## 2.3 Background Information

There are currently records for 4,625 water wells in the groundwater database for the County of Stettler. Of the 4,625 water wells, 4,161 are for domestic/stock purposes. The remaining 464 water wells were completed for a variety of uses, including municipal, observation and industrial purposes. Based on a rural population of 5,278, there are 3.2 domestic/stock water wells per family of four. The domestic or stock water wells vary in depth from less than 2 metres to 360 metres below ground level. Lithologic details are available for 2,694 water wells.

Data for completion depths are available for 4,435 water wells, with 4,088 indicated as having a completion depth of less than 80 metres. Of the remaining 347 water wells with completion depths, the completion ranges are as follows:

| Water Wells | |
| --- | --- |
| Total Depth (m) | Number |
| 80 to 99 | 212 |
| 100 to 119 | 67 |
| >119 | 68 |

From the adjacent map, it can be seen that water wells that are more than 120 metres deep, mainly occur in the western part of the County, to the north of the Town of Stettler, and in the eastern part of the County.

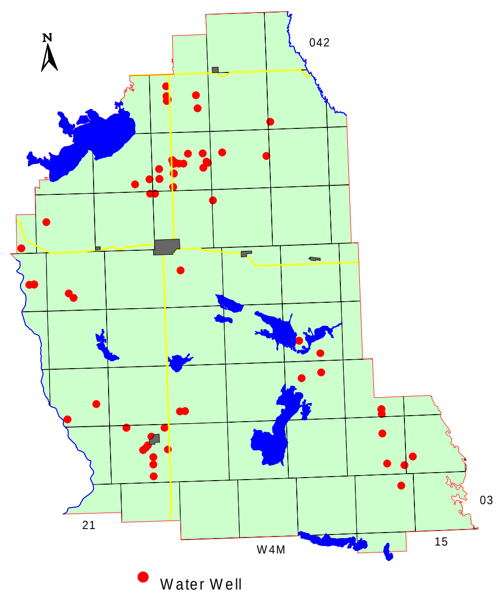


*Figure 2. Water Wells Deeper than 120 metres*

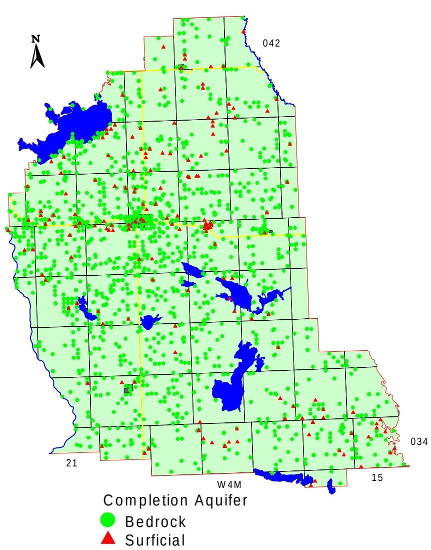


*Figure 3. Location of Water Wells*

There are 2,091 water well records with sufficient information to identify the aquifer in which the water wells are completed. 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 bedrock surface are water wells completed in surficial aquifers. The number of water wells completed in aquifers in the surficial deposits is 199. The adjacent map shows that these water wells are mainly in the north-central and southeastern parts of the County.

The remaining 1,892 water wells have the top of their completion interval deeper than the depth to the bedrock surface. From the adjacent map it can be seen that water wells completed in bedrock aquifers occur over most of the County.

Water wells not used for domestic needs must be licensed. At the end of 1996, 172 groundwater diversions were licensed in the County. The total maximum authorized diversion from these 172 water wells is 4,583 cubic metres per day (m³/day); 70% of the authorized groundwater diversion is allotted for industrial use. The largest licensed industrial groundwater diversion within the County is 1200 m³/day, for a PanCanadian Petroleum Limited saline water source well in 14-06-038-16 W4M. This saline water source well is completed at a depth of more than 1,500 metres below ground surface in the Leduc Formation. Seven other authorized industrial groundwater users in the County have water well completion depths ranging from 625 to 1,315 metres below ground surface and are located in townships 037 and 038, range 17, W4M. The water well completed at a depth of 625 metres is completed in the Basal Belly River Formation and the remaining six water wells are completed in the Glauconitic Formation, at a depth of approximately 1,300 metres. Although chemistry data were not available for the groundwater from the eight licensed water wells completed below a depth of 600 metres, the Alberta Energy and Uitlities Board (EUB) chemical database does have data for the groundwaters from the different formations. All of the groundwaters are a sodium-chloride-type. The total dissolved solids (TDS) in the groundwaters from the Leduc Formation are in the order of 100,000 milligrams per litre (mg/L); from the Glauconitic Formation the TDS are approximately 25,000 mg/L; and from the Basal Belly River Formation the TDS are in the order of 5,500 mg/L.

