are more than 30% of the total thickness of the surficial deposits, as shown on the adjacent figure. The areas where sand and gravel deposits constitute more than 30% of the total thickness of the surficial deposits are mainly associated with linear bedrock lows and river valleys.

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.

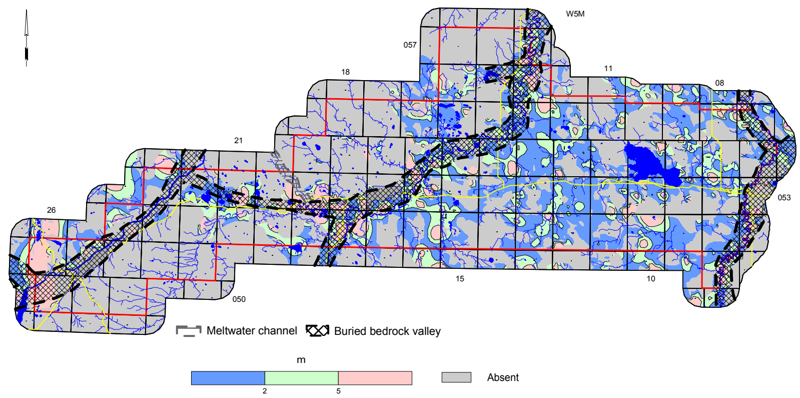

Figure 10. Thickness of Sand and Gravel Aquifer(s)

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 more than 60% 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 above map. In the County, the thickness of the Sand and Gravel Aquifer(s) is generally less than two metres, but can be more than five metres mainly in linear bedrock lows and river valleys, as shown in Figure 10, in Appendix A and on the CD-ROM.

Of the 5,855 water wells in the database, 222 were defined as being completed in surficial aquifers, based on lithologic information and water well completion details. From the present hydrogeological analysis, 542 water wells are completed in aquifers in the surficial deposits. Of the 542 water wells, 219 are completed in aquifers in the upper surficial deposits, 316 are completed in aquifers in the lower surficial deposits, and seven water wells are completed in multiple surficial aquifers. This number of water wells (542) is nearly two and a half times the number (222) 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.

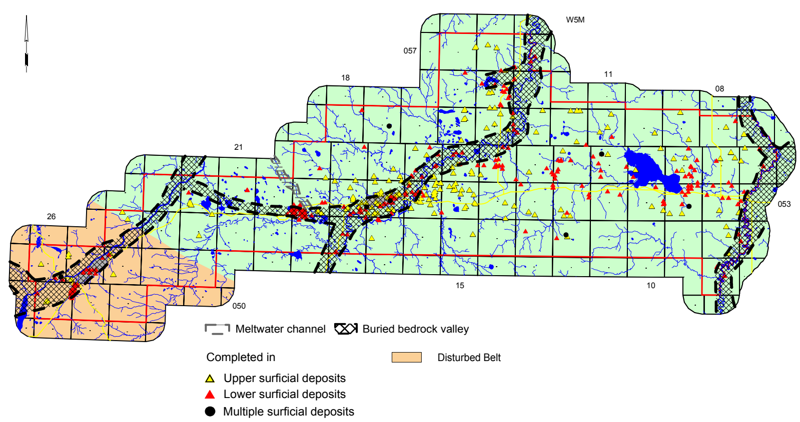

Figure 11. Water Wells Completed in Surficial Deposits

Water wells completed in the lower surficial deposits are mainly in the linear bedrock lows, and water wells completed in the upper surficial deposits are often in the linear bedrock lows but are also located throughout the County and in the Sundance meltwater channel, as shown above in Figure 11.

In the County, there are 101 records for surficial water wells with apparent yield data, which is 19% of the 542 surficial water wells. Seventeen percent of the 101 water wells completed in the Sand and Gravel Aquifer(s) have apparent yields that are less than ten m³/day, 38% have apparent yield values that range from 10 to 100 m³/day, and 45% have apparent yields that are greater than 100 m³/day. In addition to the 101 records for surficial water wells, there are eight records that indicate that the water well 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 eight dry test holes prior to gridding.

