1.2 The Project

This regional study should only be used as a guide. Detailed local studies are required to verify hydrogeological conditions at given locations.

The present project is made up of eight parts as follows:

Task 1 - Data Collection and Review
Task 2 - Hydrogeological Maps, Figures, Digital Data Files
Task 3 – Hydrogeological Evaluation and Preparation of Report
Task 4 - Groundwater Information Query Software
Task 5 – Review of Draft Report and GIS Data Files
Task 6 – Report Presentation and Familiarization Session
Task 7 – Provision of Report, Maps, Data Layers and Query
Task 8 – Provision of Compact Disk for Sale to General Public.

This report and the accompanying maps represent Tasks 2 and 3.

1.3 About This Report

This report provides an overview of (a) the groundwater resources of Cypress County, (b) the processes used for the present project, and (c) the groundwater characteristics in the County.

Additional technical details are available from files on the CD-ROM to be provided with the final version of this report. The files include the geo-referenced electronic groundwater database, maps showing distribution of various hydrogeological parameters, the groundwater query, ArcView files and ArcExplorer files. Likewise, all of the illustrations and maps from the present report, plus additional maps, figures and cross-sections, are available on the CD-ROM. For convenience, poster-size maps and cross-sections have been prepared as a visual summary of the results presented in this report. Copies of these poster-size drawings have been forwarded with this report, and are included as page-size drawings in Appendix D.

Appendix A features page-size copies of the figures within the report plus additional maps and cross-sections. An index of the page-size maps and figures is given at the beginning of Appendix A.

Appendix B provides a complete list of maps and figures included on the CD-ROM.

Appendix C includes the following:

1) a procedure for conducting aquifer tests with water wells[3]
2) a table of contents for the Water (Ministerial) Regulation under the new Water Act
3) a flow chart showing the licensing of a groundwater diversion under the new Water Act
4) interpretation of chemical analysis of drinking water
5) additional information.

The Water (Ministerial) Regulation deals with the wellhead completion requirement (no more water-well pits), the proper procedure for abandoning unused water wells and the correct procedure for installing a pump in a water well. The new Water Act was proclaimed 10 Jan 1999.

Appendix D includes page-size copies of the poster-size figures provided with this report.

Appendix E provides a list of water wells recommended for field verification.

[3] See glossary

2. Introduction

2.1 Setting

Cypress County is situated in southeastern Alberta. The County is within the Missouri and South Saskatchewan River basins; the Bow River and the South Saskatchewan River form part of the County's western boundary and a part of the County's northern boundary is the South Saskatchewan River. The other County boundaries follow township or section lines. The area includes parts of the area bounded by township 001, range 13, W4M in the southwest and township 021, range 01, W4M in the northeast.

Regionally, the topographic surface varies between 550 and 1,500 metres above mean sea level (AMSL). The lowest elevations occur in the north central part of the County along the South Saskatchewan River Valley and the highest are in the Cypress Hills Provincial Park as shown on Figure 1 and page A-3.

2.2 Climate

Cypress County lies within the Bsk climate boundary. This classification is based on potential evapotranspiration[4] values determined using the Thornthwaite method (Thornthwaite and Mather, 1957), combined with the distribution of natural ecoregions in the area. The ecoregions map (Strong and Leggatt, 1981) shows that the County is located in both the Dry Mixed Grass and Mixed Grass region. At higher elevations in the Cypress Hills Provincial Park, the Montane Region[5] is present.

A Bsk climate is characterized by its moisture deficiency, where mean annual potential evapotranspiration exceeds the mean annual precipitation.

The mean annual precipitation averaged from four meteorological stations within the County measured 332 millimetres (mm), based on data from 1961 to 1993. The mean annual temperature averaged 4.6° C, with the mean monthly temperature reaching a high of 19.4° C in July, and dropping to a low of –11.9° C in January. The calculated annual potential evapotranspiration is 559 millimetres.

