Report 76-4

Hydrogeology of the Grande Prairie area, Alberta

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HYDROGEOLOGY OF THE GRANDE PRAIRIE AREA, ALBERTA

ABSTRACT

The Grande Prairie map area is located between longitudes 118° west and 120° west and latitudes 55° north and 56° north. It covers approximately 6000 square miles (15,500 km^2). Precipitation is about 18 inches (46 cm) annually while the potential evapotranspiration is about 19 inches (48 cm).

Geological units of hydrogeological interest include the surficial deposits, the Wapiti Formation, and the Smoky Group. The latter two are of Late Cretaceous age.

The region is divided into two hydrogeological areas: 1) a southern area in which groundwater is abundant, with 20-year safe yields of 25 igpm (2 l/s) common and water of reasonably good quality and 2) a northern area in which groundwater is not usually available and is of very poor quality. In addition to the 1:250,000 scale groundwater availability map, maps at 1:1,000,000 scale present the hydrochemistry of the surficial deposits and of the bedrock.

INTRODUCTION

This report and map are part of a program of the Alberta Research Council to produce reconnaissance hydrogeological maps for the entire province under a uniform legend (Badry, 1972). Each represents the interpretation by one groundwater hydrologist of existing hydrogeological data supplemented by one summer of field work.

The area covered by this study is located between longitudes 118° west and 120° west and latitudes 55° north and 56° north. It encompasses townships 69 to 81 and ranges 1 to 14 west of the sixth meridian. Under the Canadian National Topographic System the area is designated as 83M, Grande Prairie, Alberta.

The area is dominantly used for grain growing, but clearing of the land for agricultural purposes has not taken place to any great extent along the southern and western edges of the area. The Saddle Hills in the central and west-central area contain dense bush and abundant muskeg.

Groundwater information is available from the numerous farm wells in the Grande Prairie-Sexsmith-Beaverlodge area. North of the Saddle and Birch Hills there is virtually no groundwater information available. Thus the maps of this report represent very broad assumptions in presenting interpretations in the area north of township 76.

Data collected during one summer of field mapping came from about 400 water samples, 25 2-hour pump tests, and eight geologic logs.

The reference section of this report is intended to be as complete a listing as possible of published reports pertaining to the hydrology of this area and of adjacent or similar areas.

Acknowledgments

Field and office assistance was provided by Mr. A. Beerwald. His diligent and capable help is gratefully acknowledged.

Some water well drillers operating in the area in 1973 cooperated by providing extra information on wells they completed.

R. Bibby, D. Borneuf, and G. Gabert reviewed and commented on the report. The help of these members of the Alberta Research Council is appreciated.

PHYSIOGRAPHY

The surface of the region slopes north and south from a central high known as the Saddle Hills. Elevations of about 3200 feet (975 m) are reached in these hills. Minor local highs exist at Kleskun and Saskatoon Hills in township 72, ranges 4 and 9, respectively. The northeast area is quite flat and deeply incised by the Peace River and its tributaries. The south-central area has a gently rolling surface sloping south from the Saddle Hills. The major streams in the south are also deeply incised; however, their minor tributaries have cut deeply only near their junctions with the main stream.

CLIMATE

Climatic averages for the area are presented on the meteorological side map. Mean annual precipitation is about 18 inches (46 cm). The average annual temperature is about 34°F (1°C). Potential evapotranspiration (Thornthwaite and Mather, 1957) is about 19 inches (48 cm) while pan evaporation (Bruce and Weisman, 1967) is slightly less than 25 inches (64 cm) per year.

GEOLOGY

Surficial Geology

Jones (1966) presents a map showing the surficial geology of the area. The most prevalent deposits are glacial till and glaciolacustrine materials. The Grande Prairie-Sexsmith-Beaverlodge area is shown as having lacustrine deposits. These deposits are in fact quite thin and overlie glacial till. Much of the area within a few miles of the Wapiti River is covered with sand dunes. North of the Saddle Hills the lacustrine deposits are much thicker with only minor amounts of underlying till. In the field, these deposits are difficult to distinguish from shales of the underlying Cretaceous Smoky Group.

Locally along the bluffs of the Peace River alluvial terraces are found. Many of these have been utilized as sources of sand and gravel.

Carlson and Hackbarth (1974) present the bedrock topography of the area. Most of the area south of the Saddle Hills is covered by 50 to 150 feet (15 to 46 m) of glacial drift. Thinner drift occurs in the Saddle Hills, Birch Hills, Spirit Ridge, and Saskatoon Hills.

Two major preglacial buried valleys cross portions of the map area. In the north the Shaftesbury Valley (Tokarsky, 1967) generally follows the trend of the present-day Peace River. Major deposits of gravel are predicted to occur along the thalweg of this valley. The Bezanson Buried Valley follows the general course of the present-day Smoky River. Thick, coarse-grained gravels can be observed where this valley is crossed by the Smoky River if local erosion has exceeded the rate of slumping. A tributary to the Bezanson Valley is the Wembley Buried Valley. This valley has not been viewed in outcrop but subsurface information reveals sands and gravels of significant thickness and extent. Another tributary to the Bezanson Valley is an unnamed depression in the bedrock surface which passes southwest of Grande Prairie and under Bear Lake. Occurrences of gravel have been reported along this feature.

Bedrock Geology

The bedrock units of interest to this study are all Late Cretaceous in age. The following descriptions are provided by Green (1972):

Wapiti Formation: *grey, feldspathic, clayey sandstone; grey bentonitic mudstone; bentonite; scattered coal; nonmarine.*

Smoky Group:

Puskwaskau Formation: *dark grey fossiliferous shale, silty in part; marine.*

Bad Heart Formation: *fine-grained quartzose sandstone; ferruginous oolitic sandstone and mudstone; marine.*

Kaskapau Formation: *dark grey silty shale, thin concretionary ironstone beds; interbedded in lower part with fine-grained quartzose sandstone and thin beds of ferruginous oolitic mudstone; marine.*

Dunvegan Formation: *grey, fine-grained, feldspathic sandstone with hard calcareous beds; laminated siltstone and grey silty shale; deltaic to marine.*

Shaftesbury Formation: *dark grey fish-scale bearing shale, silty in upper part; numerous nodules and thin beds of concretionary ironstone; bentonite partings; lower part with silty and sandy intervals; marine.*

Current hydrogeological information does not warrant separation of the Smoky Group into its component formations so for the purposes of this report the Smoky Group is treated as a single rock unit.

