5.3.9 Victoria Aquifer

The Victoria Aquifer comprises the porous and permeable parts of the Victoria Member. Structure contours have been prepared for the top and bottom of the Member, which underlies 60% of the County. The structure contours show the Member being mostly less than 30 metres thick.

5.3.9.1 Depth to Top

The depth to the top of the Victoria Creek Member is mainly less than 140 metres below ground level but can be more than 180 metres in the southwestern part of the County where the Member is present.

5.3.9.2 Apparent Yield

The apparent yields for individual water wells completed through the Victoria Aquifer are mainly less than 100 m³/day. The areas where water wells with yields of less than 10 m³/day are expected are where the thickness of the Aquifer is generally less than 20 metres near the western and northern edges and in the central part of the Aquifer.

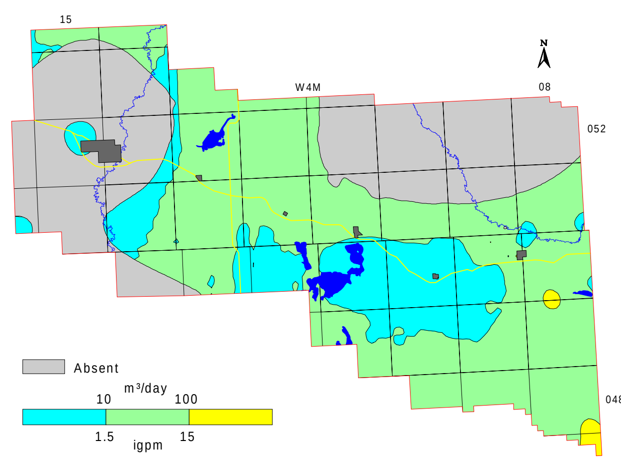

Figure 23. Apparent Yield for Water Wells Completed through Victoria Aquifer

5.3.9.3 Quality

There are not enough available data to determine the chemical type of the groundwaters from the Victoria Aquifer in the County. However, data available for the Victoria Aquifer in the M.D. of Wainwright suggests that, typically, the groundwaters from the Aquifer range from sodium-bicarbonate to calcium-magnesium-chloride types. There are two control points within the County of Minburn with TDS, sulfate and chloride concentrations. One control point is in NW 25-050-09 W4M and the other is in 10-26-049-08 W4M. By extrapolating these data with the data from the surrounding counties, TDS concentrations of less than 1,200 mg/L can be mainly expected west of range 11, W4M and more than 1,200 mg/L east of range 12, W4M. The sulfate concentrations are mainly less than 250 mg/L. Chloride concentrations in the groundwaters from the Victoria Aquifer are mainly less than 100 mg/L.

5.3.10 Lea Park Aquitard

The Lea Park Formation is composed mainly of shale and has a very low permeability. 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 above the Brosseau Member. 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.

6 GROUNDWATER BUDGET

6.1 Hydrographs

There are five 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. Three Obs WWs are in 05-23-052-15 W4M in the vicinity of the Town of Vegreville and two Obs WWs are in SW 30-050-10 W4M in the vicinity of the Village of Innisfree. Hydrographs for four of the five Obs WWs are shown on the adjacent figure; water-level measurements for one of the Obs WWs in 05-23-052-15 W4M are available for 1996 only and are of limited use.

