Report 74-10

# HYDROGEOLOGY OF THE EDMONTON AREA (NORTHWEST SEGMENT), ALBERTA

R. Bibby

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# ILLUSTRATIONS

# HYDROGEOLOGY
# OF THE EDMONTON AREA (NORTHWEST SEGMENT), ALBERTA


## Abstract

This report supplements the hydrogeological reconnaissance map of the northwest segment of the Edmonton map area (NTS 83H), providing some elaboration and discussion of map features.

The topography of the area is predominantly level to gently rolling. The area is drained by the North Saskatchewan and Sturgeon Rivers. These rivers are incised up to 200 feet below the plain level along parts of their course.

The area has a cold, humid continental climate, receiving 17.5 inches of precipitation on average each year, 70 percent as rain. The ground is frozen for 150 days in the average year.

Most of the area is covered by glacial materials, mainly till, and clay and silt. Buried valleys are coincident with the two main rivers and contain sand and gravel deposits which are in hydraulic connection with the rivers. The bedrock is the Wapiti Formation of Late Cretaceous age. It is highly heterogeneous consisting of shales, bentonitic sandstones and coal seams.

Yields are fairly high in the sand and gravel aquifers of the drift, particularly those in connection with the rivers. In the bedrock, yields are typically less than 5 igpm.

Groundwater flow systems in the upper 300 feet are largely controlled by the connection between the rivers and buried valley sand and gravel deposits, and by the incised nature of the valleys. In general, this connection has the effect of restricting regional-scale discharge areas to narrow bands paralleling the buried valleys.

The chemistry of the groundwaters shows a marked correlation with soil type and drift lithology. Groundwaters in areas covered by till, and clay and silt are typified by the presence of sulfate and higher total dissolved solids. The exchange of calcium for sodium as flow passes from the drift to the bedrock is pronounced and some sulfate reduction occurs in the bedrock.

Infiltration to groundwater systems is thought to be greatly influenced by drift lithology, soil type and topographic position, in addition to meteorologic factors. Areas of sand and gravel in topographically high positions are thought to contribute greatly to infiltration, in contrast to areas of till, and silt and clay in similar topographic positions. It is also thought that most infiltration occurs in the spring after snowmelt and after the ground has thawed.

# INTRODUCTION

This report is a brief elaboration of the information presented on the accompanying hydrogeological reconnaissance map of the northwest segment of the Edmonton map area (NTS 83H). The work of this area was undertaken during 1972 and 1973 and is part of Alberta Research's hydrogeological reconnaissance mapping program for the entire province. More detailed analyses of certain aspects of the hydrogeology are published elsewhere (Bibby, 1974a; 1974b).

## Acknowledgments

The author wishes to thank W. N. Assmus, N. Zacharko, and D. B. Brinkman who assisted in the field work undertaken during the study.

The following water well drillers greatly assisted the program by allowing wells which they had drilled for private individuals to be pump tested: Big Iron Drilling, Edmonton; L. L. Chorney, Sugden; P. E. Hansen, Edmonton; and D. Shank, Edmonton. Test drilling was carried out by J. Warehime of Barrhead.

The manuscript was reviewed by G. M. Gabert, R. Stein and E. I. Wallick and typed by Mrs. D. Borneuf. The map was edited by Mrs. A. R. Campbell and drafted by R. W. Swenson and J. H. Dey. The author would like to thank these individuals for their assistance.

# TOPOGRAPHY AND DRAINAGE

The topography of the area is mostly level to gently rolling, with an elevation of 2 200 to 2 300 feet above mean sea level. A small area in and around Tp. 54, R. 27 rises to 2 600 feet and is quite hilly. In the southeast corner of the study area the topography is also hilly and rises to 2 450 feet.

The main rivers draining the area are the Sturgeon and North Saskatchewan. Upstream from Big Lake the Sturgeon River occupies a valley having slopes of gentle gradient. Downstream from the lake the river is deeply incised, being 50 to

150 feet below the plain. The North Saskatchewan River cuts across the southeast corner of the area and is also deeply incised, being about 200 feet below the plain. Cutting across the northeast corner of the area is an incised glacial meltwater channel. It is about 100 feet below plain level but is no longer occupied by a major river. Drainage on much of the level parts of the area is poorly developed.

## CLIMATE

The climate is cold, humid continental, characterized by relatively warm summers (May to September average temperature is 56°F) and cold winters (November to March average temperature is 16° F). The growing season lasts about 175 days (Bowser ***et al.***, 1962).

The mean annual precipitation at Edmonton is 17.5 inches and in 75 percent of the years of record it has been between 14 and 21 inches. About 70 percent of the precipitation is rain and comes mostly in June, July and August, when the average is 9 inches. Summer rains are generally of the low intensity variety. The average annual snowfall at Edmonton is just over 50 inches, coming usually when the ground is frozen (on average about 150 days a year).

Further climatic information is presented on the meteorological side map.

## GEOLOGY

### Bedrock Geology

The near-surface bedrock deposits are of Late Cretaceous age. They are outlined on the geological side map. The strata are generally fine-grained, bentonitic sandstones and shales and have, on the regional scale, low transmissivities (20-100 igpd/ft). Locally, higher permeability units, such as lenses and channels, are embedded in the low transmissivity matrix. In addition, the abundant coal seams and zones generally have very high permeability, but are usually of limited areal extent.

