6.2 Estimated Water Use from Unlicensed Groundwater Users

An estimate of the quantity of groundwater removed from each geologic unit in Strathcona County must include both the licensed diversions and the unlicensed use. As stated previously on page 6 of this report, the daily water requirement for livestock for the County based on the 1996 census is estimated to be 5,131 cubic metres. Of the 5,131 m³/day required for livestock, 600 m³/day has been licensed by Alberta Environment, which includes both surface water and groundwater. To obtain an estimate of the quantity of groundwater being diverted from the individual geologic units, it has been assumed that the remaining 4,531 m³/day of water required for livestock watering is obtained from unlicensed groundwater use. In the groundwater database for the County, there are records for 6,984 water wells that are used for domestic/stock purposes. These 6,984 water wells include both licensed and unlicensed water wells. Of the 6,984 water wells, 382 water wells are used for stock, 507 are used for domestic/stock purposes, and 6,095 are for domestic purposes only.

There are 889 water wells that are used for stock or domestic/stock purposes. There are 32 licensed groundwater users for agricultural (stock) purposes, giving 857 unlicensed stock water wells. (Please refer to Table 1 on page 6 for the breakdown by aquifer of the 32 licensed stock groundwater users). By dividing the number of unlicensed stock and domestic/stock water wells (857) into the quantity of groundwater required for stock purposes that is not licensed (4,531 m³/day), the average unlicensed water well diverts 5.3 m³/day. Because of the limitations of the data, no attempt has been made to compensate for dugouts, springs or inactive water wells, and the average stock use is considered to be 5.3 m³/day per stock water well.

Groundwater for household use does not require licensing. Under the Water Act, a residence is protected for up to 3.4 m³/day. However, the standard groundwater use for household purposes is 1.1 m³/day.

To obtain an estimate of the groundwater from each geologic unit, there are three possibilities for a water well. A summary of the possibilities and the quantity of water for each use is as follows:

Domestic	1.1 m³/day
Stock	5.3 m³/day
Domestic/stock	6.4 m³/day

Based on using all available domestic, domestic/stock, and stock water wells and corresponding calculations, the following table was prepared. The table shows a breakdown of the 6,984 unlicensed and licensed water wells used for domestic, stock, or domestic/stock purposes by the geologic unit in which each water well is completed. The final column in the table equals the total amount of unlicensed groundwater that is being used for both domestic and stock purposes. The data provided in the table below indicate that most of the 11,569 m³/day, estimated to be diverted from unlicensed domestic, stock, or domestic/stock water wells, is from the Lower Horseshoe Canyon and Upper Sand and Gravel aquifers.

	Unlicensed and Licensed Groundwater Diversions							*Licensed Groundwater Diversions*	*Unlicensed Groundwater Diversions*
Aquifer Designation	Number of Domestic	Daily Use (1.1 m³/day)	Number of Stock	Daily Use (5.4 m³/day)	Number of Domestic and Stock	Daily Use (6.5 m³/day)	Totals m³/day	Totals (m³/day)	Totals m³/day
Upper Sand/Gravel	1,228	1,351	109	576	174	1,111	3,038	22	3,016
Lower Sand/Gravel	74	81	12	63	13	83	228	0	228
Bedrock	616	678	18	95	47	300	1,073	0	1,073
Lower Horseshoe Canyon	2,572	2,829	119	629	99	632	4,091	177	3,914
Bearpaw	670	737	45	238	83	530	1,505	37	1,468
Oldman	149	164	39	63	44	281	508	13	494
Birch Lake	4	4	3	16	1	6	27	0	27
Unknown	782	860	37	196	46	294	1,350	0	1,350
Totals	6,095	6,705	382	1,876	507	3,238	11,819	249	11,569

Table 6. Unlicensed and Licensed Groundwater Diversions

By assigning 1.1 m³/day for domestic use, 5.3 m³/day for stock use and 6.4 m³/day for domestic/stock use, and using the total maximum authorized diversion associated with any licensed water well that can be linked to a record in the database, a map has been prepared that shows the estimated groundwater use in terms of volume (licensed plus unlicensed) per section per day for the County.

