CANADA

DEPARTMENT OF MINES

AND

TECHNICAL SURVEYS

GEOLOGICAL SURVEY OF CANADA

WATER SUPPLY PAPER No. 314

GROUND-WATER RESOURCES OF TOWNSHIPS 31 to 34; RANGES 25 to 29; WEST OF 4th MERIDIAN, ALBERTA

(Wimborne Area)

By

A. Mac S. Stalker

OTTAWA

1953

NOTE:

Because of difficulties involved in reproduction, the tables of well records referred to are not included with this report. Information regarding individual wells may be obtained by writing to the Director, Geological Survey of Canada, Ottawa.

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CONTENTS

Illustrations

INTRODUCTION

The survey of the ground-water resources of the Red Deer region, Alberta, was resumed during the field season of 1946, and much information on these resources was obtained by a compilation of records of water wells.

A division has been made in the well records, in so far as possible, between the glacial and bedrock water-bearing sands. The water records themselves were obtained mostly from the well owners, some of whom had acquired the land after the water supply had been found, and hence had no personal knowledge of the water-bearing beds that had been encountered in their wells. Also, the elevations of the wells were taken by aneroid barometer and are, consequently, only approximate. In spite of these defects, however, it is hoped that the publication of these water records may prove of value to the farmers, town authorities, and drillers in their efforts to obtain adequate water supplies.

Publication of Results

The essential information pertaining to ground-water conditions is being issued in reports that in Saskatchewan cover each municipality, and in Alberta cover each square block of sixteen townships beginning at the 4th meridian and lying between the correction lines. The secretary-treasurer of each municipality in Saskatchewan and Alberta will be supplied with the information covering that municipality. Copies of the reports will also be available for study at offices of the Provincial and Federal Departments. Further assistance in the interpretation of the reports may be obtained by applying to the Chief Geologist, Geological Survey, Ottawa. Technical terms used in the report are defined in the glossary.

How to Use the Report

Anyone desiring information concerning ground water in any particular locality will find the available data listed in the well records. These should be consulted to see if a supply of water is likely to be found in shallow wells sunk in the glacial drift, or whether a better supply may be obtained at greater depth in the underlying bedrock formations. The wells in glacial drift commonly show no regional level, as the sands or gravels in which the water occurs are irregularly distributed and of limited extent. As the surface of the ground is uneven, the best means of comparing water wells is by the elevations of their water-bearing beds. For any particular well this elevation is obtained by subtracting the figure for the depth of the well to the water-bearing bed from that for the surface elevation at the well. For convenience, both the elevation of the wells and the elevation of the water-bearing bed or beds in each well are given in the well-record tables. Where water is obtained from bedrock, the name of the formation in which the water-bearing sand occurs is also listed in these tables, and this information should be used in conjunction with that on bedrock formations, provided in the report, which describes these formations and gives their thickness and sequence. Where the level of the water-bearing sand is known, its depth at any point can easily be calculated by subtracting its elevation, as given in the well-records tables, from the elevation of the surface at that point.

With each report is a map consisting of two figures. Figure 1 shows the distribution and type of surface deposits and bedrock formation that occur in the area. Figure 2 shows the locations of all wells for which records are available, the class of well at each location, and the contour lines or lines of equal elevation. The elevation at any location can thus be roughly judged from the nearest contour line, and the records of the wells show at what levels water is apt to be encountered. The depth of the well can then be calculated, and some information on the character and quantity of water can be obtained from a study of the records of surrounding wells.

GLOSSARY OF TERMS USED

Alkaline. The term "alkaline" has been applied rather loosely to some ground waters that have a peculiar and disagreeable taste. In the Prairie Provinces, water that is commonly described as alkaline usually contains a large amount of sodium sulphate and magnesium sulphate, the principal constituents of Glauber's salt and Epsom salts respectively. Most of the so-called alkaline waters are more correctly termed sulphate waters, many of which may be used for stock without ill effect. Water that tastes strongly of common salt is described as salty.

Alluvium. Deposits of earth, clay, silt, sand, gravel, and other material on the flood-plains of modern streams and in lake beds.

Aquifer. A porous bed, lens, or pocket in unconsolidated deposits or in bedrock that carries water.

Buried pre-Glacial Stream Channel. A channel carved into bedrock by a stream before the advance of the continental ice-sheet, and subsequently either partly or wholly filled in by sands, gravels, and boulder clay deposited by the ice-sheet or later agencies.

Bedrock. Bedrock, as here used, refers to partly or wholly consolidated deposits of gravel, sand, silt, clay, and marl that are older than the glacial drift.

Coal Seam. The same as a coal bed. A deposit of carbonaceous material formed from the remains of plants by partial decomposition and burial.

Contour. A line on a map joining points that have the same elevation above sea-level.

Continental Ice-sheet. The great ice-sheet that covered most of the surface of Canada many thousands of years ago.

Escarpment. A cliff or a relatively steep slope separating level or gently sloping areas.

Flood-plain. A flat part in a river valley ordinarily above water but covered by water when the river is in flood.

Glacial Drift. The loose, unconsolidated surface deposits of sand, gravel, and clay, or a mixture of these, that were deposited by the continental ice-sheet. Clay containing boulders forms part of the drift and is referred to as glacial till or boulder clay. The glacial drift occurs in several forms:

(1) Ground Moraine. A boulder clay or till plain (includes areas where the glacial drift is very thin and the surface uneven).

(2) Terminal Moraine or Moraine. A hilly tract of country formed by glacial drift that was laid down at the margin of the continental ice-sheet during pauses in its retreat. The surface is characterized by irregular hills and undrained basins.

(3) Glacial Outwash. Sand and gravel plains or deltas formed by streams that issued from the continental ice-sheet.

(4) Glacial Lake Deposits. Sand and clay plains formed in glacial lakes during the retreat of the ice-sheet.

Ground Water. Sub-surface water, or water that occurs below the surface of the land.

Hydrostatic Pressure. The pressure that causes water in a well to rise above the point at which it is first encountered.

Impervious or Impermeable. Beds, such as fine clays or shale, are considered to be impervious or impermeable when they do not permit of the perceptible passage or movement of ground water.

Pervious or Permeable. Beds are pervious when they permit of the perceptible passage or movement of ground water, as for example porous sands, gravel, and sandstone.

Pre-Glacial Land Surface. The surface of the land before it was covered by the continental ice-sheet.

Recent Deposits. Deposits that have been laid down by the agencies of water and wind since the disappearance of the continental ice-sheet.

Unconsolidated Deposits. The mantle or covering of alluvium and glacial drift consisting of loose sand, gravel, clay and boulders that overlies the bedrock.

Water-table. The upper limit of the part of the ground wholly saturated with water. This may be very near the surface or many feet below it.

Wells. Holes sunk into the earth so as to reach a supply of water. When no water is obtained they are referred to as dry holes. Wells in which water is encountered are of three classes.

(1) Wells in which the water is under sufficient pressure to flow above the surface of the ground.

(2) Wells in which the water is under pressure but does not rise to the surface.

(3) Wells in which the water does not rise above the water-table.