The adjacent map shows expected yields for water wells completed in the 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 50% of the County where the Sand and Gravel Aquifer(s) are present. The most notable areas where yields of more than 300 m³/day are expected are mainly in association with linear bedrock lows.

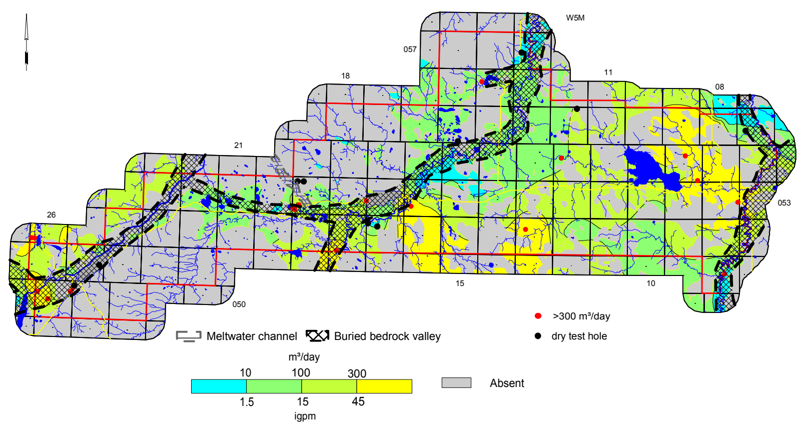

Figure 12. Apparent Yield for Water Wells Completed in Sand and Gravel Aquifer(s)

5.2.2.1 Chemical Quality of Groundwater from Surficial Deposits

The chemical analyses results of groundwaters from the surficial deposits indicate the groundwaters are generally chemically hard and high in dissolved iron. In Yellowhead County, groundwaters from the surficial aquifers mainly have a chemical hardness of greater than 200 and less than 400 mg/L (see CD-ROM).

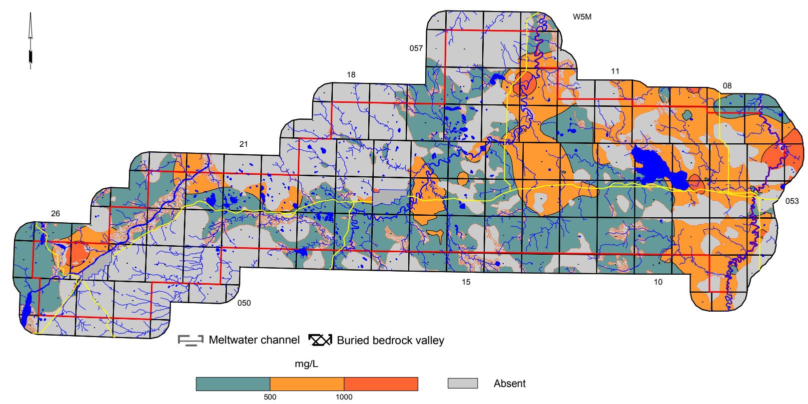

Figure 13. Total Dissolved Solids in Groundwater from Surficial Deposits

The Piper tri-linear diagram[17] for the surficial deposits (page A-26) shows that the groundwaters from the surficial deposits are mainly calcium-magnesium-bicarbonate waters. Sixty percent of the groundwaters from the surficial deposits have a TDS concentration of less than 500 mg/L. Fifty-three 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 nearly 80% of the samples analyzed for surficial deposits in the County, the chloride ion concentration is less than ten mg/L (see CD-ROM).

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 three of the 136 groundwater samples analyzed (up to about 1986).

The minimum, maximum and median concentrations of TDS, sodium, sulfate, chloride and Nitrate + 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. The range of concentrations shown in Table 5 are values in the groundwater database; however, the extreme minimum and maximum concentrations generally represent less than 0.2% of the total number of analyses and should have little effect on the median values. These extreme values are not used in the preparation of the figures.

Constituent	No. of Analyses	Range for County in mg/L Minimum	Maximum	Median	Recommended Maximum Concentration SGCDWQ
Total Dissolved Solids	231	122	2,480	450	500
Sodium	172	0	570	24	200
Sulfate	230	0	1,180	25	500
Chloride	221	0	197	3	250
Nitrate + Nitrite (as N)	136	0	40	0.1	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 5. Concentrations of Constituents in Groundwaters from Surficial Deposits

Of the five constituents that have been compared to the SGCDWQ, none of the median values exceeds the guidelines.

