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HYDROGEOLOGY OF THE DRUMHELLER AREA, ALBERTA

by

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HYDROGEOLOGY

OF THE DRUMHELLER AREA,

ALBERTA

Abstract

This hydrogeological reconnaissance map is an interpretation of the hydrogeology, groundwater chemistry and groundwater movement of the main near-surface aquifers of the Drumheller area. This work was based on information already existing, as well as on interpretation of field data and observed phenomena, complemented by a test drilling program. Yields ranging from <1 igpm to >400 igpm are found in the map area. The waters have an average value of 1500 ppm total dissolved solids. Sodium bicarbonate waters are found throughout the map area, but high sulfate contents occur very often and seem to designate areas of groundwater discharge; the high sulfate contents are related to waters having more than 1500 ppm total dissolved solids.

INTRODUCTION

This map is one of a series of hydrogeological reconnaissance maps to be published at the scale of 1:250 000.

Stalker (1950-1953), Meyboom (1961), Tóth (1966, 1968), and Vanden Berg (1969) conducted hydrogeological surveys in different parts of the Drumheller map area; their information has been used in making the present map.

The area covered by this study is located between longitudes 112° and 114° west, and latitudes 51° and 52° north; on the basis of the Alberta Land Survey system the area lies between townships 23 and 35 and ranges 15 and 29, west of the fourth meridian, and covers an area of approximately 5,000 square miles.

The main cities in the area are Calgary, with the northeast suburbs of the city extending into the map area, and Drumheller in the center of the area. Their populations in 1969 were 335,806 and 4,698, respectively (Alberta Government Travel Bureau).

Most of the land has been cleared of natural vegetation to allow for extensive cereal production. The hummocky moraine is cultivated in some areas, or is used for cattle grazing in areas of poor sandy

soils. There are very few trees remaining and erosion by surface water is severe due to bare land and light soils.

Acknowledgments

This program was financed partly by the Research Council of Alberta and partly by the federal government under the terms of the federal Agricultural and Rural Development Act (ARDA). The Soils, Geology and Groundwater Branch of the Water Resources Division, Alberta Department of Agriculture, supplied a rotary drill and crew for part of the program. The test holes drilled by this rig aided greatly in the over-all evaluation of the area.

Doering Drilling of Olds, Alberta, carried out detailed test drilling and pump testing. Field and office assistance and drill-site supervision was well handled by A. Beerwald. V. Carlson compiled water well information on 1:50 000 scale maps prior to the start of field work.

Others whose help is gratefully acknowledged include various district health units for chemical analyses of well water samples, the Provincial Analyst of the Alberta Department of Agriculture for chemical analysis of water samples, the Geochemical Laboratory of the Research Council of Alberta and the Oil and Gas Conservation Board for information such as structure test-hole E-logs, litholog and geological reports.

The author would like to thank all the people in the area for their excellent cooperation on this project and the water well drillers who submitted reports on wells drilled.

This paper was critically read by E. G. Le Breton, D. V. Currie, R. Green, and J. Tóth, and the author wishes to express his gratitude for the many helpful suggestions.

TOPOGRAPHY AND DRAINAGE

Topographic elevations range from 3,600 feet in the southwest corner of the map area, north of Calgary, to 2,300 feet in the Red Deer River valley. The important hills in the area are the Hand Hills rising to 3,500 feet and located between townships 28 and 30, ranges 15 and 17, and the Wintering Hills rising to 3,300 feet, located south of Drumheller in township 26, ranges 18 and 19. Apart from these hills, the country is flat or gently rolling as near the towns of Three Hills and Trochu. Areas of hummocky moraine are located in the northeast part of the map area near the village of Rumsey, and east and northeast of the village of Hussar.