The regional dip is to the south at 50 or more feet per mile (>15 m/km) with thickening of the units also taking place in this direction. People in the southern half of the map area are thus effectively limited to using the Wapiti Formation as a source of groundwater supply while those in the north are limited to using beds of the Smoky Group of the surficial deposits.

HYDROGEOLOGY

Groundwater Flow

The water levels shown on the main map are derived from wells 100 to 200 feet (30 to 61 m) deep and are limited, because of lack of data, to the southern area only. Flow in this area is generally southeasterly and has a downward component. An examination of water levels from other depth intervals up to 300 feet (91 m) revealed basically the same pattern. This indicates that groundwater within 300 feet (91 m) of the land surface appears to be moving toward the Wapiti and Smoky River valleys. The incised nature of these streams and the paucity of data near them results in there being little indication of the direction of groundwater movement in their vicinity at least as considered on a regional scale. There are, however, several deep flowing wells in the Wapiti River valley south of Grande Prairie, indicating that water is moving upward to discharge in the river.

Local discharge areas are present in the vicinity of Hythe and along the Beaverlodge River. Another area of groundwater discharge occurs in the valley of the Kleskun Creek in township 73, range 4. Surficial expressions of groundwater discharge observed in this valley include numerous soapholes, springs, infertile ground, and very localized salt deposits.

Local discharge of groundwater takes place along the north side of the Saddle and Birch Hills. This is probably the result of very short flow systems as the water is relatively low in total dissolved solids.

Groundwater flow north of the Saddle Hills is probably downward and northerly. The very slightly permeable lake deposits and underlying Smoky Group shales result in extremely poor water quality even at very shallow depths.

Groundwater Yield

Groundwater yields were predicted in the manner explained by Hackbarth (1975). These predictions were supplemented by about 25 2-hour pumping tests conducted during the summer of 1974. The nature of the data is such that no yield information is available from depths greater than 500 feet (152 m) and thus the main map represents yields to be expected with current completion techniques to that depth. The cross sections however do show inferred yields to depths greater than 500 feet (152 m).

South of the Saddle Hills, in the area where the Wapiti Formation is present in the subsurface, groundwater is generally abundantly available. Expected yields in this area are usually in the 1 to 25 igpm (0.1 to 2 l/s) range with higher values obtained locally from buried valleys and alluvial terraces.

A wide range of apparent yields can be observed in adjacent wells completed in the Wapiti Formation. Very high apparent yields can be obtained from wells very close to wells with very low apparent yields even though they are completed at the same depth. It is felt that this disparity is due to the presence of fractures. During short pumping tests a large amount of water stored in fractures intersecting a well bore may preclude significant amounts of drawdown, resulting in the indication of high apparent yields. It is the regional transmissivity, however, that will control long-term yields and this typically is lower than the local fracture transmissivity. Thus, although very high apparent yields are observed rather frequently, the abundant number of values falling in the 1 to 25 igpm (0.1 to 2 l/s) range indicate the true 20-year safe yield of the Wapiti Formation.

The area of 25 to 100 igpm (2 to 8 l/s) yields east of Sexsmith is not due to any change in the character of the Wapiti Formation. Rather, this expected yield is due to the very high water levels existing in this valley.

North of the Saddle Hills the expected groundwater yield is very low. This is a result of the relatively impermeable nature of the lacustrine clays and underlying Smoky Group deposits. So, except for very localized beach deposits in the surficial material, that entire portion of the map area seems to have poor groundwater prospects.

The alluvial terrace along the Peace River at Dunvegan produces large volumes of water for vegetable farming. High yields can probably be sustained by induced infiltration. Other terraces probably have similar potential.

Pleistocene terrace gravel deposits along the bluffs of the Peace River have been utilized for local water supply. The potential for use of these deposits is much greater than present utilization. Development of community wells in these deposits is quite possible.

The reader should be aware that the 1 to 5 igpm (0.1 to 0.4 l/s) yields predicted for the northeast corner of the main map are the result of the Dunvegan Formation coming within 500 feet (152 m) of the land surface (see cross section B-B'). This is the depth to which yields are considered for presentation on the main map. The yield predicted for this stratigraphic unit is based entirely upon geological considerations rather than actual data from wells.

Groundwater Chemistry

Table 1 presents average values of various chemical parameters of groundwater in the area south of township 77; also presented are guideline values used for drinking water standards in Alberta. It is apparent from this table that total dissolved solids, sulfate, alkalinity, and sodium values frequently exceed the provincial standard, particularly at shallow depths. There is, however, a very strong indication that the quality of groundwater improves with depth — at least to the depth of existing sampling. This increase in quality is evident in both total dissolved solids and sulfate concentrations which decline with increasing depth of sampling.

Groundwater of the drift

The concentration of total dissolved solids in water in the glacial drift is expected to be less than 1500 ppm over most of the area south of the Saddle Hills. Values of less than 500 ppm are predicted in the vicinity of the Bezanson Buried Valley. The presence of the buried valley at Bear Lake is indicated by the area of relatively low dissolved solids passing under it.

Table 1. Average Values in Parts per Million of Various Chemical Parameters in Groundwater in the Grande Prairie Area, Alberta

Parameter	Bedrock					Number of Samples		
	Glacial drift	0-150	150-300	300-450	Alberta Standards*	Drift	Bedrock 0-150	Bedrock 150-300	Bedrock 300-450
Total dissolved solids	1227	1251	1130	936	1000	210	288	287	79
Hardness (as $CaCO_3$)	274	164	93	49	500	210	288	287	79
Sulfate	384	394	234	87	250	210	288	287	79
Chloride	12	10	15	16	250	210	288	287	79
Alkalinity (as $CaCO_3$)	627	691	772	723	500	210	288	287	79
Fluoride	0.5	0.7	1.0	1.6	1.5	153	218	223	59
Calcium	60	33	21	18	200	146	216	224	69
Magnesium	22	14	6	4	150	146	216	224	60
Sodium	377	399	394	359	300	133	192	195	52
Potassium	2.9	2.2	1.7	1.6	-	133	192	195	52
Carbonate (as $CO_3^{=}$)	1.9	7	6.8	7.6	**	133	192	195	52
Bicarbonate (as HCO_3^{-})	836	829	913	870	**	133	192	195	52

Explanation: *Standards from: Canada Department of National Health and Welfare (1969).
**Carbonate Plus Bicarbonate (as $CaCO_3$) are subject to the same standard as alkalinity.
Data includes analyses from wells in Townships 69 through 76 only.
Glacial drift - samples obtained from a well terminating in glacial drift.
Bedrock - Water samples obtained from wells 0 to 150, 150 to 300, or 300 to 450 feet deep which terminate in bedrock.