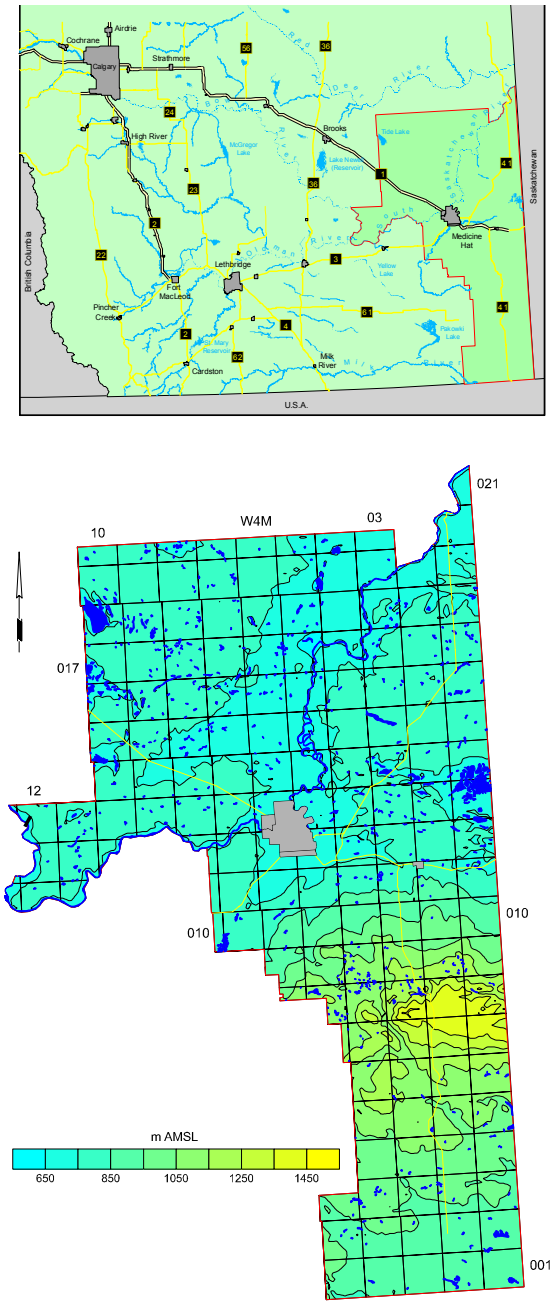

Figure 1. Index Map

[4] See glossary
[5] See glossary

2.3 Background Information

2.3.1 Number, Type and Depth of Water Wells

There are currently records for 3,348 water wells in the groundwater database for the County. Of the 3,348 water wells, 2,686 are for domestic/stock purposes. The remaining 662 water wells were completed for a variety of uses, including municipal, industrial, observation, irrigation, investigation, monitoring and dewatering. Based on a rural population of 5,683 (Phinney, 2001), there are 1.9 domestic/stock water wells per family of four. It is unknown how many of these water wells may still be active. Of the 2,598 domestic or stock water wells with a completed depth, 2,413 are completed at depths of less than 100 metres below ground level. Details for lithology[6] are available for 1,593 water wells.

2.3.2 Number of Water Wells in Surficial and Bedrock Aquifers

There are 891 water well records with completion interval and lithologic information, such that the aquifer in which the water wells are completed can be identified. The water wells that were not drilled deep enough to encounter the bedrock plus water wells that have the bottom of their completion interval above the top of the bedrock are water wells completed in surficial aquifers. Of the 891 water wells for which aquifers could be defined, 617 are completed in surficial aquifers, with 331 (54%) having a completion depth of less than 20 metres below ground level. Nearly 80% of the 331 water wells completed in surficial aquifers are bored water wells. The adjacent map shows that the water wells completed in the surficial deposits occur throughout the County, but mainly in the vicinity of linear bedrock lows and in the northeastern part of the County.

