

5.3 Bedrock

5.3.1 Geological Characteristics

The upper bedrock in the County includes the Cypress Hills Formation, the Paskapoo Formation, the Edmonton Group, the Bearpaw Formation, and the Belly River Group. The adjacent bedrock geology map, showing the subcrop of different geological units, has been prepared in part from the interpretation of geophysical logs related to oil and gas activity and in part based on Tokarsky (1985). In order to obtain a reasonable bedrock surface and, therefore, bedrock geology map in the area of the Cypress Hills, an average surficial thickness of three metres was subtracted from 7,500 DEM-determined topographic points. A generalized geologic column is illustrated in Figure 7, in Appendix A and on the CD-ROM.

The upper bedrock that underlies the Cypress Hills are the Ravenscrag, the Frenchman, the Battle and Whitemud, and the Eastend formations. Carrigy (1970) has suggested that the term Frenchman be restricted to the Saskatchewan side and on the Alberta side be included in the lower part of the Ravenscrag Formation. Westgate (1968) and Tokarsky (1985) refer to the Frenchman Formation as a separate geologic unit. For continuity with other regional studies, HCL will use the equivalent terms Paskapoo, Scollard and Horseshoe Canyon formations, as shown on the adjacent figure.

The Cypress Hills Formation underlies the summit region of the Cypress Hills. It is composed of conglomerate with minor lenses of sand and thin bentonite beds (Westgate, 1968). The Cypress Hills Formation is less than 20 metres thick. The contact between the underlying Paskapoo Formation and the Cypress Hills Formation is a source for many freshwater springs. The saturated thickness of the Cypress Hills Formation is usually minimal.

The Paskapoo Formation is exposed along the escarpment of the Cypress Hills. It is a non-marine sequence of thinly bedded, fine-grained sands, silts, and shales with numerous coal beds and lignitic laminae. The upper limit of the Formation is an erosional surface, so thicknesses are variable, but exceed 30 metres in the County (Westgate, 1968). Tokarsky (1985) shows the Ravenscrag (Paskapoo) Formation thickness to be in the order of 70 metres.

The Edmonton Group includes the Scollard Formation, the Battle and Whitemud formations, and the Horseshoe Canyon Formation. Westgate describes the Frenchman (Scollard) Formation as consisting essentially of thick, massive or coarsely cross-bedded, medium-grained sandstone with rare coaly beds. Tokarsky (1985) shows the Frenchman (Scollard) Formation to be approximately 60 metres thick.