The processes of glaciation and subsequent erosion by creeks and rivers have shaped the area. The creek and river valleys are generally deep and wide. The largest river, the Red Deer, flows in a general southeasterly direction and crosses the area from north to south, dividing the map into two different (geological and hydrogeological) units. Its valley is 300 feet deep on the average and is approximately one mile wide. The mean monthly discharge of the Red Deer River at Drumheller is 1.950 cubic feet per second. The other rivers and creeks are much smaller. They are Ghostpine Creek, Three Hills Creek, Lonepine Creek, Rosebud River and Serviceberry Creek. The first five are subparallel with a general direction of flow to the southeast, and they are all tributaries of the Red Deer River. Their mean monthly discharge rates range from 44 to 638 cubic feet per second.

CLIMATE

The climate of the area is characterized by a long, cool summer (Longley, 1968). Values of temperature, precipitation, evaporation and potential evapotranspiration are given in table 1. Using the methods of Serra and Turc the potential evapotranspiration has been calculated with the mean annual values of either the temperature or the precipitation. This is the reason why only one value of the potential evapotranspiration is given for the two different methods. The Serra method (Serra, 1954) gives a value which is much similar to evaporation on a "free body" of water. It is believed that the value given by Turc's method (Turc, 1951; Turc, 1953) is closer to reality. The difference between the two methods is due to the introduction of many more factors in Turc's method. Nevertheless, this gives a range of values for the potential evapotranspiration over the map area.

Table 1. Temperature, Precipitation and Evapotranspiration

		January		July	
		°F	°C	°F	°C
Mean Temperature	East	2	-16	62	16.2
	West	5	-15	65	18.5
		inches		millimeters	
Mean Precipitation	East	14		355	
	West	18		457	
Mean Evaporation	East	30		762	
	West	35		889	
Potential Evapotranspiration	Serra	32.16		816.7	
	Turc	15		381	

GEOLOGY

Previous geological work was done in 1925 by Allan and Sanderson in "Geology of Red Deer and Rosebud Sheets," a publication of the Research Council (1945). A geological map by E. J. W. Irish was published in 1967. Dr. R. Green of the Research Council of Alberta provided the structure contours on the Kneehills Tuff as the boundary between the Paskapoo and Edmonton Formations, and the structure contours on the Bearpaw Formation.

Bedrock Geology

Under the thin drift cover, strata of Cretaceous, Paleocene and Eocene ages are found.

The Bearpaw Formation (Upper Cretaceous) outcrops in the southwestern part of the map area. This formation, consisting mainly of shales of marine origin, dips to the west and thins in the same direction.

The Edmonton Formation (Upper Cretaceous) covers the east half of the map area, dipping towards the west and north.

The Paskapoo Formation (Lower Tertiary) covers approximately the west half of the map area. Its areal extent can be roughly

outlined as being the west side of the Red Deer River. In the south half the limit of the formation extends farther east.

The remnants of Upper Tertiary sediments are small and restricted to the Hand Hills in the center east, and to the Wintering Hills south of the Red Deer River and Serviceberry Creek. These Tertiary sediments are "...composed of gravel partly cemented with calcium carbonate." (Irish, 1967).

Surficial Deposits

Generally, the drift cover is not very thick but in some areas its development and composition can be of some importance to groundwater. These areas include the Rosebud River valley (Tps. 27-28, Rs. 24-25), where the drift cover is mainly sand and gravel about 100 feet thick; and an area located in the southeast corner of the map area, where a gravel aquifer has been studied and described by Carlson, Turner, and Geiger (1969). Further drilling carried out in this area during the summer of 1969 confirmed the yields in this area.

HYDROGEOLOGY

On the main map the following information is given for selected wells: water level, depth of the well, water-bearing formation, estimated safe yield and hydrochemistry. Selection was made on the basis of the amount of information available, representativeness of yield area, or to indicate anomalous conditions.

The average elevations of the groundwater level are shown. Where information is scarce, water-level contours are assumed to be related to topography and are shown on the map as a finely dashed line.

Areas of flowing wells have been outlined; they are numerous in the northwest quarter of the map sheet and are very common along the valleys. They are usually shallow (between 60 and 95 feet deep), and in most cases the wells just reach the bedrock. Most flowing wells are located on the west side of the map sheet and flow from the Paskapoo Formation.