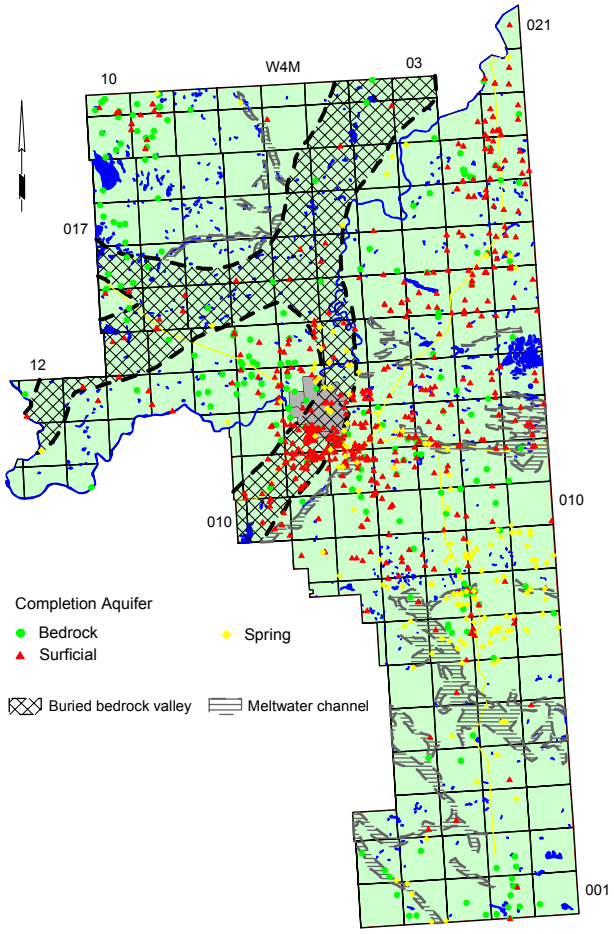

Figure 2. Location of Water Wells and Springs

The data for 274 water wells show that the top of the water well completion interval is below the bedrock surface, indicating that the bedrock water wells are completed in at least one bedrock aquifer. From Figure 2, it can be seen that water wells completed in bedrock aquifers occur throughout the County. Within the County, casing-diameter information is available for 264 of the 274 water wells completed below the top of bedrock. Of these 264 water wells, 98% have surface-casing diameters of less than 275 mm and these bedrock water wells have been mainly completed with either a perforated liner or as open hole; there are 55 bedrock water wells completed with a water well screen.

There are currently records for 167 springs in the groundwater database, including eight springs that were identified by Borneuf (1983). In the County, the spring locations appear to be mainly concentrated from townships 007 to 009 in the Cypress Hills area, and in the linear bedrock lows near Medicine Hat. Of the 106 available total dissolved solids (TDS) values for springs, 70% have TDS concentrations of more than 500

[6] See glossary

milligrams per litre (mg/L). The remaining 30% having a TDS concentration of less than 500 mg/L are mainly on the north flank of the Cypress Hills (see CD-ROM). Of the 106 available total hardness values, 85% have total hardness concentrations of less than 500 mg/L. The 12 available flow rates for springs within the County range from 4.8 to 228 litres per minute (lpm). The one available flow rate for a spring in the Cypress Hills is 228 lpm (Borneuf, 1983).

2.3.3 Casing Diameter and Type

Data for casing diameters are available for 1,275 water wells, with 706 (55%) indicated as having a diameter of less than 275 mm and 569 water wells having a surface-casing diameter of more than 275 mm. The casing diameters of greater than 275 mm are mainly bored or dug water wells and those with a surface-casing diameter of less than 275 mm are drilled water wells. In addition to the 1,275 water wells that have been designated as either bored or drilled water wells based on casing diameter, another 860 water wells have been designated as bored or drilled water wells based on the drilling method only with no casing size indicated on the water well record. Of the 860 water wells having no casing size, 417 are drilled water wells and 443 are bored water wells. The locations of the 1,123 drilled water wells and the 1,012 bored or dug water wells are shown on Figure 3. One area in particular where data are limited is within the Canadian Forces Base (CFB) Suffield borders (see overlay in back of report).

