a) Chemical Quality of Groundwater from Surficial Deposits

The chemical analysis results of groundwaters from the sand and gravel aquifers in the surficial deposits indicate the groundwaters are generally chemically hard and high in dissolved iron. In the County of Athabasca, 50% of the groundwaters from the surficial aquifers have a chemical hardness of more than 400 mg/L.

The groundwaters from the surficial deposits are mainly calcium-magnesium-bicarbonate or sodium-bicarbonate-type waters, with approximately 60% of the groundwaters having a TDS concentration of less than 1,000 mg/L. The groundwaters with a TDS concentration of more than 1,000 mg/L occur mainly in the Buried Amber Valley and in the vicinity of meltwater channels as shown on Figure 11. The large expanse showing saturated surficial deposits to be absent in the northeastern part of the County is a result of gridding a limited amount of data available for that area. Groundwaters from the surficial deposits are expected to have dissolved iron concentrations of less than 1 mg/L.

Although the majority of the groundwaters are bicarbonate-type waters, there are groundwaters from the surficial deposits with sulfate as the main anion. 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 mainly less than 100 mg/L.

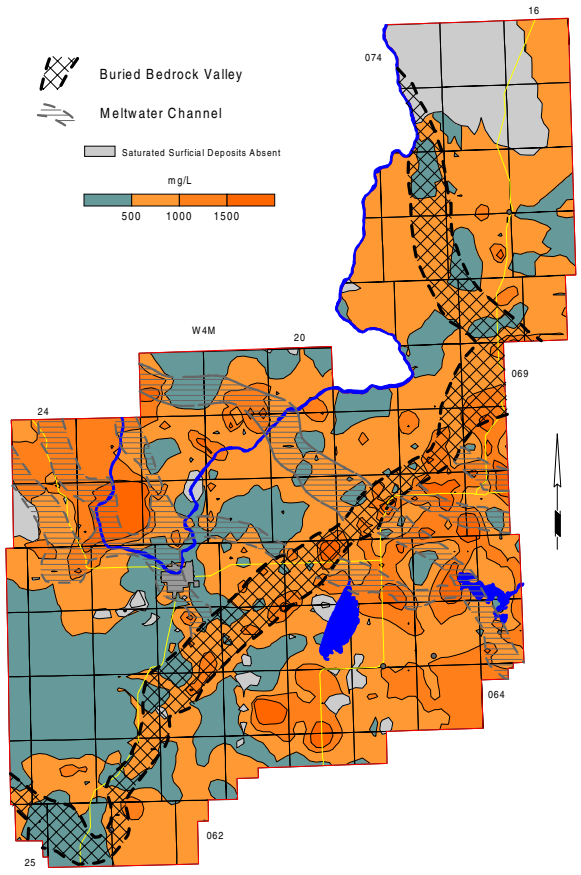

Figure 11. Total Dissolved Solids in Groundwater from Surficial Deposits

Constituent	Range for County in mg/L Minimum	Maximum	Average	Recommended Maximum Concentration GCDWQ
Total Dissolved Solids	105	7316	1444	500
Sodium	2	1762	235	200
Sulfate	0	4379	585	500
Chloride	0	2217	22	250
Nitrate + Nitrite (as N)	0	157	6.5	10

Concentration in milligrams per litre unless otherwise stated
Note: indicated concentrations are for Aesthetic Objectives

GCDWQ - Guidelines for Canadian Drinking Water Quality, Sixth Edition
Minister of Supply and Services Canada, 1996

Table 4. Concentrations of Constituents in Groundwaters in Surficial Aquifers

The nitrate + nitrite (as N) concentrations in the groundwaters from the surficial deposits exceed the maximum acceptable concentrations (MAC) of 10 mg/L mainly in the western part of the County.

The minimum, maximum and average 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 Guidelines for Canadian Drinking Water Quality (GCDWQ) in the adjacent table. Of the five constituents that have been compared to the GCDWQ, only the average values of chloride and nitrate + nitrite (as N) concentrations do not exceed the guidelines.

3) Upper Sand and Gravel Aquifer

The Upper Sand and Gravel Aquifer includes saturated sand and gravel deposits in the upper surficial deposits. These aquifers can directly overlie or be close to the bedrock surface. Saturated sand and gravel deposits are not continuous but are expected over approximately 75% of the County.

a) 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 where the Upper Sand and Gravel Aquifer is present, is less than ten metres thick; in about 25% of the County, the Aquifer is absent. Most of the greater thickness in the Upper Sand and Gravel Aquifer occurs in the areas of linear bedrock lows. However, the area in the northeastern part of the County that is indicated on Figure 12 as being unsaturated or absent may be a reflection of the limited amount of data.