### Surficial Geology

The surficial geology has been described by Bayrock (1972). Most of the area is covered by till, and silt and clay. These are low permeability materials containing large amounts of soluble salts. Areas of sand and gravel deposits occur at the surface in the southwest and northeast parts of the area.

The Sturgeon and North Saskatchewan Rivers are more or less coincident with buried valleys (Bibby, 1974a) containing sand and gravel deposits. The rivers are in hydraulic contact with the groundwater in these deposits and cause the water levels in the deposits to be at river level. There is also a buried valley running approximately due west from Big Lake. This also contains sand and gravel, but is not in hydraulic contact with a river. It is an area of flowing wells.

## HYDROGEOLOGY

### Yields

If a well were to be completed in any one of the yield-units shown on the reconnaissance map, with the entire unit open to the well, the yield value assigned to that unit is the rate at which the well could be pumped continuously for 20 years, such that, at the end of the 20-year period, the water level in the well would have drawn down to the top of the producing zone.

For the bedrock, wells in the area are usually completed in a locally high permeability unit (sandstone lens, coal seam, etc.) and most aquifer test data available to the study are from tests of only a few hours duration. Such tests give information on the hydraulic characteristics of the high permeability unit. However, it is the low permeability matrix which controls sustainable yields. This situation makes it impossible to follow the usual practice of extrapolating results from short duration pumping tests to values of 20-year safe yields, and makes it extremely difficult to define them. In general, safe yields of wells completed in the upper 250 feet of the bedrock are in the range 1 to 5 igpm. Small areas of higher and lower values do occur.

At greater depth, yields of 100 to 500 igpm are thought to be obtainable from the basal sandstone of the Belly River Formation. This sandstone occurs at a depth of 800 to 2 000 feet and overlies the Lea Park Formation. Its areal extent is shown on the geology side map. No pumping test information about this sandstone is available in this area. The yield estimate given on the map is based on its lithology, thickness, and extent as deduced from electrologs, the large available drawdown, and the fact that at shallower depths to the east it is known to have high transmissivity. The water is of the sodium chloride type with more than 10 000 ppm total dissolved solids content.

In the drift, the sand and gravel deposits usually provide good yields. In the buried valleys, where there is hydraulic connection with rivers, three factors in addition to the usual aquifer parameters influence the yields:

(1) pumping will result in induced infiltration from the river which has the effect of increasing yields;

(2) the water levels, being at river level, are lower than might otherwise be the case and this has the effect of decreasing the yields;

(3) the aquifers are unconfined, having a free water table, which means that for a given amount of drawdown the yield will be higher.

The net effect is that high yields can be obtained from these sand and gravel aquifers but that more than one well may be required to provide them.

## Flow Systems

The analysis of the water level contours of the drift and upper bedrock zones reveals two important features (Bibby, 1974b). Firstly, at all depths considered the water levels show a marked correlation with topography. Secondly, the flow directions have a downward component relative to the water table over most of the area. Areas of upward flow are restricted to narrow bands coincident with the valleys. This latter feature is considered to be the result of the following controlling influences:

(1) only a small proportion of the area has low topography;

(2) of the areas of low topography, some are deeply incised;

(3) all but one of the areas of low topography are coincident with buried valleys containing high permeability materials;

(4) these high permeability materials are in hydraulic contact with rivers, causing anomalously low potential levels (the buried valley to the west of Big Lake is an exception to this, and it, significantly, is the only area of flowing wells in the map area).

## Infiltration

Infiltration to groundwater systems could only be considered on a qualitative basis because of the absence of relevant information.

It is thought that infiltration is most important in the period following snowmelt and after the ground has thawed. Even though a substantial amount of snowmelt occurs before thawing so that there are losses to surface runoff, a lot of water accumulates in depressions and is available for infiltration. More than half the annual precipitation does occur in the summer but it is thought to be mostly lost to evapotranspiration for the following reasons. Potential evapotranspiration, as calculated by the Thornthwaite method (see meteorology side map), exceeds rainfall; there is an average water deficit of 5 inches during the growing season (Bowser ***et al.***, 1962); and rainfall is not usually of the intensive variety.

Infiltration is also considered to be greatly influenced by surficial geology. Areas covered by till, and clay and silt will have low infiltration rates, whereas areas of sand and gravel contribute significantly to infiltration. Such areas are to be found, at relatively high elevation, between Edmonton and Stony Plain, around Gladu Lake, and in the northeast corner of the map area.

## HYDROCHEMISTRY

Analysis of the chemistry of the groundwater shows that it has a marked correlation with lithology and soils and is secondarily influenced by flow direction (Bibby, 1974b). In the drift and upper part of the bedrock, groundwaters in areas in which the surficial deposits are sand and gravel have lower total dissolved solids than groundwaters in areas of till, silt and clay. The former areas have calcium bicarbonate waters in the drift and sodium bicarbonate in the bedrock. In the latter areas, sulfate occurs in significant concentrations. To the depths considered, chloride occurs only in very small concentrations.

