RESEARCH COUNCIL OF ALBERTA

REPORT 71-1

HYDROGEOLOGY

OF THE RED DEER AREA, ALBERTA

by

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HYDROGEOLOGY OF THE RED DEER AREA, ALBERTA

Abstract

The 5,800 square miles covered by the Alberta Hydrogeological Reconnaissance Map of the Red Deer area is divisible into two main topographic regions, one dominated by northwest-trending ridges (with local relief of 100 to 300 feet) to the west and the other characterized by flat to gently rolling land to the east. The area is traversed by the Red Deer and the Battle Rivers.

According to Koeppen's classification, the climate of the area is humid continental, having a cool summer and no dry season.

Most wells in the Red Deer area are completed in the near-surface bedrock strata composed of the bentonitic siltstones and local to extensive medium- to coarse-grained, friable, calcareous and bentonitic sandstone beds of the Paskapoo Formation, and the bentonitic siltstones and thin bedded sandstones, coal and carbonaceous shales of the Edmonton Formation. Surficial deposits, apart from sand and gravel deposits in preglacial valleys, are not an important source of groundwater in the Red Deer area.

Anticipated groundwater yields range from over 500 imperial gallons per minute (igpm) to less than 1 igpm in the eastern part of the region, thus limiting development of groundwater supplies here for use as rural domestic, livestock and perhaps municipal supplies.

High ground in the west generates groundwater flow systems of local to regional scale, discharge being evidenced by springs, salt deposits and flowing wells. Low local relief in the east of the map area and the limited groundwater discharge features indicate the poor groundwater resources, and the sluggish groundwater flow systems.

The chemical facies of near-surface groundwaters are predominantly sodium bicarbonate and sodium sulfate, the sulfate-type of groundwater being of secondary importance. Total dissolved solids are generally less than 1000 ppm in the western portion of the area, increasing eastwards to over 2000 ppm in the southeast corner. Changes in water chemistry with increasing depth are less pronounced in the western part of the area than in the east, as shown in the hydrogeological profiles.

Hydrogeological profiles portray also the "active zone" of groundwater in the Red Deer area to be up to 500 feet

in the western part of the area, where the groundwater flow is strongly influenced by the greater local relief, thinning to less than 300 feet in the eastern part of the area where local relief is less and bedrock materials are generally finer grained. Correspondingly, the quality of groundwater for drinking purposes is suitable to depths of 1000 feet in the west part of the Red Deer area, decreasing to only 300 feet in the east part.

INTRODUCTION

This report is a brief elaboration of the findings of groundwater reconnaissance investigations which are portrayed on the hydrogeological map of the Red Deer area. This hydrogeological map, at a scale of 1:250 000, is one of a series intended to cover completely the province of Alberta. The map area, covering 5800 square miles, is bounded by longitudes 112° and 114° west, and latitudes 52° and 53° north, which under the Alberta Land Survey system coincides with most of townships 35 to 46 and ranges 15 to 28, west of the fourth meridian.

Acknowledgments

The author wishes to express his appreciation to his colleagues who assisted in the development of this map, and to Mr. A. Beerwald and Mr. L. Topp for assistance in the field aspects of the project.

The author also wishes to acknowledge the help, in supplying chemical quality data on groundwater, of: Mr. J. Grainge, Sanitary Inspector, Canada Department of Public Health; provincial health inspectors Mr. A. Yaeck, Camrose; Mr. J. Hoskins, Wetaskiwin; Mr. N. Basarsky, Ponoka; Mr. R. Capel, Stettler; Mr. J. R. Wocks and Mr. Drymaniuw, Red Deer; and Dr. White, dentist, Red Deer.

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Mr. G. L. Nielsen and Mr. H. A. Kerr, Water Resources

Division, Alberta Department of Agriculture, supplied test drilling data for Ardley and Red Deer Lake; Mr. J. Topilka, Elk Point Drilling Co., supplied a number of electric logs for the area.

PHYSIOGRAPHY AND DRAINAGE

The Red Deer area is divisible into two main topographic regions by a line trending northwest to southeast approximately through Wetaskiwin and Stettler. To the west, the area is dominated by northwest-trending ridges with a local relief of 100 to 300 feet. To the east the land surface is flat to gently rolling. The region is traversed by two main rivers: the Red Deer, with its source in the Rocky Mountains about 100 miles to the southwest, and the Battle River, a smaller stream with its source about 15 miles west of the map area, which is the only important river rising in the plains region in the southern half of Alberta.

CLIMATE

The climate of the area is humid continental, cool summer, no dry season, according to Koeppen's classification. The total annual precipitation for most of the area ranges from 15 to 18 inches, and the region would be semi-desert were it not for the five-month period from November to March with below freezing temperatures. In the months of May to October about two thirds, or 9 to 13 inches, of the precipitation falls as rain. During this same period potential evapotranspiration exceeds precipitation, and thus only limited recharge to the water table takes place. Similarly, essentially no recharge takes place from November to March as the ground is frozen. Most groundwater recharge occurs in March and April, during the period of melting of the snow cover and thawing of the ground.

GEOLOGY

Bedrock Geology

The near-surface bedrock strata of the area, in which most of the wells are completed, belong to two rock units, the Paskapoo Formation and the Edmonton Formation. The northwest-trending boundary between these two units is delineated by the subcrop of the Kneehills Member, a thin bed of tuff and shale of volcanic origin.

