6.2 Estimated Groundwater Use in Clearwater County

An estimate of the quantity of groundwater removed from each geologic unit in Clearwater County must include both the licensed and/or registered groundwater diversions. As stated previously on page 7 of this report, the daily water requirement for livestock for the County based on the 2001 census is estimated to be 12,137 cubic metres. As of January 2003, AENV has licensed the use of 4,221 m³/day for livestock, 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 7,916 m³/day of water required for livestock watering is obtained from water wells for which there is no licence and/or registration.

There are 1,719 water wells that are used for stock or domestic/stock purposes. There are 1,358 licensed and registered water wells giving 424 stock water wells for which there is no licence and/or registration. By dividing the number of stock and domestic/stock water wells (424) into the quantity required for stock purposes for which it is not licensed and/or registered (7,916 m³/day), the average water well with a licence and/or registration diverts 18.7 m³/day per stock water well.

Groundwater for household use does not require a licence if the use is less than 1,250 m³/year. Under the *Water Act*, a residence is protected for up to 3.4 m³/day. However, the standard groundwater use for household purposes (a family of four) is 1.1 m³/day. Since there are 5,484 domestic or domestic/stock water wells in Clearwater County serving a population of 11,505, the domestic use per water well is 0.5 m^3/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	0.5 m³/day
Stock	18.7 m³/day
Domestic/stock	19.2 m³/day

Because of the limitations of the data, no attempt has been made to compensate for dugouts, springs or inactive water wells.

Based on using all available domestic, domestic/stock, and stock water wells and corresponding calculations, the following table was prepared. Table 7 shows a breakdown of the 6,118 (4,418+616+1,084) water wells for which there is no licence and/or registration 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 groundwater that is being used for both domestic and stock purposes from water wells for which there is no licence and/or registration. The data provided in Table 7 indicate that most of the 36,376 m³/day, estimated to be diverted from domestic, stock, or domestic/stock water wells for which there is no licence and/or registration, is from the Dalehurst Aquifer.

	Groundwater Diversions from Water Wells With or Without Licences and/or Registrations							*Groundwater Diversions With Licences and/or Registrations*	*Groundwater Diversions Without Licences and/or Registrations*
Aquifer Designation	Number of Domestic	Daily Use (0.5 m³/day)	Number of Stock	Daily Use (21.3 m³/day)	Number of Domestic and Stock	Daily Use (22.4 m³/day)	Totals m³/day	Totals (m³/day)	Totals m³/day
Multiple Surficial Completions	133	70	19	417	41	921	1407	171	1236
Upper Sand/Gravel	74	39	7	154	12	269	462	125	337
Lower Sand/Gravel	99	52	28	614	68	1527	2,193	142	2,051
Multiple Bedrock Completions	474	249	84	1,842	104	2,335	4,426	0	4,426
Disturbed	494	259	46	1009	78	1751	3,019	125	2,894
Dalehurst	2,791	1,464	428	9,386	761	17,087	27,937	2,998	24,939
Upper Lacombe	1	1	0	0	1	22	23	0	23
Unknown	352	185	4	88	19	427	699	228	471
Totals [1]	4,418	2,317	616	13,508	1,084	24,340	40,165	3,789	36,376

[1] The values given in the table have been rounded and, therefore, the columns and rows may not add up equally

Table 7. Total Groundwater Diversions by Aquifer

By assigning 0.5 m³/day for domestic use, 18.7 m³/day for stock use and 19.2 m³/day for domestic/stock use, and using the total maximum diversion associated with any water well with a licence and/or registration, a map has been prepared that shows the estimated groundwater use in terms of volume per section per day for the County (not including springs).

