5.2 Aquifers in Surficial Deposits

The surficial deposits are the sediments above the bedrock surface. This includes pre-glacial materials, which were deposited before glaciation, and materials deposited directly or indirectly by 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] and meltwater deposits. In the County, pre-glacial materials are expected to be present in association with parts of the Buried Beverly and Warburg valleys.

5.2.1 Geological Characteristics of Surficial Deposits

While the surficial deposits are treated as one hydrogeological unit, they consist of three hydraulic parts. The first is the sand and gravel deposits of the lower surficial deposits, the second is the saturated sand and gravel deposits of the upper surficial deposits and the third is the sand and gravel close to ground level, which is usually unsaturated. The sand and gravel deposits in the upper part of the surficial deposits can extend above the upper limit of the saturation zone and because they are not saturated, they are not an aquifer. However, these sand and gravel deposits are significant since they provide a pathway for liquid contaminants to move downward into the groundwater. Because of the significance of the shallow sand and gravel deposits, they have been mapped where they are present within one metre of the ground surface and are referred to as the “first sand and gravel”.

Over the majority of the County, the surficial deposits are less than 20 metres thick. The exceptions are mainly in association with the linear bedrock lows where the deposits can have a thickness of more than 40 metres. The main southwest-northeast-trending linear bedrock lows in the County have been designated as the Buried Beverly and Warburg valleys, as shown on the following map.

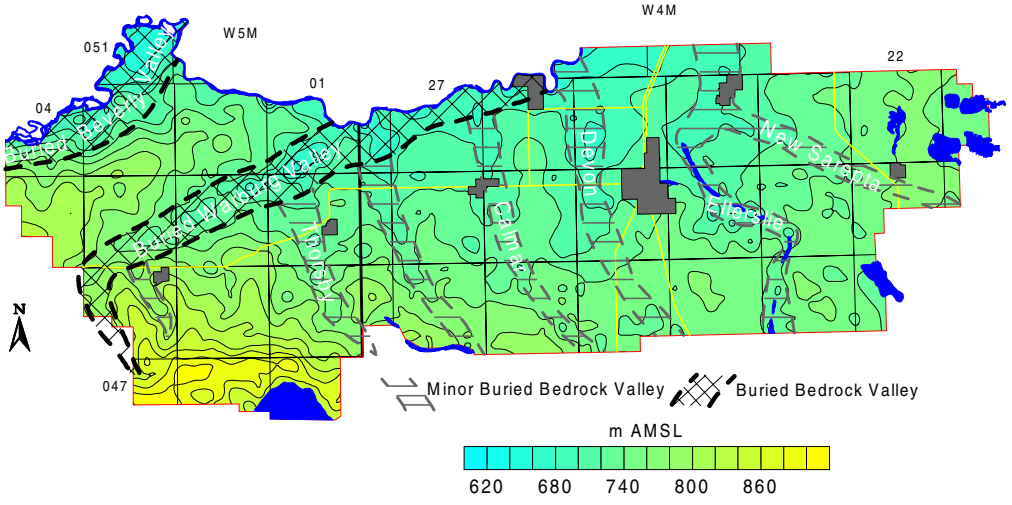

Figure 9. Bedrock Topography

[10] See glossary
[11] See glossary
[12] See glossary

The Buried Beverly Valley coincides with the North Saskatchewan River in the northwestern part of the County in townships 050 and 051, ranges 03 and 04, W5M. The Valley is approximately six to nine kilometres wide with local bedrock relief being less than 60 metres. Sand and gravel deposits can be expected in association with this bedrock low, but the thickness of the sand and gravel deposits is expected to be mainly less than 15 metres.

The Buried Warburg Valley originates near the Town of Warburg, trends from southwest to northeast and coincides with the North Saskatchewan River in townships 050 and 051, ranges 25 to 28, W4M. The Valley is approximately four kilometres wide, with local relief being less than 80 metres. Sand and gravel deposits associated with the linear bedrock lows can be expected to be mainly less than 15 metres thick.