BEDROCK FORMATIONS OF EAST-CENTRAL ALBERTA

The formations that outcrop in east-central Alberta are of Tertiary and Upper Cretaceous age, and consist entirely of relatively soft shales and sandstones, with some bands of hard sandstone and layers of ironstone nodules. The succession, character, and estimated thickness of the formations are shown in the following table:

Age	Formation	Character	Thickness
			Feet
Tertiary	Paskapoo	Light grey sandstone, in part carbonaceous; shale; small amounts of siliceous limestone and volcanic dust; coal seams.	800 ±
	Edmonton	Grey to white, bentonitic sands and sandstones, with grey and greenish shales; coal seams prominent in some areas, as at Drumheller.	1,000 to 1,150
	Bearpaw	Dark shales, green sands with smooth, black chert pebbles; partly non-marine, with white bentonic sands, carbonaceous shales, or thin coal seams similar to those in Pale Beds; shales at certain horizons contain lobster-claw nodules and marine fossils; at other horizons selenite crystals are abundant.	300 to 600
Upper Cretaceous	Pale and Variegated Beds	Light grey sands with bentonite; soft, dark grey and light grey shales with selenite and ironstone; carbonaceous shales and coal seams; abundant selenite crystals in certain layers.	600 ±
	Birch Lake (?)	Grey sand and sandstone in upper part; middle part of shales and sandy shales, thinly laminated; lower part with grey and yellow weathering sands; oyster bed commonly at base.	100 ±
	Grizzly Bear	Mostly dark grey shale of marine origin, with a few minor sand horizons; selenite crystals and nodules up to 6 or 8 inches in diameter.	100 -
	Ribstone Creek	Grey sands and sandstones at the top and bottom with intermediate sands and shales; mostly non-marine, but middle shale in some areas is marine.	325 -

WATER ANALYSES

Introduction

The following discussion of water analyses is included to assist those who wish to know the effect of various mineral constituents in well water, which give the water in some wells certain peculiar qualities.

Discussion of Chemical Determinations

The dissolved mineral constituents vary with the material encountered by the water in its migration to the reservoir bed. The mineral salts present are referred to as the total dissolved solids, and they represent the residue when the water is completely evaporated. This is expressed quantitatively as "parts per million", which refers to the proportion by weight in 1,000,000 parts of water. A salt when dissolved in water separates into two chemical units called "radicals", and these are expressed as such in the chemical analyses. In the one group is included the metallic elements of calcium (Ca), magnesium (Mg), and sodium (Na), and in the other group are the sulphate (SO_4), chloride (Cl), and carbonate (CO_3) radicals.

Mineral Constituents Present

Calcium (Ca) in the water comes from mineral particles present in the surface deposits, the chief source being limestone, gypsum, and dolomite. Fossil shells provide a source of calcium, as does also the decomposition of igneous rocks. The common compounds of calcium are calcium carbonate ($CaCO_3$) and calcium sulphate ($CaSO_4$).

Magnesium (Mg) is a common constituent of many igneous rocks and, therefore, very prevalent in ground water. Dolomite, a carbonate of calcium and magnesium, is also a source of the mineral. The sulphate of magnesium ($MgSO_4$) combines with water to form "Epsom salts", and if present in large amounts imparts a bad taste and is detrimental to the health.

Sodium (Na) is derived from a number of important rock-forming minerals, so that sodium sulphate and carbonate are very common in ground waters. Sodium sulphate (Na_2SO_4) combines with water to form "Glauber's salts", which if present in amounts over 1,200 parts per million makes the water unfit for domestic use or for irrigation. Sodium carbonate (Na_2CO_3) or "black alkali" waters are mostly soft, the degree of softness depending upon the ratio of sodium carbonate to the calcium and magnesium salts. Waters containing sodium carbonate in excess of 200 parts per million are unsuitable for irrigation.

Chlorine (Cl) is, with a few exceptions, expressed as sodium chloride (NaCl), which is common table salt. When found in water in excess of 400 parts per million it renders the water unfit for domestic use.

Iron, when present in more than 0.1 parts per million, will settle out of the water as a red precipitate on exposure to the air. Water that contains not more than 0.5 parts per million is considered the usual upper limit for potable water, but this amount is often exceeded. A water that contains considerable iron will stain porcelain, enamel ware, and clothing that is washed in it, but the iron can be almost completely removed by aeration and filtration of the water.

Hardness. Hardness is of two kinds, temporary and permanent. Temporary hardness is caused by calcium and magnesium bicarbonates, which are soluble in water but are precipitated as insoluble normal carbonates by boiling, as shown by the scale that forms in teakettles. Permanent hardness is caused by the presence of calcium and magnesium sulphates, and is not removed by boiling. Waters grade from very soft to very hard, and can be classified according to the following system[1].

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1 The "Examination of Waters and Water Supplies"; Thresh and Beale, Fourth Ed. 1933, p. 21.

A water under 50 degrees (that is, parts per million) of hardness may be said to be very soft.

A water with 50 to 100 degrees of hardness may be said to be moderately soft.

A water with 100 to 150 degrees of hardness may be said to be moderately hard.

A water with more than 200 and less than 300 degrees of hardness may be said to be hard.

A water with more than 300 degrees of hardness may be said to be very hard.

Hard waters are usually high in calcium carbonate. Almost all of the waters from the glacial drift are of this type, particularly those not associated with sand and gravel deposits that come close to the surface.

In soft water the calcium carbonate has been replaced by sodium carbonate, due to natural reagents present in the sands and clays. Bentonite and glauconite are two such reagents known to be present. Montmorillonite, one of the clay-forming minerals, has the same property of softening water, owing to the absorbed sodium that is available for chemical reaction.[2]

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2 Piper, A.M.: "Ground Water in Southern Pennsylvannia", Penn. Geol. Surv., 4th series.

If surface water reaches the lower sands by percolating through the higher beds it may be highly charged with calcium salts before reaching the bedrock formations containing bentonite or glauconite. The completeness of the exchange of calcium carbonate for sodium carbonate will, therefore, depend upon the length of time that the water is in contact with the softening reagent, and also upon the amount of this material present. The rate of movement of underground water will, consequently, be a factor in determining the extent of the reaction.

TOWNSHIPS 31 TO 34, RANGES 25 TO 29, WEST FOURTH MERIDIAN, ALBERTA

Introduction

The investigation of ground-water resources in Alberta was continued during the summer of 1949 by the writer, ably assisted by P. J. S. Byrne. The surface deposits were also mapped, and the relation of both the surface deposits and the underlying bedrock to the ground-water supply studied.

Physical Features

Several valleys, as much as 300 feet deep and with gradients of 7 to 15 feet to a mile, trend south or southeastward through the area. The two largest are occupied by Threehills and Kneehills Creeks, but those of Spruce and Lonepine Creeks are also large. Several dry valleys 50 to 150 feet deep and some smaller ones are present in the west. Threehills and Kneehills Valleys are several miles wide and have gently-sloping valley walls, whereas the other valleys are narrow and steepsided. Lakes and ponds, commonly a mile long, are present, chiefly in the south-centre of the area. Most of these lie in valleys that have been dammed by drift, such as Davey Lake, or locally deepened by glaciation, such as Stewart Lake.

