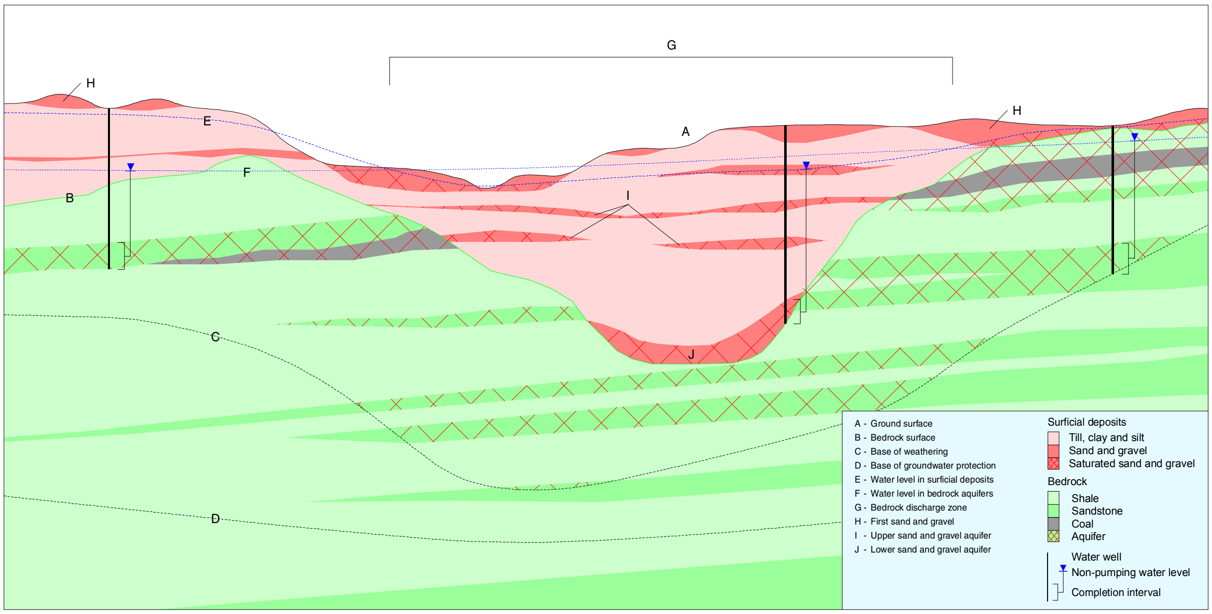

Figure 5. Generalized Cross-Section (for terminology only)

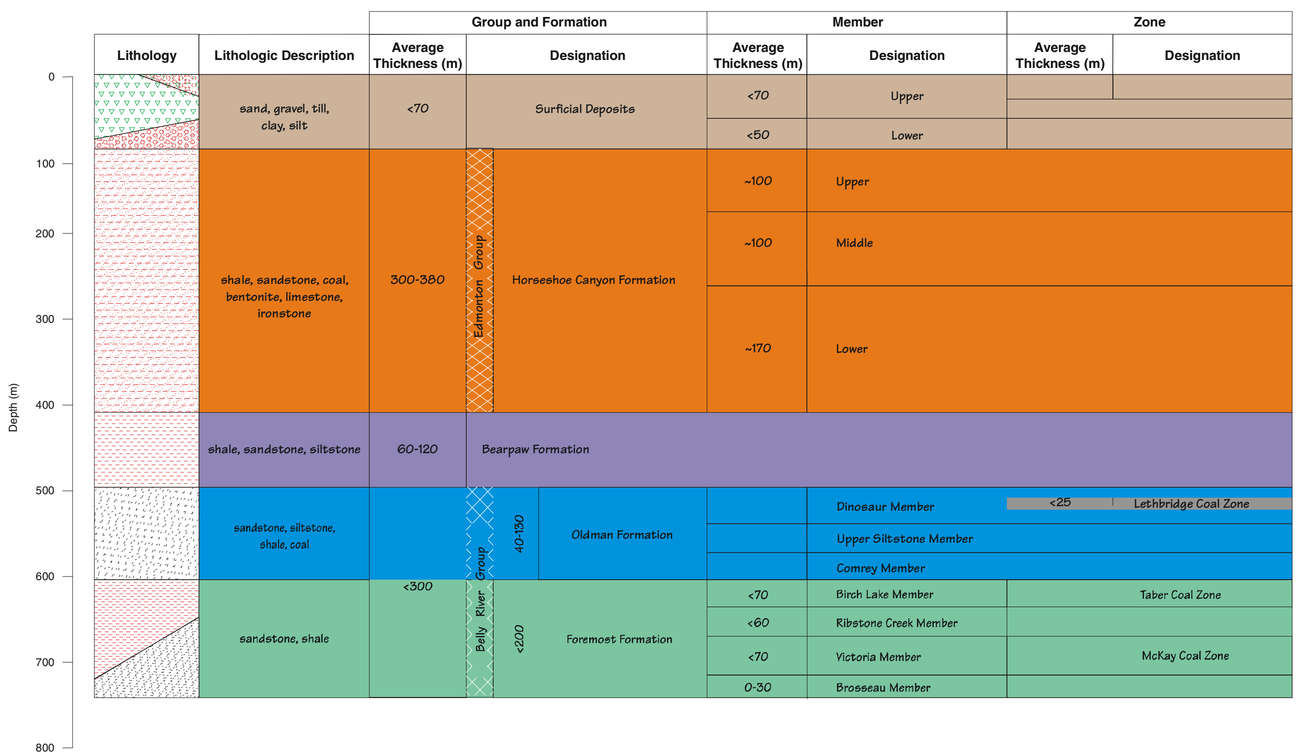

Figure 6. Geologic Column

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) water well locations determined during water well surveys
6) chemical analyses for some groundwaters
7) location of some 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 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. This means that a record for the NW ¼ of section 32, township 054, range 27, W4M, would have a horizontal coordinate with an Easting of 69,141 metres and a Northing of 5,949,398 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); 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 possible, determinations are made from individual records for the following:

1) depth to bedrock
2) total thickness of sand and gravel
3) total thickness of saturated sand and gravel
4) depth to the top and bottom of completion intervals.

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 hydrogeological map covering the majority of the County was published in 1974 (Bibby, 1974), 1,610 values for apparent transmissivity and 1,423 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.

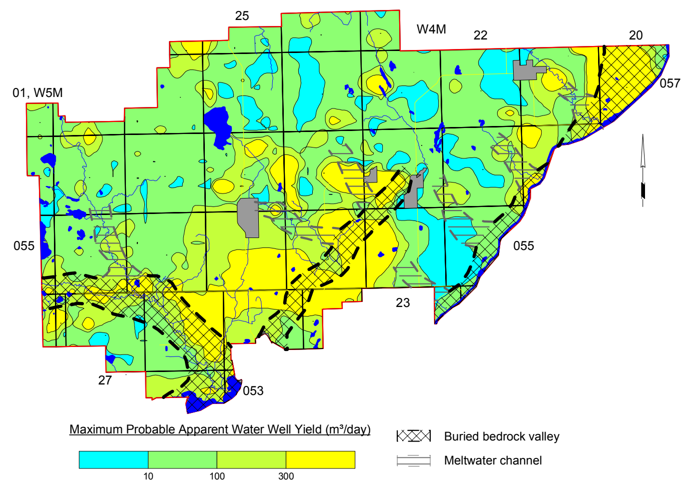

Figure 7. Hydrogeological Map

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 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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7 For definitions of Transmissivity, see glossary
8 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 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 if neither aquifer nor effective transmissivity values are available. 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.