5.3.7.4 C1

A detailed review of 174 resistivity logs available in a 12-township area (Figure 21) for the *continental* Foremost Formation was used to delineate two sandstone channels. Outside the 12-township area, the two sandstone channels have been identified using one resisitivity log per township. The lower channel was designated as C1 and the upper as C2. The sandstone thickness in C1 is more than 30 metres in township 050, range 16, W4M. The depth to the top of C1, where present, is mainly between 200 and 300 metres below ground level and is below the Base of Groundwater Protection west of range 12, W4M in the County. The sandstone thickness in C2 is mainly less than five metres.

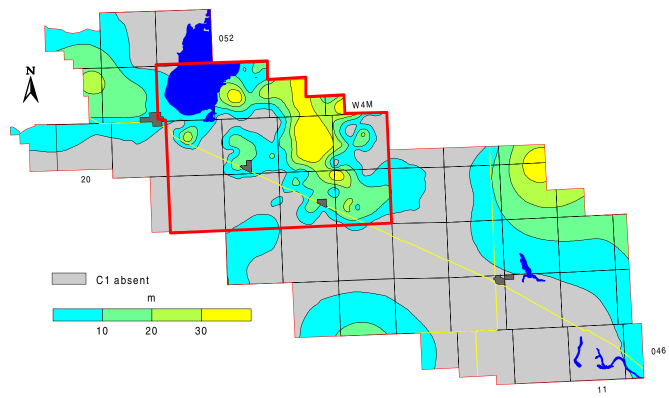

Figure 21. Thickness of C1

The summary results of drill stem tests are available from the EUB database. The DST summaries often provide a description of fluid obtained during the DST. Therefore, the DST summaries can be used to determine an apparent yield and the quality of fluid available from the Aquifer. The indications are that the TDS will be in the order of 5,000 mg/L.

The DST results associated with the C1 deposits indicate water well yields of in the order of 10 m³/day could be expected.

5.3.8 *marine* Foremost Aquifer

The *marine* Foremost Aquifer comprises the porous and permeable parts of the *marine* Foremost Formation. The Aquifer is present only in the eastern third of the County and underlies the *continental* Foremost Formation. The thickness of the *marine* Foremost Formation is generally less than 20 metres at its western extent but can be more than 180 metres in the northeastern part of the County.

5.3.8.1 Depth to Top

The depth to the top of the *marine* Foremost Formation is variable, ranging from less than 50 metres in the northeastern part of the County, to more than 250 metres at its western extent.

5.3.8.2 Apparent Yield

Although there are only four water well records in the County with apparent yields for individual water wells completed through the *marine* Foremost Aquifer, data available from the adjacent regions indicate apparent yields of less than 100 m³/day can be expected.

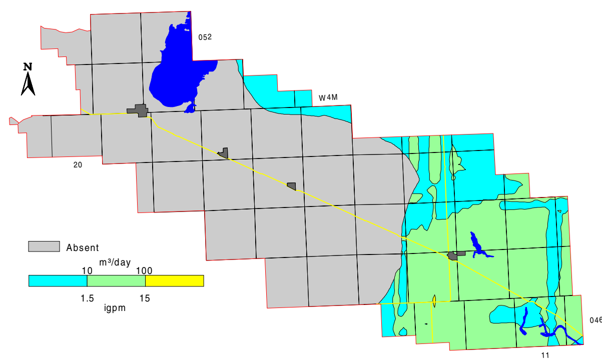

Figure 22. Apparent Yield for Water Wells Completed through marine Foremost Aquifer

5.3.8.3 Quality

There are insufficient data in the County to determine the chemical type of groundwaters from the *marine* Foremost Aquifer.

The TDS concentrations in the groundwaters from the *marine* Foremost Aquifer are expected to be mainly less than 1,500 mg/L. The sulfate concentrations are mainly less than 500 mg/L. Chloride concentrations in the groundwaters from the *marine* Foremost Aquifer are mainly less than 100 mg/L.

