CANADA
DEPARTMENT OF MINES
AND
TECHNICAL SURVEYS

GEOLOGICAL SURVEY OF CANADA

WATER SUPPLY PAPER No. 304

GROUND-WATER RESOURCES OF TOWNSHIPS 35 TO 38, RANGES 21 TO 24 WEST OF 4th. MERIDIAN, ALBERTA

by

A.Mac S. Stalker,

OTTAWA
1950

CANADA

DEPARTMENT OF MINES AND TECHNICAL SURVEYS

GEOLOGICAL SURVEY OF CANADA

WATER SUPPLY PAPER NO. 304

GROUND-WATER RESOURCES

OF

TOWNSHIPS 35 TO 38, RANGES 21 TO 24,

WEST OF 4TH MERIDIAN,

ALBERTA

By

A. MacS. Stalker

OTTAWA
1 9 5 0

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
Tertiary	Paskapoo	Light grey sandstone, in part carbonaceous; shale; small amounts of siliceous limestone and volcanic dust; coal seams.	Feet ± 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].

[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]

[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 35 to 38, RANGES 21 to 24,
WEST OF THE FOURTH MERIDIAN, ALBERTA

Introduction

The investigation of ground-water resources in Alberta was continued during the summer of 1948 by the writer, ably assisted by H. Van Camp. 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

Red Deer River is the major feature of the topography. It flows eastward through the northern townships in a valley 150 to 250 feet deep. It then makes a nearly right-angled turn in range 22 to flow southwards to the southeast corner of the area in a valley from 400 to 600 feet deep and between 1 mile and 2 miles wide. In its passage through the area the river seems to have been unaffected by the existing topography and to have cut its valley indiscriminately across ridges and valleys, and high and low areas. Along the part of the river flowing eastwards the land surface, for several miles back, slopes towards the river, but along the southward flowing part no such tendency is evident. The land a mile or so back is singularly unaffected by the nearness of the river, with no general slope towards it, and with more or less the same general topographic features as occur in places remote from the river.

A number of broad valleys, mostly striking northwest, are present in the part of the area southwest of Red Deer River. Many of these are 2 to 3 miles wide and 100 to 200 feet deep, with gently sloping sides. Only one or two of them are now occupied by streams, although several contain lakes, ponds, and sloughs. They appear to have been formed before the last advance of the ice-sheet, and are now covered with glacial debris. There are also some streams tributary to the Red Deer, most of which occupy smaller and sharper valleys than those just described.

Except where moraine deposits are thick the principal topographic features are formed by the underlying bedrock. The surface is mostly uneven, with, in many places, a local relief of over 300 feet. In general elevations range between 2,700 and 3,000 feet, although higher and lower elevations are not uncommon. Most of the surface is covered by terminal moraine with its characteristic hills and hollows. This is most noticeable in the west and south where some hills are higher than 200 feet. North and east of the river, and also in many regions to the southwest, the hills are generally much lower and the surface of the moraine is more even. In the northeast the surface is lower and mostly smooth or gently rolling.

A number of lakes are present west of the river and these, together with most of the ponds and sloughs, may contain water all summer.

Geology

Almost the entire area is mantled by glacial deposits and sand and gravel beds of varying thicknesses. The underlying bedrock is either that of the Edmonton or overlying Paskapoo formations, the latter occupying some four-fifths of the area. Older formations, mentioned in the table in the earlier part of the report, underlie the Edmonton, but at too great a depth, not less than 1,000 feet, to affect the surface features or water supply.

The prevailing dip of the bedrock is to the west and southwest, and in that direction 300 or 400 feet of the Paskapoo formation covers the Edmonton, except in low-lying places where it is thinner or may have been entirely removed. This cover thins towards the northeast and is entirely stripped off in the extreme east and northeast so that the Edmonton there directly underlies the unconsolidated material.

Red Deer River has cut through the Paskapoo all along its course for a width of 1 mile to 3 miles, and outcrops of Edmonton may be seen here and there. In fact, because of this and because the cover of glacial drift is thinnest in the northeast where the Paskapoo is not present, most outcrops in the area are of rocks of the Edmonton formation.

Edmonton Formation. The name Edmonton formation 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 a 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. Some are present east of the area.

Good sections of the upper part of the Edmonton formation are present along practically the whole valley of Red Deer River in this area. It also outcrops in the southeast of sec. 29, tp. 36, rge. 24, and at one or two other places. Some of the lower parts of the formation may be seen east of the area near Battle River, in Paintearth Creek, and near Sullivan Lake.