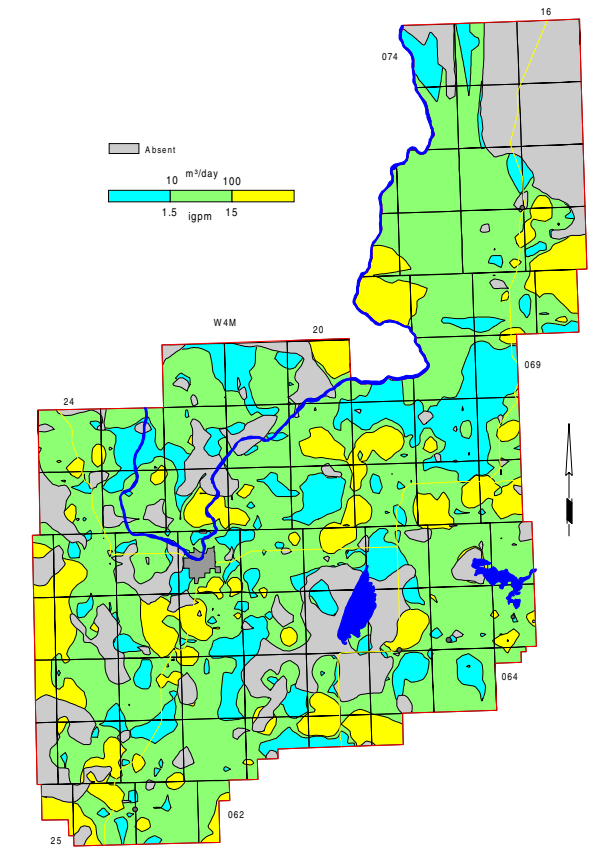

Figure 12. Apparent Yield for Water Wells Completed through Upper Sand and Gravel Aquifer

b) 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 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 between ten and 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 from this Aquifer, and construction of a water supply well into the underlying bedrock may be the only alternative in the southwestern part of the County.

A groundwater study conducted for CN Rail (Hydrogeological Consultants Ltd. (HCL), November 1991) determined a long-term yield of 60 m³/day for a water supply well at the Bondiss Station Grounds in NW 05-065-18 W4M that is completed in the Upper Sand and Gravel Aquifer. The chemical data from a groundwater sample collected from the CN Rail water supply well in October 1991 indicated a TDS concentration of 542 mg/L, a chloride concentration of 3 mg/L and a sulfate concentration of 31 mg/L. The groundwater from this water supply well is a bicarbonate-type water with no dominant cation.

C. Bedrock

1) Geological Characteristics

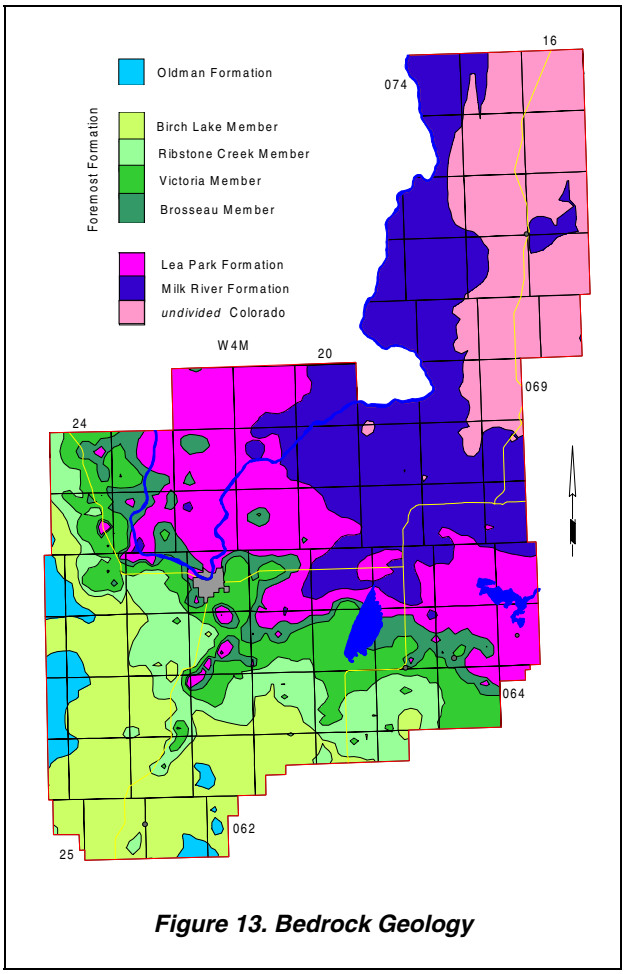

Figure 13. Bedrock Geology

The upper bedrock in the County includes the Belly River Group, the Lea Park Formation and the Colorado Group. The Belly River Group includes the Oldman Formation and the Birch Lake, Ribstone Creek, Victoria and Brosseau members of the Foremost Formation. The adjacent bedrock geology map, showing the subcrop of different geological units, has been prepared in part from the interpretation of geophysical logs related to oil and gas activity.