Groundwater in the valley of the Saddle River near Woking and in the valley of Kakut Creek near Peoria has very high total dissolved solids. This is probably due to the presence of major hills on either side of these valleys which in turn cause discharge of groundwater in the low areas. These two areas also are covered by relatively thick lacustrine clay layers as well as being underlain by shales of the Smoky Group. The combination of these three factors results in very poor water quality.

The total dissolved solids concentration in groundwater in the remaining area north of the Saddle Hills and Birch Hills is very difficult to predict. North of the Birch Hills it has been estimated to be less than 1000 ppm; however, this is based upon a few samples taken on the north flanks of those hills.

Farther to the west conditions seem to be much more irregular and greatly controlled by local geology. Just west of Spirit River are several springs and dug wells with water having total dissolved solids concentrations between 500 and 1000 ppm. These are situated in a very localized sandy area and are flanked quite closely by groundwater with total dissolved solids of 3000 to 7000 ppm.

Presentation of the chemical nature of groundwaters in the northwest corner of the area was not possible due to a lack of data. The quality is expected to be quite poor.

The nature of the surficial deposits seems to control the cation chemistry to a great extent. The waters of the glacial drift in this area, different from many other areas of the province, contain relative abundances of sodium and potassium, particularly south of the Saddle Hills. Pawluk and Bayrock (1969) note that the tills of the Peace River country contain relatively high amounts of silt and clay-sized particles as compared to other areas of the province. These fine-grained materials contain abundant exchangeable sodium and potassium which results in relative abundances of these ions in the waters of the drift.

North of the Saddle Hills it appears that the dominant cation species in the drift are calcium and magnesium.

Bicarbonate is the dominant anion except for an area around the Birch Hills where sulfates constitute over 60 pcercent of the anions. Much of this high sulfate area has upward flowing groundwater as indicated by wells with high hydrostatic heads.

Groundwater of the bedrock between 0 and 150 feet (0 and 46 m) below the land surface

The data in the northwest corner of the map area is too sparse to justify presenting values in that area. Water quality is expected to be generally poor.

South of the Saddle Hills total dissolved solids concentrations in this bedrock interval are seen to be usually between 750 and 1500 ppm. Low dissolved solids contents are observed at the foot of the Saddle Hills in the Valhalla-Demmitt area. This is due to water moving downdip in the Wapiti Formation.

The influence of the Wembley Buried Valley on the bedrock groundwater chemistry is demonstrated by the relatively low values of total dissolved solids concentrations following the trend of this feature. There is also some indication that the water in the Bezanson Buried Valley may be moving into the bedrock causing the total dissolved solids to be low.

In the vicinity of the Birch Hills and the eastern end of the Saddle Hills total dissolved solids rise rapidly. North of these hills data are very sparse and inconsistent; it does appear, however, that total dissolved solids concentrations of 2000 to 4000 ppm might be expected quite frequently.

The cation content of groundwater from this interval is basically sodium and potassium. Sodium plus potassium constitute more than 80 percent of the cations in most areas. This high concentration of sodium and potassium is a reflection of the large amount of these ions available in the bentonitic shales of the bedrock.

South of the Saddle Hills the dominant anion is bicarbonate. This ion commonly constitutes over 70 percent of the anions in groundwater obtained from the interval.

Based upon only a few samples an area of abundant sulfate is predicted north of the Birch Hills. The source of this sulfate is probably sulfide and sulfate minerals in the Smoky Group shales.

Figure 1 depicts the fluoride concentrations in groundwaters in this interval. In most instances the fluoride concentration can be expected to be less than 1.0 ppm. Table 1 shows that the average value for fluoride concentration in this interval is 0.7 ppm.

Groundwater of the bedrock between 150 and 300 feet (46 and 91 m) below the land surface

The northern half of the map area contains virtually no data and therefore no predictions of hydrochemistry were made in this area. It is expected that total dissolved solids concentrations will exceed 5000 ppm in most cases in this area at these depths.

South of the Saddle Hills the concentration of total dissolved solids in groundwater from this depth is commonly less than 1250 ppm.

