Report 76-2

Hydrogeology of the Iosegun Lake area, Alberta

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Alberta Research Council
1977

CONTENTS

ILLUSTRATIONS

HYDROGEOLOGY OF THE IOSEGUN LAKE AREA, ALBERTA

ABSTRACT

The Iosegun Lake area is only thinly covered by drift in the more rugged, hilly areas. The drift thickness may exceed 200 feet (60 m) in the area of Little Smoky River where thick buried valley sand forms an important aquifer from which yields in excess of 25 igpm (2 l/sec) are common. A continental sandstone-shale sequence, the Paskapoo Formation of Paleocene-Late Cretaceous age, underlies most of the southern and southwestern parts of the area and contains sandstone aquifers generally capable of producing upwards of 25 igpm (2 l/sec) to a single well. The Wapiti Formation, a continental sequence of bentonitic and clayey sandstones of Late Cretaceous age, underlies the remainder of the area. Aquifers within this formation are generally thin and discontinuous. Yields in a single well usually range between 5 to 25 igpm (0.4 to 2 l/sec).

Sodium bicarbonate waters with total dissolved solids contents between 500 and 1500 ppm are the rule in the normally utilized aquifers, although wells completed in the Paskapoo Formation tend to have somewhat higher percentages of calcium and magnesium, and lower total dissolved solids contents.

INTRODUCTION

The area is bounded by latitudes 54° and 55° north and longitudes 116° and 118° west. Under the Alberta Land Survey system it includes most of townships 58 to 69 and ranges 14 to 27, west of the fifth meridian. The total area encompassed is approximately 5400 square miles (approximately 14,100 sq km).

The hydrogeological survey on which the accompanying map is based was carried out in 1971 in conjunction with a survey of the adjoining area to the east (Whitecourt, NTS 83J). A previous hydrogeological study covering part of the area had been carried out by Jones (1962).

The area is almost completely unsettled; consequently water well data is sparse. Highway 43, which cuts across the area, is the main road link between central Alberta and the Peace River district. Some farming is carried out in the vicinity of Little Smoky and northwards. There are numerous gas processing plants within the area. The town of Fox Creek, with a population in 1970 of 876 people, services many of the oil and gas fields. Lumbering is an important industry. Fur trapping was important in past years and is still carried on to a small extent. The area is also popular for moose-hunting.

Fox Creek is the only community within the area and uses a groundwater source for water. Little Smoky consists of two gas stations and some cabin accommodation for travellers. There is no settlement of any kind at either Two Creeks or Windfall.

Acknowledgments

Field and office assistance and drill site supervision were ably handled by A. Beerwald, who also compiled water well information on 1:50,000 scale maps prior to the start of the field work. Thanks are extended to all the fine people that were contacted during the course of this survey.

Test drilling and pump testing of previously existing and newly drilled wells was carried out by arrangement with Charlie Saville of Valleyview and with L. M. Water Wells Ltd. of Edmonton. Thanks are extended to Colin Samis, Water Resources Division, Alberta Environment, for his help in contacting other drillers for information.

Chemical analyses of water samples were performed by the Council's Geochemical Laboratory and by the Veterinary Services Division Laboratory of Alberta Agriculture.

The manuscript was edited by R. Bibby, G. Ozoray and J. Tóth and their help is gratefully acknowledged.

CLIMATE

The climate of the area is humid continental, characterized by long, cool summers according to the Koeppen climatic zone classification (Longley, 1968). The mean temperature ranges in July, the hottest month, from 54° to 60°F (12.2° to 15.6°C), and in January, the coldest month, from 4° to 10°F (-15.5° to -12°C). The mean annual precipitation ranges from less than 20 to over 24 inches (51 to 61 cm).

Monthly rates of potential evapotranspiration have been approximated from maps prepared by Bruce and Weisman (1967) and are shown for the Lookout Tower at Snuff Mountain. Potential evapotranspiration at this site during the period from May to September inclusive appears to exceed rainfall in all months except August.