To the west, and above the Kneehills Member, is the outcrop area of the Paskapoo Formation, which contains bentonitic siltstones and local to extensive medium- to coarse-grained, friable, calcareous and bentonitic sandstone beds up to 100 feet thick. To the east and beneath the Kneehills Member lie the bentonitic siltstones and thin-bedded sandstones (commonly less than 10 feet thick), coal seams and carbonaceous shales of the Edmonton Formation. Beneath the Edmonton Formation, and outcropping in the northeast corner of the area, are the dark grey marine shales and fine-grained sandstones of the Bearpaw Formation. Locally within the Bearpaw Formation fairly well-sorted sandstone phases are present, often called the "Bulwark Sandstone," which are used as aquifers along the eastern edge of the area.

Beneath the Bearpaw Formation lies the Belly River Formation, a series of thin grey, greenish grey and pale blue bentonitic sandstones, siltstones and thin bentonites, with carbonaceous shales, thin coal seams and siderite beds. Beds of the Belly River Formation may be penetrated by a few wells in the northeast corner of the area.

The bedrock strata dip gently westward and southwestward at about 15 to 20 feet per mile.

Surficial Deposits

Most of the bedrock in the area is overlain by surficial deposits commonly comprising till (an unsorted and unstratified glacially derived mixture of clay, silt, sand, pebbles and boulders), lacustrine clay, sand and gravel, and windblown sand deposits.

A number of channels or valleys of earlier, mainly preglacial, drainage systems cross the map area from west to east, and these commonly contain fine- to coarse-grained sand and gravel deposits, normally beneath a cover of glacial materials.

For the purposes of this evaluation the surficial deposits have been divided into two categories — sand and gravel deposits, and clay and silt deposits. This categorization is to permit illustration of areas with significantly different infiltration capacities.

Apart from sand and gravel deposits buried in preglacial valleys, the surficial deposits are not an important source of groundwater.

HYDROGEOLOGY

The main map, at a scale of 1:250 000, displays anticipated water-well yields and, to a degree, the most important features influencing groundwater distribution, namely relief and geology. Also presented are some water-level contours, areas of artesian flow, flowing wells and springs, selected water wells showing water-level information, and test-hole locations.

Groundwater Yield

The map area has been divided into areas of known or anticipated groundwater yield, based on the expected yield of a single well obtaining water from the total accessible stratigraphic section. Anticipated yields range from over 500 imperial gallons per minute (igpm) to less than 1 igpm in the eastern part of the region.

Determination of potential well yields is based largely on apparent transmissivity data, calculated from some 600 water-well drillers' pump and bail tests. The transmissivity values are derived basically from "two-point curves," consisting of the nonpumping water level and the level of measured drawdown caused by the bailing or pumping. Yield values are 20-year estimates, based on apparent transmissivity and available drawdown.

Designation of the areas of highest yield, around Clive and on Threehills Creek, is based on test-drilling information of the Research Council of Alberta, a five-day pumping test at Clive and bail tests in the Threehills Creek area. Short bail- and pump-test data supplied by water-well drillers is the main basis for designating adjacent areas as capable of 100-500 igpm well yields, with geological and hydrogeological information supplying strong supporting evidence (e.g. spring discharges of 50, 40, 30, 20 igpm and less supporting a 150 igpm streamflow in township 40, range 24). Test drilling studies financed by the City of Red Deer and carried out by the Research Council substantiate the yield area classification adjacent to that city.

Well yields of up to 100 igpm were indicated by bail tests in township 36, range 23, west of Lousana. Yields of the same order of magnitude are indicated for much of the remainder of the west half of the map area, the 25 to 100 igpm yield area boundary being drawn generally coincident with the base of the Paskapoo Formation. In the Stettler area municipal supplies are obtained from a number of wells capable of producing about 50 igpm. Similar amounts of water are obtainable from preglacial sands and gravels near Bawlf and Strome, as well as along the valley of the preglacial Red Deer River northeastward from Ponoka.

Well yields generally decline eastward from the present Red Deer River valley and eastward from the hilly country around Clive and Mirror. Bail tests indicate well yields of about 5 igpm in the Meeting Creek-Battle River area, and of less than 1 igpm to the north of Halkirk. Spring discharge rates are low in this part of the region, being little in excess of evaporation in July and August. This fact, plus the limited number of springs, temporary nature of the creeks, and virtual absence of permanently moist ground conditions, all indicate the limited nature of the groundwater resources, and the low local relief implies a sluggish groundwater flow system.

Groundwater Features

The water-level contours are based on levels in wells 50 to 100 feet deep. Changes in fluid potential for some deeper test wells are shown locally, as in the generally flat country of the Halkirk area, where water levels decline with increasing depth. This denotes a significant downward component in the groundwater flow pattern. In contrast, springs, and wells and seismic shot holes that struck flowing water reflect an upward component in the groundwater flow pattern; these points and areas of artesian flow are generally delineated.

A ridge running southward from near Morningside (township 41, range 26) to the vicinity of Pine Lake (and broken by the gorge of the Red Deer River) separates local surface drainage to the west and southwest from more substantial streams flowing to the southeast. This high ground generates a number of groundwater flow systems, of local to regional scale. The discharge areas of these systems are indicated by such features as springs, flowing wells, soapholes, salt deposits and areas of perennially moist ground.