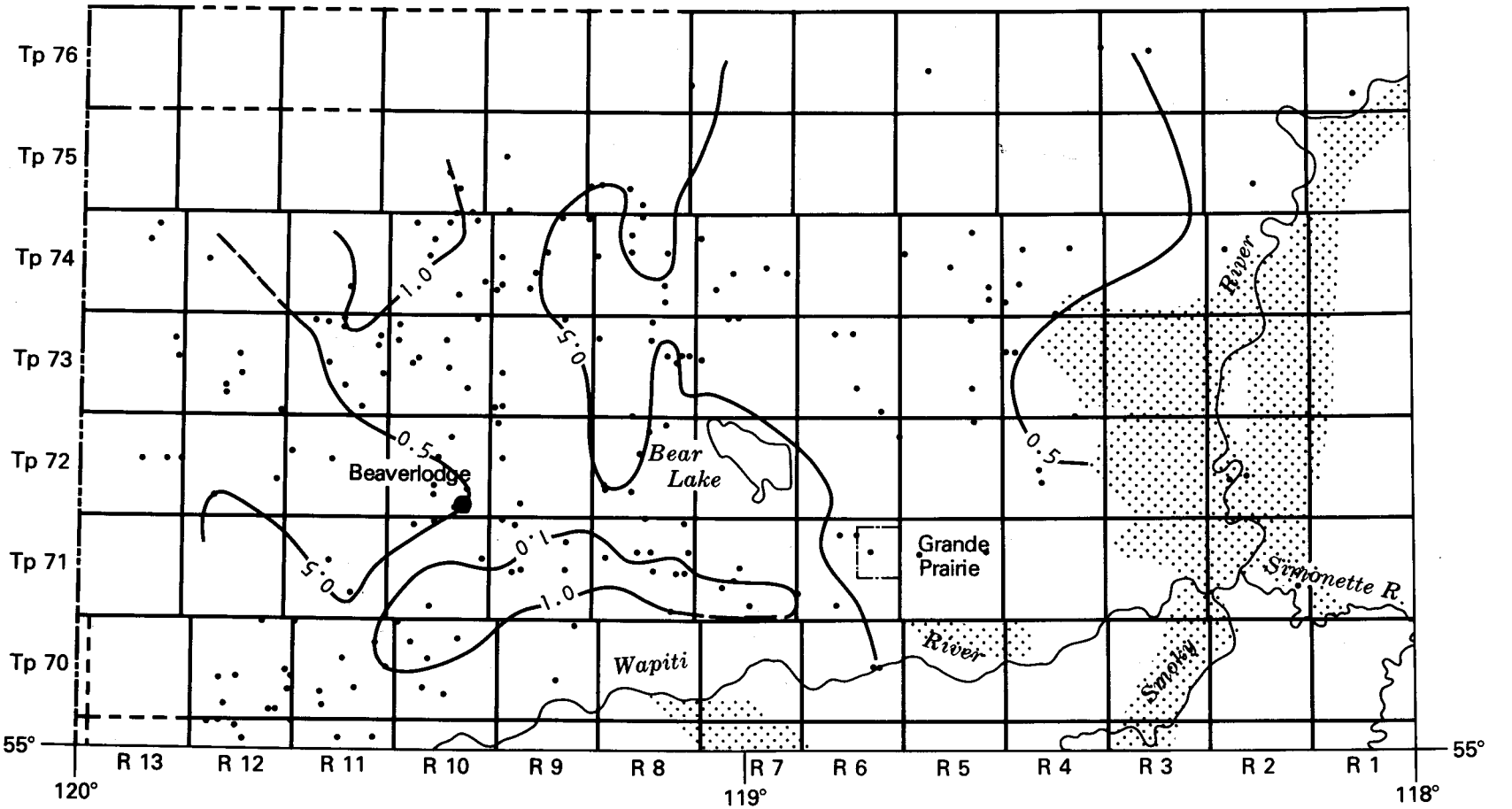

Figure 1. Fluoride in the groundwater of the bedrock between 0 and 150 feet (0 and 46 m) below the land surface

LEGEND

Data control point.....•

Fluoride content in ppm.....-1.0-

Area of drift greater than 150 feet(46 m) thick.....

Miles 5 0 5 10 15 20 Miles

Kilometres 5 0 5 10 15 20 25 30 Kilometres

The water from this interval is generally of somewhat better quality than in the overlying interval, having an average total dissolved solids concentration of 1130 ppm (see Table 1).

The influence of the Wembley Buried Valley in conducting groundwater rapidly into the bedrock is made apparent by the low dissolved solids concentrations in its vicinity. Relatively low total dissolved solids are also still noted on the south flanks of the Saddle Hills in the Valhalla-Demmitt area reflecting relatively rapid movement of water downdip in the Wapiti Formation.

Sodium plus potassium is the dominant cation species in this interval. Together these two ions constitute more than 90 percent of the cations, in most areas. An elongated area in which sodium plus potassium values constitute less than 70 percent of the cations roughly coincides with the Wembley Buried Valley and further reflects the movement of water downward from that feature.

Bicarbonate is the dominant anion in waters from this depth. This ion constitutes over 70 percent of the anions in most of the mappable area.

Fluorides are more concentrated in the water from this depth interval (Fig. 2) than in water from the interval overlying. Values can usually be expected to be below 1.5 ppm, and the average fluoride value for water from this depth interval is 1.0 ppm. The areas of the Wembley Buried Valley and the buried valley west of Grande Prairie have relatively low fluoride concentration.

Groundwater of the bedrock between 300 and 450 feet
(91 and 137 m) below the land surface

Figure 3 presents the total dissolved solids concentrations in townships 69 through 75 for this interval in the bedrock. The average dissolved solids concentration for this interval is 936 ppm (Table 1), much lower than that in any of the overlying bedrock intervals.

Even at this depth in the bedrock the vicinity of the Wembley Buried Valley is marked by a low in total dissolved solids contents as compared with local trends.

Sodium and bicarbonate are the dominant anion species present in this depth interval. Sulfate values show a significant drop from those in the overlying interval, falling from an average of 234 to 87 ppm.