A small area of climafrost (Lindsay and Odynsky, 1965) is to be found in the northeast corner of the area. In this area a frozen layer within organic soils may be encountered in shaded locations. The frozen condition is expected to be temporary but frequently lasts for more than one year. "The frozen layer ... could usually be penetrated with a steel probe, and occurred at an average depth of 24 inches." (Lindsay and Odynsky, 1965, p. 265).

The climatic factors just discussed all have an influence on the total water budget. The amount of annual recharge to the groundwater body has not been calculated for this area. However, in areas of similar climate in Alberta, the amount of recharge has been variously calculated to be: 2 percent of the total annual precipitation west of Edmonton where clay and till are the main near-surface materials (Farvolden, 1963); and 7.5 to 12 percent of the total annual precipitation near Grimshaw where gravel overlain by a thin till cover is the main near-surface material (Tokarsky, 1971).

Mean annual runoff (Neill *et al.*, 1970 Fig. 11) ranges from about 5 inches (13 cm) in the southeast corner of the area to over 10 inches (25 cm) in the southwest corner.

PHYSIOGRAPHIC FEATURES

The physiographic features of the area are named as outlined in the Atlas of Alberta (Univ. and Govt. of Alberta, 1969). The Wapiti Plain includes the lowlands which are traversed by Highway 43, and which cover the northwest and central part of the area. This plain adjoins the Eastern Alberta Plains in the Athabasca River valley near the eastern edge of the map area. The Western Alberta Plains cover the southern and southwest parts of the area and generally exceed 3000 feet (910 m) above sea level. Part of the Swan Hills Upland which also generally exceeds this elevation is present in the northeast part of the area.

The Swan Hills Upland and the Western Alberta Plains have rugged, hilly topography with maximum elevations exceeding 4400 feet (134 m) above sea level. The topography within the Wapiti Plain is much more subdued. Elevations below 2000 feet (610 m) above sea level are attained in the lower reaches of the Simonette River.

The major rivers are the Athabasca River and its tributary, the Berland River; Little Smoky River and its tributaries, Goose and Iosegun Rivers; and the Simonette River. All are part of the Mackenzie River system which drains to the Arctic Ocean.

GEOLOGY

Geological units within the bedrock are shown as indicated by Green (1972). Green's description of these units is as follows:

Paleocene and Upper Cretaceous

Paskapoo Formation (TKp): *grey to greenish grey, thick bedded, calcareous, cherty sandstone; grey and green siltstone and mudstone; minor conglomerate, thin limestone, coal and tuff beds;*

Scollard Member (Ksc): *grey, feldspathic sandstone, dark grey bentonitic mudstone; thick coal beds; nonmarine.*

Upper Cretaceous

Whitemud and Battle Formations (Kwb): *pale grey, white-weathering bentonitic sandstone and mudstone (Whitemud Formation); purplish-black, mauve-weathering bentonitic mudstone containing siliceous tuff beds (Battle Formation); nonmarine.*

Wapiti Formation (Kwt): *grey, feldspathic, clayey sandstone; grey, bentonitic mudstone and bentonite; scattered coal beds; nonmarine.*

The Wapiti Formation, based on electrolog interpretation, can be divided into two informal units as indicated on the cross sections accompanying the map. The lower unit contains more, and more continuous, sandstone lenses than does the upper, and when present at shallow depths would be expected to contain higher yielding aquifers.

Structure contours have been drawn on the top of the Battle Formation with the aid of J. W. Kramers. A general southerly to southwesterly dip of approximately 25 feet per mile (about 5 m per km) is indicated.