There are 3,632 sections in the County. In 66% (2,391) of the sections in the County, there is no domestic, stock or licensed and/or registered groundwater water well. The range in groundwater use for the remaining 1,241 sections is from 0.5 m³/day to 1,000 m³/day (industrial), with an average use per section of 30 m³/day (4.5 igpm). The estimated water well use per section can be more than 50 m³/day in 241 of the 1,241 sections. There are 480 of the total 1,461 groundwater users with a licence and/or registration in areas of greater than 50 m³/day. The most notable areas where water well use of more than 50 m³/day is expected to occur is in townships 037 and 038, range 04, W5M, as shown on Figure 28.

Groundwater Use within Clearwater County (m³/day)		%
Domestic/Stock (including agriculture and registrations)	40,165	*76*
Municipal (licensed)	301	*1*
Commercial/Industrial/Recreation et al (licensed)	12,145	*23*
Total	52,611	*100*

Table 8. Total Groundwater Diversions

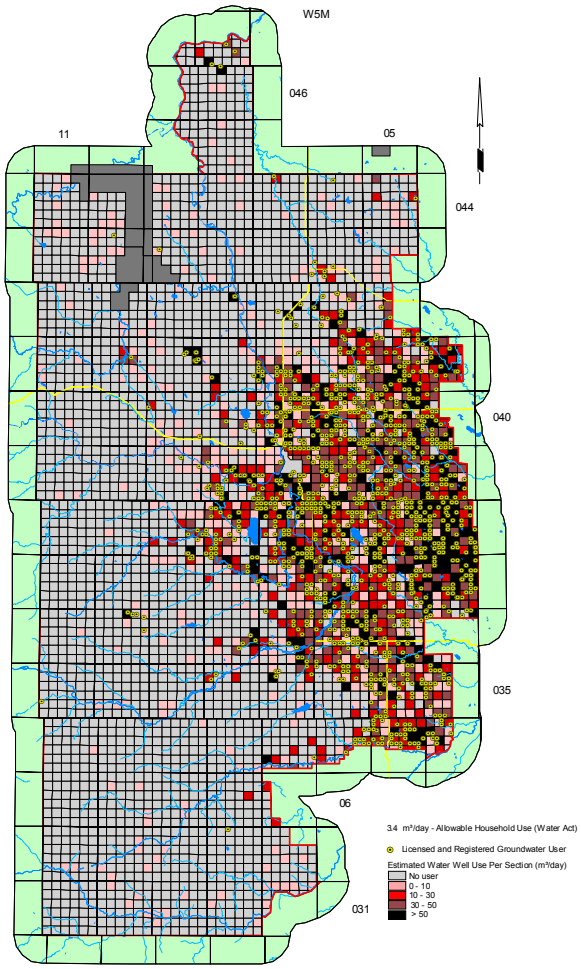

Figure 28. Estimated Water Well Use Per Section

In summary, the estimated total groundwater use within Clearwater County is 52,611 m³/day, with the breakdown as shown in the above table. An estimated 46,448 m³/day is being withdrawn from a specific aquifer. The remaining 624 m³/day or 1% is being withdrawn from unknown aquifer units. Of the 46,448 m³/day, 91% is being diverted from bedrock aquifers and 8% from surficial aquifers. Approximately 30% of the total estimated groundwater use is from water wells without a licence and/or registration.

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 various parts of individual 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 has been summarized in Table 9.

Table 9 indicates that there is more groundwater flowing through the aquifers than has been authorized to be diverted from the individual aquifers. However, even where use is less than the calculated aquifer flow, there can still be local impacts on water levels. The calculations of flow through individual aquifers as presented in Table 9 are very approximate and are intended only as a guide; more detailed investigations are needed to better understand the groundwater flow.