The highest altitudes in the area, over 3,350 feet, are about 5 miles northwest of Wimborne, and much of the west and northwest part of the township is over 3,300 feet. The surface generally falls eastward and southeastward to about 3,000 feet, and Threehills and Kneehills Creeks leave the area at about 2,800 feet above sea-level. This general trend is interrupted by the Kneehills, which rise to 3,250 feet above sea-level and have a surprisingly flat summit several miles in extent. Other hills 5 miles east of Sunnyslope also rise above 3,250 feet. Some hills and ridges are also present in the east and north. Local relief greater than 300 feet is common.

Except for the valleys and several long, narrow, low ridges, the southwest part of the area is almost monotonously flat. The north and northeast is generally characterized by broadly rolling hills and ridges, and in the southeast broad hills and valleys are common. The topography is almost entirely a reflection of the bedrock, and is a little modified by drift.

Geology

Almost the entire area has a mantle of glacial deposits or alluvium. The underlying bedrock is Paskapoo formation, but the Edmonton formation, although below the Paskapoo and probably more than 500 feet deep in the western part of the area, comes close to the surface in the southeast. Older formations, mentioned in the table on page 4, underlie the Edmonton, but as they are not less than 1,200 feet deep, they are too deep to affect surface features or water supply. The common dip of bedrock is west or southwest, and, as the land surface also rises in that direction, the Paskapoo is thicker there, and beds younger than those in the east are present. Bedrock is exposed along several stream valleys and particularly in road ditches crossing hills and ridges in the southeast.

Edmonton Formation. The name Edmonton was first applied to the beds containing coal in the Edmonton area, and later to the same beds in adjoining areas. The formation has a total thickness of 1,000 to 1,150 feet, but is bevelled off eastwards, and the eastern edge of the formation follows a northwest line from Coronation through Tofield to a point on North Saskatchewan River about midway between Edmonton and Fort Saskatchewan. No Edmonton beds occur northeast of this line, but as the formation dips to the southwest it becomes progressively thicker in that direction.

The Edmonton formation consists of poorly bedded, grey and greenish grey clay shale, coal seams, and sand and sandstone that contain clay and white material known as bentonite. Bentonite when wet is very sticky and swells greatly in volume and when dry tends to whiten the beds containing it. Such beds are relatively impervious to water, and at the surface produce the "burns" of barren ground where vegetation is scanty or absent.

Paskapoo Formation. This formation was first named by Tyrell from exposures of the lower part of the formation along Blindman River near its confluence with the Red Deer. It is composed essentially of sandstone and shale deposited in fresh water and includes some thin coal seams and carbonaceous beds. The basal beds are massive, crossbedded sandstone that weathers buff-yellow, and are in striking contrast to the underlying, light-coloured, bentonitic clay of the Edmonton formation. About 150 to 200 feet above the base of the formation are a series of lenses of siliceous limestone containing fossil gastropods and pelecypods.

Unconsolidated Material. During Pleistocene or Glacial time, great accumulations of ice formed at various centres in northern Canada. This ice moved out in all directions from these centres and covered large regions with what has been called the continental ice-sheet. As the ice advanced, it picked up great quantities of loose rock debris that was laid down when the ice finally melted. This material is unconsolidated, and is commonly called glacial drift.

The present area was entirely covered by one or more continental ice-sheets during Pleistocene time, and the final retreat of the ice left the bedrock buried to various depths by glacial drift. Most of the drift consists of boulders and pebbles of various compositions and sizes embedded in a matrix of clay or sandy clay to form a more or less impervious mass known as boulder clay or till. Irregularly intermingled with this till and also lying above it, are beds, pockets, and lenses of sand and gravel that form the water-bearing members or aquifers.

The character of the till changes gradually from east to west. In the east it is a brownish or yellowish colour and contains much clay, little sand, and few stones. It is very sticky and contains much material derived from the Edmonton formation. In the west, as it contains more material from the Paskapoo formation, it is brownish, yellowish, or reddish coloured and, although it also contains much clay, it is more sandy and is slightly less sticky than that in the east. It contains more stones, chiefly of quartzitic material gathered by the ice from gravel carried by rivers flowing eastward from the Rocky Mountains, although pockets of gravel are uncommon.

The unconsolidated material is rarely more than 20 feet thick, and its average thickness is probably less than 15 feet. It is thickest in the areas of end moraine in the northeast, but even there is not as thick as would at first appear as the moraine commonly overlies rises in bedrock.

Ground Moraine. This type of drift is chiefly till or boulder clay laid down beneath the ice-sheet. It commonly has a flat or gently rolling surface, and has a tendency to lessen the relief of the underlying bedrock surface. Ground moraine covers about 435 square miles, or most of the area.

End Moraine. Part of the material carried by the ice-sheet is dropped at its front or margin during pauses in the general retreat of the melting glacier. It consists of till, silt, sand, and gravel gathered during the advance of the ice-sheet. Much of the clay, silt, and fine sand may have been carried away by melt-water from the glacier, and the material forming end moraine is commonly coarser than that forming ground moraine, and may consist mainly of gravel, sand, and coarse till, characteristically arranged in hummocks and undrained or poorly drained hollows. In the area being discussed, however, the material of the end moraine is not noticeably coarser than that of the ground moraine. About 85 square miles, chiefly in the northeast, is covered with the typical ridges, hills, and depressions of weakly developed, clayey, end moraine.

Glacial-lake Sediments. During the melting back of the ice-sheet many lakes were formed where the normal drainage was temporarily blocked by lobes of ice or masses of glacial debris. Sand, silt, and clay were washed into these lakes and there laid down. Draining or lowering of these lakes exposed this material in discontinuous patches here and there throughout the area. Similar, although commonly coarser, material was laid down by streams draining these lakes, by streams from the melting ice, or by recent streams. The original sediments have been attacked by wind and much of the material redistributed by this agent. Sediments of these latter types affect water supply in much the same manner as do the glacial-lake sands, from which most of them are practically indistinguishable. Scattered patches of glacial-lake beds cover about 65 square miles of the area, of which 30 square miles consist of impervious lake clay or silt in the valleys of Kneehills and Threehills Creeks. North of Sunnyslope duned sand covers about 10 square miles.

Patches of stream and glacial-outwash gravel cover more than 9 square miles, and bedrock is shallow in areas totalling 3 or 4 square miles. These areas are mentioned in the descriptions of the various townships.

Water Supply

Sufficient water for ordinary farm and town use can be obtained anywhere in the area. The quality is generally good, as shown by chemical analysis of representative samples given later.

The average depth of drilled wells in the area is about 107 feet, slightly less in the north. The average depth of dug wells is about 25 feet. The water is always under pressure, and rises one-third to two-thirds of the distance to the surface. Springs occur along some valleys, and several flowing wells are present, particularly near Lonepine Creek in the west.