Paskapoo Formation. This formation was first named by Tyrrell 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, which are of importance in this area, 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. This limestone may be largely the cause of the extreme hardness of some of the ground water in the area.

Unconsolidated Deposits. 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 deposited 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, the unconsolidated

deposits in the area. Most of the glacial 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.

Two tills are present in the area, the upper one, seen nearly everywhere, is light grey and contains scattered stones, whereas the lower one, which is much less widespread, is generally dark blue or blackish and is more compact and sticky. It contains about the same number of stones as the upper till, but some of these are more weathered. Both tills are present along Red Deer River in secs. 29 and 32, tp. 38, rge. 23, where in one exposure about 5 to 15 feet of light grey till lies with uneven contact over about 15 feet of blue till. Under this about 20 feet of coarse gravel lies over the Edmonton bedrock. The blue till, though fairly common in wells and cuts, seems to occur mainly in discontinuous patches and is entirely absent in many places.

The unconsolidated deposits in this area are rarely more than 10 or 20 feet thick near Red Deer River, perhaps 20 to 50 feet thick in the extreme northeast, and probably between 40 and 60 feet elsewhere east of the river. Southwest of the river they are thicker, and a few miles back from it probably range between 40 and 100 feet in thickness, being thickest in the more rugged areas of terminal moraine. Even there, however, bedrock may form the base of many of the higher hills and areas, and the unconsolidated covering may not be as thick as it at first appears. North of the river these deposits probably average between 40 and 60 feet in thickness.

Ground Moraine. This type of glacial drift is chiefly till or boulder clay laid down beneath the ice-sheet. In the area it consists mainly of light grey or brown clay containing here and there a few stones, most of which are less than 3 or 4 inches in diameter. In a few places it encloses lenses and pockets of water-laid sand and gravel. It occurs in five or six small patches totalling some 50 square miles.

Terminal 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 boulder clay, 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 terminal moraine is mostly coarser than that seen in ground moraine, and often consists mainly of gravel, sand, and coarse till, characteristically arranged in hummocks and undrained or poorly drained hollows.

About four-fifths of the area, or about 460 square miles, is covered with the typical hills and depressions formed by terminal moraines. Though found practically everywhere in the area, this moraine has its most extreme development, and is thickest, in the west and south.

Glacial-lake Deposits. 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 deposited. Draining or lowering of these lakes exposed this material in discontinuous patches here and there throughout the area. Similar material was deposited by streams draining these lakes or running out of the melting ice, or by recent streams. The original deposits have been attacked by the wind and much of the material redistributed by this agency. Deposits of these latter types affect water supply in much the same manner as the glacial-lake sands, from which many

are practically indistinguishable, and they have been shown as a single unit on the map. They cover perhaps 50 square miles of the area, being found in the northeast corner, around Delburne Lake, and near Ghostpine Lake and Creek.

Some small areas of stream and glacial-outwash gravels are present, and will be mentioned in the descriptions of the various townships.

Water Supply

With a few exceptions to be mentioned later, sufficient supplies of water can be obtained anywhere in the area.

The surface deposits are of importance as a source of water in only a few areas, particularly the regions of glacial-lake sands, a few areas of gravel deposits, and some districts near Red Deer River where the bedrock supply is not entirely sufficient. Wells in unconsolidated deposits generally give only fair or insufficient supplies of water for local purposes. Adequate supplies of water for ordinary purposes are rarely found in ground moraine or terminal moraine, except for occasional wells in depressions in the latter and in the broad, pre-glacial valleys described previously.

Water found in the Pleistocene deposits is almost always hard, as it contains a large amount of calcium. It may also contain much iron. Some of the water is alkaline but seldom enough to render it unfit for use.

The water supply in the bedrock is far more important, and most wells draw from either the Edmonton or Paskapoo formations. Most wells east of the river and many in the central part of the area draw water from the Edmonton formation. The Edmonton contains many isolated lenses of sand irregularly distributed through the formation. Some horizons contain more of these lenses than others, and, as the water is in the sands, these horizons are the more likely to yield water. Water is also frequently found either above or below coal seams, and these aquifers can in places be traced for considerable distances. In this area the beds of the Edmonton formation dip to the west or southwest at 15 or 20 feet to a mile. Thus an aquifer at a certain elevation at one point, 3 or 4 miles to the west will be 50 or 60 feet lower, and another aquifer may appear above it. In the opposite direction it will reach the surface and disappear. Also, as the surface of the land is generally higher towards the west, these effects are emphasized and few aquifers are traceable over any great distance in an east-west direction. They may, however, be traced farther in a north-south direction.