Hydrogeological Profiles

The four cross sections are intended to illustrate the vertical or third dimension of the distribution of groundwater in the area. These profiles show firstly that much of the groundwater is concentrated in the near-surface several hundred feet of strata. Test drilling has shown that although substantial amounts of water may be present in a particular rock unit within a few hundred feet of the surface, essentially no water is obtainable from that same unit where it is more deeply buried. The near-surface rocks are thus more permeable, because of more intergranular or fracture permeability or both.

This "active zone" of groundwater is apparently up to 500 feet deep in the western part of the area, where the groundwater flow is strongly influenced by the greater local relief, but thins to less than 300 feet in the eastern part of the region, where local relief is less and where also the bedrock materials are generally finer grained. This zone is considered to conform generally to topography; its distribution beneath river valleys is, however, not fully known.

Limited exploration has been carried out below 300 or 400 feet, largely because of the cost; Research Council test drilling results permit some interpretation or prediction of yield for parts of the more deeply buried strata. At greater depths information is available from oil company exploration, but within 2,000 feet of the surface this is largely confined to hydrochemical data.

HYDROCHEMISTRY

About 1,700 chemical analyses of groundwater were used to compile the hydrochemical maps. The chemical parameters illustrated relate almost wholly to near-surface groundwaters, and thus represent known or expected composition of waters within 200 feet of the surface.

Total dissolved solids contents are generally less than 1000 ppm to the west of range 23, and in the Lacombe-Clive area groundwaters commonly have less than 500 ppm. East of range 23 total solids contents generally increase eastwards from slightly above 1000 ppm to brackish-water quality (above 2000 ppm) in the southeast corner of the region.

The groundwaters are predominantly of the bicarbonate and carbonate type. Of secondary importance in the region are sulfate-type waters, mainly in the southeast, with chloride waters appearing to be of very limited areal extent and of only minor significance, near to the surface. The predominant cation is sodium, thus groundwater types are mainly sodium bicarbonate and sodium sulfate. Calcium and magnesium bicarbonate waters exist in the Lacombe-Clive area and from New Norway to Strome (Tp. 45, R. 20, to Tp. 44, R. 15), the former indicating the control on composition exerted by the effective flow systems, and the latter the influence of surficial deposit aquifers.

The hydrogeological profiles show, where possible, an extrapolation of chemical composition to depth, the extrapolation being based mainly on limited data from drill-stem test samples from depths of 2,000 feet or more, but also on data from a few Research Council test holes. Changes in water chemistry with increasing depth are less pronounced in the western part of the area than in the east, at least in the first few hundred feet. Thus better quality water may be expected at a depth of 500 or 600 feet in the Clive area than near Halkirk — as is indeed indicated by the test drilling data. Chloride contents generally increase and bicarbonate and sulfate contents decrease with increasing depth.

A considerable amount of information is available on natural fluoride distribution in groundwaters in the Red Deer area, indicating that contents are generally less than 1 ppm. Around Wetaskiwin, the Hobbema Indian Reserve, Red Deer and to the east and southeast of Stettler groundwaters commonly contain between 1 and 2 ppm fluoride, and locally contain more, up to over 5 ppm in some samples analysed. No obvious control has been recognized that might explain the observed distribution of fluoride contents.

Iron contents are fairly common above 1 ppm, and above 2 ppm locally in many parts of the region. The largest amounts of iron, above 4 ppm, are found in waters from buried channel aquifers, particularly in the Duhamel-Strome area.

CONCLUSIONS

Topography and geology, coupled with slightly higher annual precipitation of one to two inches, render the west part of the Red Deer area favorable to the development of groundwater supplies of up to 100 igpm and sometimes to 500 igpm. The east part of the region is commonly suited only to development of groundwater supplies for rural domestic, and livestock requirements and sometimes limited municipal requirements. The quality of groundwater is likely to be suitable for drinking purposes to depths of 1000 feet in the west region but to only 300 feet in the east region.

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APPENDIX A

CONVERSION TABLE FOR CALCULATION OF WATER QUALITY FROM THE HYDROGEOCHEMICAL MAP

(E. G. Le Breton and O. Tokarsky)

Total dissolved solids	TDS as CO_3						TDS as SO_4						TDS as Cl					
	Na 1.3 : 1		Ca 1.5 : 1		Mg 2.47 : 1		Na 2.09 : 1		Ca 2.4 : 1		Mg 3.95 : 1		Na 1.54 : 1		Ca 1.77 : 1		Mg 2.92 : 1	
ppm	ppm		ppm		ppm		ppm		ppm		ppm		ppm		ppm		ppm	
500	283	217	300	200	356	144	338	162	353	147	399	101	303	197	320	180	372	128
750	424	326	450	300	534	216	507	243	528	222	598	152	454	296	480	270	558	192
1000	565	435	600	400	712	288	676	324	716	294	798	202	606	394	640	360	744	256
1250	707	543	750	500	890	360	845	405	882	368	999	251	758	492	800	450	930	320
1500	849	651	900	600	1068	432	1014	486	1059	441	1197	303	909	591	960	540	1116	384
1750	990	760	1050	700	1246	504	1183	567	1236	514	1397	353	1061	689	1120	630	1302	448
2000	1133	867	1200	800	1424	576	1352	648	1412	588	1596	404	1212	788	1280	720	1488	512
2500	1415	1085	1500	1000	1780	720	1690	810	1765	735	1995	505	1515	985	1600	900	1860	640
3000	1700	1300	1800	1200	2136	864	2028	972	2117	883	2494	606	1818	1182	1920	1080	2232	768

The above table has been included with the Red Deer report to enable map readers to calculate water quality for any point on the map-sheet. The procedure for calculations is as follows:

(1) Shaded areas on the hydrogeochemical map show the predominant anion which amounts to 60% or greater of the total anions. The above table represents the total dissolved solids content of the water, assuming 100% for each of the major anions balanced by each of the major cations. For total dissolved solids other than values in the above table use the appropriate ratio factor of anions in relation to cations.