There are 547 sections in the County. The estimated water well use per section can be more than 50 m³/day in 70 of the 547 sections. The most notable areas where water well use of more than 50 m³/day is expected occur mainly in the south-central part of the County, as shown on Figure 28. The closest AENV-operated observation water wells are outside the County in 08-11-051-20 W4M, east of Hastings Lake as shown on the adjacent figure. From 1980 to the mid-1980s, there was a water-level decline of more than one metre in AENV Obs WW No. 157. This decline could be, in part, due to (1) lack of recharge to the Upper Sand and Gravel Aquifer as a result of decreased precipitation; (2) a delay in the water level reaching equilibrium in the AENV observation water well; or (3) more than 225 water wells that have been drilled in the vicinity of Cooking Lake and Hastings Lake between the mid-1970s and the mid-1980s.

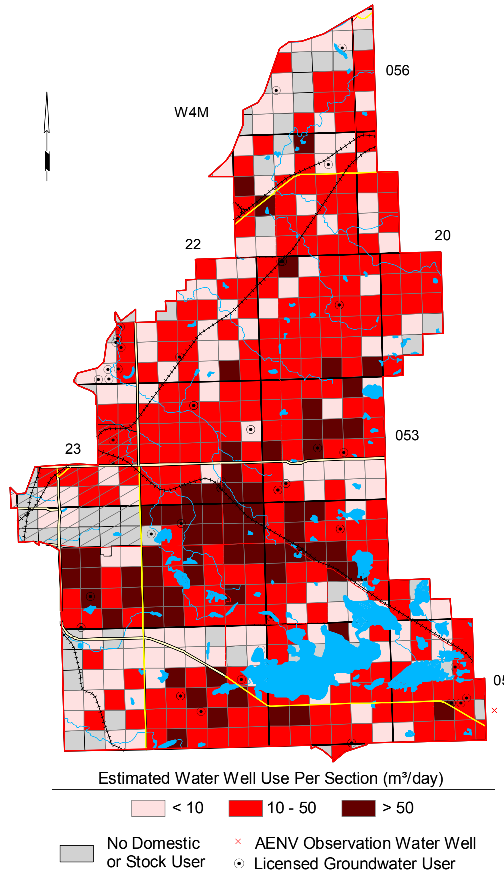

Figure 28. Estimated Water Well Use Per Section

In summary, the estimated total groundwater use within Strathcona County is 24,412 m³/day, with the breakdown as shown in the adjacent table. Approximately 1,367 m³/day is being withdrawn from unknown aquifer units. The remaining 23,045 m³/day could be assigned to specific aquifer units.

Groundwater Use within Strathcona County (m³/day)		%
Domestic/Stock (licensed and unlicensed)	11,819	48
Municipal (licensed)	162	1
Commercial/Dewatering (licensed)	12,431	51
Total	24,412	100

Table 7. Total Groundwater Diversions

The range in groundwater use per section is from 1.1 to more than 150 m³/day. The average groundwater use per section across the County is in the order of 43.5 m³/day (6.6 igpm).

Approximately 55% of the total estimated groundwater use is from licensed water wells.

6.3 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; flow through the aquifers takes into consideration hydrogeological conditions outside the County border. Based on these assumptions, the estimated lateral groundwater flow through the individual aquifers can be summarized as follows:

Aquifer/Area	Trans (m^2/day)	Gradient (m/m)	Width (m)	Flow (m^3/day)	Aquifer Flow (m^3/day)	Licensed Diversion (m^3/day)	Unlicensed Diversion (m^3/day)	Total (m^3/day)
Lower Sand and Gravel					3,680	12,048	228	12,276
Beverly Valley								
northeast	600	0.0002	8,000	960				
Upper Surficial								
northwest	8	0.0060	35,000	1680				
southeast	8	0.0020	15,000	240				
north	8	0.0040	25,000	800				
Lower Horseshoe Canyon					1,403	244	3,914	4,158
North Saskatchewan Valley								
northwest	3.8	0.003	20,000	253				
southwest	3.8	0.004	6,000	86				
Cooking Lake								
southeast	3.8	0.003	20,000	253				
north	3.8	0.007	32,000	811				
Bearpaw					1,080	193	1468	1,661
northwest	7.2	0.005	30,000	1,080				
Oldman					394	37	494	531
northwest	2.1	0.00625	30,000	394				

Table 8. Groundwater Budget

The above table indicates that the total of the licensed and unlicensed diversions from the individual aquifers is significantly more than the groundwater flowing through the aquifers. The calculations of flow through individual aquifers as presented in the above table are very approximate and are intended only as a guide for future investigations.

6.3.1 Quantity of Groundwater

An estimate of the volume of groundwater stored in the sand and gravel aquifers in the surficial deposits is 0.3 to 2.0 cubic kilometres. This volume is based on an areal extent of 1,300 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).