In addition to the Buried Beverly and Warburg valleys, there are minor buried bedrock valleys shown on the bedrock topography map. These lows trend southeast to northwest in the County, and are tributaries to the Buried Warburg and Stony valleys. The most significant of these tributaries are the Buried Thorsby, Calmar, Devon, Ellerslie and New Sarepta valleys.

The lower surficial deposits are composed mostly of fluvial and lacustrine deposits. Lower surficial deposits occur over most of the northern half of the County. The total thickness of the lower surficial deposits is mainly less than 15 metres, but can be more than 25 metres in the Buried Warburg Valley. The lowest part of the lower surficial deposits includes pre-glacial sand and gravel deposits. These deposits would generally be expected to directly overlie the bedrock surface in the Buried Beverly and Warburg valleys. The lowest sand and gravel deposits are of fluvial origin, are usually less than five metres thick and may be discontinuous.

The upper surficial deposits are either directly or indirectly a result of glacial activity. The deposits include till, with minor sand and gravel deposits of meltwater origin, which are expected to occur mainly as isolated pockets. The thickness of the upper surficial deposits is mainly less than 20 metres. The greatest thickness of upper surficial deposits occurs mainly in association with the northwest-southeast-trending linear bedrock lows; there are several areas in the County where these deposits are not present.

Sand and gravel deposits can occur throughout the surficial deposits. The total thickness of sand and gravel deposits is generally less than ten metres but can be more than 15 metres in the areas of the linear bedrock lows.

The combined thickness of all sand and gravel deposits has been determined as a function of the total thickness of the surficial deposits. Over less than 15% of the County, the sand and gravel deposits are more than 50% of the total thickness of the surficial deposits. The areas where the sand and gravel percentages are more than 50% are mainly associated with the linear bedrock lows.

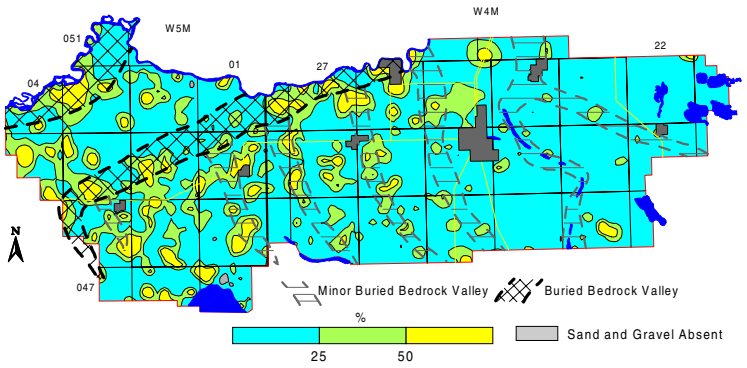

Figure 10. Amount of Sand and Gravel in Surficial Deposits

5.2.2 Sand and Gravel Aquifer(s)

One source of groundwater in the County includes aquifers in the surficial deposits. Since the sand and gravel aquifer(s) are not everywhere, the actual aquifer that is developed at a given location is usually dictated by the aquifer that is present. From the present hydrogeological analysis, 81 water wells are completed in aquifers in the lower surficial deposits and 593 are completed in aquifers in the upper surficial deposits. This number of water wells is nearly four times the number 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.

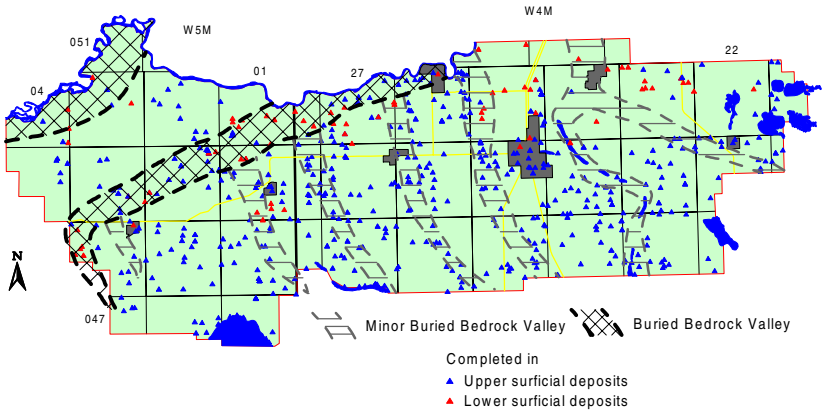

Figure 11. Water Wells Completed in Surficial Deposits

The majority of the water wells completed in the upper surficial deposits are mainly in the southeast–northwest-trending linear bedrock lows as shown in Figure 11. A large number of the water wells completed in the lower surficial deposits are located along the Buried Warburg Valley.

