5.3.8 Brosseau Aquifer

The Brosseau Aquifer comprises the porous and permeable parts of the Brosseau Member. Structure contours have been prepared for the top of the Member, which underlies 90% of the County. The structure contours show the Member being mostly less than 10 metres thick. Because the amount of hydrogeological information from the groundwater database for the Brosseau Aquifer interval is limited in the County, a complete detailed map set has not been prepared.

5.3.8.1 Depth to Top

The depth to the top of the Brosseau Member is variable, ranging from less than 20 metres near the North Saskatchewan River to more than 180 metres in the southwestern corner of the County.

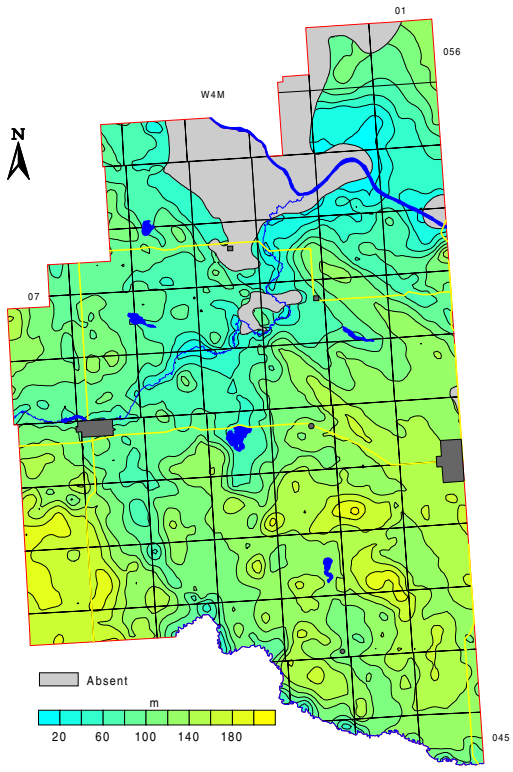


Figure 25. Depth to Top of Brosseau Member

5.3.8.2 Apparent Yield

There are eight water well records in the database with sufficient information to calculate apparent yields for individual water wells completed through the Brosseau Aquifer. Five of the apparent yields are between 10 and 100 m^3/day, two are less than 10 m^3/day, and one is greater than 100 m^3/day, with the largest being 198 m^3/day.

5.3.8.3 Quality

There are three water well records in the groundwater database with sufficient information to determine the chemical type of groundwaters from the Brosseau Aquifer in the County of Vermilion River. The groundwaters are bicarbonate-type waters with no dominant cation. There are four water well records in the database for the Municipal District (M.D.) of Wainwright. The groundwaters are either sodium-bicarbonate-chloride or sodium-chloride-type waters.

There are five water well records in the database for the County with TDS, sulfate and chloride concentrations; the TDS values are between 500 and 900 mg/L, the sulfate values are mainly less than 200 mg/L, and the chloride values are less than 50 mg/L.

6 GROUNDWATER BUDGET

6.1 Hydrographs

There are eight 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. These eight Obs WWs are in three main areas of the County. Of the eight Obs WWs, three are in the southwestern part of the County in NW 20-048-07 W4M, three are in the vicinity of the Village of Dewberry (two in 06-21-053-04 W4M, one in SW 28-052-04 W4M) and the remaining two are in or near the City of Lloydminster (one in 01-36-050-01 W4M and one in 11-01-050-01 W4M). The hydrograph for AEP Obs WW No. 237 in SW 28-052-04 W4M is shown on the adjacent figure and in Appendix A; the hydrograph for AEP Obs No. 154 in 11-01-050-01 W4M is discussed and shown on Figure 29. Hydrographs for the other six AEP Obs WWs are of limited use but are included on the CD-ROM. Three additional water well sites that are being or have been monitored over time by Mow-Tech Ltd.[14] are also discussed in the text below.