Two chemical processes are recognized as being active in the area. There is more or less complete exchange of calcium and magnesium for sodium as groundwaters move from the drift to the bedrock. The quantities of bicarbonate increase with depth at the expense of sulfate, and since organic materials are abundant in the bedrock it is thought that some sulfate reduction is occurring.

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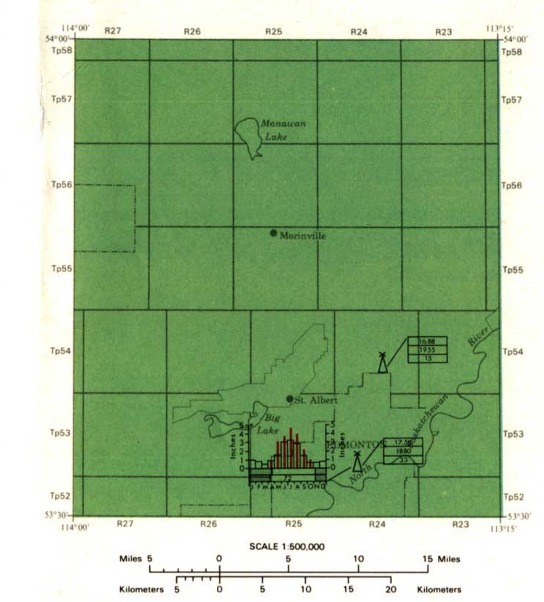
Alberta RESEARCH

## METEOROLOGY



SCALE 1:500,000

### LEGEND

Mean annual precipitation:
15-20 inches

Meteorological station

Precipitation data:

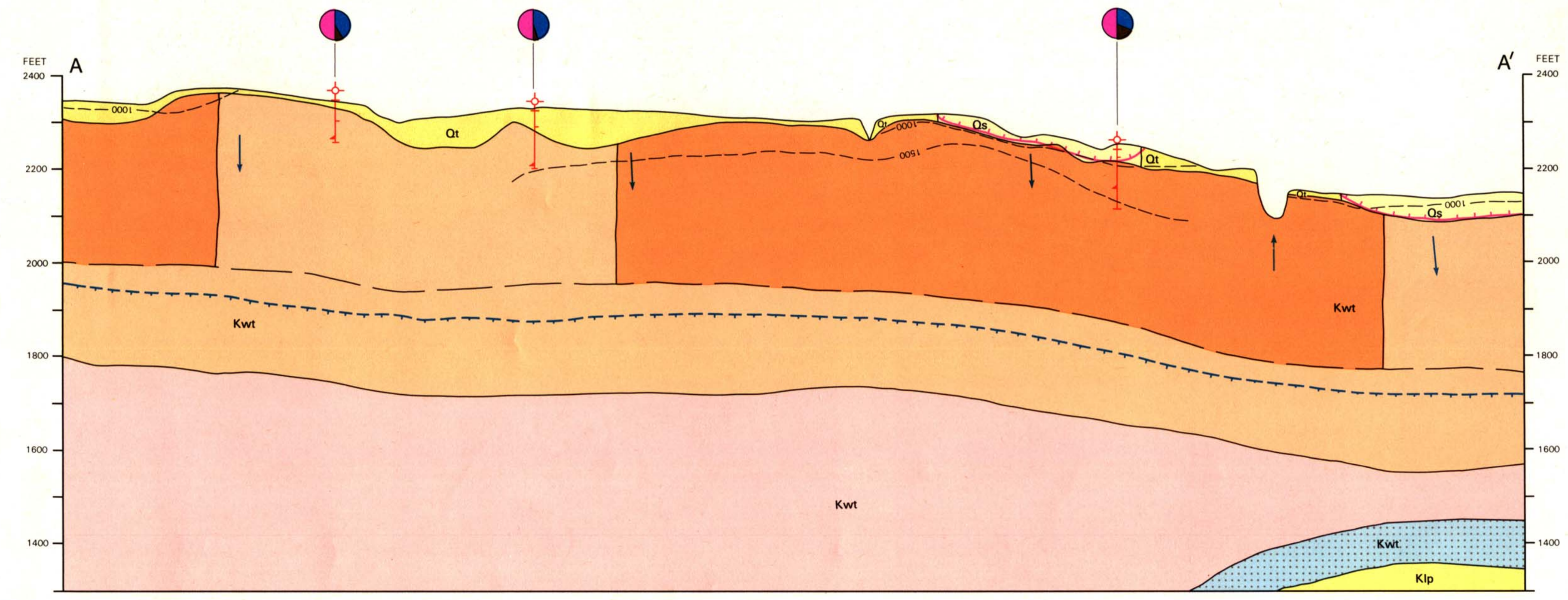
- Mean annual precipitation in inches
- Year of commencement of observations
- Number of years of record used to calculate mean annual precipitation figure
- Mean monthly potential evapotranspiration
- Mean monthly precipitation
- Period when surface is usually snow covered
- Period with mean daily temperature below freezing
- Figure indicates percentage of mean annual precipitation falling as rain