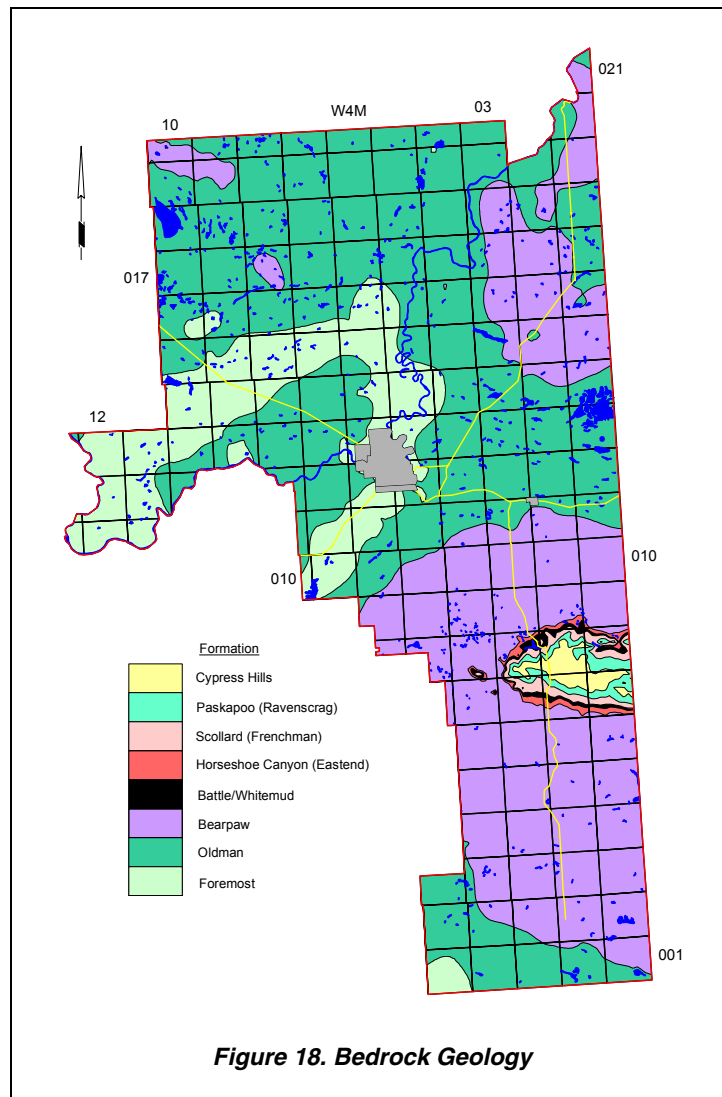


Figure 18. Bedrock Geology

There will be no direct review of either the Cypress Hills Formation or the Paskapoo Formation and only a limited review of the Scollard Formation. Because of the limited amount of hydrogeological information in the County, a complete detailed map set has not been prepared; the only maps associated with the Cypress Hills or the Paskapoo formations to be included on the CD-ROM will be structure-contour maps.

The Horseshoe Canyon Formation is the lower part of the Edmonton Group. In Cypress County, the Horseshoe Canyon (Eastend) Formation has an approximate thickness of 35 metres (Tokarsky, 1985). Westgate describes the Horseshoe Canyon (Eastend) Formation as being confined to the Cypress Hills area, where it occupies a belt at the foot of the main escarpment. It is made up of massive, medium-grained sandstone and dark shales.

The Bearpaw Formation underlies the Horseshoe Canyon (Eastend) Formation and borders the Cypress Hills on all sides. In Cypress County, the Bearpaw Formation has an approximate thickness of 370 metres (Tokarsky, 1985), and is also the upper bedrock in parts of the northeastern and extreme northwestern parts of the County. The Bearpaw Formation includes transgressive, shallow marine (shoreface) and open marine facies¹⁶ deposits. In Cypress County, the Bearpaw Formation is composed mainly of shale with occasional sandstone beds.

The Belly River Group includes the Oldman and Foremost formations. The Oldman Formation is present as the upper bedrock in most of the northern part and in the southwestern part of the County, and is mainly less than 130 metres thick. The Oldman Formation is composed of continental deposits, sandstone, siltstone, shale and coal. The Oldman Formation is the upper part of the Belly River Group.

The Foremost Formation has been eroded in most of the County and subcrops mainly along the Bow River Valley and the South Saskatchewan River Valley in the west-central part of the County. The Foremost Formation is less than 150 metres thick and is between the overlying Oldman Formation and the underlying Lea Park Formation. The Foremost Formation includes both sandstone and shale units. Coal zones occur within the Foremost Formation, with the main ones referred to as the McKay and the Taber Coal zones. There are also minor amounts of ironstone, a chemical deposit.

The present identification of the Foremost Formation would not be possible without identifying a continuous top for the Lea Park Formation. The top of the Lea Park Formation represents a geologic time border between the marine environment of the Lea Park Formation and the mostly continental environment of the Foremost Formation. The top of the Lea Park Formation is the bottom of the higher resistivity layer that occurs within a few metres below a regionally identifiable bentonite marker, as shown in the adjacent e-log. This marker occurs approximately 100 metres above the Milk River Shoulder. The Lea Park Formation is mostly composed of shale, with only minor amounts of bentonitic sandstone present in some areas. Regionally, the Lea Park Formation is an aquitard¹⁷. Because the Lea Park Formation is an aquitard, there will be no direct review in this report. Structure-contour maps associated with the Lea Park Formation are included in Appendix A and on the CD-ROM.