(2) Assume a total dissolved solids content of 1000 ppm with 60% CO_3 and 60% Na.

$$CO_3 = \frac{60}{100} \times \frac{565}{1} = 339$$

$$Na = \frac{60}{100} \times \frac{435}{1} = 261$$

Part TDS = 600

The reader then has to allocate the remaining total solids content 1000-600 = 400 between the other anions and cations. Let us assume 40% SO_4 and 40% Ca.

In this case:

$$SO_4 = \frac{40}{100} \times \frac{716}{1} = 286$$

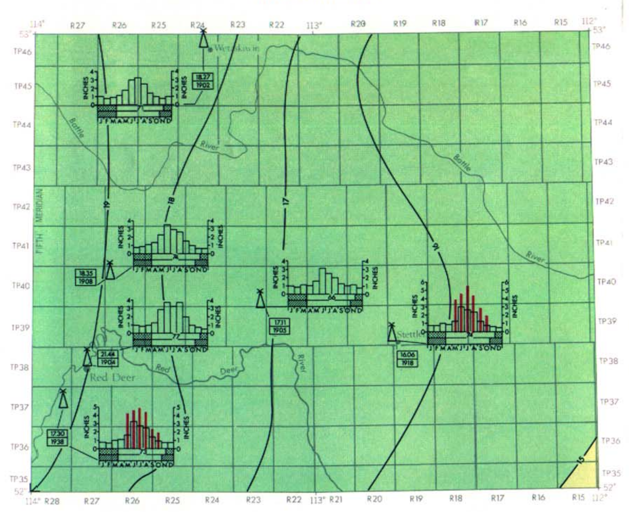
$$Ca = \frac{40}{100} \times \frac{294}{1} = 118$$

Part TDS = 404

So here TDS = 1004.

RESEARCH COUNCIL OF ALBERTA

METEOROLOGY



LEGEND

Mean annual precipitation:

- 15 to 20 inches
- less than 15 inches

—15— Isohyet, mean annual precipitation in inches

Meteorological station

Precipitation data:

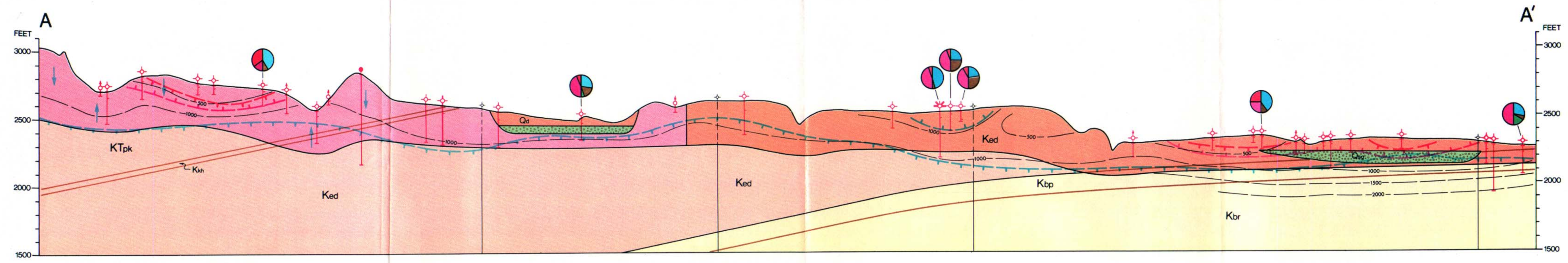
- 1730 / 1938 — Mean annual precipitation in inches; Commencement of observations