17.58 / 1880 / 33

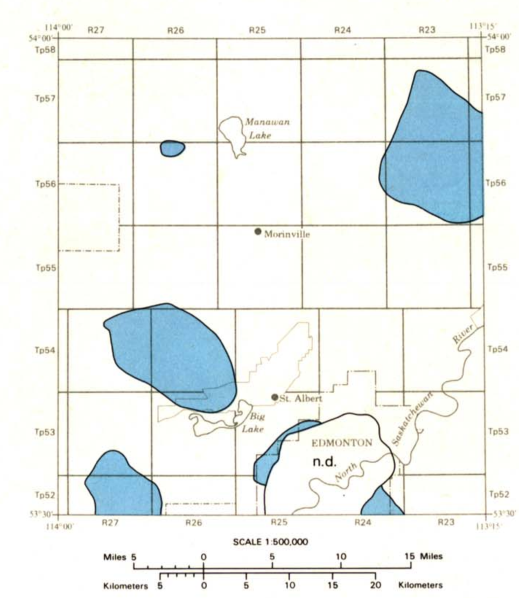
Months of the year

Sources of data:

Meteorology Summary; Long-term records 1881-1965 (Dominion Public Weather Office, Edmonton, 1965).
Monthly Record of Meteorological Observations (Meteorological Branch, Canada Department of Transport).



## FLUORIDE CONTENT: BEDROCK



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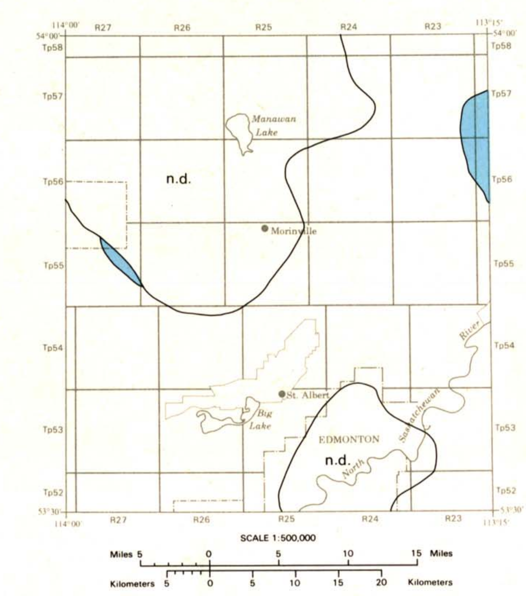
## FLUORIDE CONTENT: DRIFT



SCALE 1:500,000

### LEGEND

Fluoride content in parts per million:
0.1-0.5
0.5-1.0
Area of no data — n.d.

## MAIN MAP LEGEND

### Topography

Surface contours and elevation in feet (interval 50 feet)

### Geology

Geological boundary

Thalweg of buried valley

QUATERNARY

- Qs — Sand
- Qt — Till
- Qpsg — Saskatchewan Sands and Gravels
- Ql — Lacustrine clay, silt

CRETACEOUS

- Kwt — Wapiti Formation
- Klp — Lea Park Formation

### Lithology

Sand
Sand and gravel
Coal
Shale
Sandstone
Bentonitic sandstone

### Hydrography

Lake or slough, perennial
Lake or slough, seasonal
Stream, perennial
Stream, intermittent
Marsh
Area inundated during floods
Surface water divide

### Hydrometry

Stream gauging station

- Average annual discharge in cubic feet per second — 7720
- Year of commencement of observations — 1911
- Number of years averaged for average annual discharge figure — 60
- Drainage area in square miles — 10500

Source of data:
Surface Water Data Alberta (Inland Waters Branch, Department of Energy, Mines and Resources)

### Hydrogeology

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

*Nonpumping water level contours correspond to lithology

Groundwater divide
Boundary of area of artesian flow
Horizontal component of groundwater flow (main map)
Component of groundwater flow perpendicular to profile:
out of profile (i.e., towards reader)
in to profile (i.e., away from reader)
Component of groundwater flow parallel to profile

### Groundwater Probability†

Range of average expected yield of wells (in imperial gallons per minute)

Probable: estimated from quantitiative information (pump tests, bail tests, etc.)

Possible: estimated from qualitative information (flow regime, lithology, etc.)

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

Yield boundary
Maximum depth of investigation for yield values on main map

†The indicated average expected yields to wells are predictions based on the best data available at the time of map compilation; due to data shortcomings and special conditions, local discrepancies between predicted and actual yields are inevitable. Multiaquifer completion may be necessary to obtain the yield indicated.

### Wells and Other Artificial Works

Depth Scale — FEET 0, 100, 200, 300, 400 — Depth to water; Base of casing; Depth of well or seismic shot hole

Water well, nonflowing
Water well, 20-year safe yield calculated from apparent transmissivity
Water well, 20-year safe yield calculated from a good bail test or a short pump test
Observation well, automatic recorder
Location of Alberta Research test well — AR

Line of hydrogeological profile — A A′

### Hydrochemistry

Calcium; Magnesium; Sodium + potassium; Carbonate + bicarbonate; Sulfate; Chloride; 50%; 100%; CATIONS | ANIONS

Note: When the yellow Mg pie sector is absent, Ca + Mg are represented as a unit by the red pie sector.