Test Drilling

Test drilling was carried out during the summer of 1969 at five sites located as follows:

1-9-29-26-W4	Acme # 1
13-8-27-19-W4	Dalum #2
4-16-28-15-W4	Hanna #3
4-30-24-18-W4	Hussar #4
5-7-33-19-W4	Rumsey #5

The depths of the investigation ranged between 425 feet and 700 feet. Only two test holes have shown fairly large quantities of water. The first one is Hussar #4 where the 20-year safe yield calculated on a two-hour pump test run within the gravel aquifer gives a value of 78 igpm, a value similar to the one obtained by Carlson (1969) 12 miles southeast in the same aquifer. The second one is Rumsey #5 where water was found in large quantity at a depth of 160 to 200 feet in a fractured sandstone aquifer of the Edmonton Formation. The 20-year safe yield after a week-long pump test was 83 igpm.

Several two-hour pump tests were carried out in each hole, on different water-bearing zones. A total of 13 two-hour pump and bail tests, a step-drawdown test and a week-long pump test were run during this drilling program. The purpose of these tests was to evaluate water quantities and qualities available in different formations (in surficial deposits, Paskapoo and Edmonton formations). The following table shows the values obtained in the different formations.

Table 2. T and Q_{20} Values in Surficial Deposits, Paskapoo and Edmonton Formations

	Formation	T (igpd/ft)	Q_{20} (igpm)	Test duration	Depth (ft)
Hussar #4	surficial	10,080	68.6	2-hour bail test	90- 93
Acme #1	Paskapoo	52.75	4.6	2-hour pump test	20-196
Rumsey #5	Edmonton	2,500	83	one week	160-200

Well Yields

Groundwater yields shown on this map sheet are based on only 356 values of 20-year safe yield, most of these estimated values. In some parts of the map area good bail-test and pump-test data exist

but generally these are scarce. The average value of 20-year safe yield for the Drumheller map area is in the range of 5-25 igpm. The Paskapoo Formation, developed in the west half of the map area, has yield values ranging from less than 1 igpm to 500 igpm, depending on the extent and thickness of the sandstone lenses.

The yield values in the south half of the map area, west of the Red Deer River, are based on various assumptions and interpretation of meager data, yet a general picture of the yields to be expected in this area could be established.

The area east of the Red Deer River (Edmonton Formation) has a more homogeneous distribution of the yields, which are not as high as those in some places west of the river (Paskapoo Formation). Here again, the 0-5 igpm and the 5-25 igpm yield classes are the more common. Some wells completed in coal seams in the northeast corner of the map area seem to have fairly good yields but the water quality is quite poor (see chemistry side map). The fractured shales and sandstones of the Edmonton Formation southeast of Rumsey present good, high yields between 25-100 igpm (see 20-year safe yield of Rumsey #5). The yields in the northeast part of the map vary with the lithology of the aquifer as evidenced by the coincidence of the sandstone-shale and 5 to 25-0 to 5 igpm yield boundaries.

The drawdown portion of the first two-hour pump test in Rumsey #5 showed a transmissivity of 2,016 igpd/ft with a 20-year safe yield of 68 igpm. The same calculation made from the recovery part gives 2,917 igpd/ft and a 20-year safe yield of 98 igpm.

Another two-hour pump test conducted on 305 feet of open hole gives a transmissivity value of 3,770 igpd/ft and a 20-year safe yield of 127 igpm. This increase is the result of several water-bearing zones, to a depth of 400 feet, being tested at the same time. More observation wells would have provided a better picture of the different hydrogeological parameters such as directions of increases or decreases in permeability of the water-bearing formation, extent of the cone of depression, and so on.

HYDROCHEMISTRY

One thousand, five hundred water analyses were used for the construction of the hydrochemical side map. On this map are drawn the total dissolved solids contours and the 60 per cent lines of anions and cations.

The total dissolved solids have an average value for the area

of 1500 ppm, which is within the limits of Alberta public health standards; the total dissolved solids decrease to less than 500 ppm in recharge areas such as the Hand Hills and Wintering Hills.