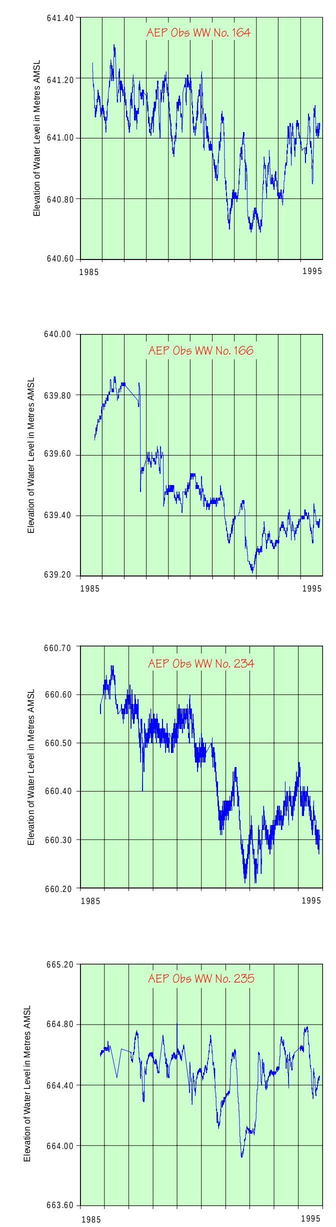

Figure 24. Hydrographs - AEP Observation Water Wells

AEP Obs WW No. 164 in 05-23-052-15 W4M is completed at a depth of 37.2 metres below ground level in the Lower Sand and Gravel Aquifer. This hydrograph shows annual cycles of recharge in spring and fall and declines in winter and summer. Overall annual fluctuations are approximately 20 to 40 centimetres. From 1985 to 1989, there is no apparent water-level decline. From 1990 to 1992, the water level declined approximately 30 centimetres. From 1993 to 1995, the water level rose in the order of 30 centimetres. There is only one licensed water well in the area that has been completed in the Lower Sand and Gravel Aquifer; this is the water well that has been authorized to use 3.4 m^3/day for irrigation purposes by the AEP Laboratory at Vegreville. There has been no authorized increase in groundwater for the AEP water well since 1977, when it was put into use.

The second AEP Obs WW in 05-23-052-15 W4M, Obs WW No. 166, is completed at a depth of 82.3 metres below ground level in the *continental* Foremost Aquifer. The water-level data from 1985 to 1988 are suspect, probably as a result of equipment calibration problems. This hydrograph also reflects a water-level decline from 1990 to 1992, followed by a rise beginning in 1993. Overall annual fluctuations are less than 20 centimetres.

AEP Obs WW No. 234 in SW 30-050-10 W4M is completed at a depth of 52.7 metres below ground level in the *continental* Foremost Aquifer. This hydrograph shows annual cycles of recharge in spring and fall and declines in winter and summer. Overall annual fluctuations are approximately 5 to 20 centimetres. This hydrograph also reflects a water-level decline from 1990 to 1992 of approximately 40 centimetres and a general water-level decline since 1986.

The fourth AEP Obs WW in SW 30-050-10 W4M, Obs WW No. 235, is completed at a depth of 16.8 metres below ground level in the *continental* Foremost Aquifer. This hydrograph also shows annual cycles of recharge and decline. Overall annual fluctuations are approximately 30 to 80 centimetres. This hydrograph also reflects a water-level decline from 1990 to 1992 of in the order of 40 centimetres. The Village of Innisfree is licensed to divert 74.4 m³/day from the *continental* Foremost Aquifer. It is possible that this diversion is having an impact on the Aquifer; however, based on similar water-level declines in AEP Obs WW Nos. 164 and 166 and in AEP Obs WW No. 234, this water-level decline appears to be regional and not as a result of local influences.

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)
Surficial Deposits						**40.6**
Upper Sand and Gravel					**#N/A**	**37.2**
Upper Sand and Gravel West	8	#N/A	#N/A	#N/A	#N/A	
Upper Sand and Gravel East	10	#N/A	#N/A	#N/A	#N/A	
Lower Sand and Gravel					**600**	3.4
Lower Sand and Gravel West	20	0.002	12	North	500	
Lower Sand and Gravel East	10	0.002	7	East	100	
Oldman	3	0.002	100	Northwest	**600**	**220**
***continental* Foremost**					**720**	**286.7**
Western part of County	1	0.002	60	North	120	
Eastern part of County	5	0.002	60	East	600	
Birch Lake	10	0.003	20	North	**600**	**37.2**
Ribstone Creek	8	0.002	30	North	**500**	**130.2**
Victoria	2	0.002	50	Northeast	**200**	**382**

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 Victoria 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 0.6 to 3.6 cubic kilometres. This volume is based on an areal extent of 3,000 square kilometres and a saturated sand and gravel thickness of four 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.