Aquifer/Area	Trans (m^2/day)	Gradient (m/m)	Width (m)	Flow (m^3/day)	Aquifer Flow (m^3/day)	Licensed and Registered (m^3/day)	Without Licences and Registrations (m^3/day)	Total (m^3/day)
Surficial					55,015	494	3,624	4,118
Drayton Valley								
	186	0.004	6,400	4,650				
Swan Creek								
North	115	0.210	6,000	14,375				
South	71	0.210	14,000	20,708				
Clearwater River								
	107	0.006	10,000	6,688				
Raven River								
	110	0.008	10,000	8,594				
Springs								
	54	0.006	14,000	4,725				
Disturbed Belt					6,800	3,861	2,894	6,755
North Saskatchewan River sub-basin					3,500			
North Saskatchewan River	4.2	0.010	30	1,313				
Swan Creek	4.2	0.017	15	1,094				
Clearwater River	4.2	0.010	25	1,094				
Red Deer River sub-basin					3,300			
Red Deer River	4.2	0.018	30	2,250				
Raven River	4.2	0.013	20	1,050				
Dalehurst					36,851	11,615	24,939	36,554
Red Deer River sub-basin					13,726			
Raven River								
NE	8	0.007	25	1,458				
SW	8	0.003	12	300				
SE	8	0.002	20	250				
Leshill Creek								
SW	8	0.003	18	450				
NE	8	0.009	25	1,875				
East	8	0.006	20	1,000				
East	8	0.015	9	1,080				
SW	8	0.020	18	2,925				
SE	8	0.013	5	500				
Lobstick Creek								
NE	8	0.010	40	3,250				
SE	8	0.005	17	638				
North Saskatchewan River sub-basin					23,125			
North Saskatchewan River								
West side of river								
ENE	8	0.012	25	2344				
ENE	8	0.023	20	3667				
Brazeau River								
North	8	0.015	25	2917				
Baptiste River								
NE	8	0.011	20	1833				
East	8	0.010	6	471				
South	8	0.025	15	3000				
East side of river								
West	8	0.006	10	500				
South	8	0.016	8	1000				
West	8	0.017	25	3375				
North	8	0.008	10	650				
West	8	0.008	18	1157				
North	8	0.004	9	253				
Clearwater River								
Northeast	8	0.007	25	1458				
Southwest	8	0.006	10	500				

Table 9. Groundwater Budget

6.3.1 Quantity of Groundwater

An estimate of the volume of groundwater stored in the sand and gravel aquifers is 0.4 to 2.4 cubic kilometres. This volume is based on an areal extent of 2,700 square kilometres and a saturated thickness of three metres. The variation in the total volume is based on the value of porosity that is used for the surficial deposits. 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 to depths of less than 20 metres 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 and for calculations of recharge/discharge areas. In areas where the elevation of the water-level surface is below the bedrock surface, the surficial deposits are not saturated (indicated by grey areas on the map). The water-level map for the surficial deposits shows a flow direction northeast toward the North Saskatchewan River.

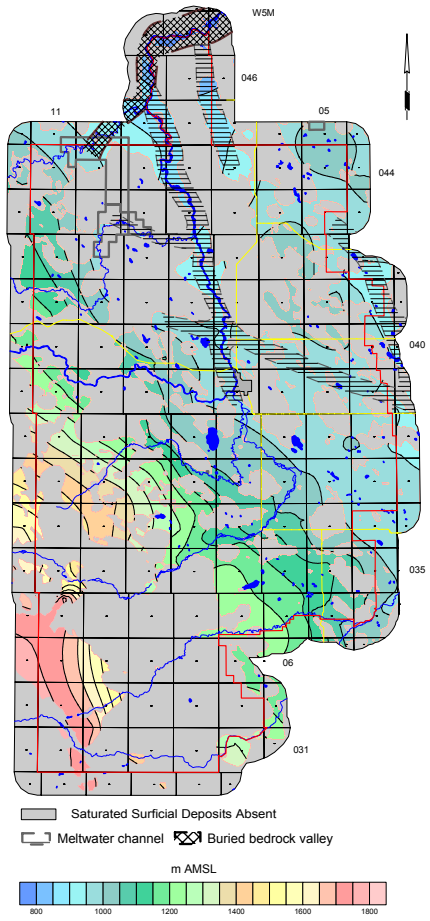

Figure 29. Non-Pumping Water-Level Surface in Surficial Deposits Based on Water Wells Less than 20 Metres Deep

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 hydraulic unit. 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 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. 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.