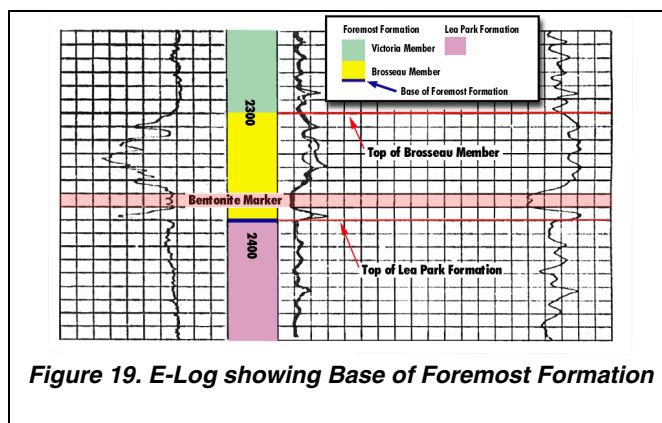


Figure 19. E-Log showing Base of Foremost Formation

The Colorado Group includes the Milk River Formation, the *undivided* Colorado Group and the Viking Formation. The Milk River Formation is present under the County but does not subcrop in the County. The Milk River Formation is composed mostly of thick-bedded sandstone with shale, and in southern Alberta can be an important source of groundwater and is an important supply of natural gas.

¹⁶ See glossary

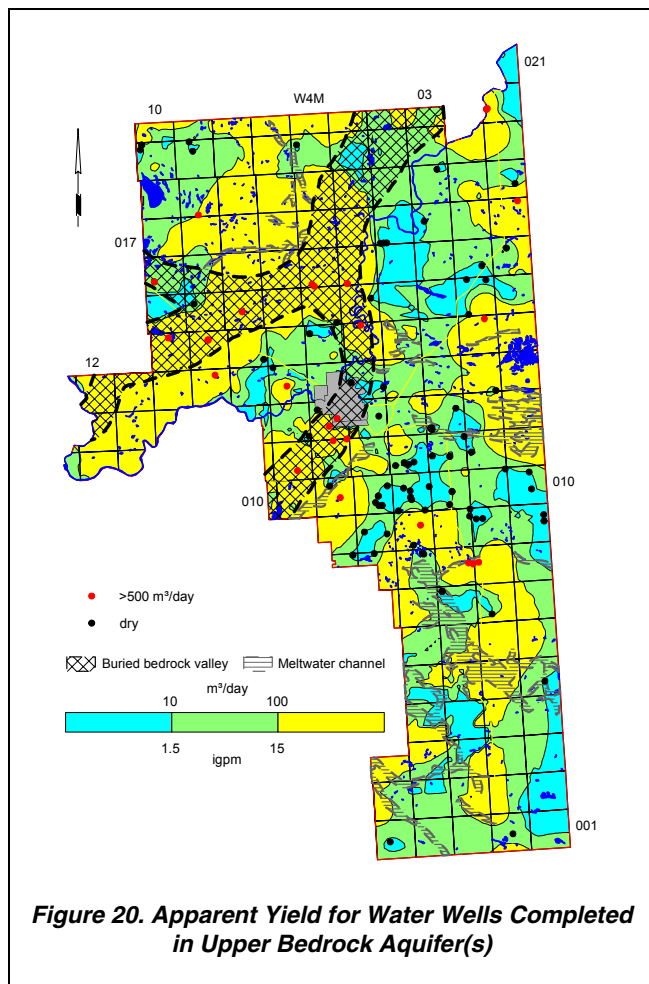
¹⁷ See glossary

5.3.2 Aquifers

Of the 3,348 water wells in the database, 274 were defined as being completed below the top of bedrock and 617 completed in surficial aquifers, based on lithologic information and water well completion details. However, at least a reported completion depth is available for the majority of the remaining 2,545 water wells. Assigning the water well to specific geologic units is possible only if the completion interval is identified. In order to make use of additional information within the groundwater database, it was assumed that if the total drilled depth of a water well was more than ten metres below the top of a particular geologic unit, the water well was assigned to the particular geologic unit. With this assumption, it has been possible to designate the specific bedrock aquifer of completion for 1,063 water wells. The remaining 86 of the total 1,149 bedrock water wells are identified as being completed in more than one bedrock aquifer. The bedrock water wells are mainly

Geologic Unit	No. of Bedrock Water Wells
Cypress Hills	0
Paskapoo (Ravenscrag)	3
Scollard (Frenchman)	6
Horseshoe Canyon (Eastend)	22
Bearpaw	277
Oldman	495
Foremost	249
Lea Park	0
Milk River	11
Saline	13
Multiple Completions	73
Total	1,149

Table 4. Completion Aquifer



Of the 360 water well records with apparent yield values, 357 have been assigned to aquifers associated with specific geologic units. Thirteen percent (48) of the 360 water wells completed in the bedrock aquifers have apparent yields that are less than 10 m³/day, 60% (217) have apparent yield values that range from 10 to 100 m³/day, and 27% (95) have apparent yields that are greater than 100 m³/day, as shown in Table 5.

completed in the Bearpaw, Oldman and Foremost aquifers, as shown in the table above.