In the western part of the area water may be found in the Paskapoo formation overlying the Edmonton, which, consequently, is less important as a source of water. It is, however, a potential source under the entire area.

Water entering the Edmonton beds through glacial deposits is usually charged with calcium carbonate and 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 medium 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 a small amount of iron in places, and some carbonaceous material from near coal seams.

The Paskapoo formation west and north of Red Deer River generally contains abundant water, mostly in porous sand lenses. None of these can be traced very far, but in most places they overlap. These lenses are more common in some horizons of the formation than in others, forming aquifer zones, each zone having water with distinguishing characteristics and some traceable over fair distances. As the Paskapoo beds dip west or southwest in much the same manner as the Edmonton beds, progressively fewer wells draw water from a certain aquifer zone as it becomes deeper to the west, until it can be traced no farther.

The fairly large area of Paskapoo east of Red Deer River seems worthless as a source of water. This area stands higher than the surrounding country, and the beds dip west towards the river. Consequently, much of the water runs off without entering the porous beds and what water does enter soaks rapidly down the bedding into the river. Wells in this area may have to pierce 100 or 200 feet of dry Paskapoo before reaching the Edmonton formation and a possible source of water, which accounts for the deep wells in much of the area 5 or 10 miles east of the river.

The water contained in the Paskapoo formation in this area varies greatly in quality, but generally contains much calcium carbonate, particularly that drawn from near the horizon of the siliceous limestone layers. Much of this water is too hard for ordinary washing. Both above and below this zone the water may not be as hard and is in some cases soft. Most of the Paskapoo water contains some iron, particularly the very hard water that stains everything yellowish or brownish. Manganese, and in a few instances phosphate, is present in some of the very hard water.

Most wells in the area obtain water at less than 150 feet. In a few places the wells are deeper, as in the Paskapoo area previously mentioned, east of the river. Also in a few areas of thick terminal moraine, and where wells go below the hard water supplies in order to tap the soft water of the Edmonton formation. Many of these wells are over 300 feet deep. The rise of the water in the wells is generally only fair, in some areas because drainage into the river valley lowers the pressure.

Over much of the area, especially the regions south and west of Red Deer River, a fair amount of gas occurs in many of the wells. If possible, wells should be drilled or bored, but if a well must be dug by hand great precautions should be taken, otherwise workmen may be overcome by the gas. No well should be entered if gas is known to be present, and someone should always remain at the surface.

Township 35, Range 21. The chief topographic feature of this township is the southward flowing Red Deer River, which here has a valley about 2 miles wide and between 400 and 500 feet deep. The surface of the land on either side maintains a relatively uniform elevation right up to the edge of the valley and is largely covered by drift. This drift in places extends some distance down the valley sides. Ground moraine is found in a narrow strip bordering the river and also appears in the northeast corner of the township. Except for the bedrock outcrops, the remainder of the township is covered by terminal moraine with typical knob and kettle topography and hills 20 to 50 feet in height. This moraine is mainly composed of clay with few pockets of sand or gravel.

The Edmonton formation underlies the drift on both banks of the river and also in places in the eastern part of the township. It is widely exposed along the river and also outcrops at some other places, particularly in a gully in section 1. The Paskapoo formation overlies the Edmonton on both sides of the river on the high land above the valley, but outcrops at only a few places.

The unconsolidated deposits are of little importance as a source of water, the water being always hard, and the supply unsatisfactory in most areas and practically non-existent in others. The supply may be greater away from the river, where these deposits are thicker.

Water is drawn from both the Paskapoo and Edmonton formations on either side of the river. That from the Paskapoo is usually hard to very hard, and generally contains much iron, and at times some manganese. Though the water from within the Edmonton is soft, many of the wells obtain their water from the top of the formation just below the Paskapoo contact, and this water still retains the hardness derived from the Paskapoo.

East of the river the wells average about 100 feet deep. The deepest well, 264 feet deep, was situated on very high ground and was drawing from a higher aquifer than any other in the vicinity. It supplied large quantities of very poor water and better water could probably be obtained at greater depth. As a large thickness of Paskapoo has to be pierced before the soft water of the Edmonton can be reached, soft water wells in much of this township have to be deep, probably below 2,750 feet elevation in the north and 2,600 in the south. The supply of water is usually good, but its rise is practically negligible and much pumping is required. This is largely due to drainage into the nearby river, as shown by the number of springs, mostly of soft water, along its valley.