Total dissolved solids in parts per million:
approximate

Isogram along which calcium + magnesium constitute 60 percent of total cations;* teeth indicate direction of lesser calcium + magnesium content

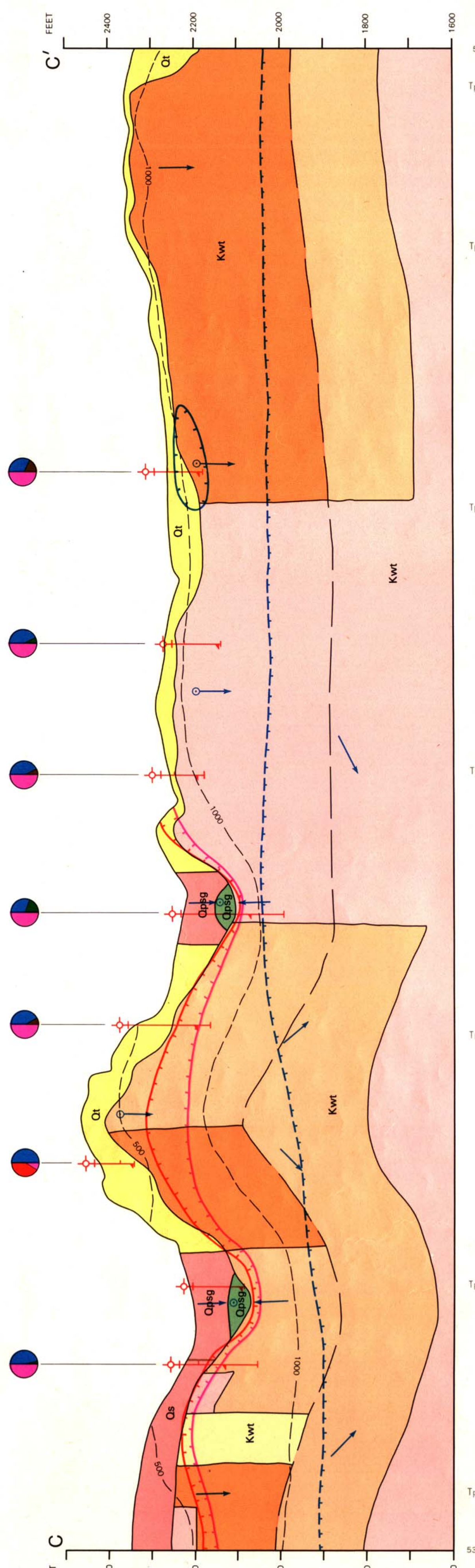
Isogram along which sodium + potassium constitute 60 percent of total cations;* teeth indicate direction of lesser sodium + potassium content

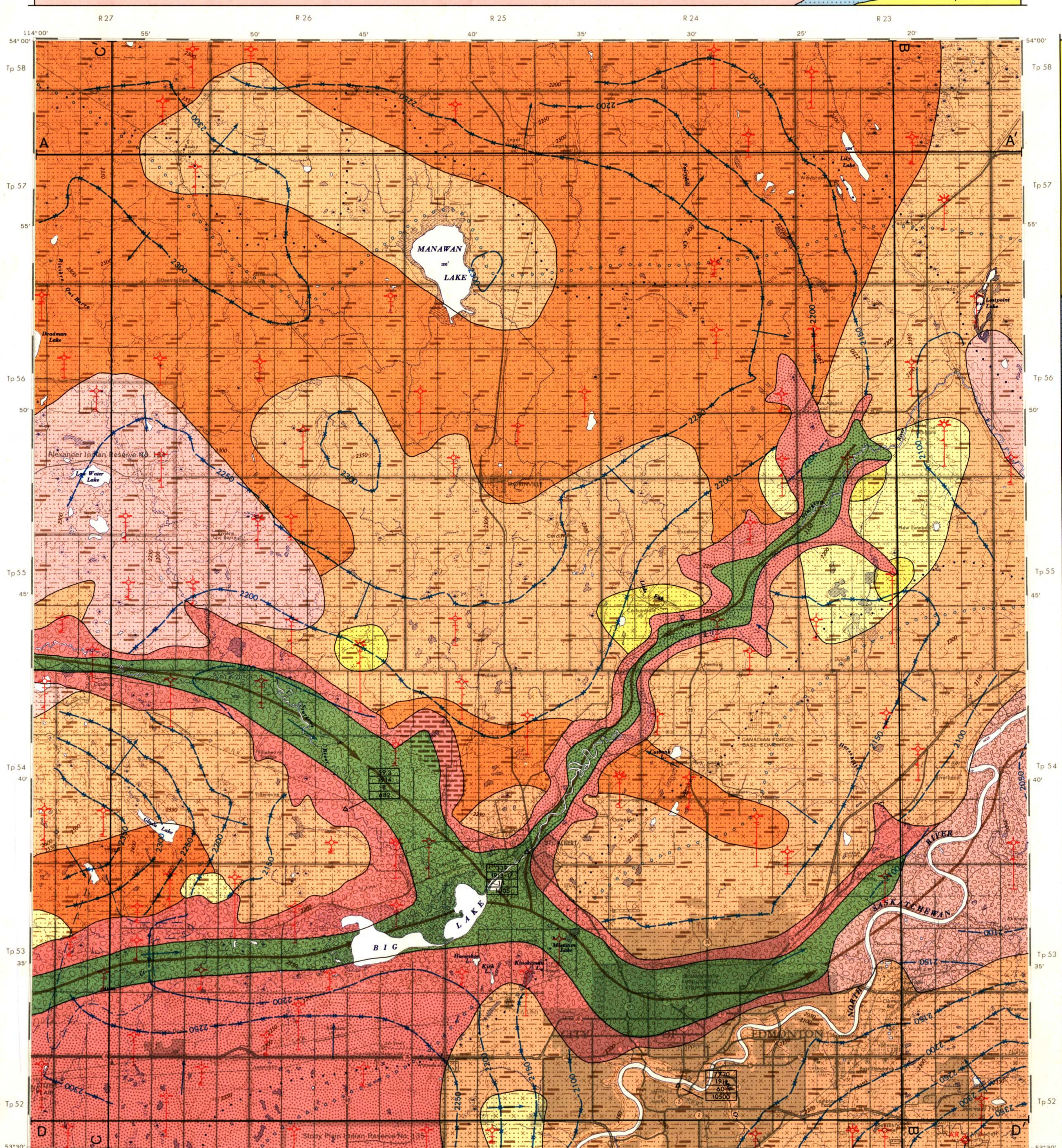
Isogram along which carbonate + bicarbonate constitute 60 percent of total anions;* teeth indicate direction of lesser carbonate + bicarbonate content:
defined
approximate

