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, 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 two metres below bedrock surface. The discharge areas are where the water level in the upper bedrock aquifer(s) is more than ten metres above the bedrock surface. When the depth to water level in the upper bedrock aquifer(s) is between two metres below and ten metres above the bedrock surface, the area is classified as a transition, that is, no recharge and no discharge.

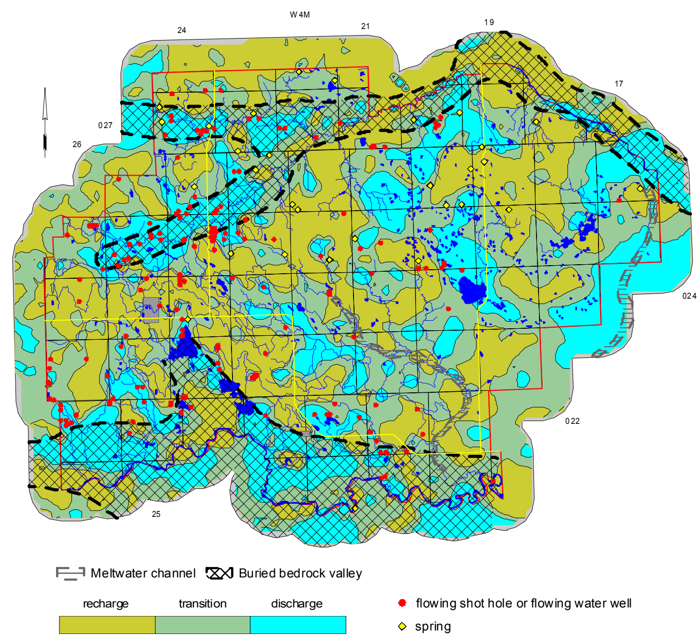

Figure 36. Recharge/Discharge Areas in Upper Bedrock Aquifer(s)

Figure 36 shows that, in more than 50% 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 creeks and river valleys and major meltwater channels. 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 70% of the County land area being one of recharge to the bedrock, and the average precipitation being 340 mm per year, 1.6% of the annual precipitation is sufficient to provide the total calculated quantity of groundwater flowing through the upper bedrock aquifer(s).

6.4 Areas of Groundwater Decline

In order to determine the areas of possible groundwater decline in the sand and gravel aquifer(s), the available non-pumping water-level elevation for each water well completed in the sand and gravel aquifer(s) was first sorted by location, and then by date of water-level measurement. The dates of measurements were required to differ by at least 365 days. Only the earliest and latest control points at a given location were used.

The areas of groundwater decline in the sand and gravel aquifer(s) have been calculated by determining the frequency of non-pumping water level control points per five-year period from 1960 to 2000. Of the 207 surficial water wells with a non-pumping water level and date in the County, 76 are from water wells completed before 1975 and 131 are from water wells completed after 1980.

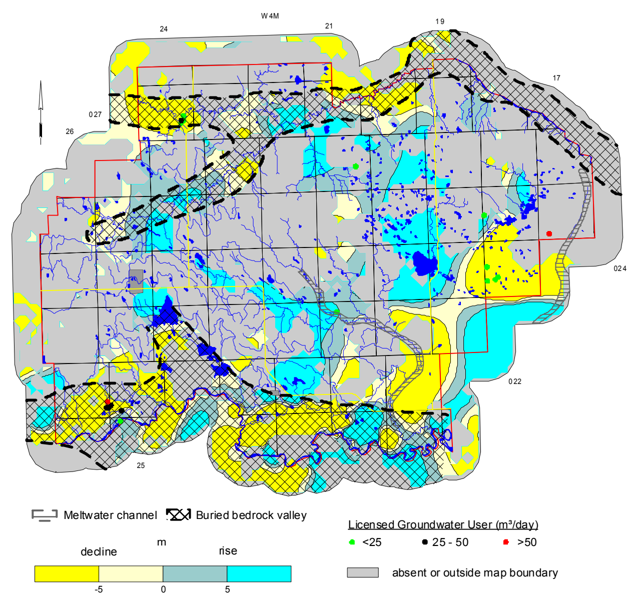

Figure 37. Changes in Water Levels in Sand and Gravel Aquifer(s)

Where the earliest water level (before 1975) is at a higher elevation than the latest water level (after 1980), there is the possibility that some groundwater decline has occurred. The adjacent map suggests that there has been a decline in the NPWL in areas of linear bedrock lows.