The adjacent water-level map has been prepared from water levels associated with water wells completed in aquifers in the surficial deposits. The water levels from these water wells were used for the calculation of the saturated thickness of the surficial deposits. In areas where the elevation of the water-level surface is below the bedrock surface, the surficial deposits are not saturated. The water-level map for the surficial deposits shows a general flow direction toward the Buried Beverly Valley.

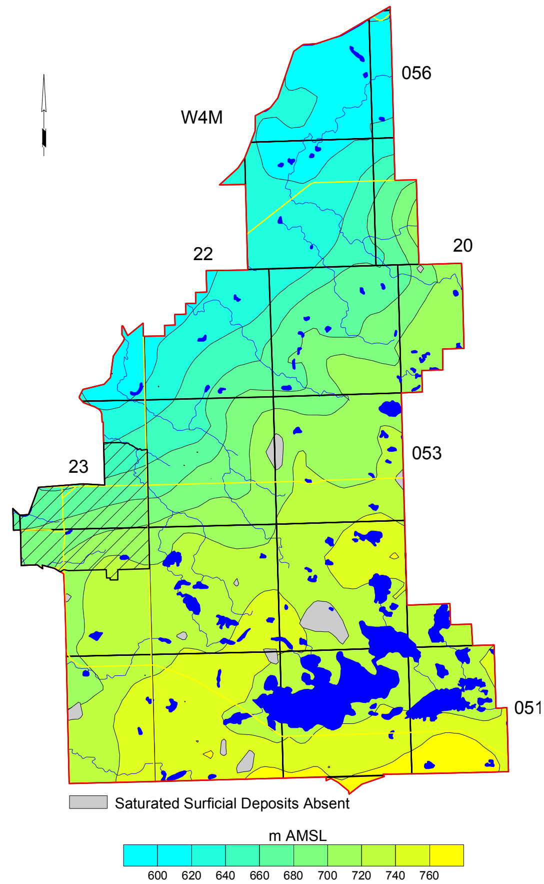

Figure 29. Non-Pumping Water-Level Surface in Surficial Deposits Based on Water Wells Less than 20 Metres Deep

6.3.2 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. In areas where the surficial deposits are unsaturated, the extrapolated water level for the surficial deposits is used.

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.

6.3.2.1 Surficial Deposits/Bedrock Aquifers

The hydraulic gradient between the surficial deposits and the upper bedrock aquifer(s) has been determined by subtracting the elevation of the non-pumping water-level surface associated with all water wells completed in the upper bedrock aquifer(s) from the elevation of 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 surface in the surficial deposits is more than five metres above the water-level surface 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 70% of the County, there is a downward hydraulic gradient from the surficial deposits toward the upper bedrock aquifer(s). The few areas where there is an upward hydraulic gradient (i.e. discharge) from the bedrock to the surficial deposits are mainly in the vicinity of linear bedrock lows except in the southwestern part of the County, which may be a result of gridding processes. 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.

6.3.2.2 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.

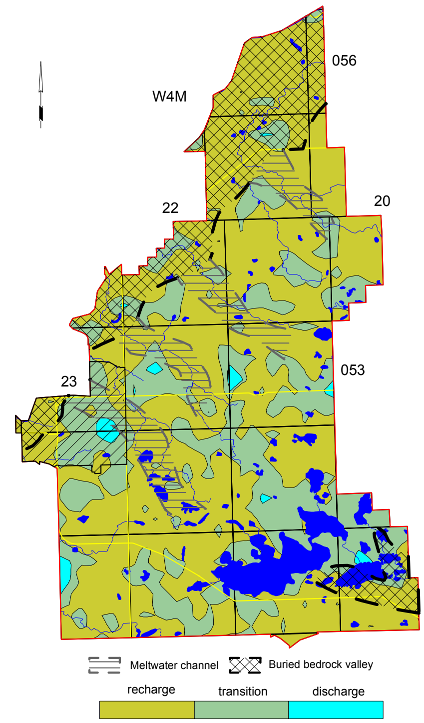

Figure 30. Recharge/Discharge Areas between Surficial Deposits and Upper Bedrock Aquifer(s)