Surficial geology within the east half of the area has been mapped by St-Onge (1969). Carlson (in prep) has mapped the bedrock topography. Drift cover is thin, generally less than 50 feet (15 m), except in the area of Goose, Iosegun, and Little Smoky Rivers where it can exceed 200 feet (60 m) in thickness. Drift thicknesses in excess of 50 feet (15 m) but generally less than 100 feet (30 m) are to be found along Athabasca River, Marsh Head Creek, and parts of Little Smoky and Berland Rivers. Campbell (1972) and Kramers and Mellon (1972) have described coal occurrences within the area. Campbell's drillhole control and some of the geological data of the latter authors have been incorporated into the hydrogeological map.

HYDROGEOLOGY

Water Levels

Few wells have been drilled in the area and they have been completed at various depths within many different aquifers. It is therefore very difficult to construct meaningful water level maps, especially on a base map with only a 200-foot (60-m) contour interval. In spite of these difficulties, average water level contours for wells 100 to 400 feet (30 to 120 m) in depth have been constructed. These give an indication of groundwater flow direction, which in fact can almost as easily be obtained from the topographic contours since the water levels are more or less a subdued replica of the topography. Areas of presumed downward (recharge) and upward (discharge) groundwater movement are indicated along the water level contours. Contours have been drawn only for the central and northern parts of the area.

Flowing Wells

Areas of flowing wells and shotholes have been delimited. Only the largest of such areas could be shown. Smaller, more localized areas are not shown and can occur along streams, at the bases of hills, and at local breaks in slope. The areas outlined are generalized and may include smaller areas in which wells will not flow.

Aquifers

The lithology of the principal aquifer underlying any area is indicated on the map. The main aquifer types are:

1) Recent alluvial gravels along the Athabasca River
2) buried valley sands along the Little Smoky, Goose, and Iosegun Rivers
3) high-level gravels on the Swan Hills and in the southern part of the area
4) Paskapoo Formation sandstones
5) bentonitic sandstones
6) more rarely, coal seams of the Wapiti Formation and Scollard Member of the Paskapoo Formation.

Fracture permeability is dominant in the coal seams, and is probably also important in other aquifers.

Aquifers within both the Paskapoo and Wapiti Formations are lenticular and may have only limited lateral extent; however, aquifer-bearing zones are often traceable for many miles.

Average Expected Well Yield

The average expected well yields shown on the map indicate the total quantity of water that can be obtained by a single, properly constructed and developed well that taps all water-bearing intervals within the upper 1000 feet (300 m) of strata, regardless of quality. In the majority of cases, most of the yield will be from a single zone and generally from depths of less than 300 feet (90 m).

The yield values are 20-year estimates based largely on apparent transmissivity and available drawdown.

It should be stressed that this is an interpretative map based on limited control, which in the higher yield ranges especially (over 25 igpm or 2 l/sec) is often of dubious reliability. Areas in which a yield range is based on long-term pump tests, production tests, or numerous short-term bail and pump tests, are shown by a dark color. Where the yield range is less well established, that is, where test data is lacking or scarce or judged to be of low reliability, a light color has been used.

Even in areas where the expected yield is shown to be established, local areas of higher or lower expected yield can be found. This can be due to presence or absence of local, relatively more permeable lenses of sandstone, sand or gravel, to weathered zones at the drift-bedrock contact, or to other unsuspected conditions. A good understanding of the subsurface geology is essential when interpreting probable well yield.

Where data are scarce, numerous assumptions have had to be made. Some of these are:

1) the geology largely determines rock permeability;
2) topography and, to a lesser extent geology, largely determine saturation and head conditions;
3) geology and topography together largely determine the yield to be expected and areas of similar geology and topography will have similar yields;
4) the amount of precipitation has little effect on short-term pumping tests (on which this evaluation is largely based) during which water is drawn almost entirely from existing storage;

5) in rock masses containing "good" aquifers (Todd, 1959) expected yields in wells of equal depth are markedly lower in topographically high areas than in low areas due to large differences in available head of water, unless the high areas have a wide lateral extent;
6) in rock masses containing poor aquifers (for example, thick shale sequences and some sandstone-shale sequences) the yield range is not noticeably different under differing topographic situations;
7) alluvial gravels normally form good aquifers.