In the absence of sufficient water-level data in the surficial deposits, a reasonable hydraulic gradient between the surficial deposits and the upper bedrock aquifer(s) could not be determined. Therefore, an alternative approach has been used to establish approximate recharge and discharge areas. The first objective was to determine the location of springs, flowing shot holes and any water wells that had a water level measurement depth of less than 0.1 metres. These locations would reflect where there is an upward hydraulic gradient from the bedrock to the surficial deposits (i. e. discharge). The depth to water level for water wells completed in 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 bedrock surface. This resulting depth to water level grid was contoured to reflect the positioning of springs, flowing shot holes and flowing water wells (i. e. discharge). The recharge classification is used where the water level in the upper bedrock aquifer(s) is more than five metres below bedrock surface. The discharge areas are where the water level in the upper bedrock aquifer(s) is more than five metres above the bedrock surface. When the depth to water level in the upper bedrock aquifer(s) is between five metres below the bedrock surface and five metres above the bedrock surface, the area is classified as a transition, that is, no recharge and no discharge.

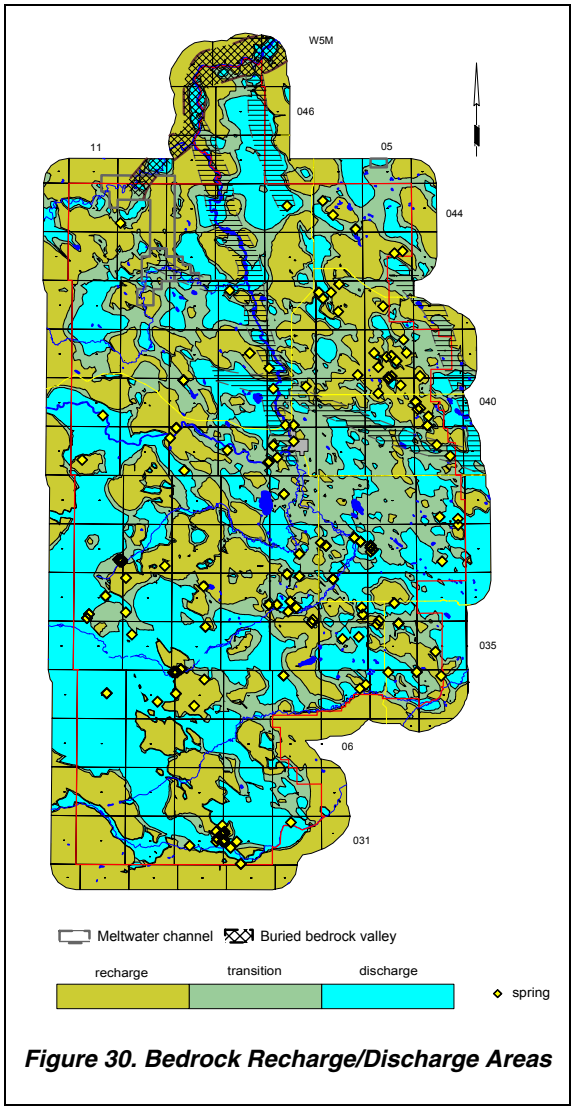

Figure 30. Bedrock Recharge/Discharge Areas

Figure 35 shows that, in more than 40% of the County, there is a downward hydraulic gradient from the bedrock surface toward the upper bedrock aquifer(s) (i. e. recharge). Areas where there is an upward hydraulic gradient from the bedrock to the bedrock surface (i. e. discharge) are mainly in the vicinity of river valleys. The remaining parts of the County are areas where there is a transition condition.

Because of the paucity of data, recharge/discharge maps for the individual bedrock aquifers have not been attempted.

With 40% of the County land area being one of recharge to the bedrock, and the average precipitation being 522 mm per year, one percent of the annual precipitation is sufficient to provide the total calculated quantity of groundwater flowing through the upper bedrock aquifer(s).