The area has a semi-arid climate and the average yearly precipitation ranges from about 14 to 19 inches, being greatest in the west and north, and least in the southeast. One-quarter to one-third of the precipitation is in the form of snow. In the southwest and southeast the run-off is rapid as the drainage is fairly good, the vegetation light, and much of the soil nearly impermeable clay. Furthermore, as the humidity is generally low and the summers are warm, the rate of evaporation is high. In much of the north and south-central parts of the area, particularly in that part covered by end moraine, drainage is poor, there are more trees and other vegetation, the surface material is commonly more permeable, and the run-off is slower and smaller than in the southwest and southeast. A much greater proportion of the precipitation, therefore, seeps into the drift and bedrock in the north, northeast, and south-central parts than in the southwest and southeast. For these reasons, and also because the total precipitation is greater in the former regions, there is more ground water available there than in the southwest and southeast. Thus, although sufficient water for farm and domestic use is available anywhere, large supplies are easily obtainable only in the north.

No dependable sources of surface water are present, for the creeks, such as Threehills, Kneehills, Spruce, and Lonepine, are small and nearly dry during much of the summer, and the lakes and ponds become low and rather alkaline in dry years.

A few wells draw generally fair or sufficient supplies of water from aquifers in glacial-lake sands, dune sand, outwash and stream gravel or alluvium, and end moraine. An adequate supply of water is unlikely to be obtained from the ground moraine, which covers most of the area, or from the lake clay and silt in Threehills and Kneehills Valleys. Most of the water found in the drift contains much calcium and is hard and may also contain noticeable amounts of iron.

Of the 528 wells recorded, 508 draw from bedrock aquifers, 2 of these in the southeast from Edmonton formation and the others from the Paskapoo. All but 70 of the bedrock wells are drilled. About 14 of the 20 non-bedrock wells are dug into glacial drift and 6 are in recent material. In thirteen of the twenty townships no non-bedrock wells are recorded.

The Edmonton formation contains many isolated lenses of sand irregularly distributed throughout the formation. Some zones contain more of these lenses than others and, as the water is in the sand, these zones are the more likely to yield water. Water is also frequently found either above or below coal seams. The Edmonton aquifers are used only in the southeast, where the formation is shallowest, but even in the eastern half of the area it is a potential source of soft water for deep drilling. Although this formation contains much water, the generally small grain size of the material composing it does not allow it to yield this water quickly.

Water entering the Edmonton beds through the overburden is usually charged with calcium carbonate and is hard, but sodium carbonate from the Edmonton formation replaces the calcium carbonate, softening the water. Generally the longer water is in contact with the Edmonton formation the softer it becomes, and although hard or moderately hard water may occur near the surface of the Edmonton, farther down practically all the water is soft. Sodium carbonate is the principal mineral matter found in water from the Edmonton formation along with small amounts of iron in places and some carbonaceous material from near coal seams.

The Paskapoo formation generally contains abundant water, mostly in porous sand lenses that are more common in some horizons of the formation than in others. None of these lenses can be traced far, but in most places they overlap and form aquifer zones each of which has water with distinguishing characteristics. In this area, each zone becomes deeper westward and finally can be traced no farther in that direction. The sand of the Paskapoo formation is commonly coarse and will yield water quickly. This is particularly characteristic of the area being discussed. As much of the Paskapoo formation is unconsolidated, trouble is experienced with sand and silt entering wells and reducing the water supply. Well screens are not used in the area, but might prove practicable in some wells.

The water contained in the Paskapoo formation in this area varies greatly in quality, but generally contains much calcium carbonate, indeed some of the water is too hard for ordinary washing. Of the wells into Paskapoo recorded in this area, 216 yield hard water, and 280 soft or moderately hard water. Much of the water from the Paskapoo contains some iron, and the very hard water may contain a great deal of it, in some wells, indeed, the water cannot be used on this account. As the soft water of the area contains much soda, aluminium or magnesium casing should not be used in wells of this type.

In the well record sheets at the end of the report, and in the descriptions of the various townships, the terms poor, insufficient, fair, sufficient, good, very good, and excellent are used to describe the water supply. Poor or insufficient is used if enough water for ordinary farm needs, perhaps 500 gallons a day, cannot be obtained from the well. The term fair supply is used if enough water for such needs can be obtained, generally more than 1,000 gallons a day, but only by slow pumping or by pumping small amounts several times a day. Sufficient supply indicates that enough water is available, but that little information could be obtained upon the amount used. Good supply is used if the well does not go dry under ordinary farm demands, and enough water for farm needs with some to spare can be obtained at one pumping. Such wells can generally yield more than 2,000 or 3,000 gallons a day. Very good supply means that no trouble has ever been experienced in obtaining sufficient water and that at least 5,000 to 15,000 gallons a day should be available. Excellent supply is used if the amount of water available is exceptionally good.

Township 31, Range 25. Kneehills Creek flows southeastward through the southwest corner of the township at about 2,285 feet above sea-level. The land rises to the north and east, and some hills in the southwest are higher than 3,250 feet in elevation. The topography is mainly that of broad, smooth, bedrock hills, little modified by drift, but cut by valleys and gullies of recently developed drainage.

A thin, flattish mantle of ground moraine covers most of the township, but in the west it is commonly overlain by sand, laid down chiefly as alluvium and outwash and in some places later duned by wind. Bedrock outcrops on some hills and in some gullies, but the average thickness of drift is probably 10 to 15 feet.

Only one of the thirty wells recorded obtains water from unconsolidated material. The sand in the west can supply some water, but, as the till is thin and relatively impervious, none can be obtained from the ground moraine. The water in the unconsolidated material is hard and in poor to fair supply only. Furthermore, the wells are difficult to maintain.

Of the twenty-nine Paskapoo bedrock wells, twenty-eight are drilled, and these are 45 to 200 feet deep with an average depth of about 100 feet. The amount of water in practically all is good, and 60 per cent yield soft water. They tap aquifers between 2,820 and 3,080 feet above sea-level, but mostly between 2,900 and 3,000 feet. Hard and soft water aquifers are intermingled. The water has some pressure, but its rise in the wells is generally negligible or slight.

Although the Edmonton formation is 200 to 500 feet below the surface, it is everywhere a potential source of soft water for deep drilling. In general, ample water, soft if desired, may be found anywhere in the township.

Township 31, Range 26. Kneehills Creek flows southeastward through a large valley across the northeast quarter of the township. Lonepine Creek flows southeastward across the southwest corner. A third valley, marked by a string of lakes, trends southeast from the northwest corner. Except for these valleys, and sand hills in the northeast, the surface is practically flat. Several lakes are present, but these usually become low in the autumn.

Ground moraine covers more than half the township. In the northeast alluvial sand, partly reworked by wind to form dunes, commonly overlies the ground moraine and some low morainal hills. Sand, silt, and clay occur along the three valleys mentioned above, and gravel is also present along Lonepine Creek. A thin layer of lake sand is present in the southwest.

The unconsolidated material probably does not average much more than 10 or 12 feet in thickness, and is not important for water supply. Of the twenty-seven wells recorded only five, all in sand or gravel areas and mostly in the wind-blown sand, tap aquifers in these deposits. The water of all five is hard and in fair to good supply. Any attempt to find water in the ground moraine is ill-advised.