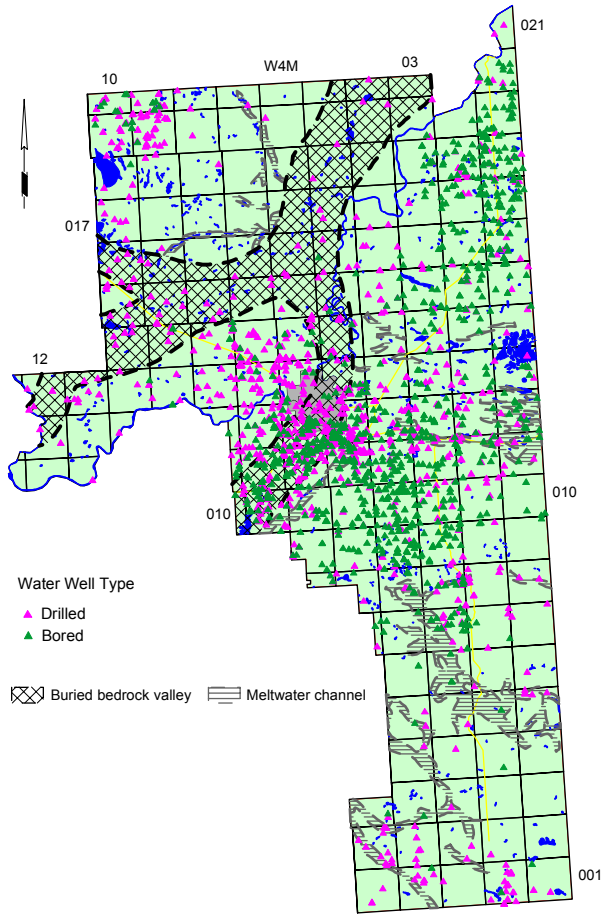

Figure 3. Location of Water Well Type

Figure 3 shows that bored water wells occur in groupings in the same areas as drilled water wells, with the exception being the buried bedrock valleys north and west of Medicine Hat and in the southern part of the County. Bored water well locations appear to be mainly focused in the buried bedrock valley south of Medicine Hat, and in the area southeast of Medicine Hat and in the northeastern part of the County. Most of the bored water wells are located in areas of generally lower groundwater development potential (see Figure 8).

In the area southeast of Medicine Hat, from townships 009 to 011, ranges 03 to 04, W4M, there are 61 drilled water wells and 219 bored water wells with a drilled depth. The average drilled depth for the 61 drilled water wells is 70 metres and for the 219 bored water wells is 10 metres.

Before 1975, an average of 46% of all water wells completed in the County were bored, with the remainder being drilled water wells. After 1975, an average of only 10% of all water wells completed in the County were bored.

In the County, steel, galvanized steel and plastic surface casing materials have been used in 99% of the drilled water wells over the last 40 years. Until the early 1970s, the type of surface casing used in drilled water wells was mainly undocumented. Steel casing was in use in the 1950s and is still used in 34% of the water wells being drilled in the County in the late 1990s.

Unlike in other areas of Alberta, galvanized steel surface casing was only in use in the County prior to 1955 and only in 4% of the drilled water wells. Plastic casing was first used in April 1973. The percentage of water wells with plastic casing has increased and by the late 1990s, plastic casing was used in 65% of the drilled water wells in the County.

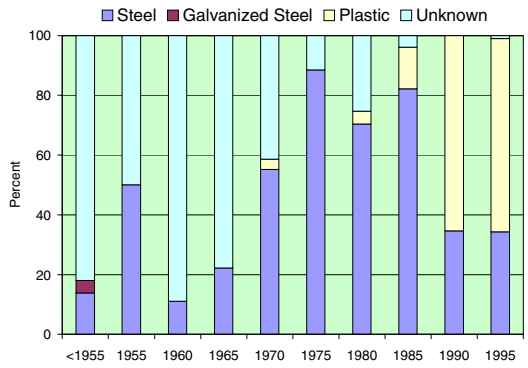

Figure 4. Surface Casing Types Used in Drilled Water Wells

2.3.4 Dry Water Test Holes

In the County, there are 4,609 records in the groundwater database. Of these 4,609 records, 215 (less than 5% of the total number of test holes drilled) are indicated as being dry or abandoned with “insufficient water”. Of the 215 “dry” test hole records, 127 were drilled or completed in the surficial deposits and 88 were in the bedrock. Also included in these dry test holes is any record that includes comments that state the water well goes dry in dry years.

2.3.5 Requirements for Licensing

Water wells used for household needs in excess of 1,250 cubic metres per year and all other groundwater use must be licensed. The only groundwater users that do not need licensing are (1) household use of up to 1,250 m^3/year and (2) groundwater with total dissolved solids in excess of 4,000 mg/L. At the end of 1999, 78 groundwater allocations were licensed in the County. Of the 78 licensed groundwater users, 41 could be linked to the Alberta Environment (AENV) groundwater database. Of the 78 licensed groundwater users, 36 are for agricultural purposes, 21 are for municipal purposes, 14 are for commercial purposes, and the remaining seven are for recreation, irrigation, industrial or exploration purposes. The total maximum authorized diversion from the water wells associated with these licences is 20,389 cubic metres per day (m^3/day), although actual use could be less. Of the 20,389 m^3/day, 13,749 m^3/day (67%) is authorized for commercial purposes from 13 water wells, as shown below in Table 1. Eighty percent of the 13,749 m^3/day is licensed to the City of Medicine Hat. Of the remaining 6,640 m^3/day, 27% is allotted for municipal use, and 6% is allotted for agricultural, irrigation and recreation use. A figure showing the locations of the licensed users is in Appendix A (page A-7) and on the CD-ROM.