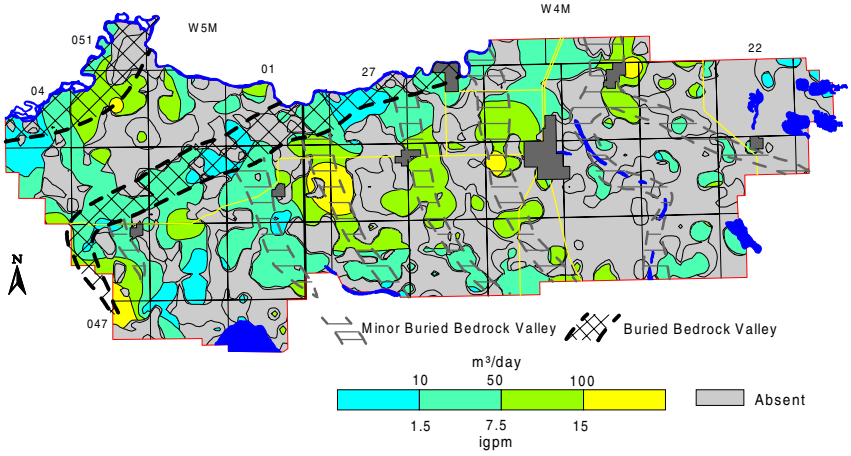

Figure 12. Apparent Yield for Water Wells Completed in Sand and Gravel Aquifer(s)

The adjacent map shows expected yields for water wells completed in aquifers in sand and gravel aquifers(s), based on the aquifers that have been developed by existing water wells. These data show that water wells with yields of less than 50 m³/day from sand and gravel aquifer(s) can be expected in most areas of the County where the sand and gravel aquifer(s) are present. The most notable areas where yields of more than 100 m³/day are expected are mainly in association with the minor buried bedrock valleys. Over approximately 60% of the County, the sand and gravel deposits are not present, or if present, are not saturated.

5.2.2.1 Chemical Quality of Groundwater from Surficial Deposits

The chemical analysis results of groundwaters from the surficial deposits have not been differentiated based on aquifers in the upper or lower surficial deposits. The main reason for not separating the chemical analysis results into the different aquifers is the lack of data that can be attributed to the Lower Sand and Gravel Aquifer. This is in part related to the number of control points from this Aquifer, which is in part related to the limited areal extent of the lower surficial deposits.

The other justification for not separating the analyses was that there appeared to be no major chemical difference between groundwaters from the upper and lower sand and gravel aquifers. The groundwaters from these aquifers are generally chemically hard and high in dissolved iron. In the adjacent municipalities of Brazeau and Parkland, chemical hardness concentrations in the groundwaters from the surficial deposits are mainly more than 200 mg/L; in Leduc County, the chemical hardness values of the groundwaters are mainly less than 200 mg/L.