There are 360 records for bedrock water wells that have apparent yield values, which is 31% of the 1,149 bedrock water wells. In the County, yields for water wells completed in the upper bedrock aquifer(s) are mainly between 10 and 100 m³/day. Many of the areas with yields of more than 100 m³/day are in association with buried bedrock valleys, as shown on the adjacent figure. These higher yield areas may identify areas of increased permeability resulting from the weathering process. In addition to the 360 records for bedrock water wells, there are 88 records that indicate that the water well is dry, or abandoned with “insufficient water”. In order to depict a more accurate yield map, an apparent yield of 0.1 m³/day was assigned to the 88 dry holes prior to gridding. A similar value has been assigned to all dry holes in bedrock aquifers.

Aquifer	No. of Water Wells with Values for Apparent Yield	Number of Water Wells with Apparent Yields			Dry Test Holes	% of Total
		<10 m ³ /day	10 to 100 m ³ /day	>100 m ³ /day		
Cypress Hills	0	0	0	0	0	0
Paskapoo	1	0	1	0	0	0
Scollard	2	0	2	0	0	0
Horseshoe Canyon	12	1	4	7	0	0
Bearpaw	34	10	16	8	52	60
Oldman	199	34	129	36	29	13
Foremost	106	3	61	42	4	4
Lea Park	0	0	0	0	0	0
Milk River	3	0	1	2	0	0
Multiple Completions	3	0	3	0	3	50
Totals	360	48	217	95	88	20

Table 5. Apparent Yields of Bedrock Aquifers

5.3.3 Chemical Quality of Groundwater

The TDS concentrations in the groundwaters from the upper bedrock aquifer(s) range from less than 500 to more than 3,000 mg/L. In approximately 90% of the area, TDS values are more than 1,000 mg/L, with only a few small areas having a TDS concentration of less than 500 mg/L. The two main areas where TDS concentrations are less than 500 mg/L are along the flanks of the Cypress Hills and along the South Saskatchewan River in the western part of the County.

The lower TDS concentrations in the Cypress Hills area may be a result of more active flow systems and shorter flow paths due to the pronounced local relief.

The relationship between TDS and sulfate concentrations shows that when TDS values in the groundwaters from the upper bedrock aquifer(s) exceed 1,200 mg/L, the sulfate concentrations exceed 400 mg/L.

The chloride concentrations in the groundwaters from the upper bedrock aquifer(s) are less than 100 mg/L in approximately 80% of the County. Chloride values of greater than the GCDWQ of 250 mg/L are mainly in the CFB Suffield area and are a result of gridding only a few points. The nitrate + nitrite (as N) concentrations are less than 0.1 mg/L in 65% of the chemical analyses for bedrock water wells. Unlike other areas in Alberta, total hardness values in the groundwaters from the upper bedrock aquifer(s) are mainly greater than 200 mg/L. The higher values of total hardness occur mainly from townships 008 to 011, ranges 01 to 08, W4M (see CD-ROM).

In the County, approximately 62% of the groundwater samples from upper bedrock aquifer(s) have fluoride concentrations that are too low (less than 0.5 mg/L) to meet the recommended daily needs of people. Approximately 29% of the groundwater samples from the entire County are between 0.5 and 1.5 mg/L and approximately 9% exceed the maximum acceptable concentration for fluoride of 1.5 mg/L. The fluoride values of greater than 1.5 mg/L occur mainly in the Oldman Aquifer where the Oldman Formation is the upper bedrock (page A-35).

The Piper tri-linear diagram for bedrock aquifers (page A-32) shows that all chemical types of groundwater occur in the bedrock aquifers. However, the majority of the groundwaters are sodium-bicarbonate or sodium-sulfate types.