Table 1 on the following page shows a breakdown of the 78 licensed groundwater allocations by the aquifer in which the water well is completed. The largest total licensed allocations are in the Lower Sand and Gravel Aquifer. Of the 18,944 m^3/day licensed groundwater use in the Lower Sand and Gravel Aquifer, 70% of the groundwater use is from water wells located at Police Point in townships 012 and 013, range 05, W4M along the South Saskatchewan River.

Aquifer **	No. of Diversions	Licensed Groundwater Users* (m³/day) Agricultural	Municipal	Commercial	Irrigation	Recreation	Industrial	Exploration	Total	Percentage
Upper Sand and Gravel	8	17	118	34	34	0	3.4	0.2	206	1
Lower Sand and Gravel	32	200	4,576	13,593	385	189	0	0	18,944	93
Horseshoe Canyon	3	0	328	0	0	0	0	0	328	2
Bearpaw	1	0	0	0	0	0	0	0	0	0
Oldman	11	68	85	0	0	0	0	0	152	1
Foremost	2	20	0	54	0	0	0	0	74	0
Milk River	4	81	0	0	0	0	0	0	81	0
Unknown	17	180	356	68	0	0	0	0	604	3
Total	78	566	5,463	13,749	419	189	3.4	0.2	20,389	100
Percentage		3	27	67	2	1	0	0	100	

* - data from AENV ** - Aquifer identified by HCL

Table 1. Licensed Groundwater Diversions

Based on the 1996 Agriculture Census, the calculated water requirement for livestock for the County is in the order of 13,767 m³/day. Of the 13,767 m³/day average calculated livestock use, AENV has licensed a groundwater diversion of 566 m³/day (4%) and a surface-water consumptive diversion of 5,504 m³/day (40%). The remaining 56% of the calculated livestock use would have to be from unlicensed sources.

2.3.6 Groundwater Chemistry and Base of Groundwater Protection

Groundwaters from the surficial deposits can be expected to be chemically hard, with a high dissolved iron content. High nitrate + nitrite (as N) concentrations were evident in 7% of the available chemical data for the surficial aquifers and 2% of the available chemical data for the upper bedrock aquifer(s); a plot of nitrate + nitrite (as N) in surficial aquifers is on the accompanying CD-ROM. The TDS concentrations in the groundwaters from the upper bedrock in the County range from less than 500 to more than 3,000 mg/L (page A-34). Groundwaters from the bedrock aquifers frequently are chemically soft, with generally low concentrations of dissolved iron. The chemically soft groundwater is high in concentrations of sodium. Less than ten percent of the chemical analyses indicate a fluoride concentration above 1.5 mg/L, with most of the exceedances occurring in the southern and east-central part of the County (see CD-ROM).

The minimum, maximum and median[7] concentrations of TDS, sodium, sulfate, chloride and fluoride in the groundwaters from water wells completed in the upper bedrock in the County have been compared to the Guidelines for Canadian Drinking Water Quality (GCDWQ) in Table 2. Of the five constituents compared to the GCDWQ, median values of TDS and sodium concentrations exceed the guidelines; maximum values of all five constituents exceed the guidelines.

The maximum TDS and sulfate values shown in the adjacent table are from an industrial water well drilled in NE 17-012-05 W4M to a depth of 121 metres and completed in the Foremost Aquifer below the Base of Groundwater Protection.