Detailed water level measurements for only 10 pump tests of 24 hours or more in duration were available at the time this study was made; and of these, six were within one small area. Most of the yield values are based on calculations of apparent transmissivity. This was supplemented by well performance records as determined from drillers, farmers, and industrial or town records. The specific capacity or apparent transmissivity could sometimes be obtained from this information.

The two most important factors which determine the yield are the geological situation and the topographic position of favorable formations. Yield boundaries and lithology changes should, therefore, often be coincident. For various reasons, the coincidence occurs less often than might be expected, although this may be more apparent than real, due to shortcomings of test interpretation, well completion and development, to unforeseen changes in facies and permeability within a single stratigraphic unit, and to lack of knowledge of stratigraphic details. The accurate delineation of yield areas is largely dependent on detailed knowledge of the geology of the area. In this area, the detailed stratigraphy of surficial materials especially is poorly known. Delineation of permeable beds and lenses by stratigraphic studies, along with some pump testing, is necessary to further evaluate this area. This has been done only in broad outline because of the limited time available for the present study. The result is small patchy areas of varying probable yield, the highest yield areas reflecting more permeable zones, largely sand and gravel within the drift and permeable sandstone within the bedrock formations. The more permeable materials are generally river-sorted and deposited and, where buried beneath later deposits, can be very difficult to locate. Sorting and thickness of different grain size ranges can be quite variable which makes accurate predictions of long-term yields difficult.

Yields of *over 500 igpm* (38 l/sec) have not been assigned to any area although such yields may be possible under favorable conditions at certain localities from alluvial gravels, from buried valley sands and gravels, or from Paskapoo Formation sandstones.

Yields of *100 to 500 igpm* (8 to 38 l/sec) are considered possible from buried valley sands along the Little Smoky River, and from Paskapoo Formation sandstones in two areas near Smoke Lake. Buried valley sands and gravels along or near Goose and losegun Rivers, as well as other areas underlain by Paskapoo Formation, may also be capable of these rates of production but are considered to be insufficiently tested and delineated at this time to merit this yield assignation.

Yields of *25 to 100 igpm* (2 to 8 l/sec) are considered possible over most of the area underlain by the Paskapoo Formation exclusive of the Scollard Member, although local sandstone developments within the Scollard Member capable of such production are also present (for example, near Fox Creek and along the Waskahigan River). Other such areas are undoubtedly present elsewhere within the Scollard Member but have not yet been delineated. Buried valley sands, and sands and gravels along Little Smoky, Goose, and losegun Rivers have been proven in places to be capable of at least this rate of production. Present-day alluvial gravels along the Athabasca River are also probably capable in favorable areas of at least this rate of production.

Yields of *5 to 25 igpm* (0.4 to 2 l/sec) are considered to be possible over most of the remainder of the area, from bedrock aquifers, thin alluvium and intertill, or near-surface sands and gravels. Areas of both higher and lower yield will undoubtedly also be found in time within this area.

Only three very small areas have been rated as capable of yielding less than *5 igpm* (less than 0.4 l/sec) to a well. Holes obtaining very low production have been drilled in two of these areas, and the third has been so rated using geological considerations.

Springs

Within this map area, springs are an indication of near-surface aquifers, and their rates of flow give an idea of possible rates of production from wells tapping these aquifers. Selected springs are shown on the map and their rates of flow as measured or calculated at the time of mapping are indicated.

The largest springs are located within the Athabasca River valley and originate from alluvial terrace gravels. These gravels are probably fairly thin although of considerable lateral extent and are probably recharged directly by rainfall and by bodies of standing water and muskeg lying on the terraces. Well yields from these gravels could very well be much higher than indicated on the map.

HYDROCHEMISTRY

The hydrochemistry of the most commonly utilized aquifers within selected depth intervals is shown on the hydrochemical side maps, and changes with depth are further illustrated on the accompanying cross sections.