The Belly River Group in the County has a maximum thickness of 200 metres. The Oldman Formation is present mainly in the extreme western part of the County and has a maximum thickness of 80 metres. The Foremost Formation includes the continental facies[16] within the County.

The *continental* Foremost Formation is less than 180 metres thick and is between the overlying Oldman Formation and the underlying Lea Park Formation. In the *continental* Foremost Formation, individual members have been identified. The members include both sandstone and shale units. For the present project, the individual members are identified by the designation given to the sandstone members, with the underlying shale member being considered as the shale facies of the sandstone member. For example, in this report the Ribstone Creek Member includes the Ribstone Creek Member (a sandstone deposit) and the underlying shale deposit. Eastward, the sandstone layers of individual members grade into marine deposits.

The present breakdown of the Foremost Formation would not be possible without identifying a continuous top for the Lea Park Formation. The top of the Lea Park Formation represents a geologic time border between the marine environment of the Lea Park Formation and the mostly continental environment of the Foremost Formation.

The top of the Lea Park Formation is the bottom of the higher resistivity layer that occurs within a few metres below a regionally identifiable bentonite marker, as shown in the adjacent e-log. This marker occurs approximately 50 metres above the Milk

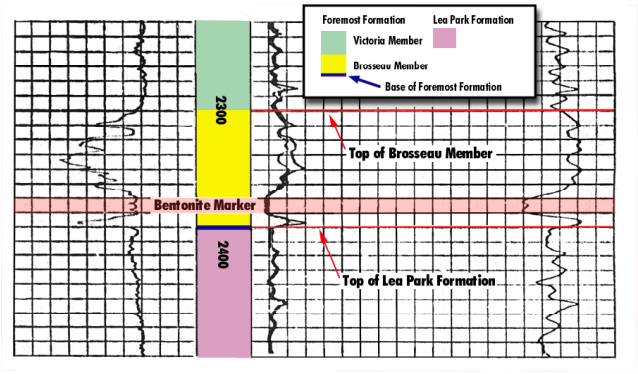

Figure 14. E-Log showing Base of Foremost Formation

[16] See glossary

River Shoulder.

The Lea Park Formation is approximately 50 metres thick and subcrops in the central part of the County. The Lea Park Formation is mostly composed of shale, with only minor amounts of bentonitic siltstone present in some areas. Regionally, the Lea Park Formation is an aquitard. Because the Lea Park Formation is an aquitard, there will be only a brief summary of the Lea Park Aquitard in the following paragraph of this report.

The apparent yields for water wells completed through the Lea Park Aquitard are less than 15 m^3/day. The groundwaters from the Lea Park Aquitard are mainly a sodium-bicarbonate type with TDS mainly between 1,000 and 1,500 mg/L. The sulfate concentrations are expected to be less than 500 mg/L and chloride concentrations are expected to be mainly less than 250 mg/L. Structure-contour maps associated with the Lea Park Formation are included in Appendix A and on the CD-ROM. In most of the area, the top of the Lea Park coincides with the Base of Groundwater Protection. In some areas, the Base of Groundwater Protection extends below the Colorado Group. A map showing the depth to the Base of Groundwater Protection is given on page 6 of this report, in Appendix A, and on the CD-ROM.

The Colorado Group includes the Milk River Formation, the *undivided* Colorado Group and the Viking Formation. The Milk River Formation is present under most of the County but subcrops in the northeastern part of the County, has a thickness of approximately 100 metres, is composed mostly of shale, with minor amounts of coal, and underlies the Lea Park Formation. In the County of Athabasca, the Colorado Group has limited importance and there will be only a brief summary in the following paragraph of this report.