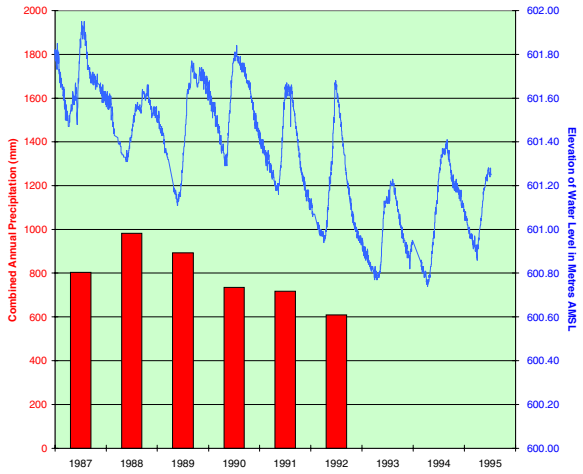


Figure 26. Annual Precipitation vs Water Levels in AEP Obs WW No. 237

AEP Obs WW No. 237 in SW 28-052-04 W4M is completed at a depth of 12.2 metres below ground level in the Ribstone Creek Aquifer. This hydrograph shows annual cycles of recharge in late spring/early summer and a decline throughout the remainder of the year. Overall annual fluctuations are approximately 0.40 to 0.80 metres. From 1986 to 1991, there has been a net decline in the water level of approximately 0.20 metres. From 1991 to 1993, the water level declined approximately 0.40 metres. From 1994 to 1996, the water level rose slightly. The Village of Islay water supply wells are licensed to divert 70 m^3/day. These water supply wells are the closest licensed users to AEP Obs WW No. 237 and are also completed in the Ribstone Creek Aquifer. There has been no authorized increase in groundwater for the Village of Islay water supply wells since 1985. They were first put into use in 1980. The water-level decline in AEP Obs WW No. 237 has been compared to the combined precipitation data measured at the Lloydminster and Paradise Valley weather stations, the closest weather stations to the Obs WW with long-term data. The comparison in Figure 26 shows that the water-level decline from 1988 to 1992 reflects the decrease in total annual precipitation measured at the two weather stations.

From 1980 to 1997, Probe Exploration Inc. (Probe) has obtained groundwater from WSW No. 03C-02 completed in the Upper Sand and Gravel Aquifer in the upper surficial deposits in 03-02-051-02 W4M. Continuous water-level measurements in Obs WW No. 03C-02 and two domestic water wells show that diversion from WSW No. 03C-02 is having an impact on the water level in both the Upper Sand and Gravel Aquifer and the Ribstone Creek Aquifer.

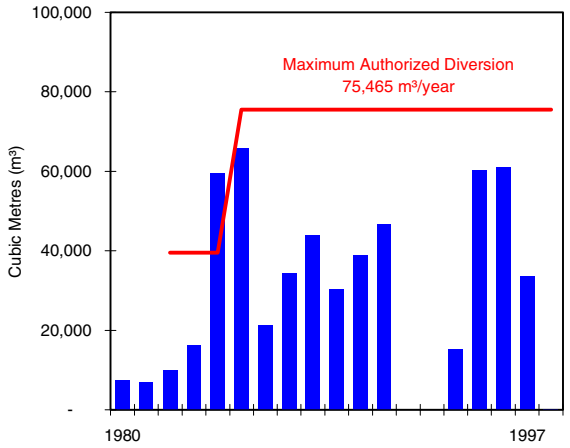
A mathematical model was used to calculate water levels at the location corresponding to Obs WW No. 03C-02, completed in the Upper Sand and Gravel Aquifer and one domestic water well completed in the Ribstone Creek Aquifer. The model is based on the annual groundwater production from WSW No. 03C-02, has an effective

[14] Mow-Tech Ltd. 1-800-GEO-WELL

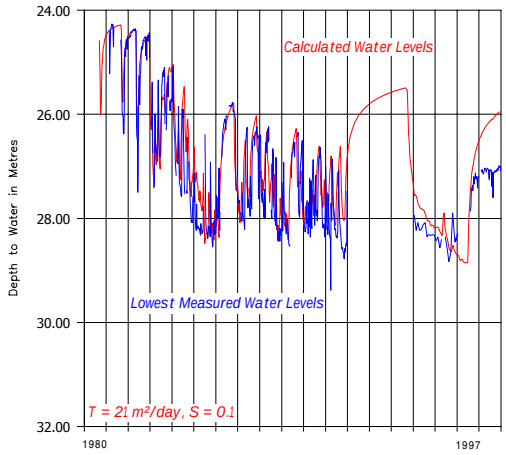
transmissivity of 21 m²/day and a corresponding storativity of 0.1. The model assumes a homogeneous, isotropic aquifer of infinite areal extent and does not account for aquifer recharge.