Calcium-magnesium bicarbonate waters of low total dissolved solids contents (generally less than 500 ppm) are the rule in wells less than 50 feet (15 m) deep. *Sodium bicarbonate* waters with total dissolved solids contents ranging mostly from 500 to 1500 ppm are the commonest in deeper wells down to about 500 feet (150 m) in depth. Water analyses from greater depths are lacking until the depth interval 1800 to about 4000 feet is reached (550 to 1200 m). A few analyses of water from sandstones within the lower parts of the Wapiti Formation at these depths indicate the predominance of water of the *sodium bicarbonate/chloride* type with total dissolved solids contents ranging from about 1000 to 2300 ppm. *Sodium chloride* waters with total dissolved solids contents exceeding that of sea water are the rule in very deep formations (that is, within the Paleozoic sequence and within Lower Cretaceous clastics).

High iron content is a problem in many of the domestic wells in the vicinity of Little Smoky River.

CONCLUSIONS

The highest expected well yields within the map area are to be found within buried valley sands and gravels, within Paskapoo Formation sandstones, and within present-day alluvial gravels.

Sodium bicarbonate waters with total dissolved solids contents generally between 500 and 1500 ppm are the rule in the normally utilized aquifers.

More, and more detailed, subsurface geological information is required and many detailed pump tests are needed in order to evaluate the area more fully.

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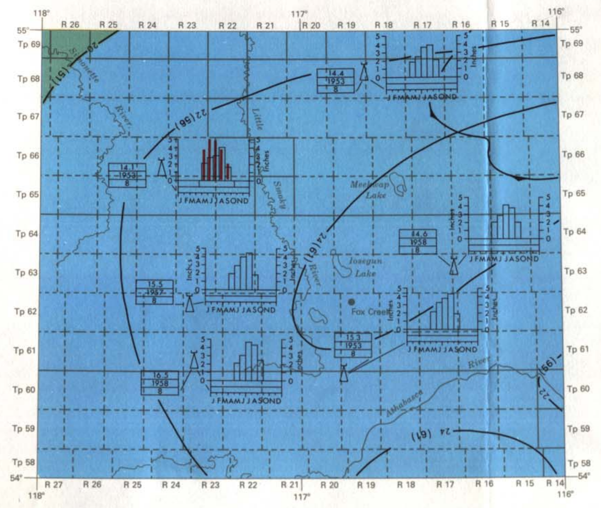
METEOROLOGY



LEGEND

Isohyet, mean annual precipitation in inches (cm) . . . . 24(61)

Mean annual precipitation:
15"-20" (38-51 cm)
20"-25" (51-63 cm)

Boundary of climafrost, approximate . . . .

Standard rain gauge only . . . .

Precipitation data:
Mean annual precipitation in inches (cm) 14
Year of commencement of observations 1953
Number of years of record averaged to determine the mean annual precipitation figure 8
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 . . . .

MAIN MAP LEGEND

Topography

Surface contours and elevation in feet 3000

Geology

Geological boundary . . . .

QUATERNARY
Qd Unconsolidated deposits
CRETACEOUS – TERTIARY
TKp Paskapoo Formation
Ksc Scollard Member of Paskapoo Formation
CRETACEOUS
Kwb Whitemud and Battle Formations
Kwt Wapiti Formation (u) (upper member) (l) (lower member)
Klp Lea Park Formation

Lithology

Gravel . . . .
Sand and gravel . . . .
Sand . . . .
Sandstone . . . .
Sandstone, bentonitic . . . .
Shale . . . .
Coal . . . .