West of the river most wells supply hard water drawn from between 2,820 and 2,850 feet elevation. Soft water is available in the Edmonton formation, but, especially in the west, at lower elevations. Water is more difficult to obtain near the river valley, as the beds dip west and few springs are present. The wells west of the river average about 75 feet in depth. The amount of water is good but the pressure is small and the rise negligible.

Township 35, Range 22. The most important topographic feature of this township is a valley with gently sloping sides, 2 to 3 miles wide and 100 to 150 feet deep, that runs south from Goosequill Lake. No stream occupies the valley at the present time.

The entire township, except for a small area of ground moraine in the northeast near Red Deer River, is covered with terminal moraine. Knob and kettle topography is most evident in the centre and west, where hills may reach a height of 100 feet, and is less well developed in the east and northeast, with lower hills. Although a few pockets of gravel are present, the moraine is mostly composed of clayey till.

The Paskapoo formation underlies the unconsolidated deposits and overlies the Edmonton formation everywhere, except perhaps in a part of the northeast of section 36. Bedrock comes fairly near the surface in the above-mentioned valley, but elsewhere is probably 60 or 70 feet deep, the depth varying with the height of the morainal hills.

A few wells, mainly in fairly low areas, obtain good supplies of hard water from the drift. Although fairly good supplies of hard water can probably be obtained from other low areas in the unconsolidated deposits, the bedrock is a surer and more satisfactory source.

Good supplies of very hard water containing much iron may be obtained from the Paskapoo formation. Most wells draw this type of water from elevations ranging between 2,805 and 2,855 feet. In a few higher areas water is obtained from horizons above this, usually above 2,850 feet elevation. This water also contains much iron, but is not so hard, and the supply, though generally good, is perhaps not as large as that lower in the Paskapoo.

It should be possible to find soft water in the Edmonton formation anywhere in the township, but only at considerable depths; probably from below 2,800 feet elevation in the northeast to below 2,750 feet in the southwest. As a rule, soft water wells from the Edmonton will be practicable only in the northeast corner of the township, and in the broad, low-lying valley along the west side.

The wells average about 140 feet deep, but the depth depends upon the aquifer drawn from and upon whether the wells are on hills or in valleys in the moraine.

Township 35, Range 23. Except for about 4 square miles of ground moraine covering a broad hill in the southwest, all this township is covered with the knob and kettle type of terminal moraine. This moraine is most rugged in the northern parts of the township, where some hills reach a height of about 100 feet, and less so in the south, with lower and gentler hills. A system of broad, pre-glacial valleys forms the main feature of the topography, upon which the smaller morainal hills have been superimposed.

The entire township is underlain by the Paskapoo formation. The Edmonton formation is generally 300 to 400 feet beneath the surface and except for a few deep wells no water is drawn from it.

No wells seen in the township obtain water from the unconsolidated deposits. Not much water is to be expected from the ground moraine, but areas of terminal moraine may in some instances give fair supplies of hard water, especially in low-lying places, in sandy areas, and in the bottoms of the broad valleys.

Wells in this township are everywhere deep, the shallowest seen being 125 feet deep and the average depth over 200 feet. The horizon of the Paskapoo that everywhere carries large amounts of very hard water with much iron extends into this township at elevations between 2,805 and 2,865 feet, and from it most of the wells draw their water. In the higher parts of the township large amounts of water may in places be obtained from horizons above this, ranging in elevation from 2,840 feet to as high as 2,950 feet. Water from the higher horizons is softer than that from the lower, but also contains much iron. The Edmonton formation undoubtedly contains large supplies of soft water, but as the formation is probably everywhere below 2,650 feet elevation the wells would have to be deep. A few of the wells in and around Elnora, 300 feet or so deep, may draw water from the Edmonton.

Good supplies of water are available at depth anywhere in this township, and there was no shortage in any of the wells seen.