5.3.9 Basal Belly River Sandstone Aquifer

The Basal Belly River Sandstone Aquifer comprises the porous and permeable parts of the Basal Belly River Sandstone Zone that underlies the *continental* Foremost Formation, west of the edge of the *marine* Foremost Formation. The depth to the top of the Basal Belly River Sandstone Zone is mainly greater than 200 metres throughout the County. The shallower locations are in the northeastern part of the County. There are no records in the database for water wells completed in the Basal Belly River Sandstone Aquifer in the County.

With no data available from the groundwater database, the summary results of drill stem tests (DSTs) available from the EUB database were used. The DST summaries often provide a description of fluid obtained during the DST. Therefore, the DST summaries can be used to determine an apparent yield and the quality of fluid available from the Aquifer.

The fluids from 110 DSTs have been grouped as water, gas and water, and oil. The distribution of the various fluids is shown on the adjacent map.

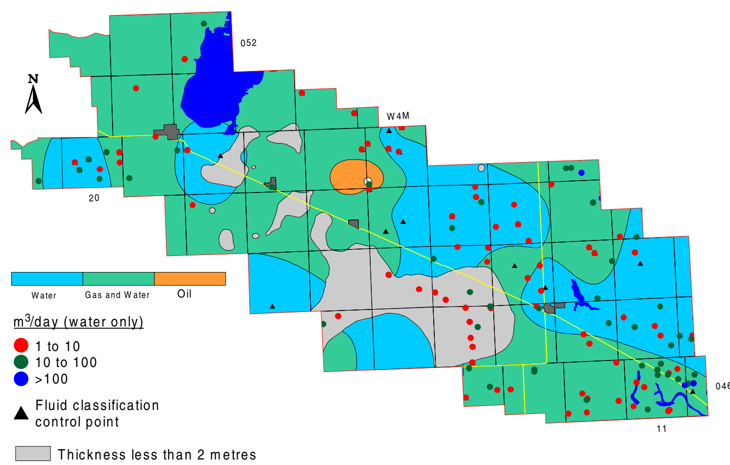

Figure 23. Type of Fluid Encountered in Basal Belly River Sandstone

Of the 110 DSTs, 69 have sufficient information to allow for the calculation of an apparent long-term yield. The projected long-term yield values vary from less than 5 m³/day to a maximum of 16.6 m³/day, with the mean being 8.7 m³/day and the median 7.7 m³/day.

The data from the DSTs have been used to prepare the map above. The contours outline the different fluids expected at various locations and the posting shows the expected long-term yield at individual locations.

5.3.10 Lea Park Aquitard

The Lea Park Formation is composed mainly of shale and has a very low permeability. In some of the area, the top of the Lea Park coincides with the Base of Groundwater Protection. In most areas, the Base of Groundwater Protection extends into the *continental* Foremost Formation. A map showing the depth to the Base of Groundwater Protection is given on page 5 of this report, in Appendix A, and on the CD-ROM.

6 GROUNDWATER BUDGET

6.1 Hydrographs

There are three locations in the County where water levels are being measured and recorded with time. These sites are observation water wells (Obs WWs) that are part of the AEP regional groundwater-monitoring network. Two Obs WWs are in 08-11-051-20 W4M in the vicinity of Cooking Lake, west of the Town of Tofield and one Obs WW is in NE 23-048-13 W4M, north of the Town of Viking. Hydrographs for the three Obs WWs are shown on the adjacent figure.

AEP Obs WW No. 157 in 08-11-051-20 W4M is completed at a depth of 34 metres below ground level in the Upper Sand and Gravel Aquifer. AEP Obs WW No. 158 in 08-11-051-20 W4M is completed at a depth of 61 metres below ground level in the Lower Horseshoe Canyon Aquifer. From 1980 to 1986, there is a water-level decline of more than one metre in AEP Obs WW No. 157. In AEP Obs WW No. 158, there is a water-level decline of more than 1.5 metres, but the decline is from 1981 to 1988. Following the water-level declines in both AEP Obs WWs, the water levels rose in the order of the same magnitude. There are no known licensed water well users in the immediate area of the Obs WWs. The closest licensed groundwater user is 5,000 metres from the Obs WWs and the licensed water well is completed in the Bearpaw Aquifer. The reason for the decline and subsequent rise in the water levels is not apparent. However, the decline does coincide with the drought of the early 1980s in Alberta. It is possible that the water-level decline is regional and is in response to the lack of groundwater recharge associated with the drought.