There is a reasonable match between the calculated and measured water levels in Obs WW No. 03C-02 as shown below in Figure 27. The non-pumping water level in the domestic water well declined 3.5 metres between 1981 and 1998 suggesting that the diversion from WSW No. 03C-02 is responsible for the water-level decline. The mathematical model showed that there is a direct relationship between the production from the Upper Sand and Gravel Aquifer and the water level in the Ribstone Creek Aquifer, at the site of the domestic water well (HCL, March 1998).

Figure 27. Water-Level Comparison



WSW No. 03C-02 Groundwater Production



Obs WW No. 03C-02

From 1982 to 1991, Dome Petroleum Limited (Dome) diverted 734,461 cubic metres mainly from one water source well completed in the Lower Sand and Gravel Aquifer associated with the Buried Vermilion Valley in 16-10-052-04 W4M. The diverted groundwater had no adverse effect on the quantity of the groundwater available for the Lower Sand and Gravel Aquifer at the site of the Dome Auxiliary Water Well as shown in the adjacent figure (HCL, June 1992).

Canadian Occidental Petroleum Ltd. (COPL) and Husky Oil Operations Ltd. (Husky) also had water source wells completed in the Lower Sand and Gravel Aquifer in townships 051 and 052, range 04, W4M in the Morgan area. Although Husky cancelled their groundwater monitoring program in 1985 (HCL, January 1986), COPL diverted 77,885 cubic metres between 1987 and 1989 without having an adverse effect on the water level in the Lower Surficial Aquifer.

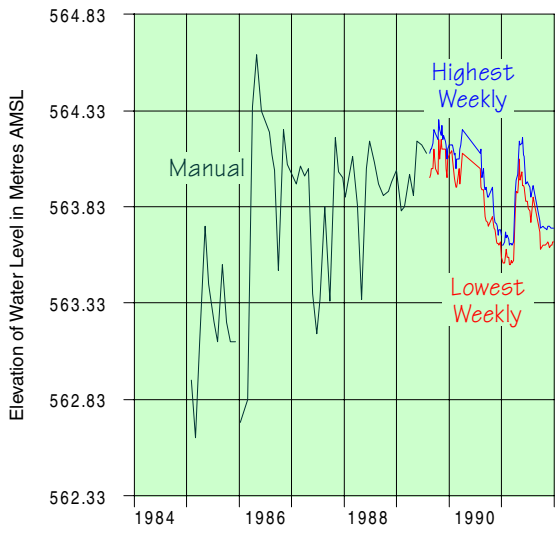


Figure 28. Hydrograph – Dome Auxiliary Water Well

There have been at least eight water source wells used to provide water at various times to a Husky refinery situated on the northern edge of the City of Lloydminster (HCL, January 1975). One of these water source wells has been used as an observation water well, first by the Alberta Research Council in 1957 and later in 1983 by AEP. This observation water well, Obs WW No. 154 in 11-01-050-01 W4M, is completed at a depth of 57.9 metres below ground level in the Lower Sand and Gravel Aquifer. Prior to 1960, when the City of Lloydminster was obtaining its water supply from the same aquifer as the Husky wells, the water level in the Lower Sand and Gravel Aquifer at the site of AEP Obs WW No. 154 declined to a depth of approximately 34 metres below ground level (610 metres AMSL). In 1960, the City of Lloydminster developed an alternate water supply well north of the City and stopped using the water wells completed in the Lower Sand and Gravel Aquifer (HCL, January 1975). Consequently, the water level in Obs WW No. 154 rose 4.5 metres in 1961, and has continued to be mainly between 620 and 625 metres AMSL. Since April 1993, Husky has been licensed to divert from two water source wells completed in the Lower Sand and Gravel Aquifer: 50.7 m³/day from a water source well in 11-01-050-01 W4M and 169 m³/day from a water source well in 12-01-050-01 W4M. There has been no apparent decline in the Lower Sand and Gravel Aquifer at the site of AEP Obs WW No. 154.