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 surficial 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 map.

Estimated Water Well Use (m^3/day)	*% of Area with More than a 5-Metre Decline*
<10	*21*
10 to 30	*21*
>30	*9*
no use	*49*

Table 19. Water-Level Decline of More than 5 Metres in Sand and Gravel Aquifer(s)

Figure 37 indicates that in 50% of the County where sand and gravel is present, it is possible that the non-pumping water level has declined. The Hamlet of Carseland is in one of the areas of decline shown on Figure 36. AENV Obs WW No. 220 in 13-06-022-25 W4M is in this area of water-level decline. The hydrograph from AENV Obs WW No. 220 indicates that there has been a water-level decline since 1986. Of the 23 licensed groundwater users that are completed in sand and gravel aquifer(s), 19 occur in areas where a water-level decline may exist and two licensed groundwater users occur in an area of rise. There are two licensed groundwater users that are shown in township 025, range 17, W4M; although this is an area where saturated sand and gravel deposits are expected to be absent, the absence may reflect the nature of gridding a limited number of control points. The areas of groundwater decline in the sand and gravel aquifer(s) where there is no estimated water well use suggest that groundwater diversion is not having an impact and that the decline may be due to variations in recharge to the aquifer.

In areas where a water-level decline of more than five metres is indicated on Figure 37, 49% of the areas has no estimated water well use; 21% of the use is less than ten m³/day; 21% of the use is between 10 and 30 m³/day per section; the remaining 9% of the declines occurred where the estimated groundwater use per section is greater than 30 m³/day, as shown previously in Table 19.

Of the 4,101 bedrock water wells with a NPWL and test date, 1,591 are from water wells completed before 1975 and 1,697 are from water wells completed after 1980. The adjacent map indicates that in more than 50% of the County, it is possible that the NPWL has declined. It may have been possible there has been a decline in the NPWL in areas of linear bedrock lows and near areas of discharge. Of the 146 groundwater users completed in upper bedrock aquifer(s) that are authorized to divert less than 50 m³/day, most occur in areas where a water-level rise exists. The two bedrock-completed AENV Obs WWs (Nos. 218 and 219) in 05-10-022-21 W4M are in one area of water-level rise. The hydrographs from these two observation water wells indicate that there was a water-level rise from 1991 to 1997.

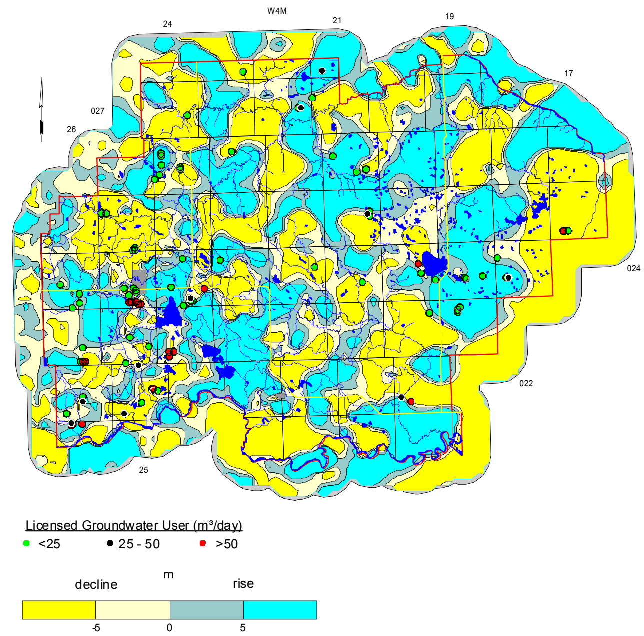

Figure 38. Changes in Water Levels in Upper Bedrock Aquifer(s)

In areas where a water-level decline of more than five metres is indicated on Figure 38, 46% of the areas has no estimated water well use; 26% is less than ten m³/day; 19% is between 10 and 30 m³/day per section; the remaining 9% of the declines occurred where the estimated groundwater use per section is greater than 30 m³/day, as shown below in Table 20.