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 40% 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. The long-term yields for water wells completed through this Aquifer are expected to be mainly less than those shown on the adjacent figure.

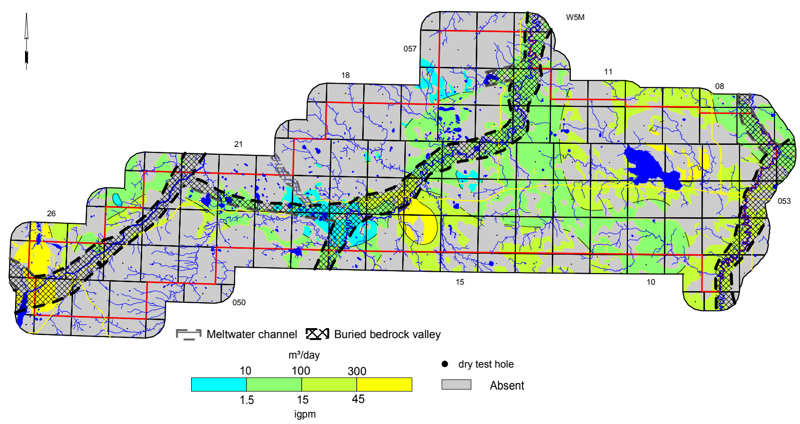

Figure 14. Apparent Yield for Water Wells Completed through Upper Sand and Gravel Aquifer

Where the Upper Sand and Gravel Aquifer is absent and where the yields are low, the development of water wells for the domestic needs of single families may not be possible from this Aquifer, and 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.

Apparent yields for water wells completed through the Upper Sand and Gravel Aquifer range from less than ten m³/day to more than 300 m³/day. The most notable areas where yields of more than 300 m³/day may be possible are in the Buried Hinton Valley near the Town of Hinton and in the Buried Edson Valley east of the Town of Edson, where the saturated thickness of the upper sand and gravel deposits is more than five metres.

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

In the County, there are 20 authorized non-exempt water wells that are completed through the Upper Sand and Gravel Aquifer, for a total authorized diversion of 536 m³/day (Table 1, page 6). The highest authorized amount is 179.1 m³/day for a water supply well in 16-12-053-08 W5M. Seven of the 20 authorized non-exempt 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. The top of the lower surficial deposits is based on more than 1,000 control points across Alberta.

5.2.4.1 Aquifer Thickness

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

5.2.4.2 Apparent Yield

Apparent yields for water wells completed through the Lower Sand and Gravel Aquifer range from less than ten m³/day to more than 300 m³/day. The most notable areas where yields of more than 300 m³/day are expected are mainly in areas where the thickness of the Lower Sand and Gravel Aquifer is greater than five metres.

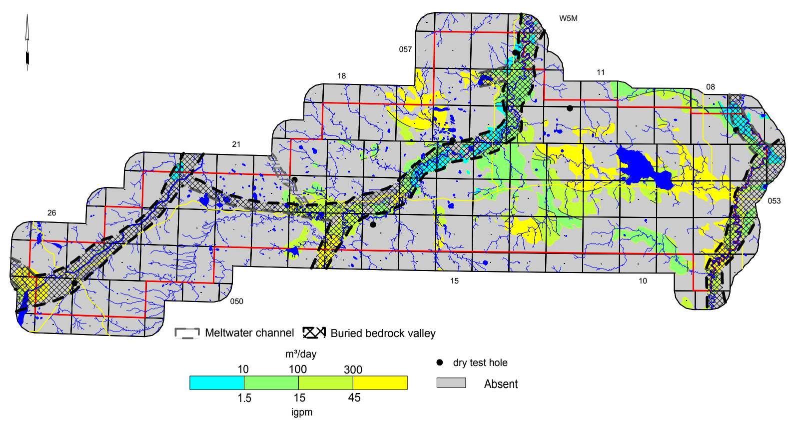

Figure 15. Apparent Yield for Water Wells Completed through Lower Sand and Gravel Aquifer

For most of the County, the Lower Sand and Gavel Aquifer is of limited groundwater importance mainly due to the Aquifer having a thickness of less than two metres. However, the lower sand and gravel deposits associated with the Buried Edson Valley have been an important source of groundwater for the Town of Edson for more than 40 years.