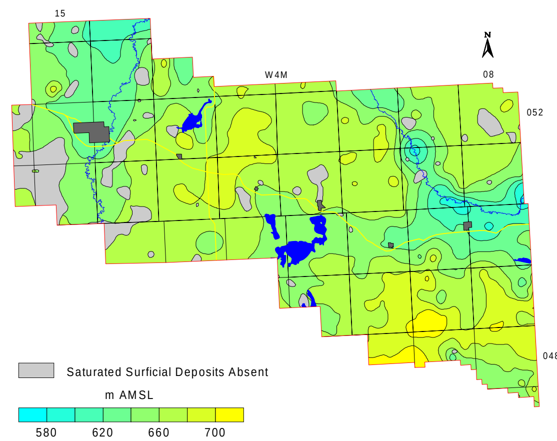

Figure 25. Non-Pumping Water-Level Surface in Surficial Deposits

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 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. The recharge classification on the map below includes those 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 areas are 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 a transition.

The adjacent map shows that, in more than 80% of the County, there is a downward hydraulic gradient from the surficial deposits toward the upper bedrock aquifer(s). Areas where there is an upward hydraulic gradient from the bedrock to the surficial deposits are mainly in the vicinity of lows in the bedrock surface. The remaining parts of the County are areas where there is a transition condition.

Because of the paucity of data, a calculation of the volumes of groundwater entering and leaving the surficial deposits has not been attempted.

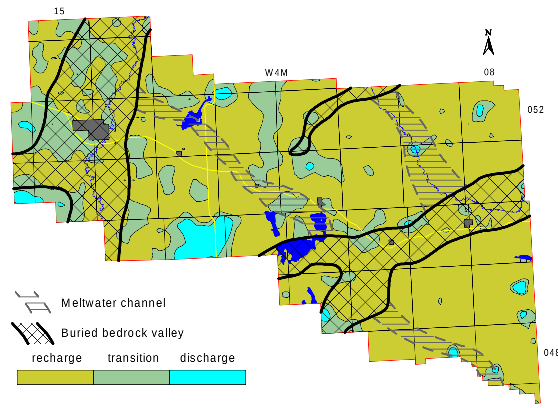

Figure 26. Recharge/Discharge Areas between Surficial Deposits and Upper Bedrock Aquifer(s)

6.4.1.2 Bedrock Aquifers

Recharge to the bedrock aquifers within the County takes place from the overlying surficial deposits and from flow in the aquifer from outside the County. The recharge/discharge maps show that generally for most of the County, there is a downward hydraulic gradient from the surficial deposits to the bedrock, i.e. recharge to the bedrock aquifers. On a regional basis, calculating the quantity of water involved is not possible because of the complexity of the geological setting and the limited amount of data. However, because of the generally low permeability of the upper bedrock materials, the volume of water is expected to be small.

The hydraulic relationship between the surficial deposits and the Oldman Aquifer indicates that in more than 40% of the County where the Oldman Aquifer is present, there is a downward hydraulic gradient. Discharge areas for the Oldman Aquifer are either in or adjacent to the bedrock lows. The hydraulic relationship between the surficial deposits and the remainder of the bedrock aquifers present in the County indicates there is mainly a downward hydraulic gradient.

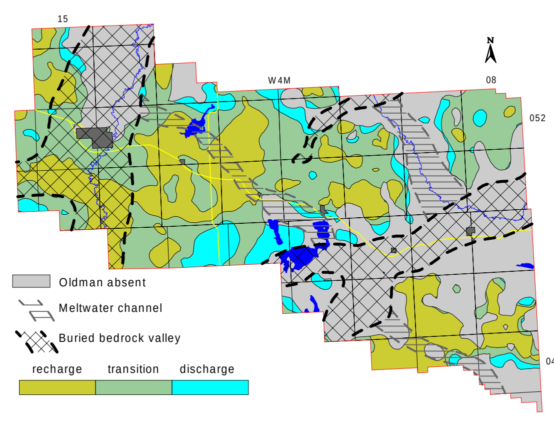

Figure 27. Recharge/Discharge Areas between Surficial Deposits and Oldman Aquifer

7 POTENTIAL FOR GROUNDWATER CONTAMINATION

The most common sources of contaminants that can impact groundwater originate on or near the ground surface. The contaminant sources can include leachate from landfills, effluent from leaking lagoons or from septic fields, and petroleum products from storage tanks or pipeline breaks. The agricultural activities that generate contaminants include the spreading of fertilizers, pesticides, herbicides and manure. The spreading of highway salt can also degrade groundwater quality.