Estimated Water Well Use (m³/day)	*% of Area with More than a 5-Metre Decline*
<10	*26*
10 to 30	*19*
>30	*9*
no use	*46*

Table 20. Water-Level Decline of More than 5 Metres in Upper Bedrock Aquifer(s)

The areas of groundwater decline in the upper bedrock aquifer(s) where there is no estimated water well use suggest that groundwater production is not having an impact and that the decline may be due to variations in recharge to the aquifer.

6.5 Discussion of Specific Study Areas

As per the Request for Proposal, Wheatland County requested that comments be made, where possible, on the following four study areas and issues. The issue is stated at the beginning of each of the following sections. Figure 39 shows the four specific study areas in the County; in Figure 40, the four specific study areas have been color outlined on the bedrock geology map; Figure 41 shows the apparent yield for water wells completed in the Sand and Gravel Aquifer(s); and Figure 42 shows the apparent yield for water wells completed in the Upper Bedrock Aquifer(s).

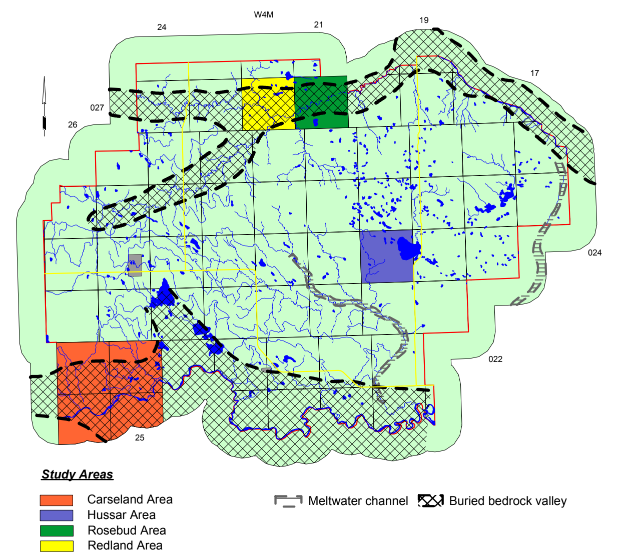

Figure 39. Specific Study Areas

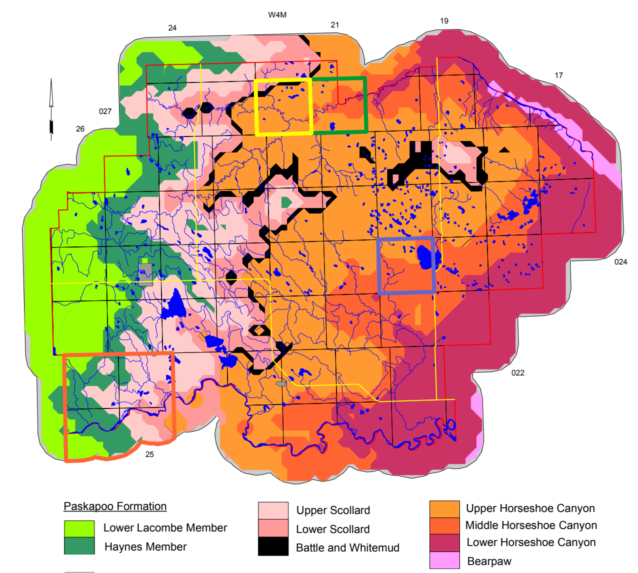

Figure 40. Bedrock Geology of Specific Study Areas

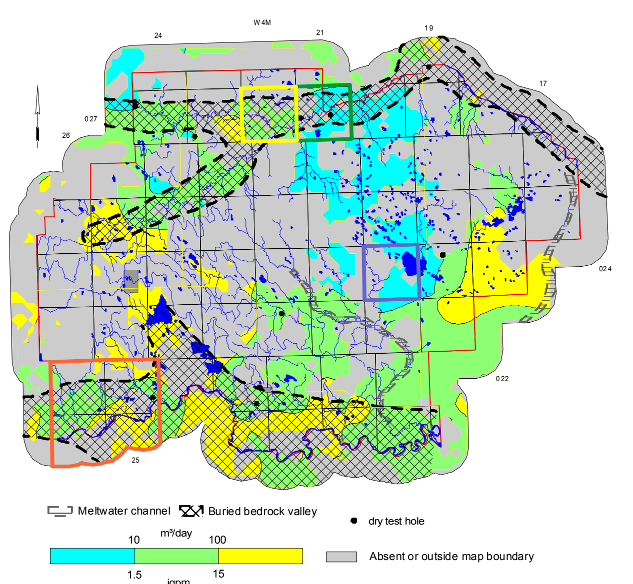

Figure 41. Apparent Yield for Water Wells Completed in Sand and Gravel Aquifer(s) - Specific Study Areas