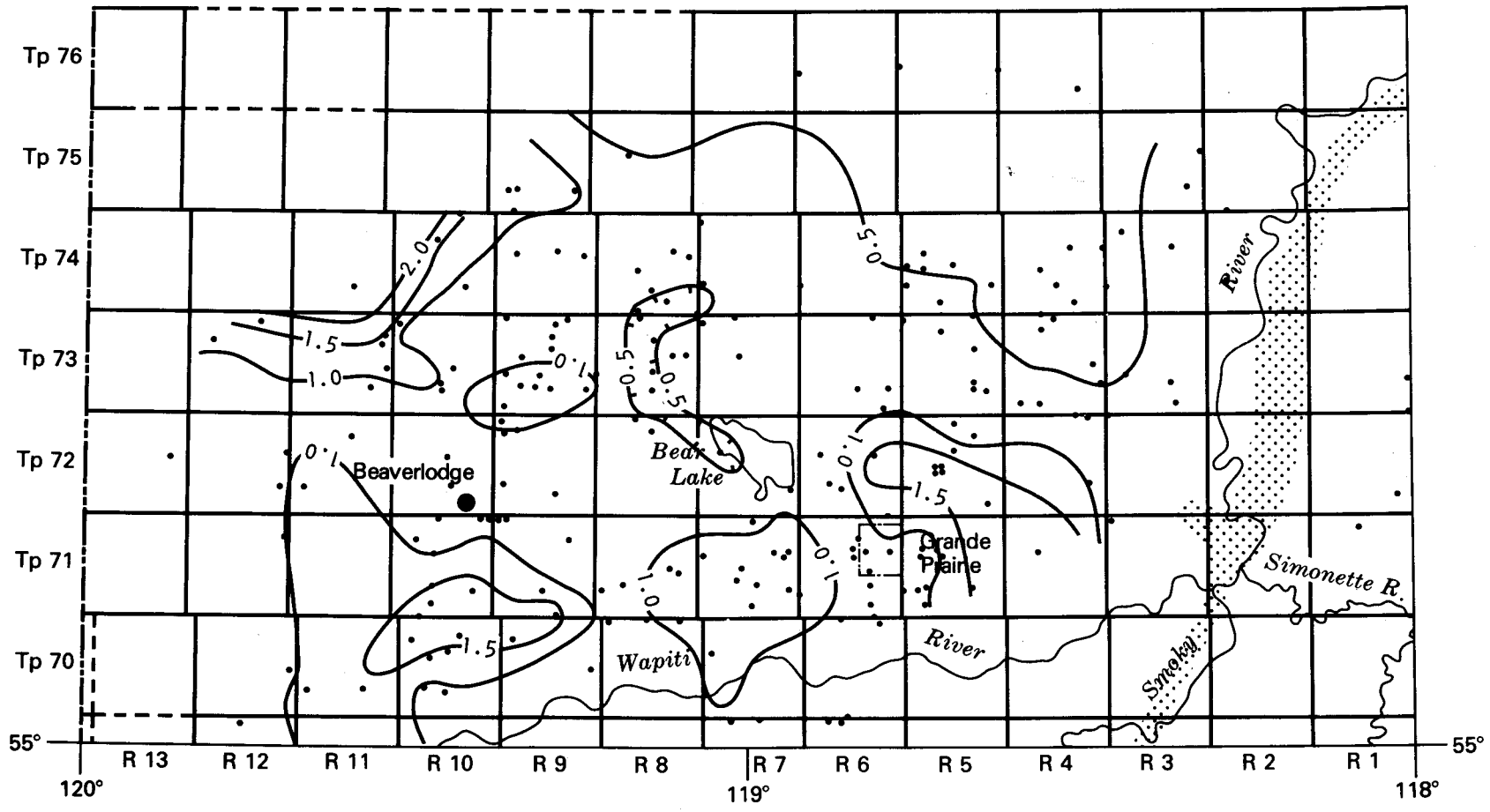

FIGURE 2. Fluoride in the groundwater of the bedrock between 150 and 300 feet(46 and 91 m) below the land surface

LEGEND

Data control point.....•

Fluoride content in ppm.....–1.5–

Area of drift greater than 300 feet(91 m) thick.....

Miles 5 0 5 10 15 20 Miles

Kilometres 5 0 5 10 15 20 25 30 Kilometres

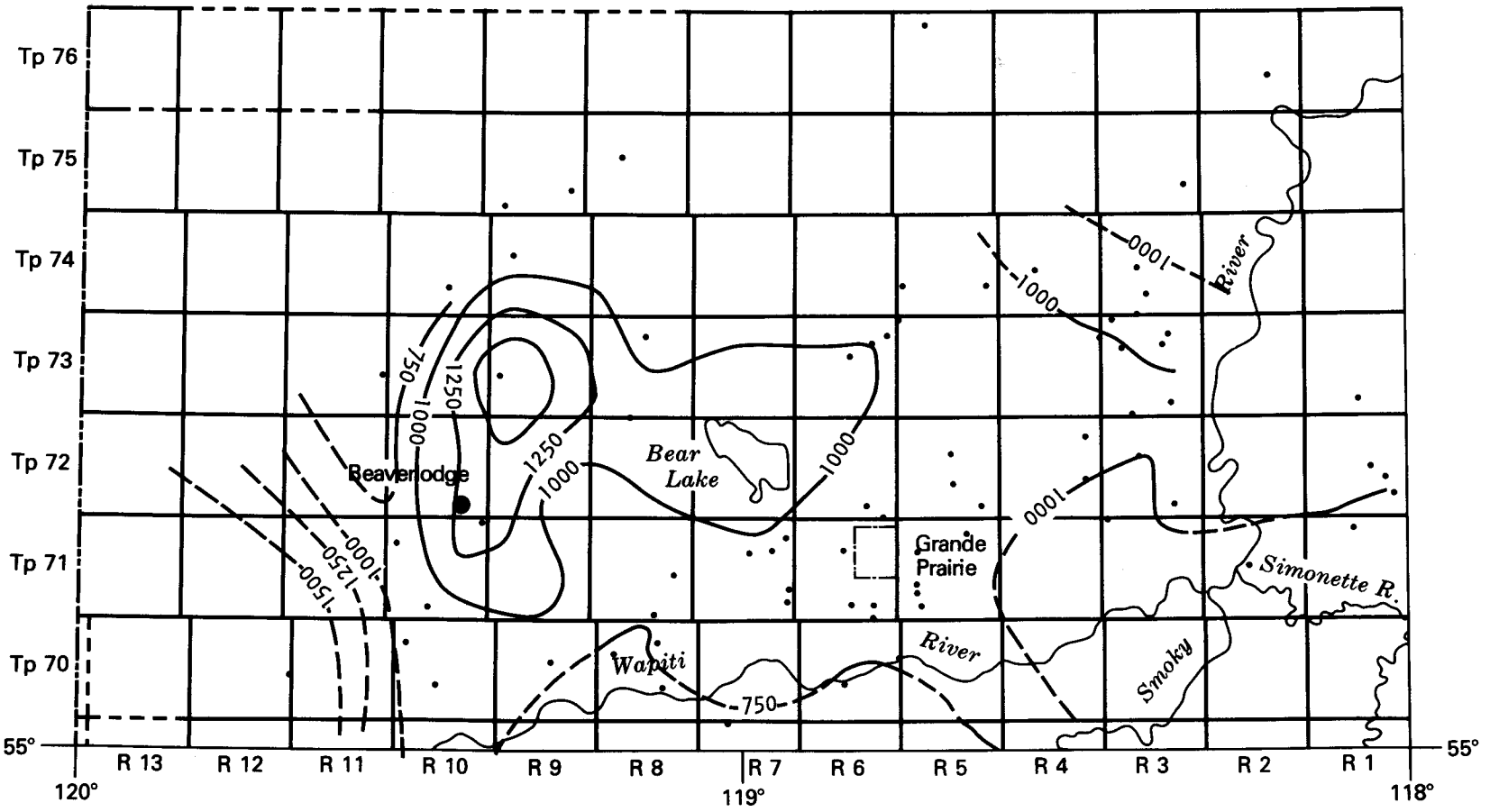

FIGURE 3. Total dissolved solids of the groundwater of the bedrock between 300 and 450 feet(91 and 137 m) below the land surface

Data control point.....•

Total dissolved solids in ppm

defined.....750

approximate.....

Miles 5 0 5 10 15 20 Miles

Kilometres 5 0 5 10 15 20 25 30 Kilometres

Figure 4 presents fluoride concentrations for groundwater from this depth interval. The average value for fluoride in this interval is 1.6 ppm. Fluoride concentrations are expected to exceed the recommended health standard of 1.5 ppm in waters from depths greater than 300 feet (91 m).