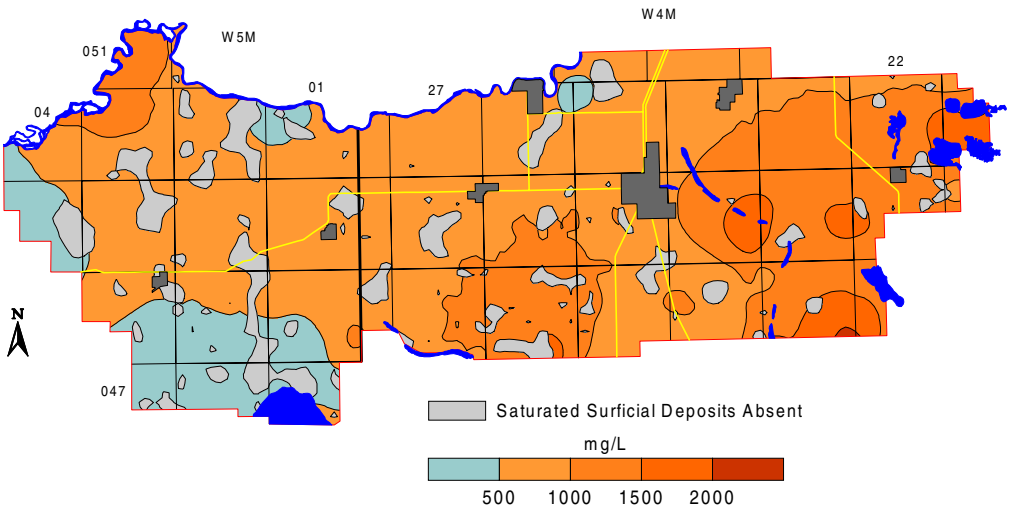

Figure 13. Total Dissolved Solids in Groundwater from Surficial Deposits

The groundwaters from the surficial deposits are generally calcium-magnesium-bicarbonate-type waters; however, in Leduc County sodium-bicarbonate-type waters dominate, with 70% of the groundwaters having a TDS of less than 1,000 mg/L. The groundwaters with lower TDS values occur in the western part of the County. Groundwaters from the surficial deposits are expected to have dissolved iron concentrations of greater than 1 mg/L.

Although the majority of the groundwaters from surficial deposits are sodium-bicarbonate-type waters in the County, there are groundwaters from the surficial deposits with calcium as the main cation; there are also groundwaters with significant concentrations of the sulfate ion. 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 and in most of the County, the chloride ion concentration is less than 30 mg/L.

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 directly overlie or are close to the bedrock surface. Saturated sand and gravel deposits are not continuous but are expected over approximately 25% 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 upper surficial deposits; and (2) the depth to the bedrock surface. Since the non-pumping water-level surface in the surficial deposits tends to be a subdued replica of the bedrock surface, the thickness of the Upper Sand and Gravel Aquifer tends to be directly proportional to the thickness of the surficial deposits.

While the sand and gravel deposits in the upper surficial deposits are not continuous, the Upper Sand and Gravel Aquifer includes all of the aquifers present in the upper surficial deposits. The Upper Sand and Gravel Aquifer is more than 15 metres thick in a few areas, but over the majority of the County, is less than five metres thick; in over 65% of the County, the Aquifer is absent. Most of the greater thickness in the Upper Sand and Gravel Aquifer occurs in the areas of the northwest-southeast-trending linear bedrock lows.

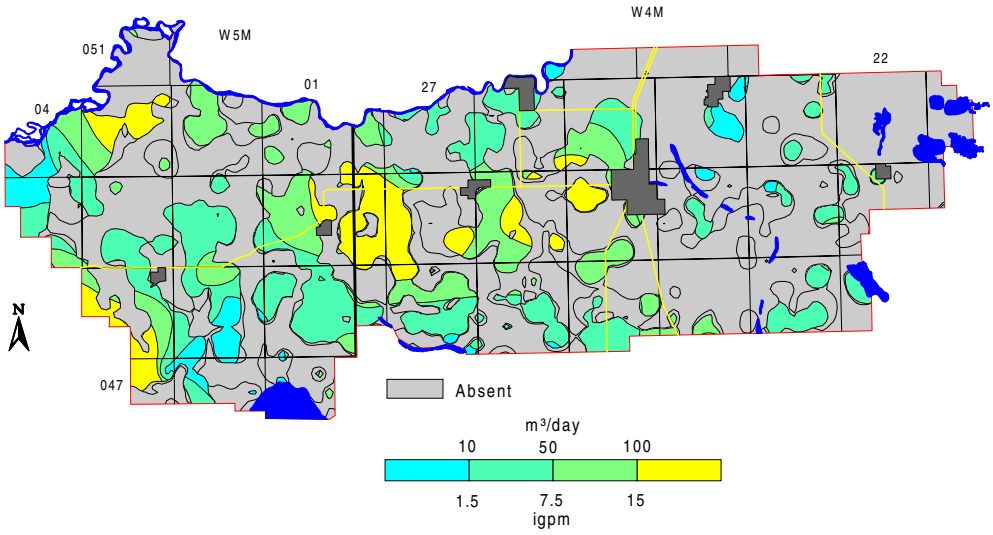

Figure 14. Apparent Yield for Water Wells Completed through Upper Sand and Gravel Aquifer

The permeability of the Upper Sand and Gravel Aquifer can be high. The high permeability combined with significant thickness leads to an extrapolation of water wells with high yields; however, because the sand and gravel deposits occur mainly as hydraulically discontinuous pockets, the apparent yields of the water wells are limited. The apparent yields for water wells completed in this Aquifer are expected to be mainly less than 100 m³/day. 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.