The third AEP Obs WW in NE 23-052-15 W4M, Obs WW No. 298, is completed at a depth of 103.6 metres below ground level in the *continental* Foremost Aquifer. This hydrograph shows annual cycles of water-level rise and decline; however, the water-level rise begins in winter and the decline begins in spring. Overall annual fluctuations are approximately 10 centimetres.

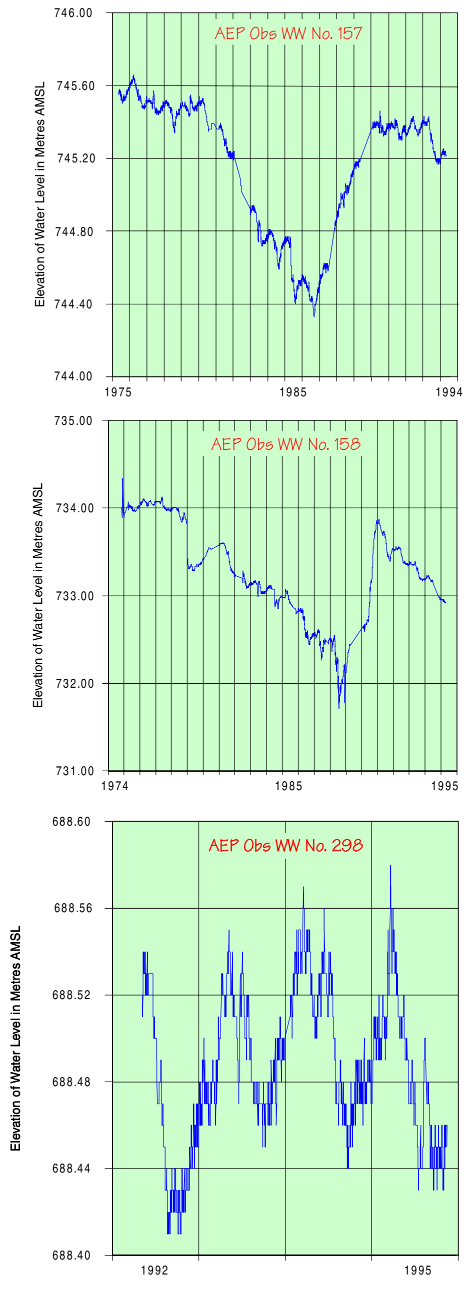

Figure 24. Hydrographs - AEP Observation Water Wells

6.2 Groundwater Flow

A direct measurement of groundwater recharge or discharge is not possible from the data that are available for the County. One indirect method of measuring recharge is to determine the quantity of groundwater flowing laterally through each individual aquifer. This method assumes that there is sufficient recharge to the aquifer to maintain the flow through the aquifer and the discharge is equal to the recharge. However, even the data that can be used to calculate the quantity of flow through an aquifer must be averaged and estimated. To determine the flow requires a value for the average transmissivity of the aquifer, an average hydraulic gradient and an estimate for the width of the aquifer. For the present program, the flow has been estimated for those parts of the various aquifers within the County.