Township 35, Range 24. Ghostpine Creek flows diagonally southeast through the centre of this township in a broad valley with gently sloping sides, the floor of which is mostly covered by sand. About 10 square miles in the southwest of the township and about 2 square miles in the southeast are covered by ground moraine, generally overlying broad bedrock hills. Terminal moraine, with the typical knob and kettle topography, covers the rest of the township, including the upper flanks of Ghostpine Valley. Unconsolidated deposits are underlain by the Paskapoo formation throughout the township. It is covered by some 20 feet of drift in the southwest and southeast and in the Ghostpine Valley, and by at least 50 or 60 feet in most of the knob and kettle area in the north. No outcrops were seen.

Only a few wells draw their water from the unconsolidated deposits. It is unlikely that much water is to be found in the ground moraine but fair supplies of hard water are probable in the terminal moraine, especially where it is sandy or contains pockets of sand, and in the sand areas near Ghostpine Creek.

As the Edmonton formation is 400 or 500 feet below the surface throughout the township it is of little practical importance as a source of water. Wells in the Paskapoo formation generally obtain good supplies of water from three zones. One zone, at elevations between 2,820 feet and 2,750 feet, yields water of a medium hardness containing much iron and rising to around 2,860 feet. Another zone, at elevations between 2,869 feet and 2,975 feet, gives soft water with little or no iron under very little pressure. The third zone overlaps the other two in elevation, being between 2,810 feet and 2,975 feet. This is a continuation of the very hard water zone containing much iron that occurs in the townships to the east and north. The water in this zone is also under little or no pressure.

Township 36, Range 21. Red Deer River runs through the southeast corner of this township in a valley some 2 miles wide and over 400 feet deep. Only a small part of the township lies west of the river and will be described in the next section. This description will be confined to the area east of the river. Terminal moraine covers the area except for Red Deer River Valley and two small areas in the southeast that are covered by ground moraine. Deposits of glacial drift have dammed many of the pre-glacial stream valleys forming numerous small ponds, especially in the eastern parts of the township.

Bedrock is near the surface along much of Red Deer River Valley, and is generally only 10 or 20 feet deep in the northeast corner of the township. Elsewhere it is deeper but not everywhere as deep as it might at first appear. The Paskapoo formation underlies the drift along a strip 2 or 3 miles wide running north through the centre of the township. Elsewhere the Edmonton formation underlies the drift and outcrops at many places along the river.

Wells in the unconsolidated deposits offer little prospect of providing an adequate supply of water. This is due in part to the thinness of the deposits and in part to their clayey character. Small pockets of sand may in places give fair supplies, and in the eastern parts good supplies of hard water may occur in the pre-glacial stream valleys that have been blocked by moraine, especially where gravel underlies the till.

No well seen in this township provided a good supply of water from the Paskapoo formation and there is little chance of obtaining more than a poor supply of hard water from it. Consequently, any well drilled in the central part of the township that is underlain by Paskapoo must be expected to pass through 100 or 200 feet of this formation before reaching the Edmonton formation and good supplies of water. This is the reason that so many farms in the central part of the township are without good wells.

Some springs along the valley of the Red Deer supply a large amount of water, mostly soft, from the Edmonton formation. Elsewhere, good supplies of fairly soft water, in most places under fair pressure, can be obtained in the Edmonton at an average depth of about 150 feet except where it is overlain by the Paskapoo. A number of aquifers appear to be present and wells obtain their water at elevations ranging from 2,665 to 2,833 feet. In the southeast part of the township several wells draw their water from an elevation of about 2,750 feet.

Township 36, Range 22. The following description is confined to the parts of this township and the next one to the east that lie west of Red Deer River.

Two areas of ground moraine are present in the northern part of the township and a third in the southeast, but most of the area is covered by terminal moraine with knob and kettle topography of low relief. The drift is 10 to 20 feet thick in the areas of ground moraine and about 40 feet thick elsewhere.

The Edmonton formation underlies the drift along the eastern part of the area, but is overlain by the Paskapoo elsewhere. Outcrops of it are, however, common along Red Deer River.

No wells were seen that draw water from the unconsolidated material and it is unlikely that any but small supplies of hard water can be obtained from these deposits.

Two or three wells draw water from between elevations of 2,720 and 2,755 feet in the Edmonton in the eastern part of the township. In this township as elsewhere it should be possible to obtain fairly large amounts of soft water from the Edmonton at any point, but as it dips to the west the elevations of the aquifers will be somewhat lower in that direction.

The wells elsewhere in the township tap the Paskapoo formation at elevations between 2,805 and 2,905 feet, the water-bearing horizons being highest in the west. In general the deeper into the formation a well is drilled the better the supply and the softer the water, although all the wells have a sufficient supply. In some wells the water is too hard for washing and most of it contains considerable iron and, in one or two instances, some phosphate. In a few cases other minerals render the water poor. With a few exceptions, the water shows little rise in the wells.