Hydrography

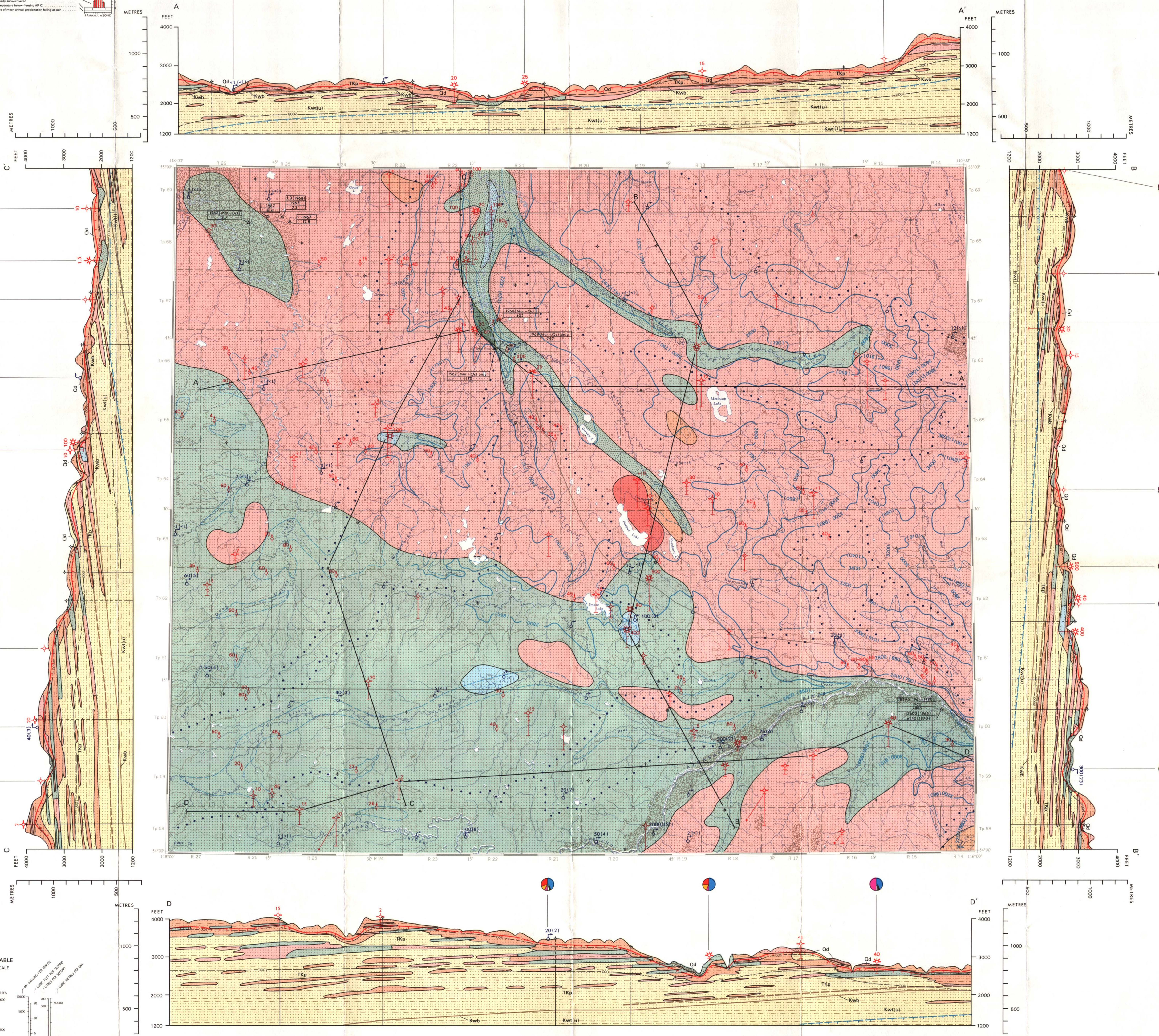
Hydrometry

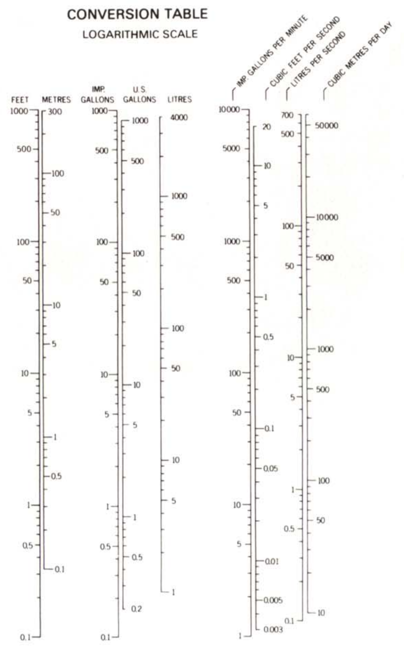
Hydrogeology

Groundwater Probability

Wells and Other Artificial Works

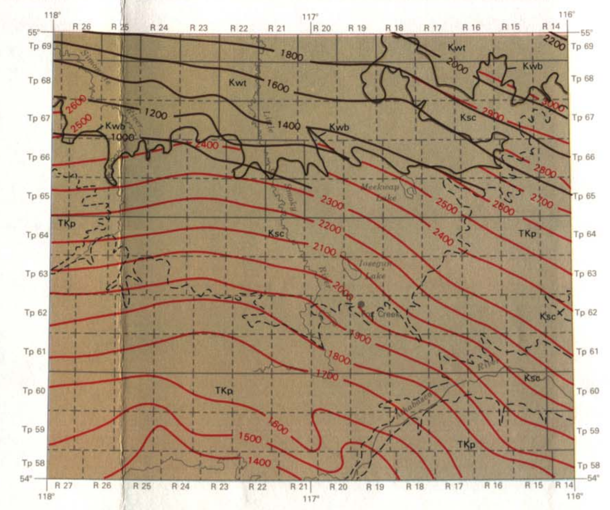
Hydrochemistry





CONVERSION TABLE
LOGARITHMIC SCALE

GEOLOGY



LEGEND

Paskapoo Formation: *grey to greenish grey calcareous sandstone, siltstone, mudstone, minor conglomerate, limestone, coal, and tuff beds; Scollard Member (Ksc): grey feldspathic sandstone, bentonite mudstone, coal beds, nonmarine* (TKp)