The two main geological formations, Paskapoo and Edmonton, give different facies to waters encountered in the east and west halves of the map area. The east half is mostly sodium-bicarbonate water with some sulfates. The west half is sodium-bicarbonate or sulfate, or both.

The recharge areas are delineated hydrogeologically by the presence of the calcium-magnesium 60 per cent isogram. Over 60 per cent sodium is present in all other parts of the map area.

Carbonate-bicarbonate waters are located in recharge areas, where also total dissolved solids are less than 1500 ppm.

High sulfate content (over 60 per cent SO_4) seems to designate areas of groundwater discharge. This may be modified by lithology however, as the presence of shales increases the sulfate content of groundwater flowing through them. The sulfate 60 per cent isograms indicate areas where groundwaters have more than 1500 ppm total dissolved solids.

Generally, the longer the travel time of groundwater in the flow media, the more minerals the water dissolves (Chebotarev, 1955). In areas of groundwater discharge evaporation of the water may leave a salt deposit on the ground surface. This is a common phenomenon in the Drumheller map area, in association with flowing wells, springs, seepages and soap holes.

CONCLUSIONS

The depth of investigation, apart from the test holes, is limited in general to 200 feet. Generally, the phenomena shown on the cross section below this depth are assumed or interpreted. Deeper drilling to 1,000 feet would be needed to improve the picture.

Nevertheless, at this stage of the study it can be stated that reasonable yields (0-25 igpm) and adequate quality of water for human use can be found in the area. Further exploration in the area of Rumsey will be profitable to find the extension of the fractured sandstone aquifer in the Edmonton Formation. Other exploration in the Rosebud River valley could outline good potential aquifers in surficial deposits (Tps. 27-28, Rs. 24-25); the gravel and sand aquifer in the Bassano-Gem area, which has already been described, shows good possibilities of groundwater.

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APPENDIX A. TRACE ELEMENT DETERMINATIONS

Waters to undergo trace-element determination are filtered through Whatman #1 filter paper. The filtrate is thus considered to represent dissolved material.

Analytical methods used for trace determinations are as follows:

SiO_2 - colorimetric, heteropoly blue method;

Al - colorimetric, aluminum method;

Cr(hexavalent) - colorimetric, diphenylcarbozide method;

Cu - colorimetric, cuprethal method;

Zn - colorimetric, zincon method;

Mn - colorimetric, tetraphenylarsonium chloride extraction;

Se - colorimetric, diaminobenzidine method;

P_2O_5 - colorimetric, molybdate method;

Pb - atomic absorption;

Hg - atomic absorption preceded by solvent extraction (samples are not filtered through paper but through membrane filters);