Groundwater of the bedrock greater than 450 feet (157 m) below the land surface

There is not much information available about groundwater at depths greater than 450 feet (137 m) because an adequate supply of good quality water can be obtained at shallower depths. The information which does exist indicates that water of reasonably good quality may be obtained to great depths in the area south of the Saddle Hills. An Alberta Research Council testhole along the Wapiti River south of Grande Prairie yielded water with a dissolved solids concentration of 746 ppm from a depth of 1105 feet (336 m). Analyses of water obtained during drill stem tests indicate total dissolved solids concentration of only 5000 ppm at depths of 2000 to 3000 feet (600 to 900 m) in the Beaverlodge area. This is caused by relatively fresh water entering the ground at outcrops in the Saddle Hills and moving rapidly downward and southward along the steeply dipping sandstone beds in the Wapiti Formation. It is not known how much of this water discharges into the Wapiti River; springs and other evidence of groundwater discharge are lacking. The ultimate disposition of this water remains open to speculation.

The fact that the above phenomenon is unique to the Wapiti Formation and its relation to the Saddle Hills is emphasized by observations of total dissolved solids in water samples from drillstem tests performed north of those hills. Samples of water obtained from 2000- to 3000-foot depths (600 to 900 m) in this area are from the Shaftsbury Shale and have total dissolved solids of 18,000 to 22,000 ppm. Thus, the thin drift cover over relatively permeable members of the Wapiti Formation in the Saddle Hills apparently leads to substantial recharge of water there.

CONCLUSIONS

Groundwater is generally quite readily available in the area south of the Saddle Hills. In this area the Wapiti Formation yields suitable quantities of water with reasonably good quality. Much of the groundwater movement is hypothesized to take place in fractures in the sandy units of the Wapiti.

North of the limits of the subcrop of the Wapiti Formation the availability of groundwater is quite limited. The comination of lacustrine deposits over Smoky Group shales results in very poor yields combined with poor water quality.

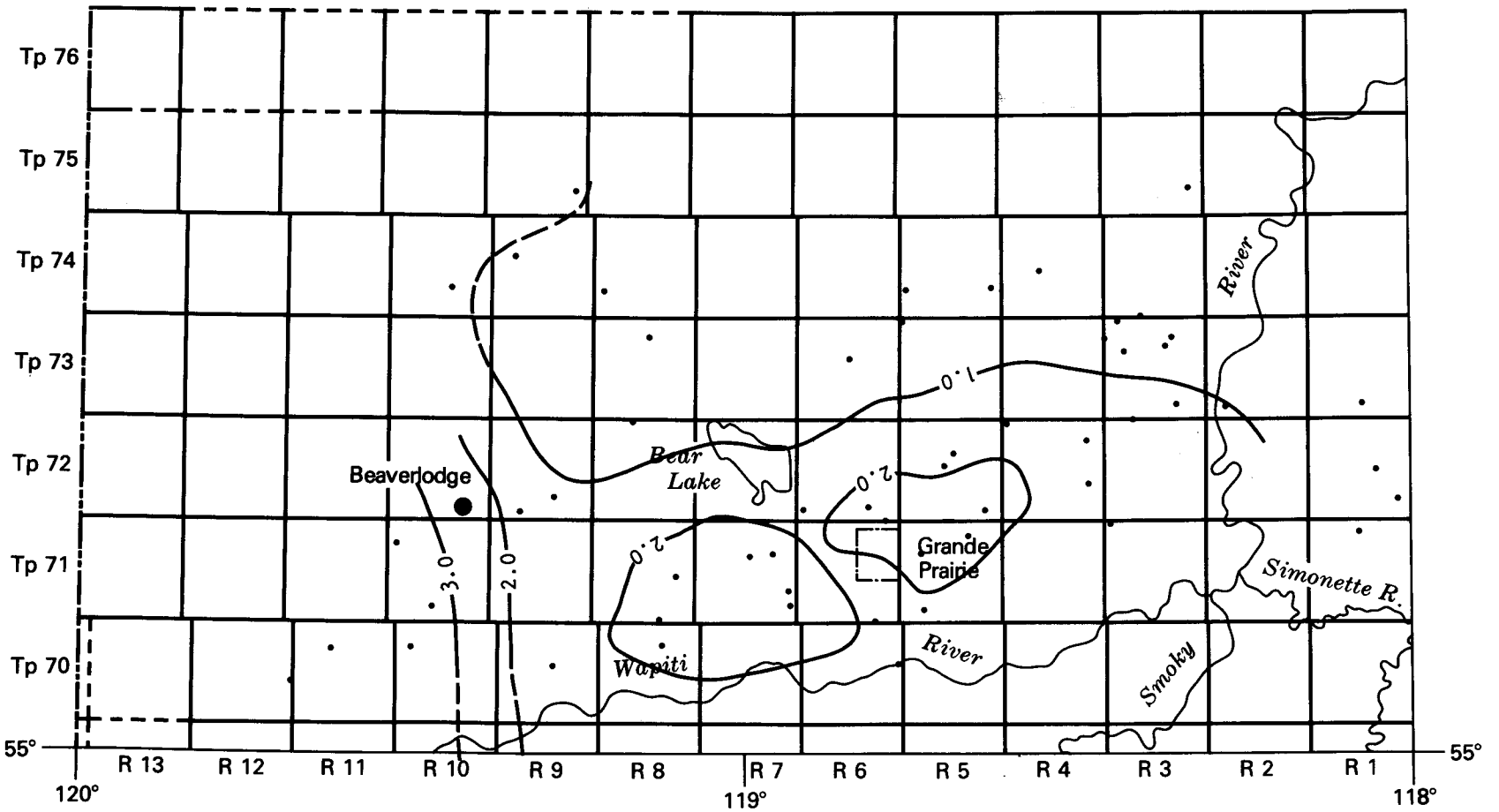

FIGURE 4. Fluoride in the groundwater of the bedrock between 300 and 450 feet(91 and 137 m) below the land surface

LEGEND

Data control point.....•

Fluoride content in ppm.....—1.0—

Miles 5 0 5 10 15 20 Miles

Kilometres 5 0 5 10 15 20 25 30 Kilometres

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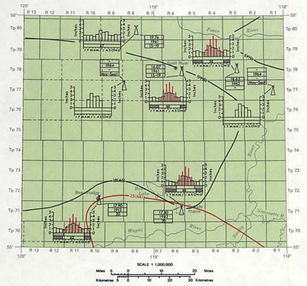
METEOROLOGY



LEGEND

Isohyet, mean annual precipitation in inches (cm) ..... (40/40)

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

Meteorological station. .....

Standard rain gauge only .....