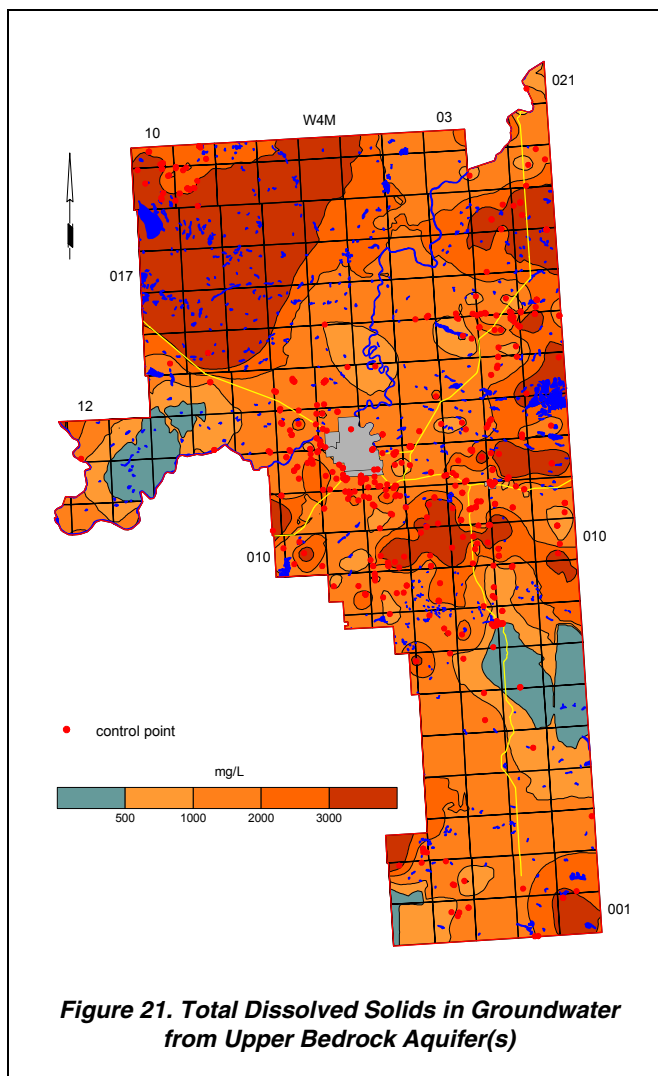


Figure 21. Total Dissolved Solids in Groundwater from Upper Bedrock Aquifer(s)

5.3.4 Horseshoe Canyon (Eastend) Aquifer

The Horseshoe Canyon Aquifer comprises the permeable parts of the Horseshoe Canyon Formation that occupies the base of the main escarpment of the Cypress Hills in south-central Cypress County. The thickness of the Horseshoe Canyon Formation is approximately 35 metres (Tokarsky, 1985); outside the Cypress Hills area, the Horseshoe Canyon Formation has been eroded. The groundwater flow direction in the Horseshoe Canyon Aquifer is to the northwest (see CD-ROM).

5.3.4.1 Depth to Top

The depth to top of the Horseshoe Canyon Formation ranges from less than 50 to more than 150 metres below ground level at the Cypress Hills summit (page A-39).

5.3.4.2 Apparent Yield

The apparent yields for individual water wells completed through the Horseshoe Canyon Aquifer are mainly greater than 100 m³/day. There are 12 water well records with apparent yield values, of which seven have apparent yields of more than 100 m³/day. The areas where apparent yields are greater than 100 m³/day are in the Elkwater area.

In the County, Alberta Recreation and Parks operates three water supply wells completed in the Horseshoe Canyon Aquifer that are licensed to divert a total of 330 m³/day for municipal purposes. Aquifer testing within the Cypress Hills Provincial Park was conducted by HCL in 1972, 1974 and 1981. Based on the results of extended aquifer tests conducted with the three water supply wells, it was recommended that the three water supply wells completed in the Horseshoe Canyon Aquifer not exceed a total maximum pumping rate of 550 m³/day (HCL, 1982).

5.3.4.3 Quality

The groundwaters from the Horseshoe Canyon Aquifer are a bicarbonate-type with no dominant cation (see Piper diagram on CD-ROM), with 60% of the groundwater samples having TDS concentrations of less than 500 mg/L. The sulfate concentrations are less than 100 mg/L. Chloride concentrations from the Horseshoe Canyon Aquifer are less than ten mg/L. There are no analyses where fluoride concentrations exceed 0.5 mg/L.