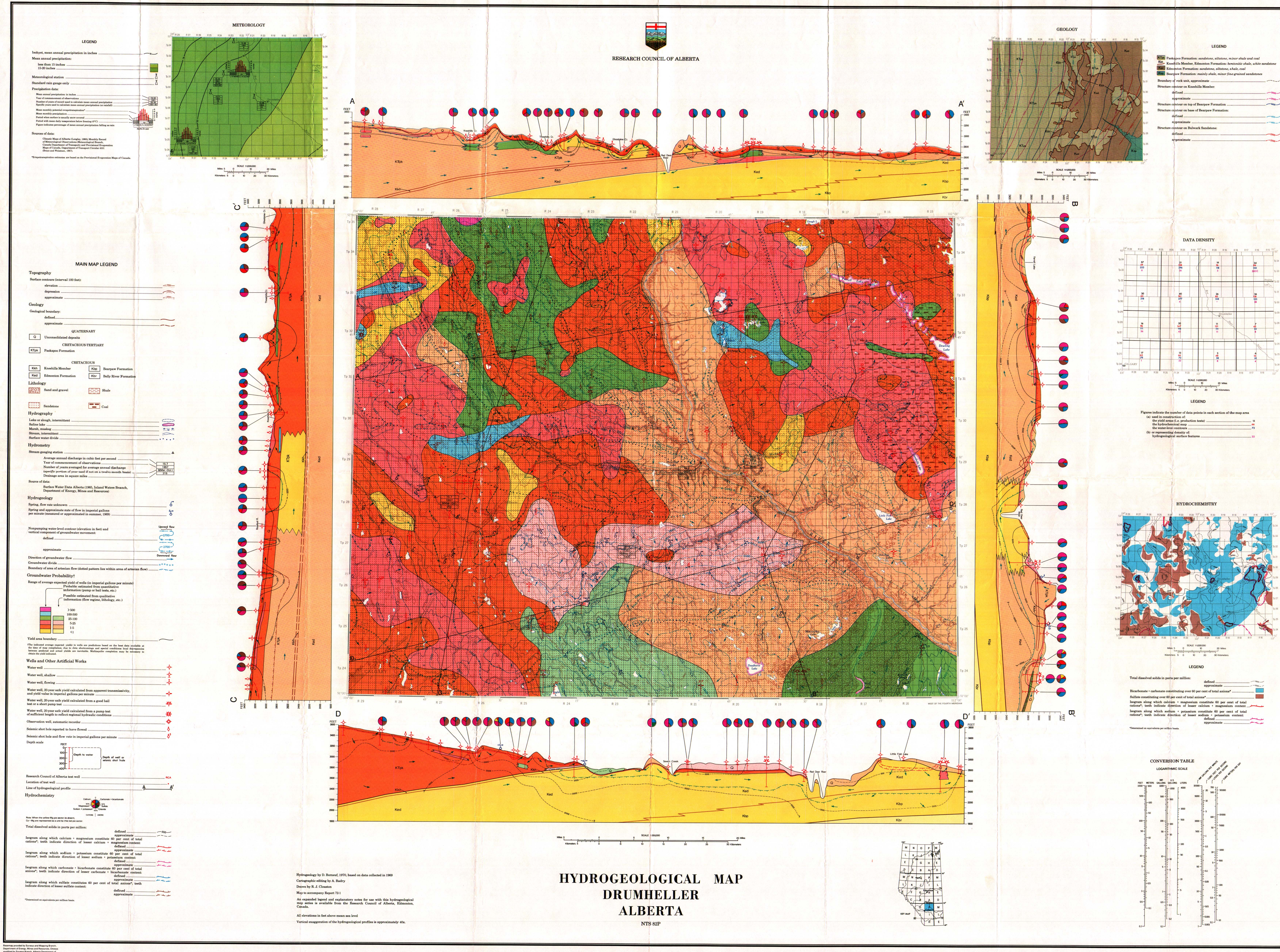
Br - specific ion electrode;

I - specific ion electrode.