Whitemud and Battle Formations: *pale grey bentonitic sandstone and mudstone (Whitemud Formation); purplish-black bentonitic beds containing siliceous tuff beds (Battle Formation); nonmarine* (Kwb)

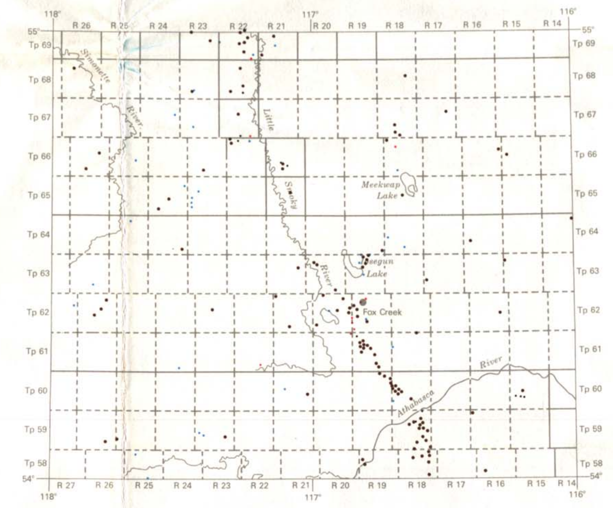
Wapiti Formation: *grey feldspathic clayey sandstone, bentonitic, mudstone and bentonite, scattered coal beds, nonmarine* (Kwt)

Rock unit boundary . . . .