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 deepest part of the pre-glacial linear bedrock lows. The thickness of the Lower Sand and Gravel Aquifer is mainly less than five metres. The Lower Sand and Gravel Aquifer is mostly restricted to the Buried Beverly and Warburg valleys in the County.

5.2.4.1 Apparent Yield

Apparent yields for water wells completed in the Lower Sand and Gravel Aquifer range from less than 10 m³/day to more than 30 m³/day. The highest yields are expected in the northern part of the County in association with a linear bedrock low, in the vicinity of the Town of Beaumont.

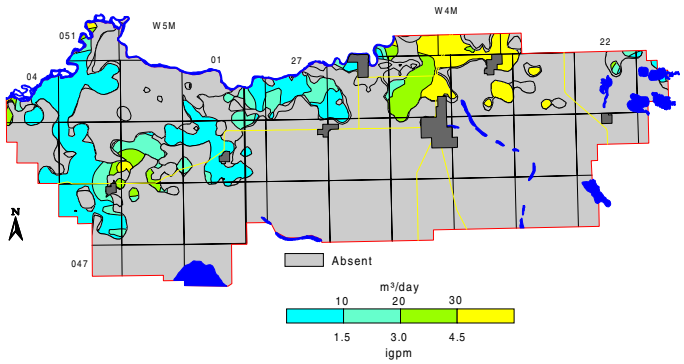

Figure 15. Apparent Yield for Water Wells Completed through Lower Sand and Gravel Aquifer

5.3 Bedrock

5.3.1 Geological Characteristics

The upper bedrock in the County is the Paskapoo Formation and the Edmonton Group. The Paskapoo Formation consists of cycles of thick, tabular sandstones, siltstone and mudstone layers (Glass, D. J. [editor], 1990). The Edmonton Group consists of fresh and brackish-water deposits of fine-grained sandstone and silty shale, thick coal seams, and numerous bentonite beds (Carrigy, 1971). The maximum thickness of the Paskapoo Formation can be 800 metres, but in the County, the thickness is from 0 to 200 metres. The thickness of the Edmonton Group varies from 400 to 480 metres. The Edmonton Group in the County includes the Scollard, Battle, Whitemud and Horseshoe Canyon formations.

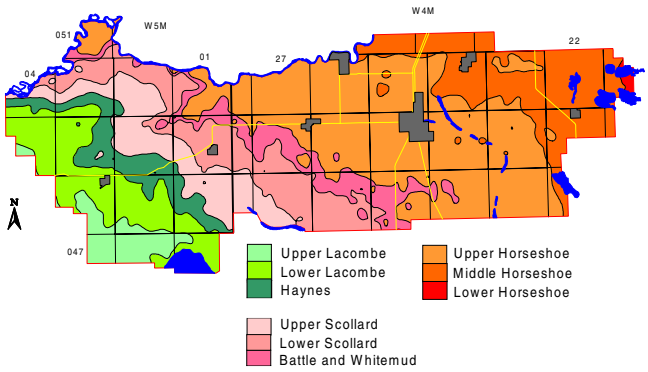

Figure 16. Bedrock Geology

The Paskapoo Formation is the upper bedrock and subcrops in the southwestern quarter of the County. The Paskapoo Formation in central Alberta consists of the Dalehurst, Lacombe and Haynes members (Demchuk and Hills, 1991); in Leduc County, the Dalehurst Member is not present.