When activities occur that can or do produce a liquid which could contaminate groundwater, it is prudent (from a hydrogeological point of view) to locate the activities where the risk of groundwater contamination is minimal. Alternatively, if the activities must be located in an area where groundwater can be more easily contaminated, the necessary action must be taken to minimize the risk of groundwater contamination.

The potential for groundwater contamination is based on the concept that the easier it is for a liquid contaminant to move downward, the easier it is for the groundwater to become contaminated. In areas where there is groundwater discharge, liquid contaminants cannot enter the groundwater flow systems to be distributed throughout the area. In groundwater recharge areas, low-permeability materials impede the movement of liquid contaminants downward. Therefore, if the soils develop on a low-permeability parent material of till or clay, the downward migration of a contaminant is slower relative to a high-permeability parent material such as sand and gravel of fluvial origin. Once a liquid contaminant enters the subsurface, the possibility for groundwater contamination increases if it coincides with a higher permeability material within one metre of the land surface.

To determine the nature of the materials on the land surface, the surficial geology map prepared by the Alberta Research Council (Shetsen, 1990) has been reclassified based on the relative permeability. The classification of materials is as follows:

1. high permeability - sand and gravel;
2. moderate permeability - silt, sand with clay, gravel with clay, and bedrock; and
3. low permeability - clay and till.

To identify the areas where sand and gravel can be expected within one metre of the ground surface, all groundwater database records with lithologies were reviewed. From a total of 1,759 records in the area of the County with lithological descriptions, 239 have sand and gravel within one metre of ground level. In the remaining 1,520 records, the first sand and gravel is deeper or not present. This information was gridded to prepare a distribution of where the first sand and gravel deposit could be expected within one metre of ground level.

7.1.1 Risk of Contamination Map

The information from the reclassification of the surficial geology map is the basis for preparing the initial risk map. The depth to the first sand and gravel is then used to modify the initial map and to prepare the final map. The criteria used for preparing the final Risk of Groundwater Contamination map are outlined in the adjacent table.

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 5. Risk of Groundwater Contamination Criteria

The Risk of Groundwater Contamination map shows that, in 35% of the County, there is a high or very high risk of the groundwater being contaminated. These areas would be considered the least desirable ones for a development that has a product or by-product that could cause groundwater contamination. However, because the map has been prepared as part of a regional study, the designations are a guide only; detailed hydrogeological studies must be completed at any proposed development site to ensure the groundwater is protected from possible contamination. At all locations, good environmental practices should be exercised in order to ensure that groundwater contamination would not affect groundwater quality.

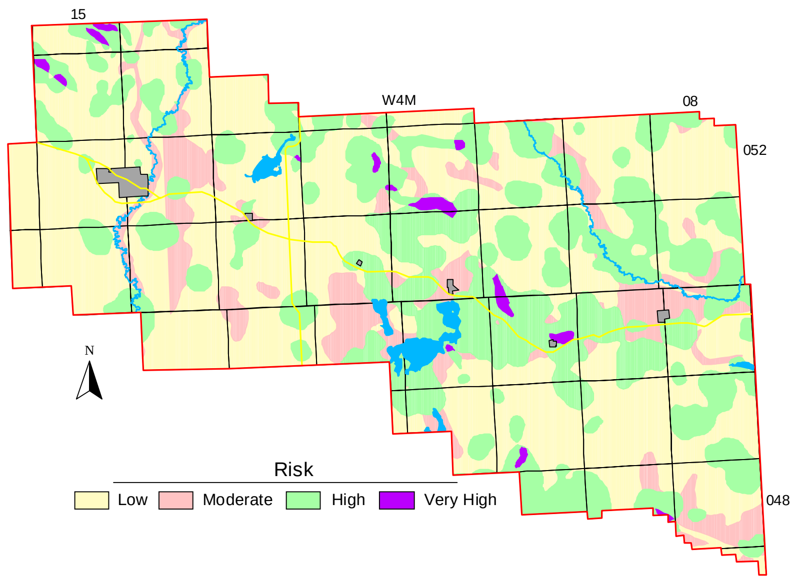

Figure 28. Risk of Groundwater Contamination