The apparent yields for water wells completed through the Milk River Aquitard are less than 15 m^3/day. The groundwaters from the Milk River Aquitard are mainly a sodium-bicarbonate type with TDS mainly less than 1,000 mg/L. The sulfate concentrations are expected to be less than 500 mg/L, with concentrations decreasing with depth of burial. The chloride concentrations are less than 250 mg/L, with concentrations increasing with depth of burial. Structure-contour maps of the Milk River Formation are included in Appendix A and on the CD-ROM. The *undivided* Colorado Group, composed mostly of shale, underlies the Milk River Formation, has a thickness of 250 metres, is present under all of the project area, but subcrops in the extreme northeastern part of the County. The Viking Formation, a 50-metre-thick sandstone unit that sometimes can be distinguished near the base of the Colorado Group, is the only geological unit within the Colorado Group with any significant permeability. However, even the Viking Formation would not be expected to have yields of greater than 20 m^3/day.

2) Aquifers

Of the 5,671 water wells in the database, 599 were defined as being completed below the top of bedrock. However, at least a reported completion depth is available for the majority of boreholes[17] and assigning the boreholes to specific geologic units is possible only if the completion interval is identified. In order to make use of additional information within the groundwater database, it was assumed that if the total drilled depth of a borehole was more than ten metres below the top of a particular geological unit, the borehole was assigned to the particular geological unit. With this assumption, it has been possible to designate the aquifer of completion for 902 additional boreholes. There are 779 boreholes that have been identified as being completed in bedrock aquitards/aquifers below the Brosseau Member, or in more than one bedrock aquifer.

Geological Unit	No. of Boreholes
Oldman	5
Birch Lake	121
Ribstone	168
Victoria	264
Brosseau	164
Other	386
Multiple Completions	393
Total	1,501

Table 5. Completion Aquifer

The bedrock boreholes are mainly completed in the Victoria and Ribstone Creek aquifers, as shown in the above table. More than 25% of the bedrock boreholes are likely to have multiple completions, of which 96% have the top of the first completion interval less than 100 metres below ground level.

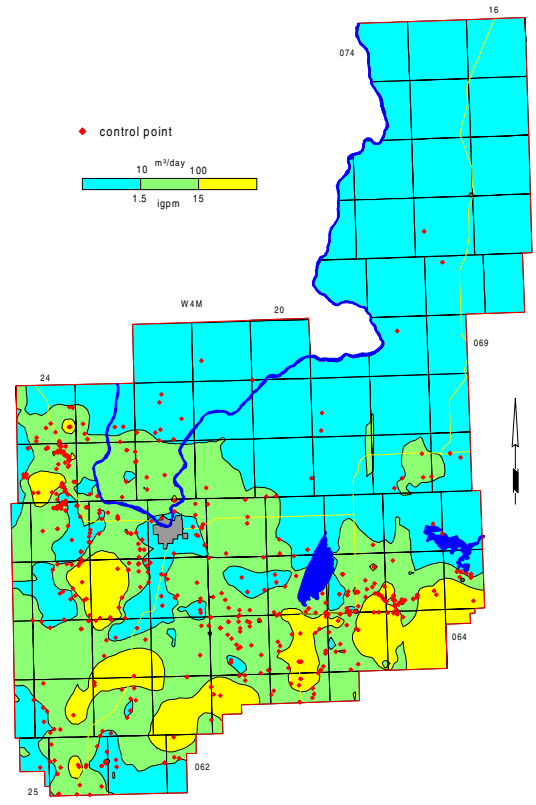

Figure 15. Apparent Yield for Water Wells Completed in Upper Bedrock Aquifer(s)

There are 527 records for bedrock water wells that have apparent yield values, 35% of all bedrock water wells. In the County, yields for water wells completed in the upper bedrock aquifer(s) are mainly between ten and 100 m³/day. The few areas with yields of more than 100 m³/day indicated on the adjacent figure are in the southern part of the County. These higher yield areas may identify areas of increased permeability resulting from the weathering process.

Aquifer	No. of Water Wells with Values for Apparent Yield	Number of Water Wells with Apparent Yields <10 m³/day	10 to 100 m³/day	>100 m³/day
Birch Lake	58	26	22	10
Ribstone Creek	98	36	51	11
Victoria	160	42	96	22
Brosseau	116	12	62	42
Totals	432	116	231	85

Table 6. Apparent Yield of Bedrock Aquifers

Of the 527 water well records with apparent yield values, 432 have been assigned to aquifers associated with specific geologic units that are being discussed. Fifty-three percent or 231 of the water wells completed in the bedrock aquifers have apparent yields that range from ten to 100 m³/day, and 27% or 116 have apparent yields that are less than ten m³/day, as shown in the table above.

[17] See glossary