RESEARCH COUNCIL OF ALBERTA

REPORT 72-2

HYDROGEOLOGY OF THE BISON LAKE AREA, ALBERTA

by

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Research Council of Alberta
Edmonton, Alberta
1972

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ILLUSTRATIONS

Abstract

The Bison Lake area is largely unsettled and access is poor. The few existing water wells are mainly hand-dug and shallow. Hydrogeological evaluation is based on existing well data, limited test drilling, field observations of groundwater features, and on inferences made from the geologic and topographic situation.

Much of the area is of low relief underlain by shales, clays and tills of low permeability. Movement of groundwater is consequently slow, well yields very low, and water quality very poor. The highest well yields and best quality water are to be expected in Recent alluvial sands and gravels. High yields of poor quality water may be obtained from buried channel sands and gravels, and moderate yields of variable quality water from sandstones of the Upper Cretaceous Dunvegan Formation.

INTRODUCTION

This report is a guide to direct attention to anomalies, points of interest, and significant details that cannot be clearly shown on the maps and cross sections, and to provide brief explanations, where necessary, for some of these items.

The map area covers slightly more than 5000 square miles. It was mapped in conjunction with the Mount Watt map area (NTS 84K), adjacent to the north, during the summers of 1967 and 1968.

The area is unsettled except for farming activity centered about Hotchkiss, Hawk Hills, Keg River, and Paddle Prairie. Access by road is confined to the area west of the Peace River and only a small part of this is accessible in this manner. Much of the area was mapped by helicopter. This involved the mapping of surface expressions of groundwater discharge and the sampling of water from test holes hand-augered to depths of up to 10 feet.

The majority of the few water wells in the map area are hand-dug.

No previous hydrogeological surveys have been conducted. A preliminary soil survey was carried out by Lindsay *et al*. (1970).

Acknowledgments

Field operations were financed jointly by the provincial and federal governments under the terms of the Agricultural and Rural Development Act (ARDA). This financial support is gratefully acknowledged.

Other organizations contributing significantly to the project were the Water Resources Division, Alberta Department of Agriculture, which supplied logs of test holes and results of chemical analyses, and the Peace River Health Unit, which supplied hydrochemical data.

Shot hole logs and structure test-hole information were supplied by a number of oil companies and by the Energy Resources Conservation Board, formerly the Oil and Gas Conservation Board.

Test drilling was carried out by E. R. Kinsella Drilling of Innisfail and by R. Forrester Drilling of Red Deer. Field assistance was ably provided at various times by D. Withers, G. Borthwick, and W. Wolodko.

Thanks are due to D. H. Lennox and J. Tóth for suggestions on the manner of presentation of data, to Miss A. Badry for help in map synthesis and editing, to H. Weiss for drafting of the maps, and to Miss D. Cunliffe for typing of this report. G. F. Ozoray, G. M. Gabert, and D. V. Currie have critically reviewed and commented on the manuscript.

TOPOGRAPHY AND DRAINAGE

The area has a maximum of 2000 feet of local relief, from a low of less than 900 feet above sea level in the Peace River valley to a high of 2873 feet in the Hawk Hills. The Peace River flows northward through a broad, flat plain, the Fort Vermilion Lowland, flanked on the west by the Naylor and Hawk Hills which form part of the Clear Hills Upland and on the east by the Buffalo Head Hills. The Chinchaga River, which is part of the Hay River drainage system, cuts across the northwest corner of the map area.

CLIMATE

The climate of the area is one of short, cool summers according to the Koeppen climatic zone classification. There is a scarcity of climatic records for the area. However, the mean annual temperature at Buffalo Head Prairie, just north of the northeast corner of the area, is 29.8°F, based on 17 years of record.

The mean annual precipitation (refer to meteorological map) ranges from less than 15 inches along the Peace River to an estimated total of more than 18 inches in the Buffalo Head, Hawk, and Naylor Hills (modified from Longley, 1968).

Monthly rates of evapotranspiration have been approximated from maps prepared by Bruce and Weisman (1967) and are shown for the weather station at Keg River. Evapotranspiration apparently exceeds precipitation for the months of May to October inclusive, and is essentially negligible in other months.