Since 1959, numerous aquifer tests have been conducted with water wells completed in the Lower Sand and Gravel Aquifer associated with the Buried Edson Valley. Extended aquifer tests conducted with water wells located in the Town of Edson area have indicated long-term yields ranging from 700 to 3,300 m³/day. In addition, because the McLeod River has locally downcut into the Aquifer, surface water can be induced to recharge the Lower Sand and Gravel Aquifer (Vogwill, 1983).

In the County, there are seven dry water test holes completed in the Lower Sand and Gravel Aquifer.

In the County, there are 25 non-exempt authorizations for water wells that are completed through the Lower Sand and Gravel Aquifer, for a total authorized diversion of 1,922 m³/day. Twelve of the 25 authorized non-exempt water wells completed through the Lower Sand and Gravel Aquifer could be linked to a water well in the AENV groundwater database.

Of the 1,922 m³/day, there are six non-exempt groundwater users that have been licensed to divert up to 1,091 m³/day for municipal purposes, of which 1,037 m³/day is for the Town of Edson.

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 Disturbed Belt, Paskapoo Formation (Dalehurst, Upper and Lower Lacombe, and Haynes members), as well as the Scollard, Battle and Whitemud and Upper Horseshoe Canyon formations, as shown below on cross-section A-A’ (see page A-11). 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.