The flow through each aquifer assumes that by taking a large enough area, an aquifer can be considered as homogeneous, the average gradient can be estimated from the non-pumping water-level surface, and flow takes place through the entire width of the aquifer. Based on these assumptions, the estimated lateral groundwater flow through the individual aquifers can be summarized as follows:

Aquifer Designation	Transmissivity (m^2/day)	Gradient (m/m)	Width (km)	Main Direction of Flow	Quantity (m^3/day)	Authorized Diversion (m^3/day)
Upper Sand and Gravel						65.2
Lower Horseshoe Canyon	2.6	0.003	40	Northeast	312	34.0
Bearpaw	1.0	0.003	70	Northeast	200	67.7
Oldman	2.6	0.002	90	North	468	108.5
continental Foremost	1.0	0.002	100	North	200	223.6
marine Foremost	3.1	0.001	40	Northwest	124	13.5

The above table indicates that there is more groundwater flowing through the aquifers than has been authorized to be diverted from the individual aquifers, with the exception of the *continental* Foremost Aquifer. In the case of the Upper Sand and Gravel Aquifer, no value has been calculated for the flow through the Aquifer because of the difficulty in obtaining a reasonable value for hydraulic gradient in the Upper Sand and Gravel Aquifer. However, because of the very approximate nature of the calculation of the quantity of groundwater flowing through the individual aquifers, more detailed work is required to establish the flow through the aquifers.

6.3 Quantity of Groundwater

An estimate of the volume of groundwater stored in the sand and gravel aquifers in the surficial deposits is 0.2 to 1.5 cubic kilometres. This volume is based on an areal extent of 3,500 square kilometres and a saturated sand and gravel thickness of 1.5 metres. The variation in the total volume is based on the value of porosity that is used for the sand and gravel. One estimate of porosity is 5%, which gives the low value of the total volume. The high estimate is based on a porosity of 30% (Ozoray, Dubord and Cowen, 1990).

The adjacent water-level map has been prepared by considering water wells completed in surficial deposits, except in the vicinity of the Buried Vegreville and Vermilion valleys. In these two valleys, only the water levels from water wells completed in the deeper sand and gravel deposits have been included. These water levels were used for the calculation of saturated surficial deposits and for the calculation of recharge/discharge areas.

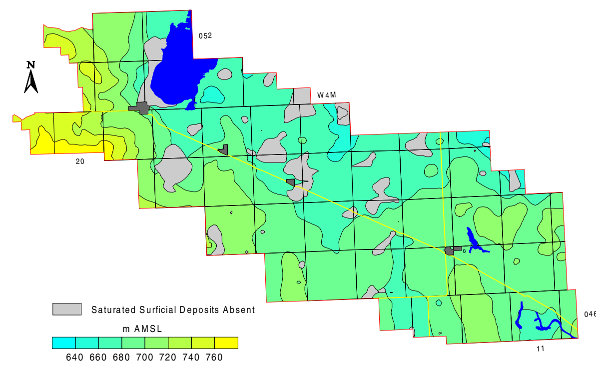

Figure 25. Non-Pumping Water-Level Surface in Surficial Deposits

6.4 Recharge/Discharge

The hydraulic relationship between the groundwater in the surficial deposits and the groundwater in the bedrock aquifers is given by the non-pumping water-level surface associated with each of the hydraulic units. Where the water level in the surficial deposits is at a higher elevation than the water level in the bedrock aquifers, there is the opportunity for groundwater to move from the surficial deposits into the bedrock aquifers. This condition would be considered as an area of recharge to the bedrock aquifers and an area of discharge from the surficial deposits. The amount of groundwater that would move from the surficial deposits to the bedrock aquifers is directly related to the vertical permeability of the sediments separating the two aquifers.

When the hydraulic gradient is from the bedrock aquifers to the surficial deposits, the condition is a discharge area from the bedrock aquifers, and a recharge area to the surficial deposits.

6.4.1.1 Surficial Deposits/Upper Bedrock Aquifer(s)

The hydraulic gradient between the surficial deposits and the upper bedrock aquifer(s) has been determined. The determination is made by subtracting the non-pumping water-level surface associated with all water wells completed in the upper bedrock aquifer(s) from the non-pumping water-level surface determined for all water wells in the surficial deposits that are less than 15 metres deep. The recharge classification includes areas where the water level in the surficial deposits is more than five metres above the water level in the upper bedrock aquifer(s). The discharge classification includes areas where the water level in the surficial deposits is more than five metres lower than the water level in the bedrock. When the water level in the surficial deposits is between five metres above and five metres below the water level in the bedrock, the area is classified as one of transition.