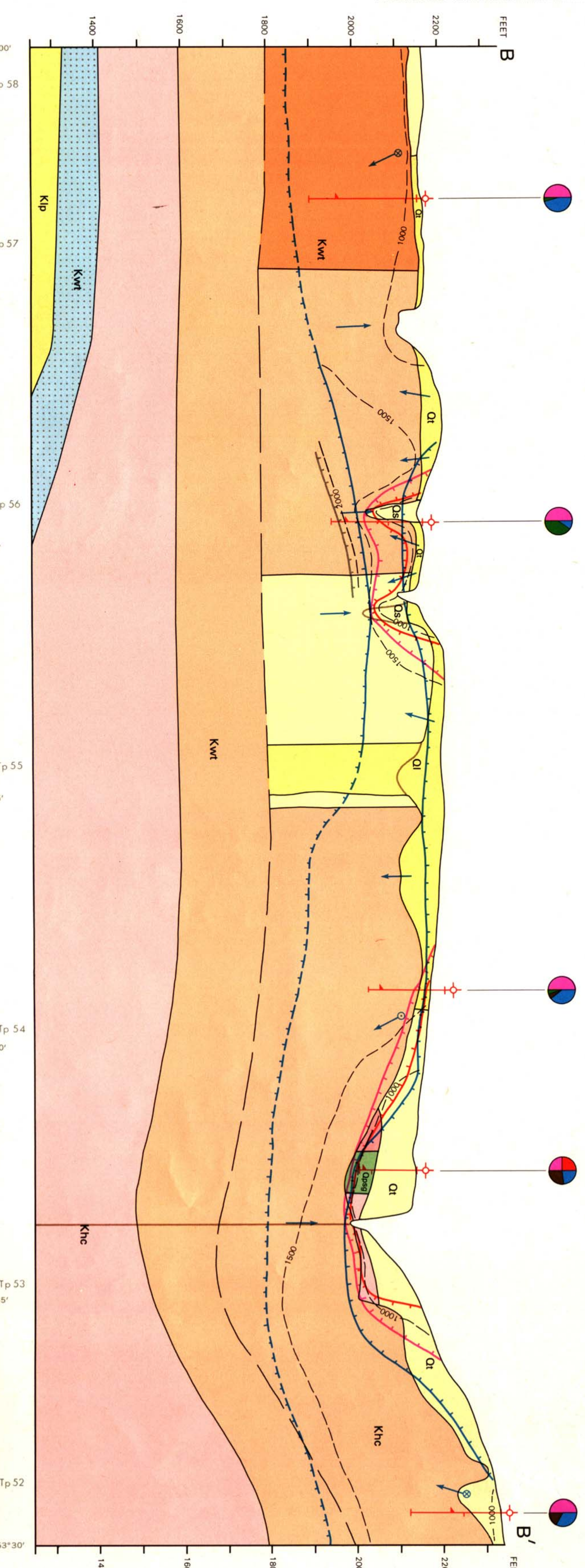
Isogram along which chloride constitutes 60 percent of total anions*; teeth indicate direction of lesser chloride content

*Determined on equivalents per million basis.

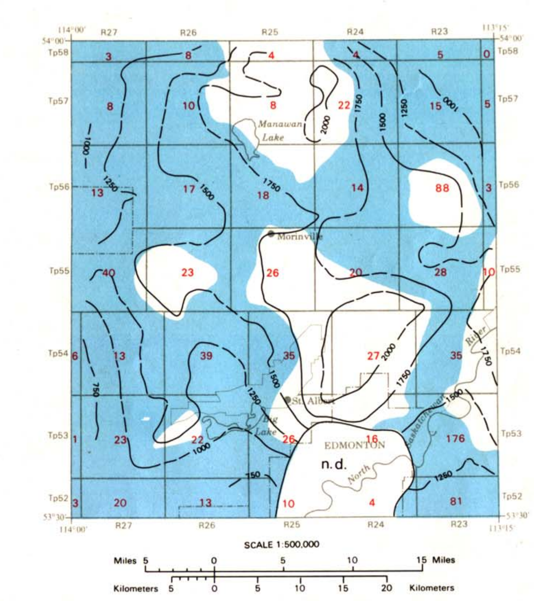
Base map provided by Alberta Lands and Forests.