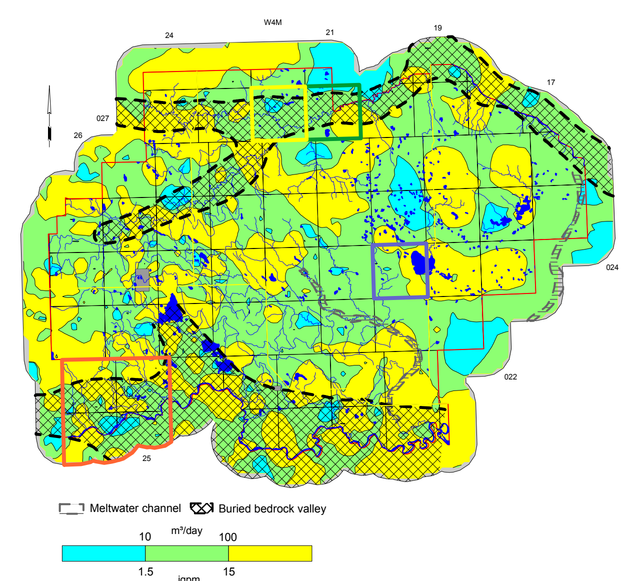

Figure 42. Apparent Yield for Water Wells Completed in Upper Bedrock Aquifer(s) - Specific Study Areas

6.5.1 Carseland Area

What are the possible causes of the apparent reduction in yields of aquifers in this area?

The Hamlet of Carseland is licensed to divert a total of 300 m³/day from five licensed water supply wells that are completed in the Lower Sand and Gravel Aquifer (see Table 15, page 42).

The available monitoring data provided by the County are from 1996 to 2000 and show that production data are recorded daily from WSW No. 2, WSW No. 85-3, WSW No. 85-5 and WSW Nos. 93-1/97-1. Water levels are being measured weekly to the nearest 0.01 metres in Obs WWs 85-1, 85-3, 85-4 and 93-1.

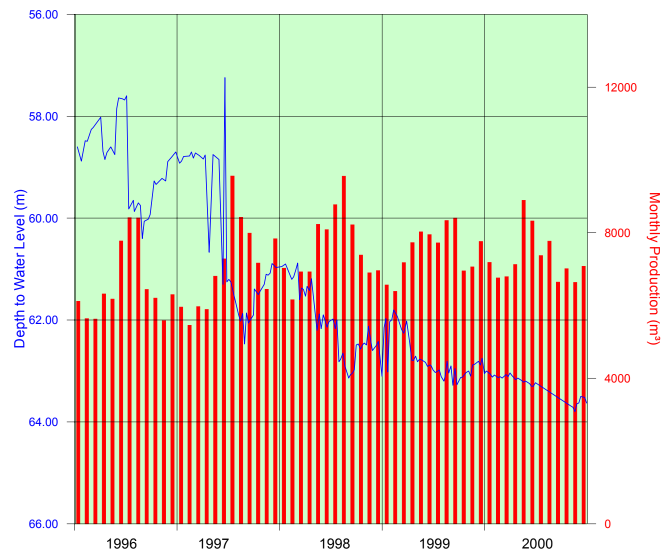

Figure 43. Groundwater Production vs Water Levels in Obs WW No. 93-1

From 1996 to 2000, the water level in all four of the Carseland Obs WWs declined approximately five to six metres. From 1996 to 1998, the maximum water-level decline during peak production ranged between two and three metres per year in Obs WW No. 93-1. In 1999 and 2000, the water level in Obs No. 93-1 declined in the order of one metre. The decrease in the rate of water-level decline in 1999 and 2000 may be a result of decreased groundwater production during the months of peak demand.