The southern limit of the zone of discontinuous permafrost (Brown, 1967) passes approximately through Keg River in an east-west direction. Brown (1967) reports a thickness of 5 feet of permafrost at Keg River. During the course of the present hydrogeological investigations, ground ice was encountered during augering operations at a few locations. The permanence of this ice is not known.

GEOLOGY

The formation boundaries shown on the geological side map are essentially those of Green, Carrigy, and Mellon (1970). Some changes in the positioning of these boundaries were made on information derived from a bedrock topography map constructed to determine drift thickness.

Most of the area is underlain by a thick sequence of marine shales of the Lower Cretaceous Loon River Formation and the Lower and Upper Cretaceous Shaftesbury Formation. These formations are separated by the Peace River Formation, a sandstone-siltstone-shale sequence, which becomes progressively finer grained northward and eventually shales out in the northwestern portion of the map area.

The Upper Cretaceous Dunvegan Formation, a sequence of interbedded sandstone and shale, overlies the Shaftesbury Formation. It is present only in the Naylor, Hawk, and Buffalo Head Hills, where it is overlain in places by an unnamed shale unit of the Upper Cretaceous Smoky Group.

Drift cover is thin over the Naylor and Hawk Hills, and over the northern part of the Buffalo Head Hills. There is very little information on drift thicknesses over the main portion of the Buffalo Head Hills, although a few scattered points indicate local thicknesses of over 70 feet. Drift thickness increases rapidly downslope from the highland areas to over 100 feet. Drift in excess of 200 feet thick fills buried valleys in these lowland areas. A maximum thickness of over 800 feet has been recorded in a buried valley near Keg and Kemp Rivers.

HYDROGEOLOGY

Water levels have not been contoured on the hydrogeological map because of the lack of suitable well information. Wells are usually of the shallow dug type in which water levels conform closely to the land surface and cannot be represented adequately at this scale of mapping.

Due to the scarcity of wells, expected average well yields have had to be inferred from the geologic and topographic situation and from a few test wells.

The highest yields are to be expected from gravels and sands within buried valleys and in alluvial gravels along the Peace River. The approximate positions of buried valleys, except east of the Peace River, are fairly well established; therefore the yield areas shown along these valleys are located reasonably well. The actual yields to be expected, however, may be locally in considerable error, dependent upon the nature of the infilling materials. Sustained yields of over 500 igpm are likely to be obtained in those parts of the buried channels in which extensive sands and gravels occur.

Sands and gravels in terraces along the Peace River and in Recent alluvium along tributary rivers and along the Chinchaga River are rated as capable of supplying 5 to 25 igpm of water to a well. Again this will be dependent on local conditions. In places the yield can be much higher, in other places lower than the figures quoted.

Two areas of aeolian sand near the Peace River are rated as capable of producing 5–25 igpm, as are the soft sandstones of the Dunvegan Formation. The general lowland area adjacent to the Peace River valley is also rated at 5–25 igpm. This is a more generalized yield grouping than in other parts of the area because of lack of control points. However, drift is relatively thick in this region and in all probability includes local lenses and pockets of relatively permeable materials, as well as containing more extensive permeable materials along undiscovered buried valleys. In many places, however, yields of less than 5 igpm are likely.

The poorest yield areas are those lying between the areas of relatively thick drift material of the lowland region and the Dunvegan Formation of the uplands. Drift cover is relatively thin over this region and consists mostly of poorly permeable till and lacustrine clay overlying equally poorly permeable Cretaceous shales. More permeable materials (such as fractured shales, sand lenses, etc.) may be present locally and may provide better yields.

HYDROCHEMISTRY

Hydrochemical control over much of the map area is provided by analyses of water samples from shallow auger holes less than 10 feet deep. In most places, although water may be obtained, no portion of the upper 10 feet of earth material constitutes an aquifer in the commonly accepted sense of the word, and the chemistry of the water may be quite different from that obtained from lower-lying, more permeable water-bearing zones. However, it is assumed that these analyses will have regional significance and therefore are worthy of presentation.

Hydrochemical changes with depth are largely inferred from water samples obtained in the few test holes drilled, from geologic conditions and inferred position in the hydrologic flow system.