The Lacombe Member is the upper bedrock in the western part of the County and subcrops in parts of townships 047 to 050, ranges 01 to 04, W5M. The Lacombe Member has a maximum thickness of 140 metres and has two separate designations: Upper and Lower. The Upper Lacombe Member is mostly composed of shale interbedded with sandstone and has a maximum thickness of 70 metres. The Lower Lacombe Member is composed of sandstone and coal layers. In the middle of the Lower Lacombe Member, there is a coal zone, which can be up to five metres thick. The Lower Lacombe Member has a maximum thickness of 70 metres.

The Haynes Member subcrops in the western part of the County, in parts of townships 048 to 050, ranges 01 to 04, W5M and underlies the Lower Lacombe Member. The Haynes Member has a maximum thickness of 60 metres and is composed mainly of sandstone with some siltstone, shale and coal.

The Scollard Formation underlies the Haynes Member and subcrops in the western part of the County. The Scollard Formation has a maximum thickness of 120 metres within the County and has two separate designations: Upper and Lower. The Upper Scollard consists mainly of sandstone, siltstone, shale and coal seams or zones. Two prominent coal zones within the Upper Scollard are the Ardley Coal (up to 20 metres thick) and the Nevis Coal (up to 3.5 metres thick). The bottom of the Nevis Coal Seam is the border between the Upper and Lower Scollard. The Lower Scollard has a maximum thickness of 50 metres and is composed mainly of shale and sandstone.

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 bentonite, and includes the Kneehills Member, a 2.5- to 30-cm thick tuff bed. The Whitemud Formation is composed mainly of shale, siltstone, sandstone and bentonite. The Battle and Whitemud formations are significant geologic markers, and were used in the preparation of various geological surfaces within the bedrock. Because of the ubiquitous nature of the bentonite in the Battle and Whitemud formations, there is very little significant permeability within these two formations.

The Horseshoe Canyon Formation is the lower part of the Edmonton Group and is the upper bedrock in the eastern half of the County. The Horseshoe Canyon Formation has a maximum thickness of 350 metres and has three separate designations: Upper, Middle and Lower. The Upper Horseshoe Canyon, which can be up to 100 metres thick, is the uppermost bedrock in the east-central part of the County immediately east of the area where the Scollard Formation subcrops. The Middle Horseshoe Canyon, which is up to 70 metres thick, subcrops in the northeastern part of the County. The Lower Horseshoe Canyon, which is up to 170 metres thick, subcrops in a small part of township 050, range 21, W4M in the extreme northeastern corner of the County.

The Horseshoe Canyon Formation consists of deltaic[13] and fluvial sandstone, siltstone and shale with interbedded coal seams, bentonite and thin nodular beds of limestone and ironstone. Because of the low-energy environment in which deposition occurred, the sandstones, when present, tend to be finer grained. The lower 60 to 70 metres and the upper 30 to 50 metres of the Horseshoe Canyon Formation can include coarser grained sandstone deposits.

The Bearpaw Formation underlies the Horseshoe Canyon Formation and is in the order of 80 metres thick within the County. The Bearpaw Formation includes transgressive, shallow marine (shoreface) and open marine facies[14] deposits. In Leduc County, the Bearpaw Formation is composed mainly of shale and as such is a regional aquitard. Because the Bearpaw Formation is an aquitard, there will be no direct review of the Bearpaw Formation in the text of this report.

5.3.2 Aquifers

Of the 5,922 water wells in the database, 2,464 were defined as being completed in bedrock aquifers. This designation is based on the top of the completion interval being below the bedrock surface. The completion depth is available for the majority of water wells. In order to make use of additional information within the groundwater database, it was statistically determined that water wells typically have completion intervals equivalent to one quarter of their completed depth. This relationship was used to increase the number of water wells identified as completed in bedrock aquifers to 5,249 from 2,464. With the use of geological surfaces that were determined from the interpretation of geophysical logs, it has been possible to assign the water wells completed in bedrock aquifers to specific aquifers based on their completion intervals. Of the 5,249 bedrock water wells, 4,420 have been assigned a specific geologic unit. The bedrock water wells are mainly completed in the Upper and Middle Horseshoe Canyon aquifers and the Lower Lacombe Aquifer, as shown in the table above.