Eighty per cent of the wells enter bedrock, and most of these are drilled. The latter are 55 to 225 feet deep, with an average depth of 110 feet. They tap aquifers between 2,735 and 3,070 feet above sea-level, but chiefly between 2,805 and 2,965 feet. The lowest aquifer, at 2,737 feet, is probably in the

Edmonton formation, which, although it does not outcrop and is at a general depth of 200 to 300 feet, is everywhere a potential source of soft water. The other aquifers are in the Paskapoo formation. This formation underlies the unconsolidated material everywhere and outcrops along Kneehills Creek and beside some lakes, in the southeast of section 29 for example. The quantity of water is generally good, and the water is under pressure and rises one-half to four-fifths of the distance to the surface. Soft and hard water aquifers alternate, and one-third of the wells yield soft or moderately hard water and the remainder hard.

In general, ample water, mostly hard, can be obtained at reasonable depth anywhere in the township.

Township 31, Range 27. Lonepine Creek flows eastward in a shallow valley, and is joined near the centre of the township by another valley, now dry. Other major topographic features are lacking.

A mantle of ground moraine, probably averaging 15 feet in thickness, covers most of the township. The surface of this is practically flat except for a few morainal ridges 10 to 30 feet high and several miles long. Five to ten feet of coarse gravel with a very flat surface covers about 5 square miles along the dry valley in the northwest part of the township and some lake sand is present in the southeast corner. Several shallow wells draw hard water from the gravel, but no water can be obtained from the ground moraine.

The Paskapoo formation underlies the unconsolidated material everywhere but rarely outcrops, and 95 per cent of the wells recorded enter it. All but two of the bedrock wells are drilled, and these are 60 to 170 feet deep with an average depth of about 120 feet. They use aquifers from 2,895 to 3,100 feet above sea-level, and many tap aquifers near 2,950 feet. Soft-water aquifers are interposed with hard-water ones, and the same aquifer may yield hard water to one well and soft to another some distance away. About 60 per cent yield soft or moderately hard water. The supply is generally good except in those wells being filled with silt, in which it is commonly insufficient. Most of the water is under enough pressure to force it nearly to the surface, and one flowing well is recorded.

In general, ample water is available in the bedrock at moderate depth anywhere in the township.

Township 31, Ranges 28 and 29. Several low, morainal ridges offer some relief to an otherwise flat and featureless surface that slopes slightly down towards Lonepine Creek in the northeast corner of the township.

Ground moraine 10 to 30 feet thick covers the entire township, except for a few ridges of end moraine 20 to 50 feet high and ½ mile to 3 miles long. The worthlessness of the ground moraine for water supply is indicated by the fact that not one of the seventy three wells recorded taps aquifers in it, and any attempt to obtain water from the drift is ill-advised.

The unconsolidated material is underlain by the Paskapoo formation, which contains much water. Aquifers in it are particularly numerous in this region, perhaps reflecting a greater than usual proportion of sandstone and less clay. All the wells are drilled into this formation, and are 15 to 250 feet deep, with an average depth of 105 feet in range 28 and 140 feet in range 29. They tap aquifers between 2,845 and 3,195 feet above sea-level, but mostly above 3,000 feet. The water in the lower aquifers is commonly softer than that in the higher. More than half the wells yield soft water and another fifth moderately hard water. The quantity in practically all wells is good to very good. The water is under much pressure, and in five wells rises to or above the surface. The rise is greatest in sections 21, 26, 27, 28, 30, 34, 35, 36, range 28, or in the vicinity of a valley tributary to Lonepine Creek.

In general, the Paskapoo formation yields ample, mostly soft water under strong pressure at moderate depth anywhere in these townships.

Township 32, Range 25. The Knee Hills, which cover more than half the township, are the chief topographic feature. In the west they form a flat-topped strath at more than 3,200 feet above sea-level. In the southwest also they rise above 3,200 feet, and at lower elevations they cover the centre of the township. From Kneehills the surface slopes east and northeast to below 2,850 feet in the northeast corner of the township. Several gullies drain in this direction into Threehills Creek. The topography reflects bedrock features that are little modified by drift.

A flat mantle of ground moraine, with an average thickness of perhaps 10 feet, covers most of the township. Bedrock is exposed near the surface on Knee Hills and in some gullies. Lake clay, a continuation of the body laid down in Threehills Creek Valley, covers several square miles in the northeast. The fact that probably none of the wells examined draws water from them, indicates that the ground moraine and lake clay is too thin and too impervious to hold satisfactory supplies of water.

Of the 21 bedrock wells recorded, 17 are drilled, 32 to 200 feet deep, with an average depth of 90 feet. As the surface has much relief, aquifers between 2,790 and 3,130 feet above sea-level are used, but most wells tap aquifers between 2,790 and 2,955 feet. The water is under pressure and rises in the wells, but the depth to water is extremely variable because of the broadly rolling nature of the surface. The quantity of water in all wells is good to very good. In more than half the water is soft, although no particular soft-water zones in the bedrock are apparent.

Sufficient good water for ordinary farm use, and in places large amounts, is obtainable anywhere in this township at rather shallow depth.

<u>Township 32, Range 26.</u> Kneehills Creek flows southward in a valley 3 miles wide and more than 150 feet deep. Spruce Creek, in a valley equally deep but narrower, joins it near the centre of the township. In the east the broad Kneehills, composed largely of bedrock, rise 350 feet above the valleys. The surface in the southeast is rolling, in the southwest fairly flat, and in the northwest rolling with many small hills.

A thin mantle of ground moraine covers 9 square miles of the northeast part of the township and 8 of the southwest. Lake and stream alluvium, mostly sand and commonly duned by wind, covers the valleys except where outwash gravel and end moraine occur on the south side of Spruce Creek. The unconsolidated mantle probably averages 15 to 20 feet in thickness, being thicker in areas of end moraine and thinner in ground moraine.

Some water is available in the end moraine and sand, but little can be expected in the ground moraine. In general, the water in the surficial material is hard and the wells are difficult to maintain. Bedrock aquifers are a more attractive source of water.

The Paskapoo formation underlies the unconsolidated mantle throughout the township and contains the aquifers tapped by most of the wells. These wells are 50 to 250 feet deep, and average about 140 feet in depth. They tap aquifers between elevations of 2,810 and 3,085, but mostly between 2,810 and 2,950 feet. The quantity of water in each well is satisfactory, and in 80 per cent the water is soft or moderately hard. A single aquifer may, however, yield soft water in one place and hard in another. The water is under pressure and generally rises one-half to two-thirds of the distance to the surface. Springs are present along the valleys.

Large amounts of water, generally soft, can be obtained at moderate depth in the bedrock practically anywhere in the township.

Township 32, Range 27. Spruce Creek crosses the northeast corner of the township in a narrow, steep-sided valley as much as 250 feet deep. A large valley, now dry except for several lakes, trends southeast to the southeast corner, and a shallow valley crosses the extreme southwest corner of the township. These valleys are the chief topographic features. The land in the northeast is markedly rolling, but elsewhere, except for several long, narrow ridges, the land is flat to gently rolling.

South of Spruce Creek outwash gravel and end moraine forming knob and kettle topography cover 3 square miles. In other places linear end moraines, 10 to 40 feet high and ½ mile to 5 miles long, are present. Gravel beds, 5 to 10 feet thick and flat surfaced, cover about 1 square mile of the southwest. Over the remainder of the township bedrock is covered by ground moraine. The unconsolidated cover has an average thickness of perhaps 15 feet, and is thickest in areas of end moraine.