Structure contour on top of Whitemud and Battle Formations (Kneehills Tuff Zone) 1700

Structure contour on top of sandier lower part of the Wapiti Formation: (Belly River Formation equivalent) 2000

DATA DENSITY

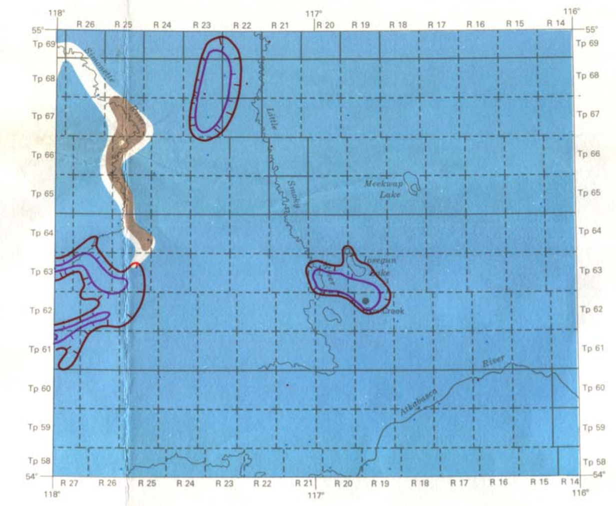


SCALE 1:1,000,000

LEGEND

Approximate yield calculated from:
Long term pump test . . . .
Short term or bail test . . . .
Apparent transmissivity values . . . .
Other data (lithology, etc.) . . . .

HYDROCHEMISTY: WELLS LESS THAN 50 FEET (15 M) IN DEPTH



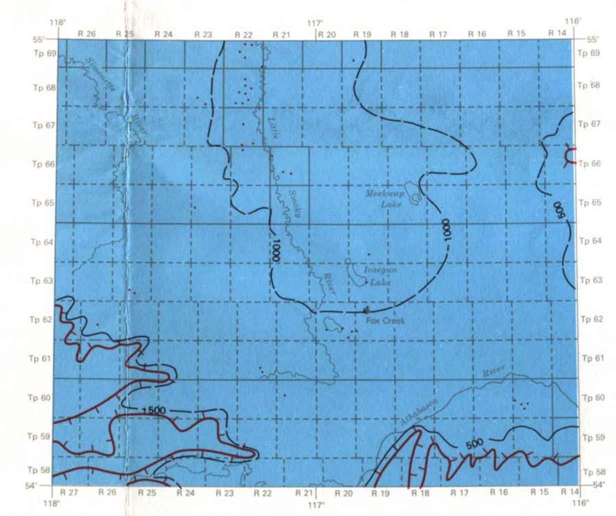
SCALE 1:1,000,000

LEGEND

Data control point marking location of well . . . .
Data control point marking location of a spring . . . .
Data control point marking location of a well with high nitrates content . . . .
Carbonate + bicarbonate constituting over 60 percent of total anions* . . . .
Sulfate constituting over 60 percent of total anions* . . . .
Isogram along which calcium + magnesium constitute 60 percent total cation content*; teeth indicate direction of lesser cation content . . . .
Isogram along which sodium + potassium constitute 60 percent of total cation content*; teeth indicate direction of lesser cation content . . . .

* Determined on equivalents per million basis

HYDROCHEMISTRY: WELLS 50 TO 500 FEET (15 TO 152 M) IN DEPTH



SCALE 1:1,000,000

LEGEND

Data control point marking location of well . . . .
Total dissolved solids:
defined 500
approximate 500
Carbonate + bicarbonate constituting over 60 percent of total anions* . . . .
Isogram along which calcium + magnesium constitute 60 percent of total cation content*; teeth indicate direction of lesser cation content . . . .

* Determined on equivalents per million basis

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

All elevations in feet above mean sea level.

Vertical exaggeration of the hydrogeological profiles is approximately 21X.

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

Map to accompany Report 76 2

Hydrogeology by O. Tokarsky, 1972.

Drafted by R. W. Swenson.

Edited by A. R. Campbell.

HYDROGEOLOGICAL MAP IOSEGUN LAKE ALBERTA

NTS 83 K