Geological Unit	No. of Water Wells
Upper Lacombe	95
Lower Lacombe	616
Haynes	240
Upper Scollard	289
Lower Scollard	395
Upper Horseshoe Canyon	1,897
Middle Horseshoe Canyon	830
Lower Horseshoe Canyon	58
Other	829
Total	5,249

Table 2. Completion Aquifer

[13] See glossary
[14] See glossary

There are 676 records for bedrock water wells that have apparent yield values; this constitutes 13% of all bedrock water wells. In the County, water well yields in the upper bedrock aquifer(s) are mainly less than 50 m³/day. The few areas of higher yields that are indicated on the adjacent figure are sporadic in the County. These higher yields may be a result of increased permeability that has resulted from the weathering process.

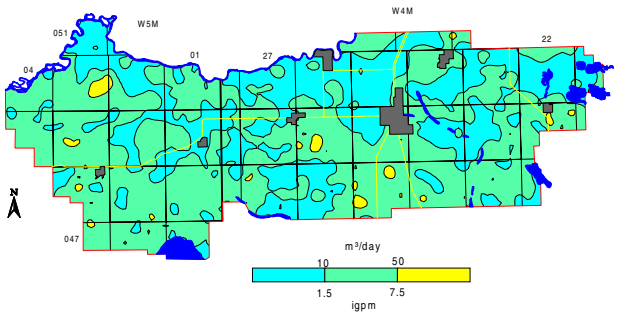

Figure 17. Apparent Yield for Water Wells Completed in Upper Bedrock Aquifer(s)

All of the bedrock water wells with apparent yield values can be assigned to aquifers associated with specific geologic units. The majority of the water wells completed in the bedrock aquifers have apparent yields that range from 10 to 100 m³/day, as shown in the table below.

Aquifer	No. of Water Wells with Values for Apparent Yields	Number of Water Wells with Apparent Yields <10 m³/day	10 to 100 m³/day	>100 m³/day
Upper Lacombe	35	8	17	10
Lower Lacombe	220	74	117	29
Haynes	60	14	29	17
Upper Scollard	95	16	53	26
Lower Scollard	95	54	34	7
Upper Horseshoe Canyon	62	10	50	2
Middle Horseshoe Canyon	98	30	60	8
Lower Horseshoe Canyon	11	4	3	4
Totals	676	210	363	103

Table 3. Apparent Yields of Bedrock Aquifers

5.3.3 Chemical Quality of Groundwater

The TDS concentrations in the groundwaters from the upper bedrock aquifer(s) range from less than 200 to more than 2,000 mg/L. The TDS values of more than 1,500 mg/L are mainly east of range 24, W4M.

The relationship between TDS and sulfate concentrations shows that when TDS values in the upper bedrock aquifer(s) exceed 1,200 mg/L, the sulfate concentrations exceed 400 mg/L. The chloride concentrations in the groundwaters from the upper bedrock aquifer(s) are less than 100 mg/L in more than 90% of the County.

In 85% of the County, the fluoride ion concentration in the groundwater from the upper bedrock aquifer(s) is less than 1.5 mg/L.

The Piper tri-linear diagrams[15] (see Appendix A) show that all chemical types of groundwater occur in the bedrock aquifers. However, the majority of the groundwaters are sodium-bicarbonate or sodium-sulfate types.

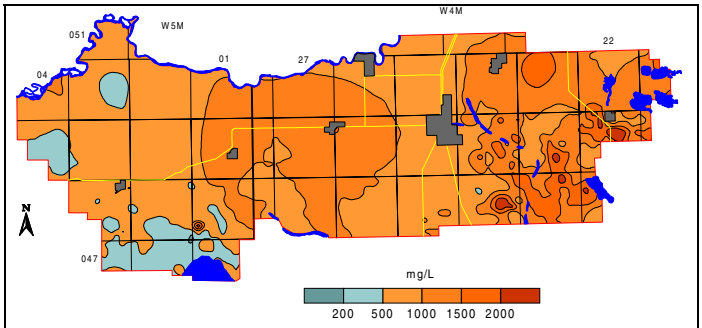

Figure 18. Total Dissolved Solids in Groundwater from Upper Bedrock Aquifer(s)

[15] See glossary