5.3.5 Other Cypress Hills Area Aquifers

The formations that overlie the Horseshoe Canyon Formation in the Cypress Hills area are the Scollard, the Paskapoo and the Cypress Hills formations; however, the only hydrogeological information available in the database for these aquifers are three samples of chemistry data for water wells completed in the Scollard Aquifer. The TDS concentrations from these three groundwater samples are below 500 mg/L, the sulfate concentrations are less than or equal to ten mg/L, the chloride concentrations are one mg/L and the fluoride concentrations are less than 0.5 mg/L.

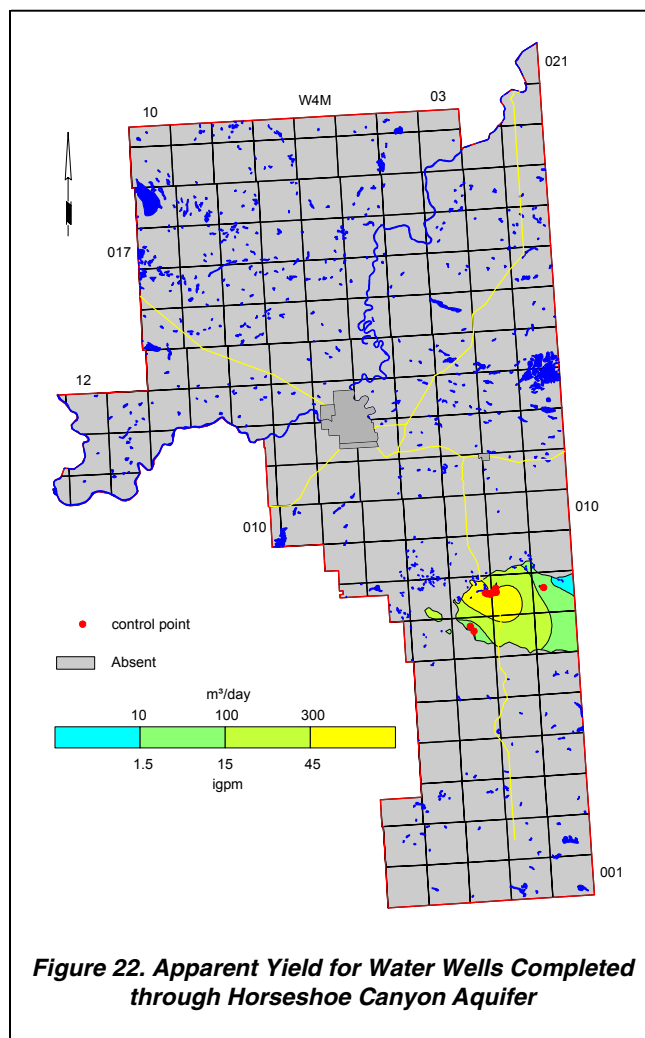


Figure 22. Apparent Yield for Water Wells Completed through Horseshoe Canyon Aquifer

5.3.6 Bearpaw Aquifer

The Bearpaw Aquifer comprises the permeable parts of the Bearpaw Formation. The Bearpaw Formation borders the Cypress Hills and forms the upper bedrock unit for some distance on all sides of the Cypress Hills. In Cypress County, the Bearpaw Formation has an approximate maximum thickness of 370 metres (Tokarsky, 1985), and is the upper bedrock in parts of the northeastern and extreme northwestern parts of the County.

5.3.6.1 Depth to Top

The depth to the top of the Bearpaw Formation is mainly less than 50 metres below ground level; however, the top of the Formation can be more than 200 metres below ground level where the Formation underlies the Cypress Hills (page A-42).

5.3.6.2 Apparent Yield

The apparent yields for individual water wells completed through the Bearpaw Aquifer are mainly in the range of 10 to 100 m³/day. There are 34 water well records with apparent yield values, of which 26 have apparent yields that are less than 100 m³/day. In addition to the 34 water well records with apparent yields, there are 52 records that indicate dry, or abandoned with “insufficient water”.

In the County, there is one licensed water well that is completed in the Bearpaw Aquifer. This is presumably a standby water supply well for Alberta Recreation and Parks because there is a licensed diversion of 0 m³/day. This water supply well (WTH No. 1-81) in 03-24-008-03 W4M was part of a drilling and aquifer testing program conducted by HCL (HCL, 1982).

The results of an extended aquifer test conducted with WTH No. 1-81 indicated a long-term yield of 98 m³/day based on an effective transmissivity of 7.8 m²/day (HCL, 1982).