## HYDROCHEMISTRY: BEDROCK



SCALE 1:500,000

### LEGEND

Number of data points used in each township and range — 3

Total dissolved solids in parts per million:
defined
approximate

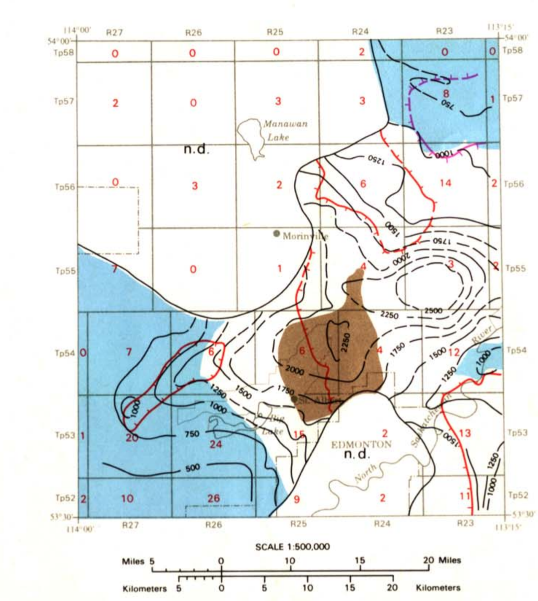
Carbonate + bicarbonate constituting over 60 percent of total anions*

Area of no data — n.d.

Over entire map area calcium + magnesium constitute less than 60 percent of total cations* and sodium + potassium constitute more than 60 percent of total cations.*

*Determined on equivalents per million basis.

## HYDROCHEMISTRY: DRIFT



SCALE 1:500,000

### LEGEND

Number of data points used in each township and range — 2

Total dissolved solids in parts per million:
defined
approximate

Carbonate + bicarbonate constituting over 60 percent of total anions*

Sulfate constituting over 60 percent of total anions*

Area of no data — n.d.

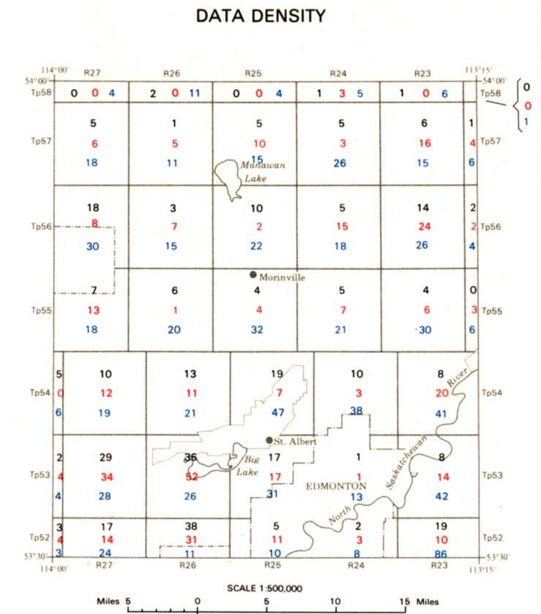
Isogram along which calcium + magnesium constitute 60 percent of total cations;* teeth indicate direction of lesser calcium + magnesium content:
defined
approximate

Isogram along which sodium + potassium constitute 60 percent of total cations;* teeth indicate direction of lesser sodium + potassium content:
defined
approximate

Over entire map area chloride constitutes less than 60 percent of total anions.*

*Determined on equivalents per million basis.

## DATA DENSITY



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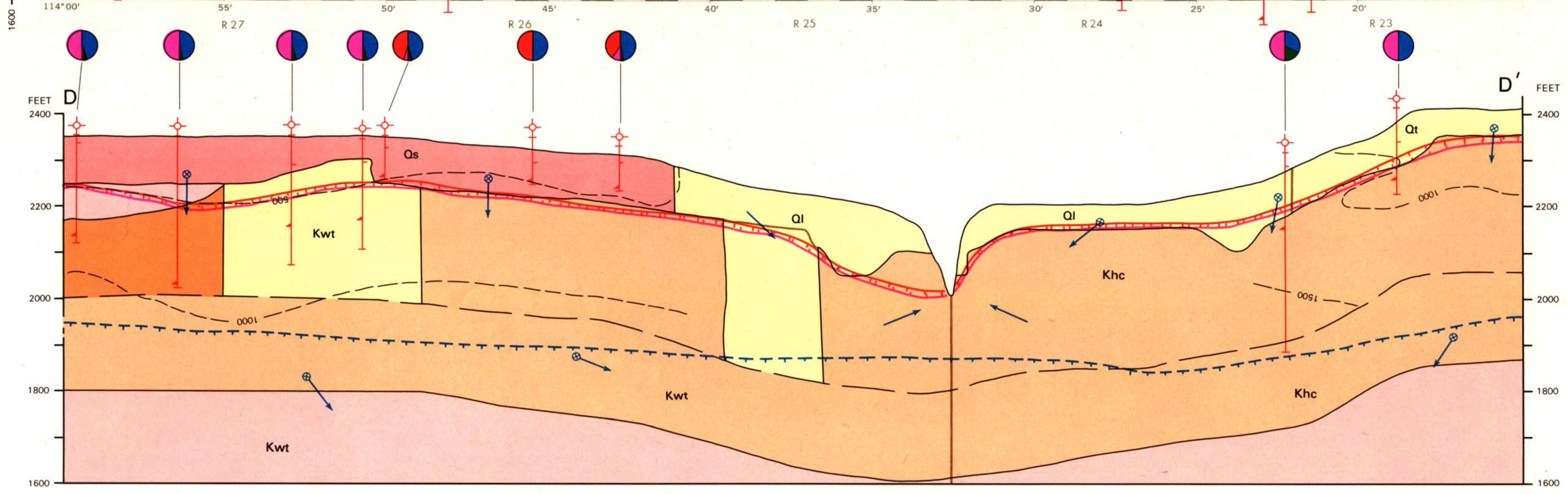
### LEGEND