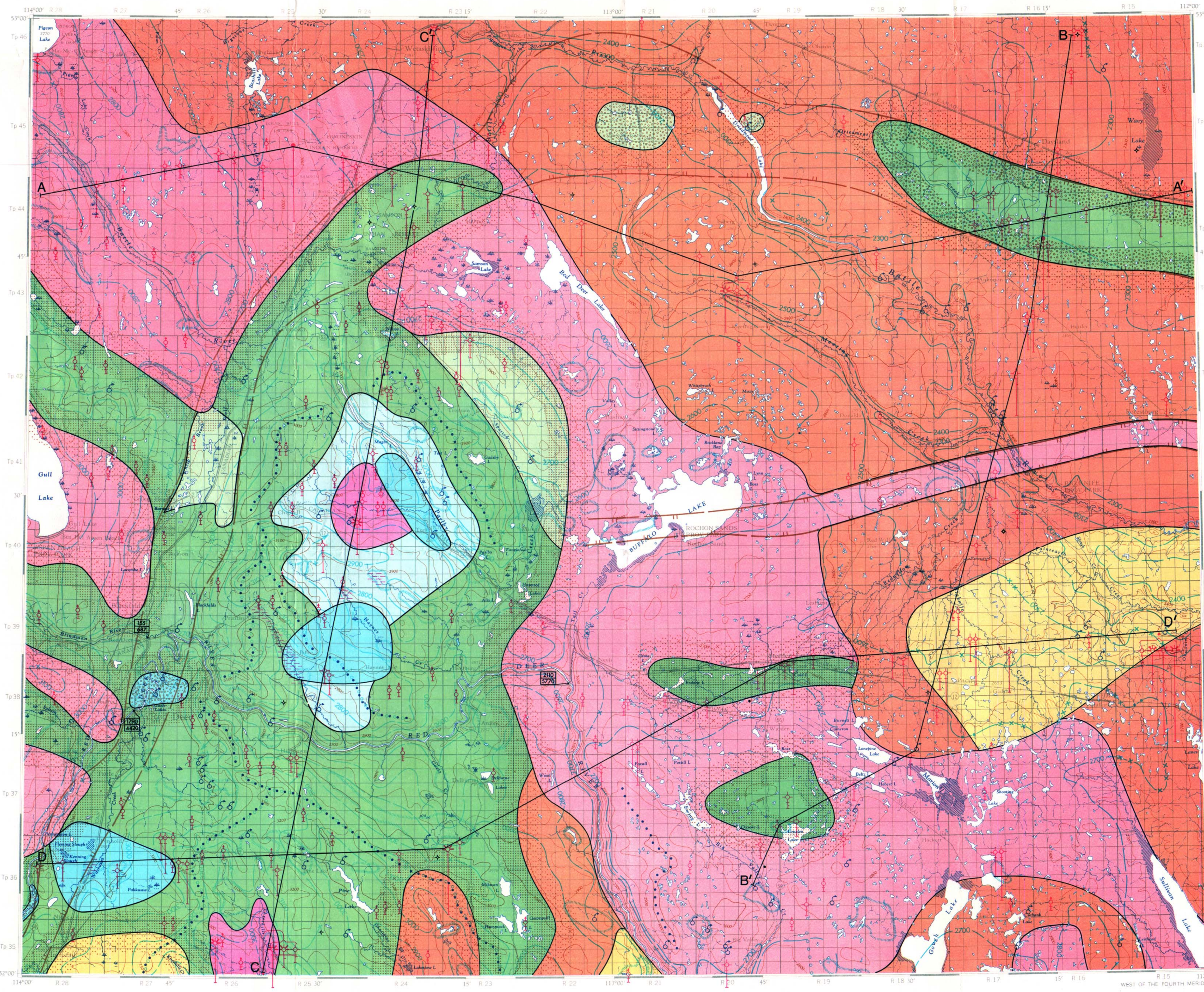
- Mean monthly potential evapotranspiration*
- Mean monthly precipitation
- Period when surface is usually snow covered
- Period with mean daily temperature below freezing (0°C)
- Figure indicates percentage of mean annual precipitation falling as rain