Of the wells examined only three, in end moraine or the more sandy ground moraine, draw water from unconsolidated materials. This water is hard and in only fair supply. Although the gravel in the southwest, the end moraine, and the sandy ground moraine will yield water, most of the ground moraine contains little, and the use of bedrock aquifers is everywhere advisable.

Paskapoo formation underlies the drift throughout the township and most wells are drilled into it. They are from 20 to 262 feet deep, with an average depth of 110 feet, and tap aquifers between 2,910 and 3,145 feet above sea-level. They generally supply a fair to good quantity of water, but quicksand commonly causes trouble and deepening would improve those with poor supplies. The wells are fairly equally divided between those that produce soft, moderately hard, and hard water; those that tap the lower aquifers generally yield the softer water. The water commonly contains noticeable iron, and in some cases in large amounts. The water is under pressure, and its rise in the wells, although variable, is mostly high, particularly so in the south and west.

In general, sufficient water for ordinary farm use is available anywhere at moderate depth in the bedrock, and very large supplies are commonly available.

Township 32, Ranges 28 and 29. Lonepine Creek flows southward through the centre of the township in a very small valley. A second shallow but wider valley parallels Lonepine Creek through the eastern part. A few low ridges, some several miles long, are present near Lonepine Creek, but otherwise these townships are relatively flat and without any striking topographical feature.

Ground moraine covers both townships, except for some gravel and sand along the easterly of the two valleys, and several small, linear end moraines. The unconsolidated cover is thin, particularly in the southeast, and probably does not average much more than 15 feet in thickness. Bedrock outcrops or is close to the surface near some of the valleys. The drift is too thin, and the ground moraine is too impervious to be of any value for water supply, and none of the wells recorded obtains water in them.

The Paskapoo formation underlies the drift and most wells are drilled into it. These wells are 55 to 230 feet deep, with an average depth of 125 feet in range 28 and 135 feet in range 29. They tap aquifers between 2,905 and 3,160, but mostly from 3,040 to 3,160 feet above sea-level. The supply practically everywhere is good to very good, and the few wells with insufficient water could be improved by deepening. Although no aquifer yields the same kind of water everywhere, the water in 60 per cent of the wells is soft. Most of the water contains noticeable iron, and some water a great deal of it. As the water is under considerable pressure, it commonly rises high, and flowing wells, several with excellent flow, are present in the low land drained by Tenmile Creek in sections 17 and 18 of range 28, and 13 and 24 of range 29.

Ample water for farm or town use, mostly soft, is generally available at moderate depth in the bedrock anywhere in these townships.

Township 33, Range 25. Threehills Creek flows south down the east side of the township, and its valley, 3 or 4 miles wide and as much as 200 feet deep, is the chief feature of the township. The valley floor is almost flat, but elsewhere the surface of the township is rolling with a general slope down towards Threehills Creek. Here and there it is cut by gullies, and broad bedrock hills or smaller ones of drift rise above the general level. Trees are present in the northern part of the township, but the tree limit runs through the township and in the southern part they are absent.

Low end moraine, with knobs rising 20 or 30 feet above the kettles, covers more than half the township. Lake clay forms a fairly flat surface in 8 square miles of Threehills Valley and gravel is present in sections 3, 4, 5, 9, and 10. A mantle of ground moraine, not thick enough to mask entirely irregularities in the top of the underlying bedrock, covers the rest of the township. The surficial material, of which the end moraine is thickest, averages perhaps 15 feet in thickness. The lake clay yields no water, and the ground and end moraine, although they contain patches of sand, are so thin that bedrock aquifers are a more reliable source of water. None of the wells recorded obtains water from the drift.

The Paskapoo formation underlies the drift and supplies all the water used. The Edmonton formation, which underlies the Paskapoo at depths of 200 to 400 feet, is a potential source of soft water for deep drilling. The drilled wells are 50 to 176 feet deep, with an average depth of 100 feet, and tap aquifers between 2,685 and 3,050 feet above sea-level, but mostly between 2,775 and 2,825, 2,850 and 2,895, and 2,980 and 3,020 feet. The lower aquifers supply hard to very hard water to about 70 per cent of the wells. The moderately hard and hard water generally contains noticeable to much iron that gives a strong iron taste. Practically all wells have ample water, under sufficient pressure in the east to rise nearly to the surface but with practically no rise in the west.

In general, sufficient water for ordinary farm use is available from the bedrock anywhere in the township, and larger amounts can be obtained. However, the quality may not be as good as desired.

Township 33, Range 26. Kneehills Creek flows southward along the west side of the township through a flat-floored valley several miles wide and 200 feet deep. The rest of the township is marked by broad, bedrock hills and ridges, and lesser, rolling, morainal hills. The surface rises from Kneehills Creek eastwards towards Wimborne.

Knob and kettle end moraine, with hills as much as 30 feet high, covers 15 square miles in the northeast, and lake clay covers about 9 square miles of Kneehills Valley. Elsewhere, ground moraine, too thin to hide the irregularities of the underlying bedrock surface, covers the township. The drift, which is thickest in areas of end moraine, has an average thickness of perhaps 15 to 20 feet. The lake clay and ground moraine yield no water, but the end moraine contains sandy lenses that may yield fair amounts. However, as the drift is thin, bedrock is a more certain source of water, and none of the wells examined tapped aquifers in the overburden.

As the Edmonton formation is 400 to 600 feet deep, its soft water is not easily available in this township, and all the wells enter the Paskapoo formation, which directly underlies the drift. The drilled wells are 40 to 235 feet deep, with an average depth of 95 feet, and tap aquifers between 2,905 and 3,120 feet above sea-level, but chiefly from 2,945 to 3,035, and 3,070 to 3,120 feet. Half the wells yield hard water, the others moderately hard or soft. The water from above 3,070 feet is chiefly hard to very hard and contains noticeable, to much, iron, whereas water from the lower aquifers is generally softer and contains less iron. The quantity of water in all the wells is fair to good, and the water is generally under enough pressure to rise more than half the distance to the surface. Two shallow wells, dug into bedrock, flow and yield large quantities of hard water.

Township 33, Range 27. A dry valley about 1 mile wide and 200 feet deep in the western part of the township is the chief topographic feature. Elsewhere the surface is more or less flat but slopes downward in the east towards Kneehills Creek.

Ten to fifteen feet of a sticky, clayey, grey or brown, relatively stoneless ground moraine covers all the township except in the dry valley where bedrock is near the surface. As it is thin and contains much clay any attempt to obtain water from the drift is ill-advised, and no wells use aquifers in it.

The Paskapoo formation underlies the surficial material and is the only potential source of water. All wells tap aquifers in it. Only 4 of the 37 wells recorded are dug, and the 33 drilled wells are 38 to 210 feet deep, with an average depth of 105 feet. They tap aquifers distributed fairly evenly between 2,925 and 3,225 feet above sea-level. Soft-water aquifers are alternated with those yielding hard water, about half the wells yielding hard water and the others moderately hard or soft. Iron is noticeable in the water from about half the wells. The only two wells have insufficient water, and these are shallower than the average and would be improved by deepening. The water is mostly under enough pressure to raise it one-third to two-thirds of the distance to the surface.