	Annual Groundwater Production (m³)					
WSW No.	1996	1997	1998	1999	2000	Total
2	9,992	10,304	7,588	7,907	3,770	39,561
85-3	15,773	19,652	13,881	14,544	17,868	81,718
85-5	6,996	8,349	6,324	7,972	14,976	44,617
93-1/97-1	45,422	46,485	63,344	59,107	50,955	265,313
Total	78,183	84,790	91,137	89,530	87,569	431,209

Table 21. Carseland WSW Groundwater Production

From 1996 to 2000, the majority of the groundwater diverted from the Carseland water supply wells was from WSW No. 97-1. The aquifer model, *IAAM,* was used to calculate water levels at a location corresponding to Obs WW No. 93-1. The model is based on the estimated groundwater production from 1969 and the monthly recorded groundwater production from each of the four producing water supply wells. The model aquifer has an effective transmissivity of 34 m²/day, a corresponding storativity of 3 x 10^{-5}, is homogeneous and isotropic, and behaves as an aquifer of infinite areal extent; the model does not account for recharge to the aquifer.

The adjacent figure shows there is a reasonable degree of comparison between the calculated and measured water levels in Obs WW No. 93-1 from mid-1996 to mid-1998.

However, in late 1998 to 2000, the difference between the calculated and measured water levels increased to as much as three metres. The difference between measured and calculated water levels indicates that, from the present understanding of the local hydrogeology, the continued water-level decline in all four Carseland Obs WWs is a result of overuse of the Lower Sand and Gravel Aquifer in the Carseland Area.

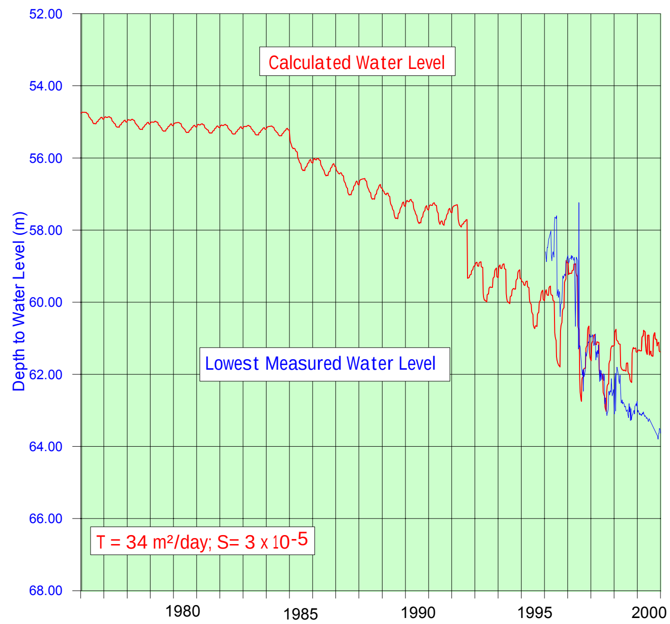

Figure 44. Water-Level Comparison - Obs WW No. 93-1

The closest licensed groundwater water wells to the Carseland WSWs are three water supply wells in NW 05-022-25 W4M, more than 2 kilometres east of the Hamlet of Carseland. These three water supply wells completed in 1993 and 1994 in the Lower Sand and Gravel Aquifer have been licensed to divert up to 72.2 m³/day since 1999 for agricultural (feedlot) purposes.

In view of the water levels continuing to decline, it is recommended that the Hamlet of Carseland investigate supplementing their present groundwater supply. There are indications that a significant aquifer may be present in the Upper Scollard Aquifer. The results of an extended aquifer test conducted with a water supply well completed in the Upper Scollard Aquifer in SE 16-022-26 W4M indicated a long-term yield of 60 m³/day. The depth to the top of the Upper Scollard in the Hamlet of Carseland is about 70 metres below ground surface.

However, a test-drilling program would be needed to evaluate the Upper Scollard Aquifer in the Carseland area.