Precipitation data:
- Mean annual precipitation in inches
- Year of commencement of observations.
- Number of years of record averaged to determine mean annual precipitation figure
- Months of record
- Mean monthly potential evapotranspiration
- Mean monthly precipitation
- Period when surface is usually snow covered

Mean annual potential evapotranspiration in inches (cm) ..... 25(64)

Source of data:
Temperature and precipitation 1941-1970 — Prairie Provinces Atmospheric Environment Service, Ottawa.

MAIN MAP LEGEND

Topography

Surface contours and elevation in feet. 1800

Geology

Geology boundary .....
Thalweg of buried valley:
- defined .....
- approximate .....

QUATERNARY
- Qd Unconsolidated deposits

CRETACEOUS
- Kwt Wapiti Formation
- Kd Dunvegan Formation
- Ks Smoky Group
- Ksh Shaftesbury Formation

Lithology

Sand and gravel .....
Sandstone. .....
Shale .....

Hydrography

Lake or slough, perennial .....
Lake or slough, intermittent. .....
Marsh, muskeg .....
Stream, perennial .....
Stream, intermittent .....
Surface water divide .....

Hydrometry

Stream gauging station .....
- Average annual discharge in cubic feet per second — 37(20)
- Year of commencement of observations — 60-69
- Number of years averaged for average annual discharge figure — 10
- Drainage area in square miles — 90200

Lake level recording station. .....

Hydrogeology

Spring , flow rate unknown .....

Nonpumping water level contour (elevation in feet followed by metres in brackets) and vertical component of groundwater movement ..... (Upward Flow) 2000 (610) (Downward Flow)

Direction of groundwater flow. .....

Boundary of area of artesian flow .....

Groundwater Probability†

Range of average expected yield of wells in igpm (l./sec)

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

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

- 100-500 (8-38)
- 25-100 (2-8)
- 5-25 (0.4-2)
- 1-5 (0.1-0.4)
- <1 (<0.1)

Yield area boundary .....

†The indicated average expected yields to wells are based on the best available data 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; Depth of well or seismic shot hole

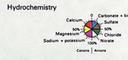
Water well, nonflowing .....
Water well, flowing .....
Water well, shallow depth .....
Water well, 20 year safe yield calculated from apparent transmissivity 27
Water well, 20 year safe yield calculated from a good bail test or a short pump test ...
Water well, 20 year safe yield calculated from a pump test of sufficient length to reflect regional hydraulic conditions. .....

Adjacent wells 1
Non-producing well ..... NP
Alberta Research Council test well ..... ARC
Observation well with automatic recorder .....
Seismic shothole reported to have flowed .....
Oil well* .....
Gas well* .....
Abandoned well* .....
Structure testhole* .....
Depth of exploratory well .....

* The vertical line portion of oil, gas or other exploratory test well symbols indicates the well depth; the dashed portion indicates the surface casing interval where applicable or where known (otherwise, a solid line is used).

Line of hydrogeological profile ..... A — A′

Hydrochemistry



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:
- defined 500
- approximate 500

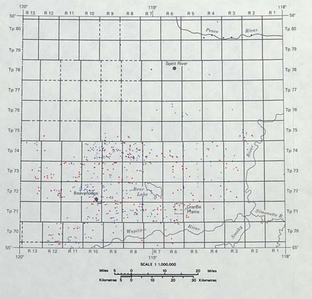
Isogram along which calcium + magnesium constitute 60 percent of total cations*; teeth indicate direction of lesser calcium + magnesium content:
- defined .....
- approximate .....