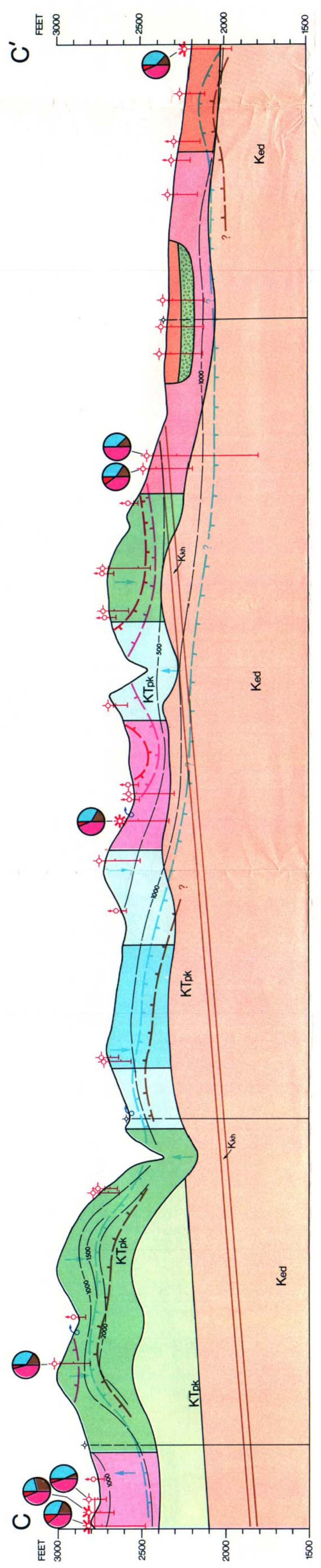
Months of a year

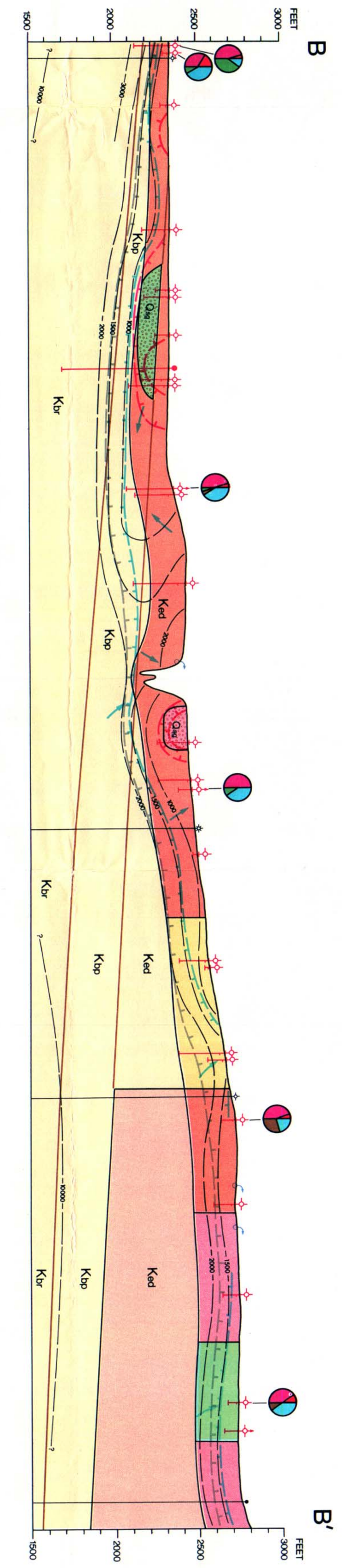
*Evapotranspiration estimates are based on the Thornthwaite Method.

Source of data:
Climatic Maps of Alberta (Longley, 1968) and Monthly Record of Meteorological Observations (Meteorological Branch, Canada Department of Transport)









MAIN MAP LEGEND

Topography

Surface contours (interval 100 feet)

- elevation
- depression
- approximate

Geology

Geological boundary

QUATERNARY

Qd	Unconsolidated deposits
Qsg	Sand and gravel

CRETACEOUS

KTpk	Paskapoo Formation
Kkh	Kneehills Member
Ked	Edmonton Formation
Kbp	Bearpaw Formation
Kbr	Belly River Formation

- Sand and gravel
- Bentonitic sandstone
- Bentonitic siltstone

Buried valley

Hydrography

- Lake, intermittent
- Marsh, muskeg
- Stream, intermittent
- Stream, indefinite
- Rapids, falls
- Irrigation canal or ditch
- Area covered by a salt precipitate
- Surface water divide
- Spring
- Stream gauge:
  - 155 — area in square miles
  - 687 — average annual discharge in cubic feet per second

Groundwater Hydrology

Upward flow / 2300 / Downward flow — Nonpumping water level contour (elevation in feet) and vertical component of groundwater movement

- Groundwater divide
- Boundary of area of artesian flow
- Direction of groundwater flow

Boreholes, Wells and Other Works

- Shothole (FEET 0, 100, 200 — Depth of shot hole)
- Borehole (FEET 0, 100, 200 — Depth of borehole)
- Water well (FEET 0, 100, 200, 300, 400, 500 — Depth to water; Depth of well)
- Water well, flowing
- Water well, 20-year safe yield calculated from a pump test of sufficient length to reflect regional hydraulic conditions
- Water well, 20-year safe yield calculated from a good bail test or a short pump test
- Recharge pit
- Location of test well

- Oil well*
- Gas well*
- Abandoned oil or gas well*

*Line symbols for oil and gas wells on cross sections indicate well depth; dashed portion indicates surface casing interval.

A —— A' Line of cross section

Groundwater Probability†

Average expected yield of wells (in imperial gallons per minute)

- established from pump or bail tests, etc.
- estimated from flow regime, lithology, etc.

>500
100 - 500
25 - 100
5 - 25
1 - 5
<1

Boundary of yield area

†The expected yields of individual wells are predictions, based on the best data available at the time of map compilation; due to data shortcomings, local variations in geology, well completion techniques and similar noncontrollable factors, less water may be obtainable from some individual wells than the yield range predicted.

Hydrochemistry

Calcium, Magnesium, Sodium + potassium — CATIONS | ANIONS — Carbonate + bicarbonate, Sulfate, Chloride (0, 50%, 100%)

- —500— Total dissolved solids in parts per million
- Isogram along which calcium + magnesium constitute 60 per cent of total cations; teeth indicate direction of lesser calcium + magnesium content
- Isogram along which sodium + potassium constitute 60 per cent of total cations; teeth indicate direction of lesser sodium + potassium content
- Isogram along which carbonate + bicarbonate constitute 60 per cent of total anions; teeth indicate direction of lesser carbonate + bicarbonate content
- Isogram along which sulfate constitutes 60 per cent of total anions; teeth indicate direction of lesser sulfate content*
- Isogram along which chloride constitutes 60 per cent of total anions; teeth indicate direction of lesser chloride content*

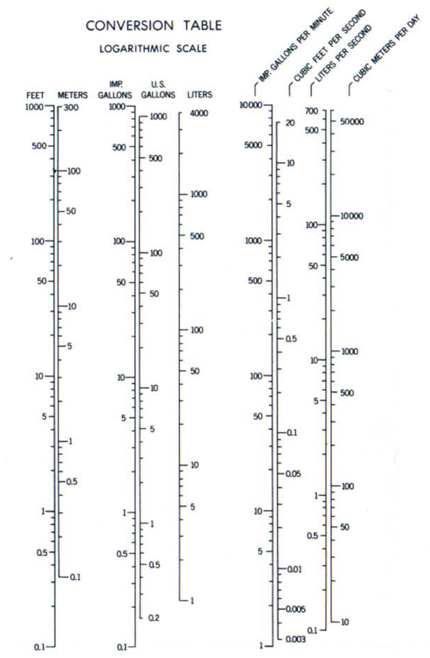
*Determined on equivalents per million basis.