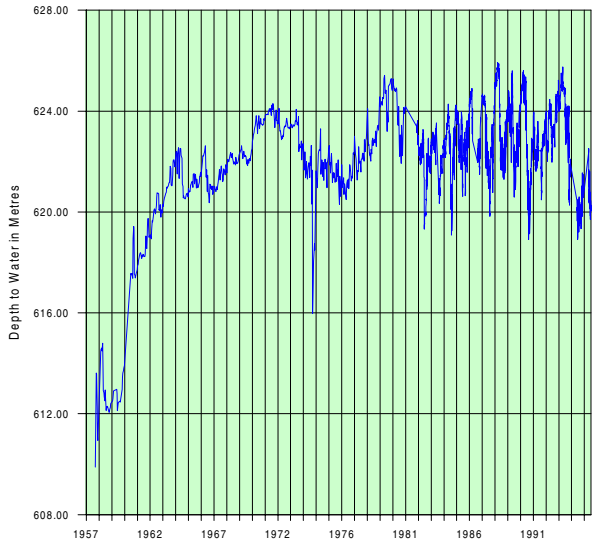


Figure 29. AEP Obs WW No. 154

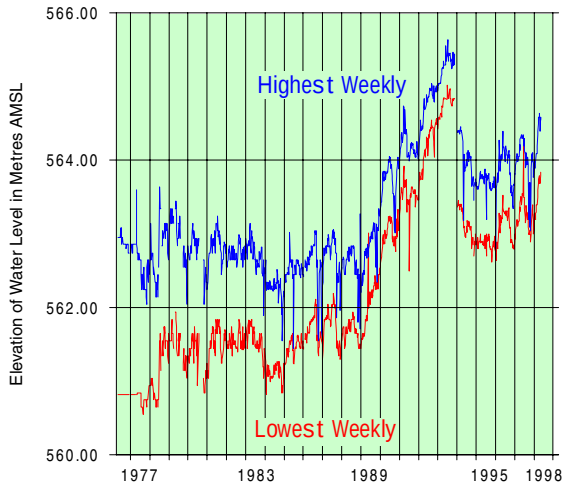


Figure 30. Hydrograph – Village of Marwayne WSW No. 3

The Village of Marwayne diverts groundwater from four water supply wells. Water Supply Well No. 3 is completed open-hole from 37.0 to 40.5 metres below ground level in the Victoria Aquifer and is licensed to divert 78.4 m³/day. As a result of the Village maintaining an excellent groundwater monitoring program, HCL has been able to advise the Village to divert no more than 63 m³/day from WSW No. 3, if the water levels are to remain above the top of the completion interval of 561.34 metres AMSL (HCL, January 1999).

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 bedrock 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						**5,138**
Upper Sand and Gravel						1,135
Upper Sand and Gravel (Buried Vermilion Valley)	20	0.0025	10	Northeast	500	
Upper Sand and Gravel (NW from Lloydminster)	15	0.003	15	Northwest, southeast	675	
Lower Sand and Gravel						4,003
Lower Sand and Gravel (Buried Vermilion Valley)	1800	0.0003	1	Northeast	540	
Lower Sand and Gravel (NW from Lloydminster)	1800	0.002	1	Northwest	3600	
Birch Lake						**98**
Birch Lake-Northeast of Grizzly Bear Creek	8	0.004	50	Northeast	1600	
Birch Lake-Southwest of Grizzly Bear Creek	8	0.003	15	Northeast	360	
Ribstone Creek						**1,421**
Ribstone Creek	8	0.002	60	Northwest, Southeast	960	
Ribstone Creek	8	0.002	45	Southwest	720	
Victoria						**953**
Victoria, Eastern part	5	0.002	100	West	1000	
Victoria, Western part	5	0.002	50	East	500	

The data provided in the above table indicate there is more groundwater flowing through the individual bedrock aquifers than has been authorized to be diverted from each aquifer. The calculations of flow through individual aquifers as presented in the above table are very approximate and are intended as a guide for future investigations.

6.2.1 Quantity of Groundwater

An estimate of the volume of groundwater stored in the sand and gravel aquifers in the surficial deposits is 1 to 5.3 cubic kilometres. This volume is based on an areal extent of 3,500 square kilometres and a saturated sand and gravel thickness of five 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).