Number of data points used in each township and range in determining:
- Yield values and apparent transmissivities — 3
- Water levels in drift — 4
- Water levels in bedrock — 3



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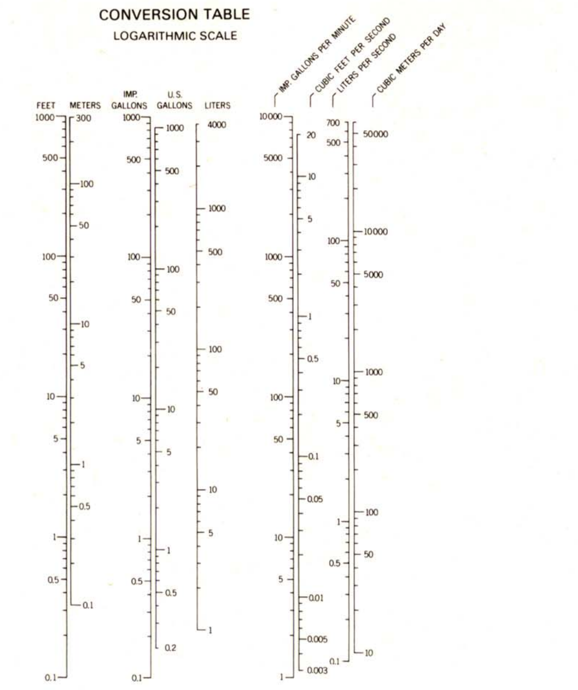
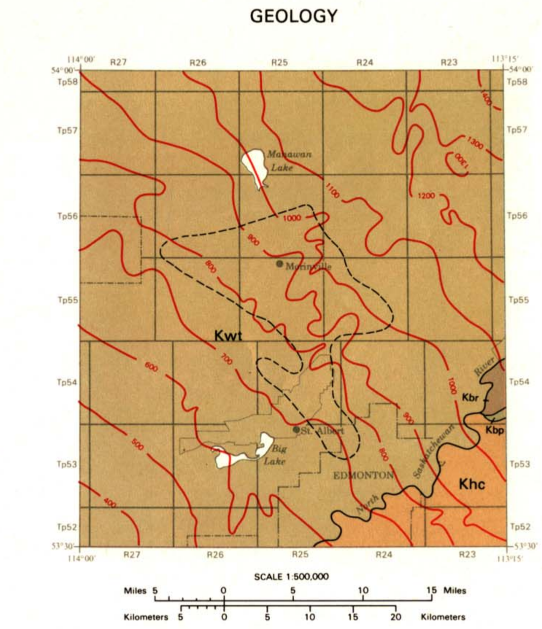
## CONVERSION TABLE

LOGARITHMIC SCALE



## GEOLOGY



SCALE 1:500,000

### LEGEND

- Kwt — Wapiti Formation: *sandstone, mudstone, bentonite, coal beds*
- Khc — Horseshoe Canyon Formation: *sandstone, bentonitic mudstone, shale, ironstone beds, coal*
- Kbp — Bearpaw Formation: *shale, sandstone, thin ironstone and bentonite beds*
- Kbr — Belly River Formation: *sandstone, siltstone, mudstone, ironstone beds*

Rock unit boundary
Structure contour on top of Lea Park Formation
Area within which basal Belly River sandstone is absent

All elevations in feet above mean sea level.

Vertical exaggeration of the hydrogeological profiles is approximately 50X.

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

Map to accompany Report 74-10.

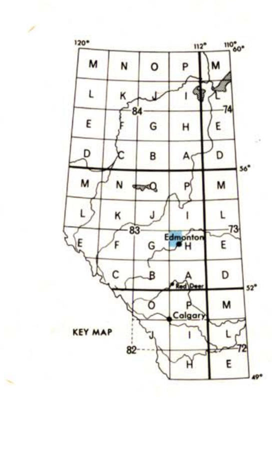
Hydrogeology by R. Bibby, 1973, based on data collected in 1972 and 1973.

Drawn by R. Swenson and H. Dey.

Cartographic editing by F. H. Smith and A. R. Campbell

# HYDROGEOLOGICAL MAP EDMONTON AREA (Northwest Segment) ALBERTA

NTS 83H-N.W.(Part)



KEY MAP