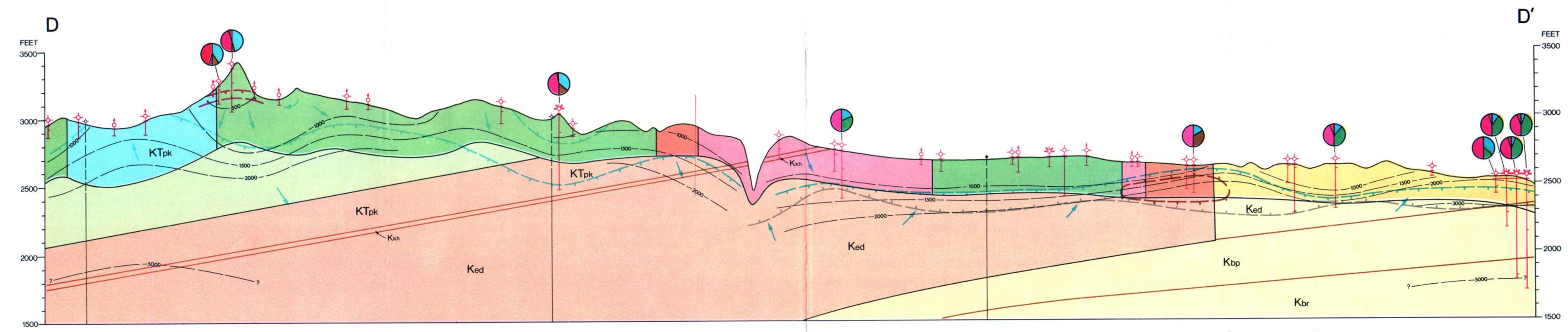
All elevations in feet above mean sea level.

Vertical exaggeration of the cross sections is approximately 40X.

An expanded legend and explanatory notes for use with this hydrogeological map series is available from the Research Council of Alberta, Edmonton, Canada.

CONVERSION TABLE
LOGARITHMIC SCALE





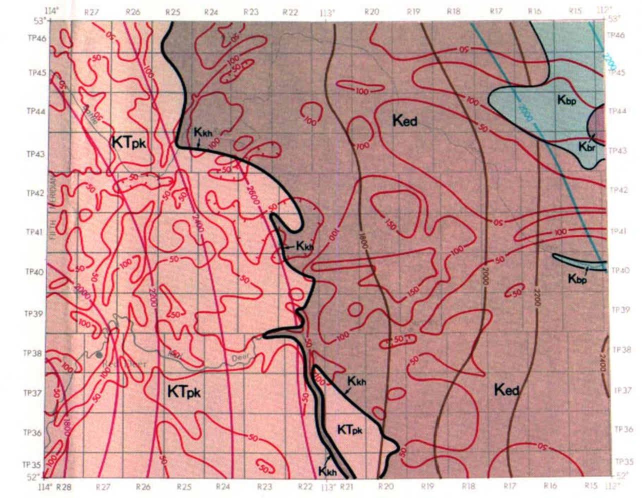
SCALE 1:250,000
Miles 5 0 5 10 15 20 Miles
Kilometers 5 0 5 10 15 20 25 30 Kilometers

Hydrogeology by E. Gordon Le Breton and R. Green, 1970, based on data collected in 1968
Cartographic editing by R. Green
Drawn by H. Weiss

HYDROGEOLOGICAL MAP
RED DEER AREA
ALBERTA

NTS 83A

GEOLOGY



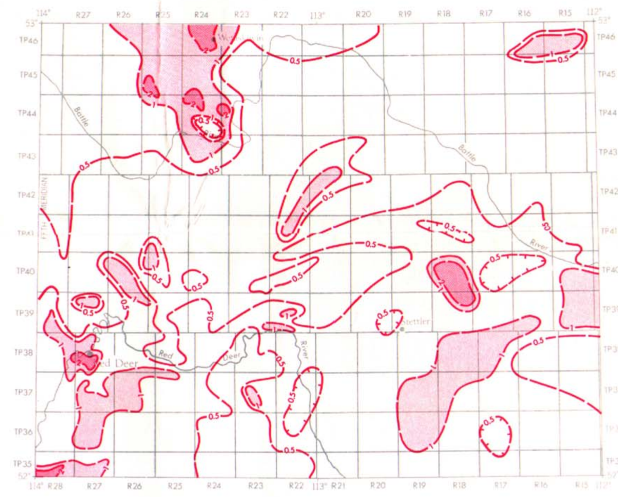
SCALE 1:1,000,000
Miles 5 0 10 20 Miles
Kilometers 5 0 10 20 30 Kilometers

LEGEND

KTpk	Paskapoo Formation: *sandstone, siltstone, minor coal*
Kkh	Kneehills Member, Edmonton Formation: *tuff, shale*
Ked	Edmonton Formation: *siltstone, sandstone, coal, shale*
Kbp	Bearpaw Formation: *shale*
Kbr	Belly River Formation: *sandstone, siltstone, shale*