In general, ample water for farm and domestic use, and probably in most places also for town use or other large requirements, is available at moderate depth in the bedrock.

Township 33, Ranges 28 and 29. A narrow, dry valley, about 150 feet deep, that for several miles is divided into two parallel branches, trends southeastward through the centre of range 28. Except for this valley, only a few low, scattered ridges break the monotony of the flat and featureless townships.

Except for the valley where bedrock is near the surface and a few ridges of end moraine perhaps 20 feet high and as much as 3 miles long, ground moraine covers these townships. East of the valley this material has an average thickness of about 7 feet, and west of it a thickness of about 10 or 12 feet, as it is thin and generally contains much clay, any attempt to obtain water from it is inadvisable. The only well that does not enter bedrock draws a good supply of hard water from a local pocket of gravel in sec. 23, rge. 28.

The Paskapoo formation underlies the drift and supplies practically all the water used. The drilled bedrock wells are 45 to 240 feet deep, with an average depth of 105 feet in range 28 and 115 in range 29. They tap aquifers between 2,980 and 3,240 feet above sea-level, but particularly in the zones between 3,010 and 3,030 feet, 3,100 and 3,175 feet, and 3,205 and 3,240 feet. About two-thirds of the wells yield soft or moderately hard water, the others hard to very hard, and the water from about one-third has noticeable amounts of iron. The amount of water from all these drilled wells is sufficient for ordinary farm use, and the water generally has enough pressure to raise it half the distance to the surface. One flowing well is recorded near Lonepine Creek and others could be found in the same locality, as in the townships to the north.

An interesting feature of these townships, and of those to the north, is the large number of rather similar wells dug into bedrock. Ten wells of this type are recorded and others are undoubtedly present. They average 30 feet in depth and yield hard or moderately hard water in which iron is seldom noticeable, the quantity being generally sufficient for farm use. They use aquifers between 3,180 and 3,280 feet above sea-level, but mostly from 3,180 to 3,195 feet, a zone from which no drilled well obtains water. The water level of these dug, bedrock wells falls in dry years.

In general, large amounts of good water can be obtained, at comparatively shallow depth, in the bedrock anywhere in these townships.

Township 34, Range 25. Threehills Creek flows southeastwards from corner to corner across this township and, although only a small stream, it occupies a flat-floored valley several miles wide and 100 to 150 feet deep that is the chief topographic feature of the township. The surface elsewhere is rough, with broad, bedrock hills and ridges commonly overlain by smaller, rolling drift knolls 20 to 50 feet high. Gullies are present near the creek.

An almost flat mantle of lake clay and silt covers 6 square miles of the valley floor. Knob and kettle end moraine, with hills perhaps 20 feet high, covers about 7 square miles of the southwest and nearly 11 square miles in the north. The end moraine crosses Threehills valley in a strip about ½ mile wide through which the creek flows with a winding course and steep gradient. The eastern edge of this end moraine rises remarkably suddenly from the level of the ground moraine to hills 30 to 50 feet high. Ground moraine covers the rest of the township. The drift, which is thin in ground moraine areas and near Threehills Creek but thicker in areas of end moraine, has an average thickness of perhaps 20 to 25 feet.

None of the wells recorded obtains water from the surficial material. The lake sediment and ground moraine are too thin and contain too much clay to provide an adequate water supply. Although water should be available from the end moraine, it will be hard in quality, variable in quantity, and the wells will require much maintenance.

The Paskapoo formation underlies the surface material and is the common source of water. However, several wells that tap lower aquifers may enter the Edmonton formation, which is everywhere a potential source of soft water for deep drilling. All the wells recorded are drilled, are from 32 to 200 feet deep with an average depth of about 90 feet, and tap aquifers between 2,765 and 2,950 feet above sea-level. Most aquifers between 2,765 and 2,865 feet yield good quantities of soft water without noticeable iron, whereas most between 2,875 and 2,950 feet supply fair to good quantities of hard water, usually with a considerable amount of iron but never so much as to prevent use. The water commonly has enough pressure to rise one-half to two-thirds of the distance to the surface.

In general, the bedrock yields ample water for ordinary farm use at comparatively shallow depth anywhere in the township, and larger quantities are probably available.

Township 34, Range 26. The west part of the township is marked by a hilly, uneven ridge of bedrock that forms the divide between Kneehills and Threehills Creeks and rises 300 to 400 feet above them. Kneehills Creek crosses the southwest corner and Threehills Creek the northeast. The surface of the township is mainly rough and hilly, with the major, bedrock features modified by lesser, drift features.

Rolling knob and kettle end moraine, with knolls as much as 20 to 30 feet high, covers about 20 square miles, chiefly in the higher districts of the centre and southeast. A flat mantle of lake clay covers about 2 square miles in the southwest and northeast, and the remaining area, mostly on the gentle valley walls of the creeks, has a cover of ground moraine. The drift, which is thickest in end moraine areas, probably averages 15 to 20 feet in thickness.

The only well recorded that draws water from the surface material obtains an adequate supply of hard water from end moraine.

Although water could be obtained elsewhere in the end moraine, wells into it would not be as satisfactory as wells into bedrock. Any attempt to obtain water from the ground moraine or lake clay is inadvisable as they are thin and contain much clay.

The Paskapoo formation directly underlies the surficial material. The Edmonton formation is 300 to 500 feet below the surface and is too deep to affect either the topography or the water supply. Two wells dug into bedrock obtain sufficient hard water with much iron. All other bedrock wells are drilled to depths of from 33 to 210 feet, with an average depth of 85 feet. They tap aquifers between 2,895 and 3,190 feet above sea-level, but mostly in the zones 2,985 to 3,005, 3,075 to 3,120, and 3,150 to 3,190 feet. About half the wells yield hard water, the others moderately hard or soft water, and one-quarter supply water that contains noticeable iron, although rarely so much as to prevent its use. The quantity of water is generally fair to good, and the one well with insufficient water, although deep, is drilled on a hillside that drops below the elevation of the well bottom. Its supply would be improved with deepening. The water commonly has enough pressure to rise half the distance to the surface.

In general, ample water is available anywhere in the bedrock at a smaller average depth than in surrounding townships, and large supplies, as for town use, should be obtainable.

Township 34, Range 27. Kneehills Creek flows southward near the east border of the township through a broad valley 150 feet deep, and is joined by another valley that drains Davey Lake near the centre of the township. A dry valley, 200 feet deep and a mile wide, crosses the southwest corner. The surface is rolling, and large, commonly isolated, drift hills, 20 to over 50 feet high, cover 5 square miles south of Davey Lake and have indeed blocked a valley to form the lake.

Except for some 3 square miles of the valley of Kneehills Creek that is covered by a relatively flat mantle of lake silt and clay, the rest of the area is underlain by ground moraine that is never thick enough to obscure the bedrock topography. As the average thickness of drift probably is not more than 15 feet, and as it contains much clay, any attempt to find water in it is inadvisable, although some may be available in the end moraine.