Water quality is poor over much of the area. The most common water is a calcium-magnesium sulfate type with a high content of total dissolved solids. Better-quality water occurs in:

1) areas of aeolian sand near the Peace River,

2) sand and gravel terraces along the Peace and Notikewin Rivers,

3) Recent alluvial sand and gravel,

4) Dunvegan sandstones in the Naylor, Hawk and Buffalo Head Hills, and

5) local alluvial floodplain sand in the vicinity of Keg River.

Except in these areas, potable waters can usually be obtained only by the use of surface water or rainwater: by collecting snowmelt, rainfall and runoff in a dugout, or by melting snow or ice.

CONCLUSIONS

The highest well yields are to be obtained from buried channel and Recent alluvial sands and gravels. Bedrock possibilities are extremely poor, although moderate yields may be obtained from the sandstones of the Dunvegan Formation. Water quality is poor over most of the area; calcium-magnesium sulfate waters predominate. Bicarbonate waters are found in areas of near-surface sand and gravel and in Dunvegan sandstones in upland areas.

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APPENDIX A. RESEARCH COUNCIL OF ALBERTA TEST HOLES

1) Location: Approximately 100 feet north, 440 feet west of NE corner, Sec. 12, Tp. 101, R. 23, W. 5

Elevation: 1 328 feet estimated

Contractor: McAuley Drilling, Aug. 1966

0- 17	clay, slightly silty, brownish (oxidized)
17- 23	clay, slightly silty, dark brownish grey
23-118	till, dark grey
118-119	sand, fine to medium grained, fairly well sorted
119-410	till, dark grey, occasional streaks of sand and gravel
410-500	sand and gravel and intercalated clay or till; water-bearing, some gas; water level at 38 feet below ground surface

Tests: 2-hour bail test at total depth in uncased borehole at 6 igpm. Total drawdown about 15 feet.

2) Location: Approximately 700 feet west, 240 feet north of NE corner, Sec. 12, Tp. 101, R. 23, W. 5

Elevation: 1 332 feet estimated

Contractor: McAuley Drilling, Aug. 1966

0- 20	clay, slightly silty, brownish (oxidized)
20- 25	clay, slightly silty, dark brownish grey
25-138	till, dark grey, gravelly zone at 73-76 feet
138-148	silt and sand, very fine to fine grained; water-bearing; water level at 80 feet below ground surface
148-150	till, dark grey

Tests: Uncased hole bailed dry in 1/2 hour at 5 igpm.

3) Location: Lsd. 12, Sec. 5, Tp. 94, R. 23, W. 5

Elevation: 1 930 feet (altimeter survey)

Contractor: E. R. Kinsella Drilling, Aug. 1968

0- 77	till, dark grey, pebbly
77-135	clay, gritty, soft, dark grey, pebbles few and tiny (till?)
135-137	quicksand, very fine grained; water-bearing; water level at 45 feet from ground surface
137-144	clay, silty, dark grey
144-147	quicksand, very fine grained
147-165	clay, silty, dark grey
165-178	quicksand, very fine grained
178-192	clay, very silty, dark grey, some sand streaks
192-200	quicksand, very fine grained
200-235	clay, silty, dark grey, thin sand layers and streaks
235-270	shale, soft, poorly fissile, occasional small gypsum crystals and yellow colored weathering alteration product
270-318	shale, hard, dark grey

Tests: None. Quicksand zones were too fine to screen.

4) Location: NE 1/4 of Lsd. 9, Sec. 29, Tp. 97, R. 22, W. 5

Elevation: 2 380 feet estimated (43 feet above level of East Twin Lake)

Contractor: E. R. Kinsella Drilling, 1968

0- 40	sandstone, fine grained, brownish
40- 82	shale, grey
82- 90	sandstone, fine grained, grey; water-bearing; water level at 62 feet below ground surface
90-105	shale, grey
105-142	sandstone, fine to medium grained, grey; water-bearing; water level at 99 feet below ground surface
142-195	shale, silty, dark grey
195-265	shale, dark grey
265-360	shale, with silty interbeds
360-485	shale, dark grey
485-755	shale, dark grey; a few silty interbeds

755-768	siltstone, argillaceous, bentonitic
768-830	shale, dark grey, a few fish scales noted
830-860	interbedded shale, and argillaceous siltstone, bentonitic
860-900	shale, dark grey; water level at 600 feet below ground surface

Tests:
1) 70-minute bail test at 90-foot hole depth at 8 igpm. 23.6 feet of drawdown in 70 minutes. Hole cased to 65 feet.
2) 2-hour bail test at 170-foot hole depth at 16 igpm. 11.4 feet of drawdown in 2 hours. Hole cased to 95 feet.
3) 32-hour pump test at 155-foot hole depth at 18 igpm. 17.6 feet of drawdown in 32 hours. Ten feet of #7 slot screen set at 132-142 feet. Test with one observation hole 50 feet east of pumping well. Drawdown 5.1 feet in observation well.