APPENDIX A. TRACE ELEMENT DETERMINATIONS

Location West of 4th Mer.				Trace Element								
Lsd. or 1/4	Sec.	Tp.	R.	SiO_2 ppm	Al ppm	Cr ppm	Br ppm	I ppm	Zn ppm	Mn ppm	Se ppm	Cu ppm
5	10	24	18	14.6	0.13	0.01	0.18	0.01	0.04			0.01
12	34	24	19	10.5	0.05	0.01	0.17	0.01	0.06			0.03
SW	19	24	21	8.8	0.04	0.01	0.27	0.01	0.04			0.01
5	19	24	26	5.8	0.03	0.01	0.51	0.01	0.08			0.01
13	19	24	28	9.3	0.04	0.01	0.37	0.01	0.07			0.01
16	7	25	15	8.3	0.06	0.01	0.14	0.01	0.04			0.01
2	1	25	16	24.8	0.06	0.01	0.26	0.01	0.05			0.01
NE	31	26	19	12.3	0.02	0.01	0.27	0.01	0.07			0.01
1	15	26	22	9.6	0.02	0.01	0.34	0.01	0.38			0.01
13	34	26	24	8.8	0.02	0.01	0.37	0.02	0.03			0.04
15	19	26	25	6.8	0.19	0.01	0.65	0.01	0.06			0.18
NE	13	26	28	6.8	0.02	0.01	0.18	0.01	0.04			0.01
9	9	27	17	17.0	0.04	0.01	0.26	0.01	0.05			0.01
9	26	28	19	11.4	0.02	0.01	0.30	0.04	0.03			0.01
SW	3	28	21	8.8	0.02	0.01	0.20	0.01	0.13	0.02		0.03
NE	17	28	23	7.8	0.06	0.01	0.35	0.01	0.04	0.06		0.01
13	21	28	25	3.5	0.04	0.01	0.31	0.04	0.18		0.01	
13	9	28	27	7.0	0.02	0.01	0.56	0.10	0.07	0.03		0.01
NE	3	28	29	9.6	0.07	0.01	0.93	0.04	0.05			0.01
1	20	29	22	7.5	0.02	0.01	0.40	0.08	0.14		0.01	0.01
13	10	30	26	5.4	0.03	0.01	0.26	0.01	0.08			0.01
13	31	30	28	5.8	0.06	0.01	0.13	0.01	0.08			0.01
	6	31	25	5.8	0.02	0.01	0.23	0.01	0.07			0.01
3	30	31	28	8.8	0.03	0.01	0.23	0.01	0.07		0.01	0.03
15	24	33	26	7.2	0.02	0.01	0.17	0.01	0.15		0.01	0.01
5	32	35	26	6.8	0.02	0.01	0.35	0.01	0.06			0.01
NE	12	34	27	5.4	0.02	0.01	0.21	0.01	0.06			0.01
8	13	24	23	16.0	0.24							
16	23	24	24	12.6	0.18							
6	33	24	24	5.0	0.19							
1	27	24	27	9.2	0.12							
14	7	25	15	2.3	0.28							
1	4	25	16	15.9	0.23							
11	36	25	19	11.2	0.24							
4	2	25	21	13.1	0.24							
SE	12	25	22	8.5	0.18							
4	15	25	23	12.7	0.23							
13	12	25	24	9.4	0.13							
8	27	25	25	9.7	0.05							
16	36	25	26	14.3	0.23							
13	35	25	29	10.0	0.15							
6	22	26	20	16.2	0.26							

Location West of 4th Mer.				Trace Element								
Lsd. or 1/4	Sec.	Tp.	R.	SiO_2 ppm	Al ppm	Cr ppm	Br ppm	I ppm	Zn ppm	Mn ppm	Se ppm	Cu ppm
9	30	26	23	13.3								
SW	34	26	27	10.6								
4	18	27	18	20.2								
SE	8	27	19	9.8								
NW	17	27	20	19.4								
NW	10	27	21	14.8								
SW	10	27	22	9.7								
7	10	27	22	1.7	0.23							
11	10	27	22	3.8	0.25							
SW	4	27	23	2.5								
13	22	27	24	7.3								
NW	20	27	26	12.4								
15	21	27	27	7.6								
NW	15	27	28	12.0								
NE	15	27	29	9.1								
2	9	28	16	9.2	0.27							
6	29	28	18	16.6								
12	18	28	19	2.1	0.29							
NE	20	28	20	1.5								
12	17	28	22	11.2								
16	20	28	24	9.8								
NE	21	28	26	10.4								
4	20	28	28	8.3								
12	13	29	16	7.5	0.02							
4	6	29	18	11.1								
SE	21	29	19	13.2								
SE	3	29	21	11.0								
14	21	29	21	1.0	0.26							
4	14	29	21	3.1	0.27							
12	16	29	23	12.7								
16	16	29	24	12.9								
4	16	29	25	7.2								
3	16	29	26	10.7								
3	18	29	27	12.3								
6	18	29	28	8.3								
16	10	29	29	5.2								
4	16	30	22	7.3	0.29							
9	19	30	25	2.9	0.26							
4	3	31	22	2.5	0.23							
1	12	32	27	5.9								
3	7	32	28	8.7								
2	1	33	27	12.4								
13	29	33	27	7.6								
13	34	34	21	2.6	0.26							



Basemap provided by Surveys and Mapping Branch, Department of Energy, Mines and Resources, Ottawa; modified by Surveys Branch, Alberta Department of Highways and Transport, Edmonton.