The Paskapoo formation underlies the drift, and all wells enter it. Five are dug to an average depth of 25 feet and yield good supplies of hard water. All the other wells examined are drilled and are 34 to 204 feet deep, with an average depth of 100 feet. They tap aquifers between 2,870 and 3,220 feet above sea level, but most draw from a zone between 3,060 and 3,160 feet. The higher aquifers are used in the west. All yield a fair to good quantity of water, which in half the wells, particularly in those tapping the lower aquifers, is soft without noticeable amounts of iron. With some exceptions, the water is under enough pressure to raise it more than half-way to the surface.

In general, sufficient good water for ordinary farm needs or even for uses requiring large quantities is present at relatively shallow depth in the bedrock everywhere in this township.

Township 34, Ranges 28 and 29. The surface of these townships, which characteristically is gently rolling, rises towards the south. The chief topographic features are two southeast trending dry valleys 100 to 200 feet deep and about 1 mile wide, one in the east and the other in the centre of the area.

Alluvial sand overlies bedrock in the valleys, but the rest of the area has a mantle of rolling ground moraine, which here and there becomes as hilly as low end moraine. Chiefly because the average thickness of drift is probably no greater than 10 or 15 feet, no wells obtain water from it, and any attempt to do so is inadvisable.

The Paskapoo formation, which directly underlies the drift, supplies all the water used, and the drilled wells into it are 12 to 280 feet deep, with an average depth of about 90 feet. They tap aquifers between 2,830 and 3,260 feet above sea-level, and particularly from the zones 3,055 to 3,085, 3,110 to 3,120, and 3,150 to 3,215 feet. Sixty per cent of the wells yield soft water, and although that from low aquifers is generally softest, many of these low aquifers do not yield as much water as higher ones. The amount of iron is negligible, and the water has generally enough pressure to rise about half the distance from the aquifer to the surface.

These townships, like those to the south, are interesting for the large number, 24 in this instance, of rather similar wells dug into bedrock. These wells have an average depth of 27 feet and tap aquifers between 3,065 and 3,275 feet above sea-level, but chiefly from 3,175 to 3,255 feet. Most of them yield hard water, some with noticeable iron, in fair to good quantity. These wells generally are adequate for ordinary farm use, but the supply in several is insufficient during dry years.

In general, adequate water for normal needs is available in the bedrock at comparatively shallow depth anywhere in these townships, and large amounts can be obtained.

ANALYSES OF WELL WATERS FROM Townships 31-34, Ranges 25-29, West 4th Meridian, Alberta

										Constituents as Analysed (parts per million)								Hardness as(CacO3) (pts. per million)		
Sample Number	¼	Section	Township	Range	Meridian	Owner	Depth of well (feet)	Aquifer *	Total dissolved solids (parts per million)	Calcium (Ca)	Magnesium (mg)	Alkalis (Na,K)	Sulphate (SO4)	Chloride (Cl)	Nitrate (NO_3)	Bicarbonate (HCO_3)	Alkalinity (as $CaCO_3$)	Ca hardness	Mg hardness	Total hardness
3768	NE	2	3[illegible]	29	4	A. Synder	200	P	1374	6.8	5.2	465.5	607.0	1.4	1.8	525.8	437.0	17.0	21.4	38.4
3769	SW	24	3[illegible]	29	4	W. Ausenhus	175	P	1254	12.1	52.2	356.7	674.1	2.8	Nil	267.7	261.5	30.2	214.8	245.0
3770	SE	20	31	28	4	J.E. McNeill	35	P	1420	8.4	5.0	481.2	547.3	1.4	1.8	542.9	451.0	21.0	20.6	41.6
3771	NW	8	31	28	4	A. Morasch	85	P	1032	11.2	6.3	385.9	361.7	2.1	1.6	545.8	447.4	27.9	25.9	53.8
3772	NW	22	31	27	4	H. Thomson	109	P	1482	78.5	32.5	441.0	489.7	7.1	Nil	849.1	696.0	195.9	132.9	328.8
3773	NW	30	31	27	4	S.R. McAllister	120	P	1066	38.0	20.1	355.4	290.1	7.8	6.2	706.4	579.0	94.8	82.7	177.5
3782	SW	14	31	27	4	R. Jenkins	100	P	918	49.2	18.6	299.1	103.3	1.2	Nil	832.0	682.0	122.8	76.5	199.3
3783	NE	32	31	26	4	J. Raffan	60	P	2130	218.8	133.5	198.2	1162.2	1.8	40.0	303.0	248.6	545.9	549.4	1095.3
3784	SE	28	31	26	4	J. Fleming	96	P	1140	167.3	65.6	117.7	434.6	Nil	Nil	577.3	473.2	417.4	269.9	687.3
3785	SW	6	32	25	4	G. Schafer	58	P	684	12.2	5.7	261.1	156.0	1.5	8.0	496.5	407.0	30.4	23.5	53.9
3786	NW	24	32	29	4	S.M. McDonald	188	P	1472	46.6	22.9	488.5	632.9	Nil	Nil	626.3	513.4	116.3	94.2	210.5
3920	NW	31	32	28	4	L.C. Hammer	85	P	752	36.0	13.6	238.5	155.6	Nil	10.6	586.6	480.8	89.8	56.0	145.8
3921	NE	17	32	28	4	A. Zimmerman	140	P	894	13.0	5.6	355.0	101.6	60.4	Nil	723.7	593.2	32.4	23.0	55.4
3922	NW	29	32	27	4	F.J. Grapentine	262	P	712	55.8	19.1	189.5	142.4	Nil	6.2	567.3	465.0	139.2	78.6	217.8
3923	NW	28	32	27	4	H. Walshlager	73	P	686	39.9	12.8	200.0	127.2	Nil	6.2	567.3	465.0	99.6	52.7	152.3
3924	NW	6	32	26	4	N. McCullough	250	P	1900	12.3	3.5	647.2	933.4	19.6	0.7	539.2	450.0	30.7	14.4	45.1
3953	SE	2	33	26	4	E.M. Enzie	80	P	1426	57.0	19.0	433.5	475.3	13.7	3.5	793.0	650.0	142.2	78.2	220.4
3954	SW	19	33	26	4	G.L. Kline	130	P	1160	4.5	1.3	431.0	314.4	Nil	2.7	731.0	630.4	11.2	5.3	16.5
3955	SW	7	33	25	4	A. Schlichenmayer	5	P	1836	39.3	58.8	500.5	947.3	Nil	1.8	479.0	417.4	98.1	242.0	340.1
3956	SW	10	33	24	4	W.H. Kinsey	85	P	2636	203.2	117.5	511.5	1282.7	7.7	31.9	833.7	683.4	507.0	483.5	990.5
4183	NW	30	34	25	4	H. Howard	56	P	1960	64.0	45.0	554.2	903.3	Nil	TRACE	718.5	584.0	159.7	185.2	344.9
4184	NE	5	34	25	4	J. Veres	117	P	1910	99.5	116.7	384.6	845.7	Nil	TRACE	806.4	661.0	248.3	480.2	728.5

* Symbols used for aquifers; P - Paskapoo Formation.