The largest licensed groundwater diversion within the County not used for industrial purposes is for the Village of Donalda, having a diversion of 71 m³/day.

The adjacent table shows a breakdown of the 172 licensed groundwater diversions by the aquifer in which the water well is completed. Even though ten saline water source wells are licensed, these supplies no longer need to be licensed. The next highest diversions are for licensed water wells completed in the Upper and Lower Horseshoe Canyon aquifers, of which most of the groundwater is used for agricultural purposes.

| | Licensed Groundwater Diversions (m³/day) | | | | | |
|---|---|---|---|---|---|---|
| Aquifer | Agricultural | Domestic | Industrial | Municipal | Other | Total |
| Surficial | 39 | 0 | 3 | 264 | 0 | 306 |
| Scollard | 129 | 0 | 0 | 0 | 0 | 129 |
| Upper Horseshoe Canyon | 404 | 30 | 31 | 132 | 10 | 607 |
| Lower Horseshoe Canyon | 324 | 0 | 0 | 173 | 0 | 497 |
| Saline Source Wells | 2 | 0 | 3043 | 0 | 0 | 3044 |
| Total | 898 | 30 | 3077 | 568 | 10 | 4,583 |

***Table 1. Licensed Groundwater Diversions***

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 surface was prepared representing the minimum depth for water wells and a second 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, the impression is that there is only one aquifer that is being used. Over approximately 75% of the County, the difference between the maximum and minimum depth is less than 15 metres. The areas where the greatest differences occur most often are in the eastern and north-central parts of the County. In these areas, aquifers in the surficial deposits and aquifers in the bedrock are developed.

Groundwaters from the surficial deposits can be expected to be chemically hard with a high dissolved iron content. The TDS concentrations in the groundwaters from the upper bedrock in the County are generally less than 2,000 mg/L. Groundwaters from the bedrock aquifers frequently are chemically soft with generally low concentrations of dissolved iron. The chemically soft groundwater is high in sodium concentration. Approximately 30% of the chemical analyses indicate a fluoride concentration above 1.0 mg/L.

Alberta Environmental Protection (AEP) defines the Base of Groundwater Protection as the elevation below which the groundwater is expected to have more than 4,000 mg/L of total dissolved solids. By using the ground elevation, the bedrock surface and the Base of Groundwater Protection, a depth to the Base of Groundwater Protection can be determined. This depth, for the most part, would be the maximum drilling depth for a water supply well. In the County, the depth to the Base of Groundwater Protection generally increases from north to south. Over approximately 20% of the County, the depth to the Base of Groundwater Protection is less than 200 metres, which mainly includes townships 041 and 042, and areas close to the Red Deer and Battle river valleys.

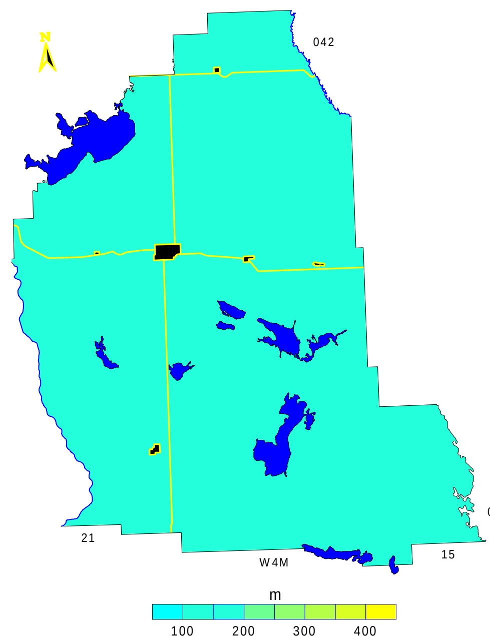


***Figure 4. Depth to Base of Groundwater Protection***

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

**However, even with the available sources of data, the number of water-level data points relative to the size of the County is too few to provide a reliable groundwater budget. The most cost-efficient method to collect additional groundwater monitoring data would be to have the water well owners measuring the water level in their own water well on a regular basis.**