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

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

* Determined on equivalents per million basis

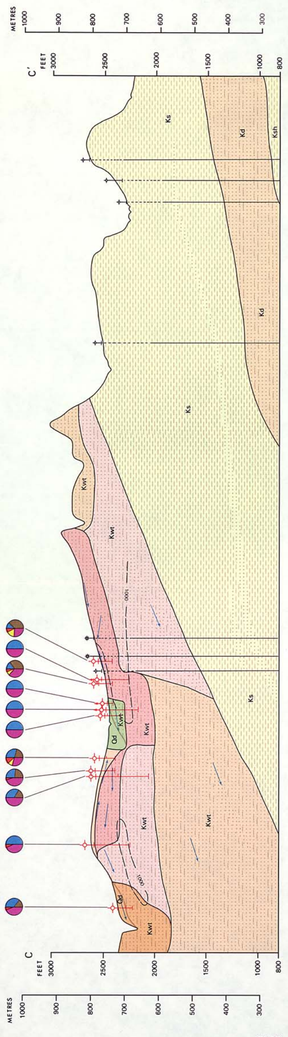
DATA DENSITY

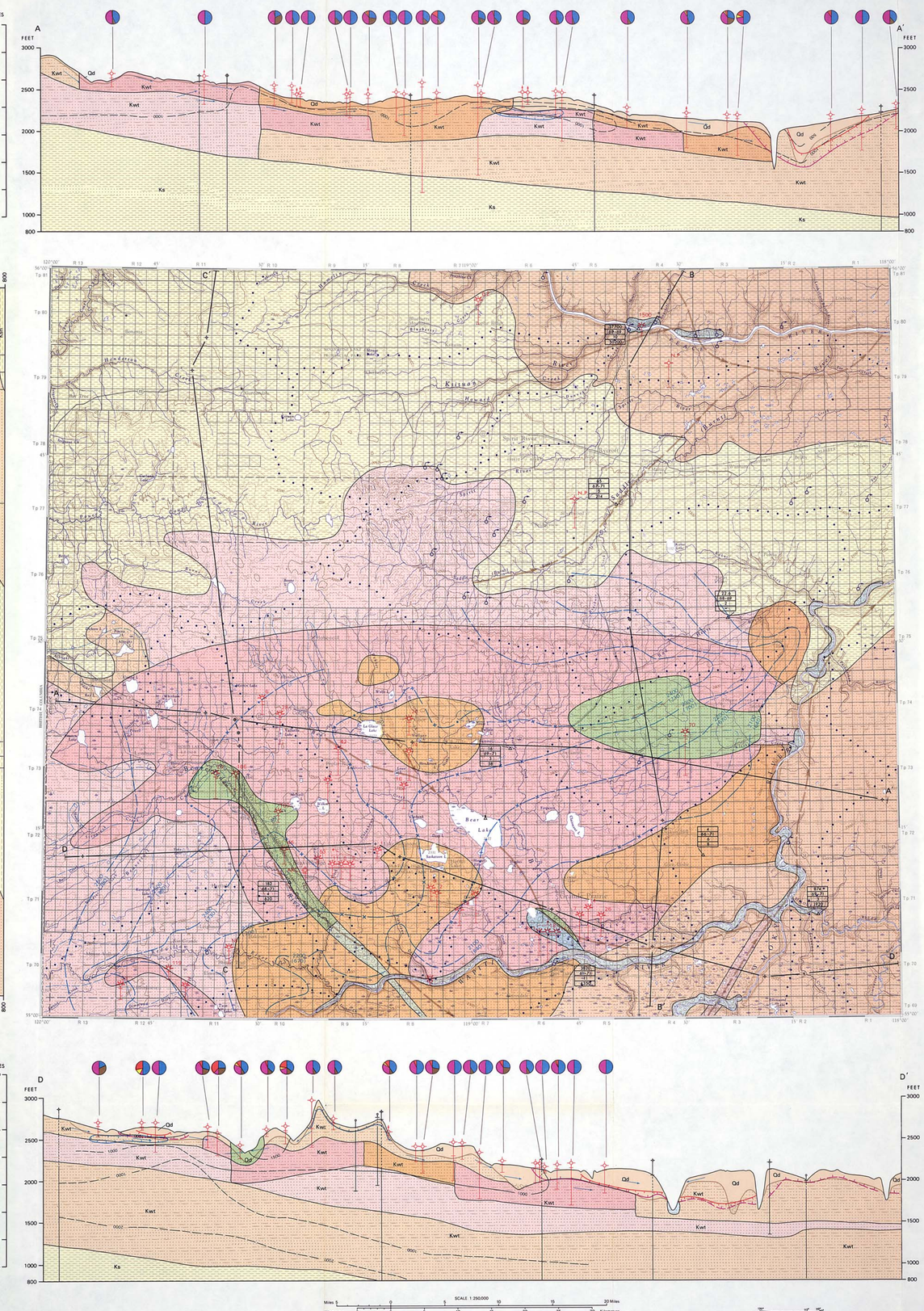


SCALE 1:1,000,000

LEGEND

Data control point marking the location of a well with water level information only .....
Data control point marking the location of a well with yield information (i.e. production test) ...
Data control point marking the location of a hydrogeological surface feature .....





All elevations in feet above mean sea level.
Vertical exaggeration approximately 40X.

An expanded legend (Report 72-121 and explanatory notes for use with this map series is available from the Alberta Research Council, Edmonton, Canada.

Map to accompany Report 76-4.
Hydrogeology by D. Hackbarth, 1974.
Editing by A. Campbell
Drafting by R. Swenson

HYDROGEOLOGICAL MAP GRANDE PRAIRIE AREA ALBERTA

NTS 83 M

LEGEND

Wapiti Formation: *grey feldspathic clayey sandstone, grey bentonitic mudstone, bentonite, scattered coal, nonmarine*

Smoky Group: *dark grey shale and silty shale nodules and thin beds of concretionary iron formation, marine*

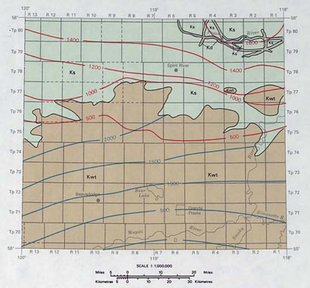
Dunvegan Formation: *grey, fine-grained, feldspathic sandstone with hard calcareous beds; laminated siltstone and grey silty shale; deltaic to marine.*

Rock unit boundary .....

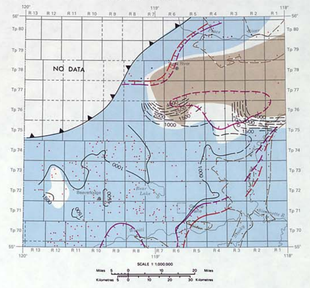
Structure contour on top of the Puskwaskau Formation (Smoky Gp) (in feet) 1000 500

Structure contour on top of the Dunvegan Formation (in feet) .....

GEOLOGY



HYDROCHEMISTRY: BEDROCK 0 TO 150 FT (0 TO 46 M)



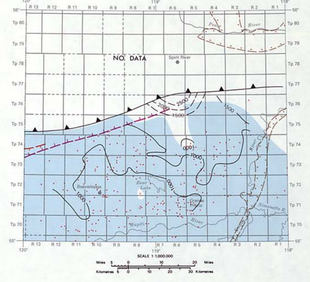
LEGEND

Data control point marking location of a well with a chemical analysis .....
Data control point marking location of a spring with a chemical analysis .....
Total dissolved solids in parts per million:
- defined 500
- approximate 500

Carbonate + bicarbonate constituting 60 percent of total anions* .....
Sulfate constituting 60 percent of total anions* .....
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 .....
Boundary of area within which drift is greater than 150 feet (46 m) thick. .....
Boundary of area of no data .....

* Determined on equivalents per million basis

HYDROCHEMISTRY: BEDROCK 150 TO 300 FT (46 TO 91 M)

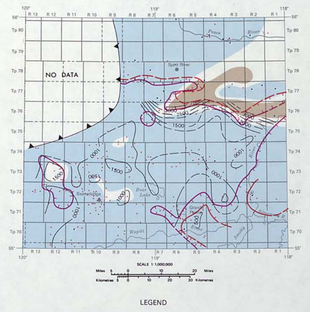


LEGEND

Data control point marking the location of a well with a chemical analysis .....
Total dissolved solids in parts per million: 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 calcium + magnesium content .....
Isogram along which sodium + potassium constitute 60 percent of total cation content*; teeth indicate direction of lesser sodium + potassium content .....
Boundary of area within which drift is greater than 300 ft (91 m) thick. .....
Boundary of area of no data .....

* Determined on equivalents per million basis

HYDROCHEMISTRY: DRIFT 0 TO 200 FT (0 TO 60 M)



LEGEND

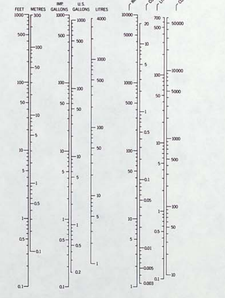
Data control point marking the location of a well with a chemical analysis .....
Data control point marking the location of a stream with a chemical analysis .....
Total dissolved solids in part per million:
- defined 500
- approximate 500

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 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 .....
Boundary of area of no data .....

* Determined on equivalents per million basis

CONVERSION TABLE

LOGARITHMIC SCALE



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

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