5.3.6.3 Quality

The groundwaters from the Bearpaw Aquifer are mainly a bicarbonate-to-sulfate type, with calcium-magnesium or sodium as the main cation (see Piper diagram on CD-ROM). TDS concentrations range from less than 500 to more than 3,000 mg/L, with lower values being next to the Cypress Hills and higher values being further from the Cypress Hills as a result of longer groundwater flow paths (see CD-ROM). The sulfate concentrations are mainly below 1,000 mg/L and the chloride concentrations are mainly less than 100 mg/L. There are only two out of 124 analyses where fluoride concentrations exceed 1.5 mg/L.

The groundwater from WTH No. 1-81 has TDS concentrations from three samples that range from 600 to 800 mg/L, sulfate concentrations that range from 100 to 200 mg/L, and chloride concentrations of <10 mg/L. The iron concentrations ranged from 0.3 to 0.5 mg/L. The groundwater from WTH No. 1-81 is a sodium-bicarbonate type.

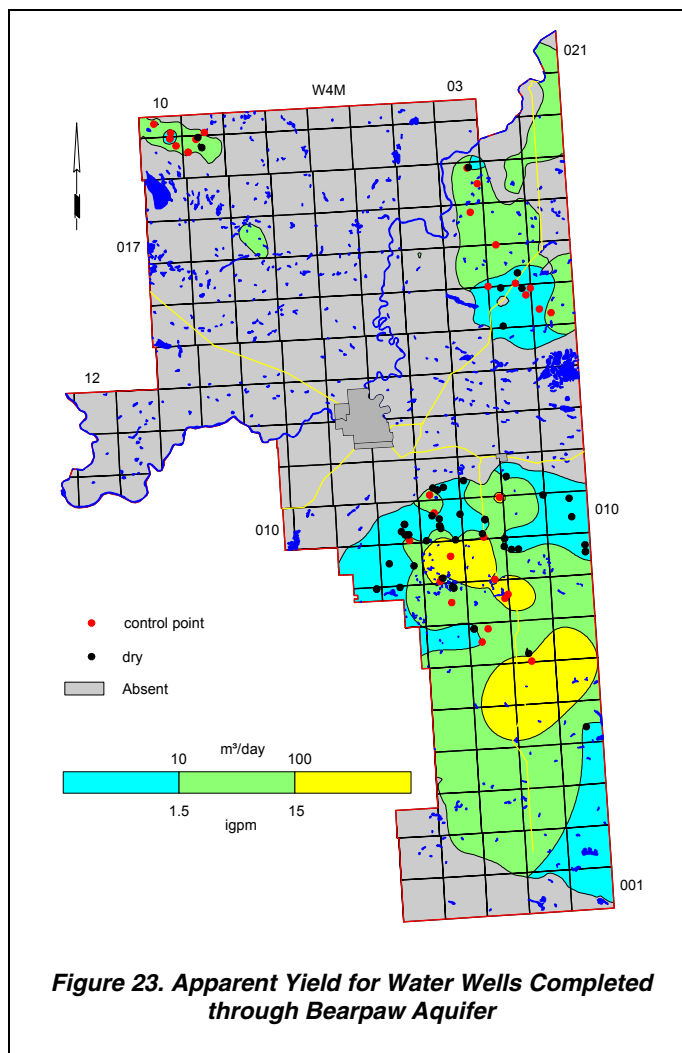


Figure 23. Apparent Yield for Water Wells Completed through Bearpaw Aquifer

5.3.7 Oldman Aquifer

The Oldman Aquifer comprises the permeable parts of the Oldman Formation. The Oldman Formation is present under most of the County, being absent only in parts of the Buried Lethbridge and Medicine Hat valleys and in the extreme southwestern corner of the County. The maximum thickness of the Oldman Formation is in the order of 130 metres in most of the County. The regional groundwater flow in the Oldman Aquifer is down dip to the east and northeast in the County.

5.3.7.1 Depth to Top

The depth to the top of the Oldman Formation (page A-45) is mainly less than 100 metres in the County except where the surface elevation is greater than 900 metres AMSL. Where the Oldman is below the Cypress Hills, the depth to the top of the Oldman Formation can be more than 600 metres. Even at a depth at over 600 metres below ground surface, the Oldman Formation is generally above the Base of Groundwater Protection (Fig. 10).