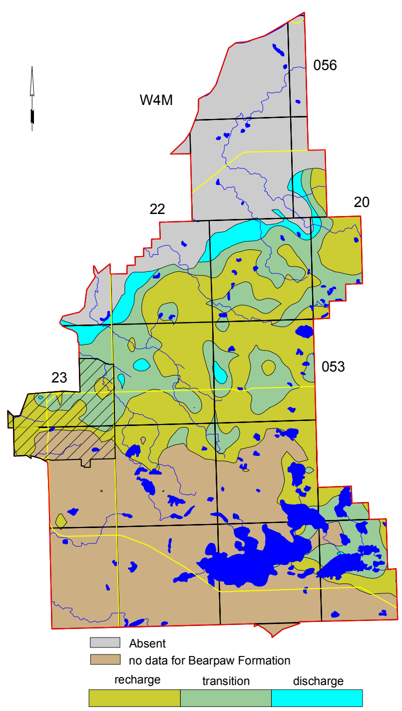

Figure 31. Recharge/Discharge Areas between Surficial Deposits and Bearpaw Aquifer

The hydraulic relationship between the surficial deposits and the Bearpaw Aquifer indicates that in more than 60% of the County where the Bearpaw Aquifer is present and there is data control, there is a downward hydraulic gradient (i.e. recharge). Discharge areas for the Bearpaw Aquifer are mainly associated with the edge of the Aquifer or in areas of linear bedrock lows.

The hydraulic relationship between the surficial deposits and the remainder of the bedrock aquifers indicates there is mainly a downward hydraulic gradient (see CD ROM).

6.4 Areas of Groundwater Decline

The areas of groundwater decline in both the sand and gravel aquifer(s) and in the bedrock aquifers have been determined by using a similar procedure in both situations. Because major development began occurring in the 1970s, the changes in water-level maps are based on the differences between water-level elevations available before 1970 and after 1984. Where the earliest water level is at a higher elevation than the latest water level, there is the possibility that some groundwater decline has occurred. Where the earliest water level is at a lower elevation than the latest water level, there is the possibility that the groundwater has risen at that location. The water level may have risen as a result of recharge in wetter years or may be a result of the water well being completed in a different bedrock aquifer. In order to determine if the water-level decline is a result of groundwater use by licensed users, the licensed groundwater users were posted on the maps.

Of the 463 water wells completed in the sand and gravel aquifer(s) with a NPWL and test date, 119 are from water wells completed before 1970 and 53 are from water wells completed after 1984. The adjacent map shows that it may have been possible there has been a rise in the NPWL in areas of meltwater channels and in the Buried Vegreville Valley. In the area east of Sherwood Park, there has been a rise in the water levels in the sand and gravel aquifer(s). This area is also one of high water use or water demand (see Fig. 28). The rise in water level may be a result of water being introduced into the groundwater from septic systems. The areas that indicate a decline of more than five metres are based on only one or two control points.

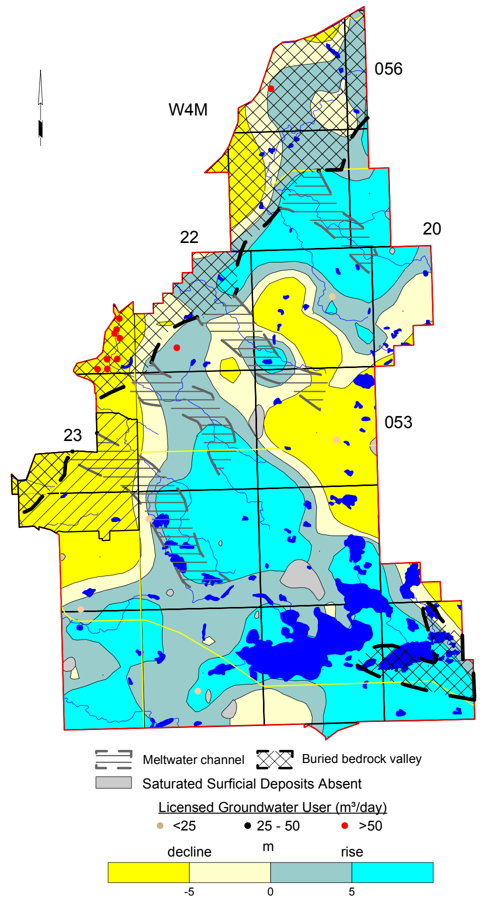

Figure 32. Changes in Water Levels in Sand and Gravel Aquifer(s)

Nearly 46% of the areas where there has been a water-level decline of more than five metres in sand and gravel aquifer(s) corresponds to where the estimated water well use is between 10 and 50 m³/day; 27% of the declines occurred where the estimated water well use is less than 10 m³/day; 13% of the declines occurred where the estimated water well use is more than 50 m³/day; the remaining 14% of the declines occurred where there is no groundwater use shown on Figure 28.