Constituent	Range for County in mg/L Minimum	Maximum	Median	Recommended Maximum Concentration GCDWQ
Total Dissolved Solids	26	26,646	1514	500
Sodium	1	5,761	380	200
Sulfate	0	11,861	426	500
Chloride	0	9,615	26	250
Fluoride	0	6	0.4	1.5

Concentration in milligrams per litre unless otherwise stated
Note: indicated concentrations are for Aesthetic Objectives except for Fluoride, which is for Maximum Acceptable Concentration (MAC)

GCDWQ - Guidelines for Canadian Drinking Water Quality, Sixth Edition Minister of Supply and Services Canada, 1996

Table 2. Concentrations of Constituents in Groundwaters from Upper Bedrock Aquifer(s)

[7] see glossary

Alberta Environment defines the Base of Groundwater Protection as the elevation below which the groundwater will have more than 4,000 mg/L of total dissolved solids. By using the ground elevation, formation elevations, and Alberta Energy and Utilities Board (EUB) information indicating the formations containing the deepest useable water for agricultural needs, a value for the depth to the Base of Groundwater Protection can be determined. These values are gridded using the Kriging[8] method to prepare a depth to the Base of Groundwater Protection surface. This depth, for the most part, would be the maximum drilling depth for a water well for agricultural purposes or for a potable water supply. If a water well has total dissolved solids exceeding 4,000 mg/L, the groundwater use does not require licensing by AENV. In the County, the depth to Base of Groundwater Protection ranges from less than 100 metres to more than 800 metres below ground level, as shown on Figure 5 and on each cross-section presented in Appendix A and on the CD-ROM. The main area where the depth to Base of Groundwater Protection is less than 100 metres is in the Buried Medicine Hat Valley north of Medicine Hat.

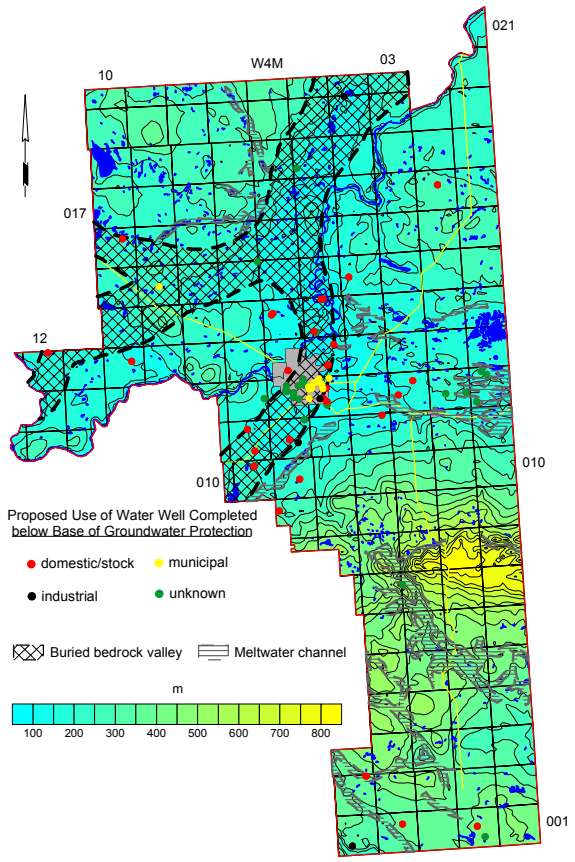

Figure 5. Depth to Base of Groundwater Protection (after EUB, 1995)

Of the 3,476 water wells with completed depth data, 68 are completed below the Base of Groundwater Protection. These 68 water wells identified on the CD-ROM have been posted on the adjacent figure and show that they are mainly completed in linear bedrock lows. Of the 11 water wells that were completed for municipal purposes, ten were for the City of Medicine Hat drilled to a depth of approximately 300 metres below ground surface in the early 1900s; none are currently licensed for groundwater diversion by AENV.

Proper management of the groundwater resource requires water-level data. These data are often collected from observation water wells. At the present time, there are 16 AENV-operated observation water wells within the County. Of the 16 AENV-operated observation water wells, only five are currently active. Additional data can be obtained from some of the licensed groundwater diversions. In the past, the data for licensed diversions have been difficult to obtain from AENV, in part because of the failure of the licensee to provide the data.

However, even with the available sources of data, the number of water-level data points relative to the size of the County is too few to provide a reliable groundwater budget (see section 6.0 of this report). The most cost-efficient method to collect additional groundwater monitoring data would be to have the water well owners measuring the water level in their own water well on a regular basis.

[8] See glossary