5.3.7.2 Apparent Yield

The apparent yields for individual water wells completed through the Oldman Aquifer are mainly between 10 and 100 m³/day. There are 199 water well records with apparent yield values, of which 129 have an apparent yield of between 10 and 100 m³/day. In addition to the 199 water well records, there are 29 records that indicate dry, or abandoned with “insufficient water”. The large area of lower yields shown in the north-central part of the County is based on a few control points.

An extended aquifer test conducted with a water supply well completed in the Oldman Aquifer in 16-32-017-01 W4M indicated a long-term yield of 52 m³/day (HCL, 1981). The water supply well is not currently licensed.

In the County, there are 11 licensed water wells that are completed in the Oldman Aquifer. The highest allocation is 40 m³/day for a Bauer Farm Ltd. water supply well used for agricultural purposes in 16-09-018-02 W4M. Three of the 11 licensed water wells completed through the Oldman Aquifer could be linked to a water well in the AENV groundwater database.

5.3.7.3 Quality

The groundwaters from the Oldman Aquifer are mainly a sodium-bicarbonate or sodium-sulfate type (see Piper diagram on CD-ROM). Total dissolved solids concentrations are expected to be mainly greater than 1,000 mg/L, with lower concentrations expected in the southwestern part of the County. The sulfate concentrations are mainly below 1,000 mg/L. The indications are that chloride concentrations in the Oldman Aquifer are expected to be mainly less than 250 mg/L. There are 21 out of 183 analyses where fluoride concentrations exceed 1.5 mg/L. There is a higher percentage of fluoride exceedances in the Oldman Aquifer than in the other bedrock aquifers within the County (see CD-ROM).

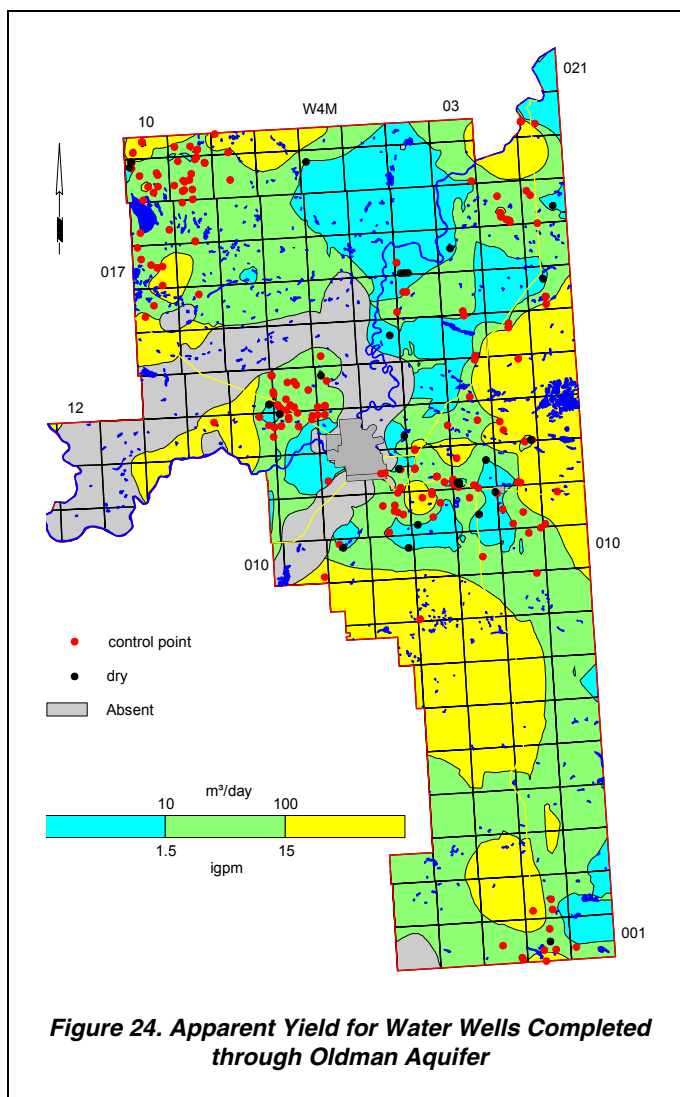


Figure 24. Apparent Yield for Water Wells Completed through Oldman Aquifer