- Rock unit boundary
- —50— Thickness of surficial deposits in feet
- —1800— Structure contour on top of Kneehills Member
- —1800— Structure contour on top of Bearpaw Formation
- —2000— Structure contour on top of Belly River Formation

FLUORIDE CONTENT

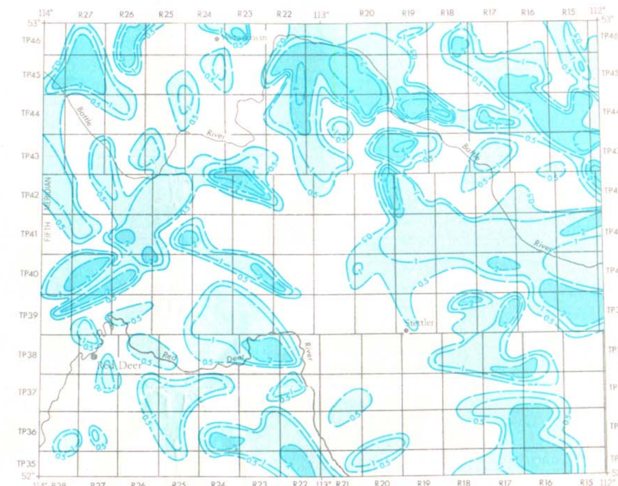


SCALE 1:1,000,000
Miles 5 0 10 20 Miles
Kilometers 5 0 10 20 30 Kilometers

LEGEND

- —2— Fluoride content in parts per million
- Fluoride content ranging between 1 and 2 parts per million
- Fluoride content over 2 parts per million

IRON CONTENT

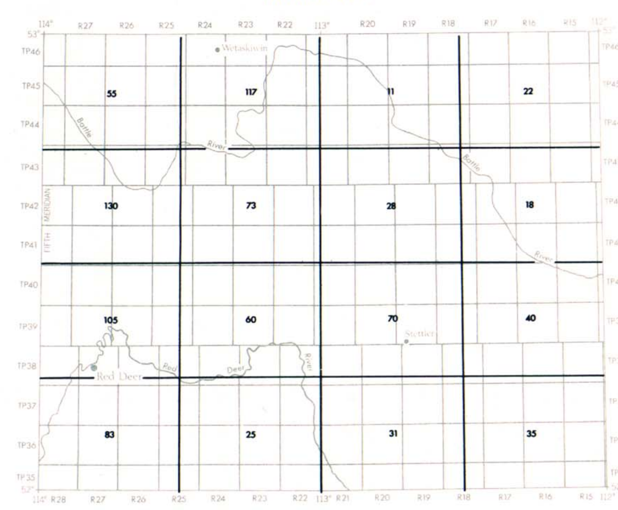


SCALE 1:1,000,000
Miles 5 0 10 20 Miles
Kilometers 5 0 10 20 30 Kilometers

LEGEND

- —2— Iron content in parts per million
- Iron content ranging between 0.5 and 2 parts per million
- Iron content over 2 parts per million

DATA DENSITY

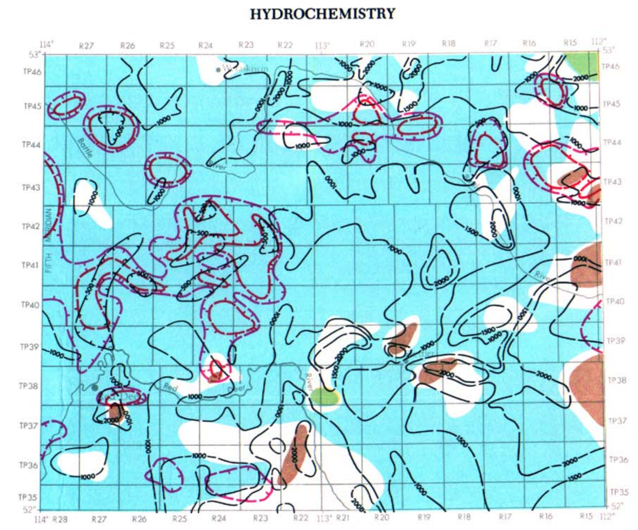


SCALE 1:1,000,000
Miles 5 0 10 20 Miles
Kilometers 5 0 10 20 30 Kilometers

LEGEND

Figures indicate the number of data points in each section of the map area used in construction of the yield area and hydrochemical maps.

HYDROCHEMISTRY



SCALE 1:1,000,000
Miles 5 0 10 20 Miles
Kilometers 5 0 10 20 30 Kilometers

LEGEND

- —1000— Total dissolved solids in parts per million
- Bicarbonate + carbonate constituting over 60 per cent of total anions, on equivalents per million basis
- Sulfate constituting over 60 per cent of total anions, on equivalents per million basis
- Chloride constituting over 60 per cent of total anions, on equivalents per million basis
- Isogram along which calcium + magnesium constitute 60 per cent of total cations; teeth indicate direction of lesser calcium + magnesium content
- Isogram along which sodium + potassium constitute 60 per cent of total cations; teeth indicate direction of lesser sodium + potassium content

Base maps provided by the Surveys and Mapping Branch, Department of Energy, Mines and Resources, Ottawa.

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