The following holes were drilled by Hi-Rate Drilling Co. Ltd. in 1963 under the supervision of J. F. Jones:

1) Location: Lsd. 3, Sec. 9, Tp. 110, R. 19, W. 5 (T.H. #4)

0- 13	clay, dark grey
13- 15 1/2	clay, reddish
15 1/2- 27	clay, boulders, dark grey
27- 39	shale, black

2) Location: Lsd. 3, Sec. 9, Tp. 110, R. 19, W. 5 (T.H. #5)

0- 17	clay, cobbles and boulders, brown
17- 36	clay, boulders, grey
36- 60	shale, black

3) Location: Lsd. 3, Sec. 9, Tp. 110, R. 19, W.5 (T.H. #6)

0- 14	clay, brown
14- 36	clay, boulders, grey
36- 60	shale, black

4) Location: Lsd. 16, Sec. 31, Tp. 110, R. 19, W. 5 (T.H. #7)

0- 8	clay, light brown
8- 14	clay, dark brown
14-123	clay, boulders, dark grey
123-140	shale, black

5) Location: Lsd. 4, Sec. 16, Tp. 110, R. 19, W. 5 (T.H. #8)

0- 9	clay, brown
9- 11	gravel, pea size
11- 16	sand, medium grained
16- 18	gravel, pea size
18- 57	clay, grey, pebbles, cobbles
57- 80	shale, black

6) Location: Lsd. 9, Sec. 31, Tp. 110, R. 19, W. 5 (T.H. #9)

0- 10	clay, dark brown, pebbles and cobbles
10-109	clay, grey, pebbles and cobbles

7) Location: Lsd. 4, Sec. 16, Tp. 110, R. 19, W. 5 (T.H. #10)

0- 9	clay, brown, pebbles
9- 10	gravel, pea size
10- 70	clay, grey, pebbles and cobbles

8) Location: Lsd. 4, Sec. 16, Tp. 110, R. 19, W. 5 (T.H. #11)

0- 9 1/2	clay, brown
9 1/2- 11	gravel, pea size
11- 16	sand, medium grained
16- 19	gravel, pea size
19- 28	sand, gravel — interbedded layers
28- 40	clay, grey, sand, pebbles and cobbles

Well was screened, developed and tested. Water non-potable. No. 7 slot screen set at 22-27 feet.

9) Location: Lsd. 7, Sec. 3, Tp. 110, R. 19, W. 5 (T.H. #12)

0- 2	soil
2- 3	gravel, pea size
3- 10	clay, dark brown
10- 37	clay, grey
37- 38	gravel, pea size
38- 60	shale, black

10) Location: Lsd. 7, Sec. 3, Tp. 110, R. 19, W. 5 (T.H. #13)

0-	soil
3- 11	gravel, sand, pea-size gravel
11- 37	clay, dark grey, pebbles and cobbles (some pink clay)
37- 39	clay, dark grey, cobbles
39- 60	shale, black

11) Location: Lsd. 7, Sec. 30, Tp. 109, R. 19, W. 5 (T.H. #14)

0- 4	road bed
4- 5	muskeg
5- 15	clay, medium grey
15- 24	clay, light grey, some pinkish clay
24- 58	clay, dark grey, cobbles
58- 86	clay, dark grey, sand and pebble fragments
86- 92	sand
92- 97	clay, dark grey, pebbles and cobbles
97- 98	sand; water-bearing; water level at 25 feet below ground surface
98-109	clay, dark grey with sand and pebble fragments
109-120	shale, black

Well was cased, developed and tested. Water non-potable. No. 7 slot screen set at 88-93 feet.