# 3 TERMS

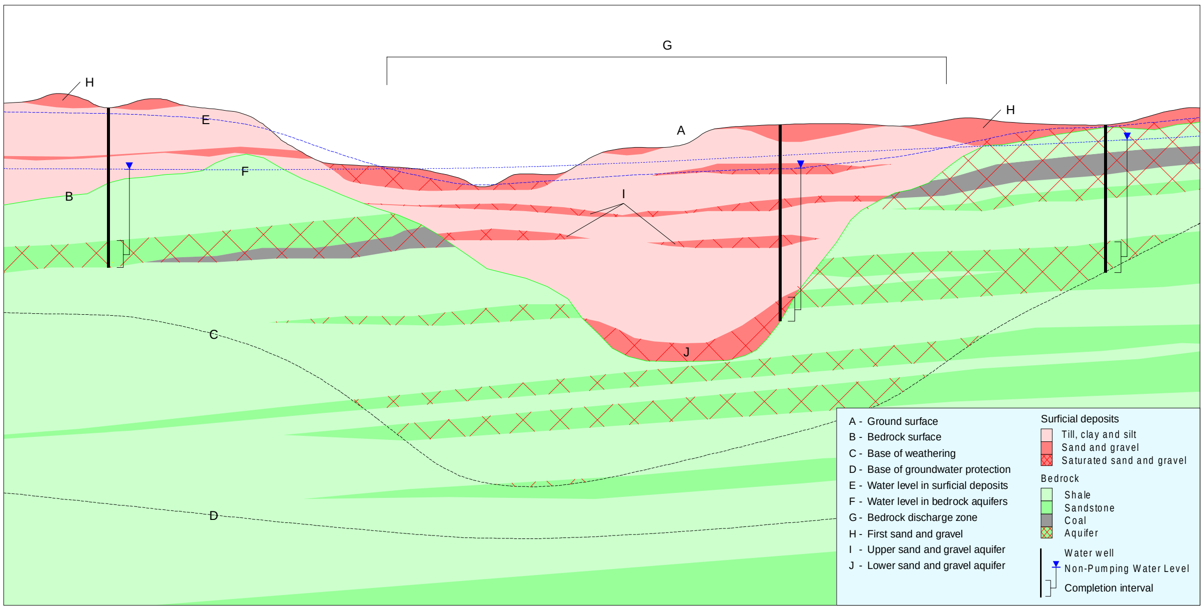


***Figure 5. Generalized Cross-Section (for terminology only)***

| Lithologic Description | Group | Thickness (Group and Formation) | Designation (Group and Formation) | Thickness (Member) | Designation (Member) | Thickness (Zone) | Designation (Zone) |
|---|---|---|---|---|---|---|---|
| sand, gravel, till, clay, silt | | <60 | Surficial Deposits | | | <30 | First Sand and Gravel |
| shale, sandstone, coal | Edmonton Group | 60-150 | Scollard Formation | 40-100 | Upper | <2 | Upper Ardley Coal Zone |
| | | | | | | ~20 | Ardley Coal Zone (main seam) |
| | | | | | | <1 | Nevis Coal Seam |
| | | | | 20-60 | Lower | | |
| shale, clay, tuff | Edmonton Group | ~25 | Battle Formation | <0.3 | Kneehill Member | | |
| shale, siltstone, sandstone | Edmonton Group | 5-10 | Whitemud Formation | | | | |
| shale, sandstone, coal, bentonite, limestone, ironstone | Edmonton Group | 300-380 | Horseshoe Canyon Formation | ~200 | Upper | | |
| | | | | ~170 | Lower | | |
| shale, sandstone, siltstone | | 60-120 | Bearpaw Formation | | | | |
| sandstone, siltstone, shale, coal | Belly River Group | 40-80 | Oldman Formation | <30 | Dinosaur Member | <25 | Lethbridge Coal Zone |
| | | | | <20 | Upper Siltstone Member | | |
| | | | | 8-20 | Comrey Member | | |
| shale, sandstone, coal | Belly River Group | 180-220 | Foremost Formation | | | <20 | Taber Coal Zone |
| | | | | | | <20 | McKay Coal Zone |
| sandstone, shale | | | | <30 | Basal Belly River Sandstone | | |

Depth (m): 0, 100, 200, 300, 400, 500, 600, 700, 800, 900

***Figure 6. Geologic Column***

# 4 METHODOLOGY

## 4.1 Data Collection and Synthesis

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

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

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

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

The present project uses the 10TM coordinate system. This means that a record for the SW ¼ of section 01, township 039, range 20, W4M, would have a horizontal coordinate with an Easting of 152,819 metres and a Northing of 5,796,604 metres, the centre of the quarter section. Once the horizontal coordinates are determined, a ground elevation is obtained from the 1:20,000 Digital Elevation Model (DEM) from the Resource Data Division of AEP.

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

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

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

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

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

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

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

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

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

### 4.2 Spatial Distribution of Aquifers

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

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

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

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

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

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

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

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

### 4.3 Hydrogeological Parameters

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

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

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

#### 4.3.1 Risk Criteria

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

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

***Table 2. Risk of Groundwater Contamination Criteria***

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6 See glossary