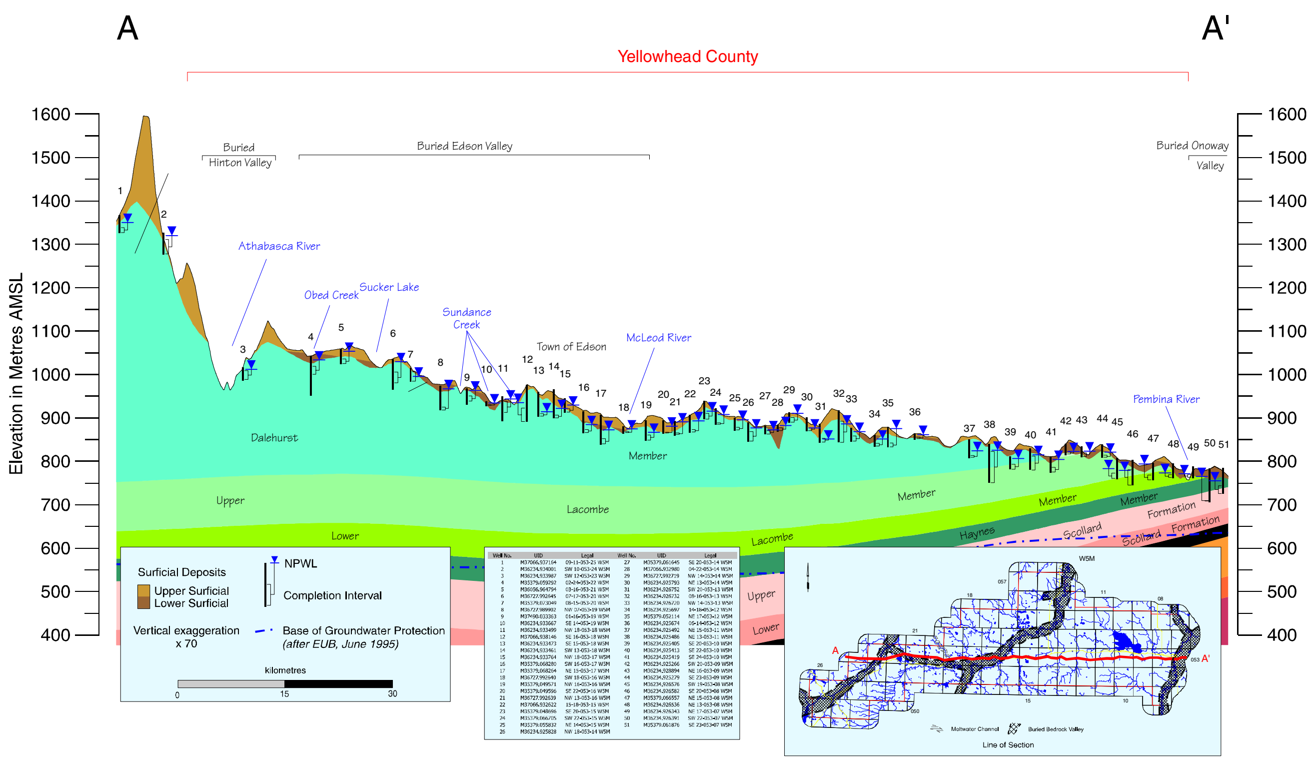

Figure 16. Cross-Section A - A'

In the study area, the Base of Groundwater Protection is variable, extending from a depth as little as 25 metres to a depth of over 1,000 metres below ground surface. In the County, the Base of Groundwater Protection is below the Lower Lacombe Member. A map showing the depth to the Base of Groundwater Protection is given in Figure 4 on page 8 of this report, in Appendix A (Page A-7), and on the CD-ROM.

19 See glossary

5.3.2 Geological Characteristics

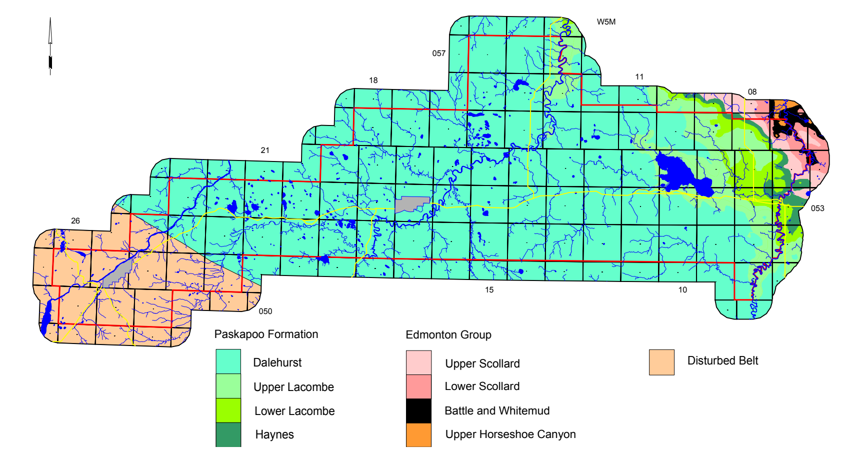

Figure 17. Bedrock Geology

The Disturbed Belt is the upper bedrock in the southwestern part of the County. The outline of the Disturbed Belt has been defined based on the Geological Map of Alberta (Hamilton et al, 1998, and Green, 1972). The Rocky Mountains and Foothills together form the Disturbed Belt, which is an area that has been deformed by folding and thrust faulting (Tokarsky, 1971). Water wells that were located within the Disturbed Belt boundary were defined as being completed in surficial deposits or in the Disturbed Belt Aquifer. 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. The Edmonton Group includes the Scollard, the Battle and Whitemud, and the Horseshoe Canyon formations and consists of fresh and brackish-water deposits of fine-grained sandstone and silty shale, thick coal seams, and numerous bentonite beds (Carrigy, 1971). A generalized geologic column is illustrated in Figure 6, in Appendix A, and on the CD-ROM.

The Paskapoo Formation is the upper bedrock and is the main bedrock formation 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 500 metres.

The Dalehurst Member is the upper bedrock and subcrops in 80% of the County. This Member has a maximum thickness of 500 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). If the coal seams are not fractured, they are impermeable.

The Lacombe Member underlies the Dalehurst Member and has a maximum thickness of 230 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 there is a coal zone, which can be up to five metres thick. In the County, the Lower Lacombe Member has a maximum thickness of 75 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 55 metres.

The Scollard Formation underlies the Haynes Member, is the upper bedrock in the northeastern part of the County, 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 Upper Scollard Formation has a maximum thickness of 120 metres and the Lower Scollard has a maximum thickness of 70 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