Several springs occur along the valley of the Red Deer, and one in section 2 has a measured flow of about 900 gallons an hour of hard water with much iron. The springs decrease in number and water supply towards the north.

Township 36, Range 23. The main topographic features of this township are reflections of the underlying bedrock. The township is crossed by a valley 2 or 3 miles wide and about 150 feet deep that is in part occupied by Mikwan, Goosequill, and Hummock Lakes, and through which runs the Calgary-Tofield branch of the Canadian National Railways. The southern part of the township is only thinly populated.

Both high and low parts of the township are covered by terminal moraine with a fairly rugged knob and kettle topography. Many of the morainal hills are 100 to 150 feet or more high. The till is mostly over 50 feet thick, but the thickness varies considerably from place to place.

The Paskapoo formation underlies the drift over the entire township. It outcrops beside a road in the northwest of section 10 and on a hill in the southwest of section 15. It probably also forms the core of many of the morainal hills.

No wells seen were deriving their water from the unconsolidated deposits. Satisfactory supplies of water are not likely to be found in these except for parts of the broad valley mentioned above, from which fair supplies of hard water could be obtained.

All the wells seen were drawing water from the Paskapoo formation, mostly from between 2,890 and 2,945 feet elevation, although some draw from a bit lower. The average depth of the wells is about 115 feet and all the wells are within 75 feet of this depth. All have good supplies of water, most of which is hard to very hard. The soft water wells, with a few exceptions, obtain their water at slightly lower levels than the hard. Most of the water contains much iron and in one or two instances is of poor quality. Mostly it is under little pressure.

The Edmonton formation, which contains plenty of soft water, is too deep over most of the township to be reached by wells less than 300 feet deep except in the valley bottoms.

Township 36, Range 24. Nearly all this township, except for the area round Ghostpine Lake, is covered by terminal moraine with well-developed knobs and kettles and with many hills rising over 100 feet in height. Ghostpine Lake, in the southwest part, is surrounded by a hilly area largely composed of sand deposited when the lake was standing higher and later reworked by wind. This sand overlies the moraine and the hills are formed of sand, till, or till covered by sand. The depth of the drift varies greatly, but generally ranges from 20 to 70 feet.

The Paskapoo formation underlies the drift over the entire township and outcrops near the crossroads in the southwest of section 28 and in the southeast of section 29. In this part of the township several hills have only a thin covering of moraine and it seems likely that other hills in the township are largely composed of bedrock.

The Edmonton formation is too deep to be a useful source of water in this township. Wells would mostly have to be deeper than 350 or 400 feet to tap its large supplies of soft water.

No wells seen obtained their water from the unconsolidated deposits. Only the sand areas around Ghostpine Lake are likely to yield much water, and even there it would probably be difficult to obtain large supplies because the sand areas themselves are small and drain off into the lake or its outlet.

All the wells seen draw water from the Paskapoo formation. They averaged 120 feet in depth, the deepest being 210 feet. The deeper wells are mostly on high ground. All the wells have good supplies of water; soft in about two-thirds of the wells and varying from medium to very hard in the remainder, the very hard water being too hard for washing. Most of the hard water contains much iron but the soft water only a little. Most wells, including most of those yielding soft water, draw their water from between 2,890 and 2,960 feet elevation. Some wells, situated in sections 19 to 30 where the surface is higher, obtain water, mostly hard, from elevations ranging up to 3,090 feet. These wells could probably obtain better water at 100 feet or less greater depth.

Township 37, Range 21. The principal topographic features of this township are Foxall and Ewing Lakes. These normally cover about 4 square miles but almost disappear in very dry years.

A gently rolling ground moraine, flatter near the lakes, covers about 10 square miles northeast of them. Gently rolling glacial-lake sand, reworked by wind and overlying ground moraine, covers about 2 square miles near the northeast corner of the township. The rest of the township is covered by terminal moraine with knob and kettle topography of moderate relief except in the south and west where some hills are 75 to 100 feet high. Many sloughs and lakes are present in the terminal moraine area.

In the areas of ground moraine near the lakes the unconsolidated material is mostly less than 30 feet thick. It is perhaps 50 feet thick in the sand areas, and mostly thicker in the areas of terminal moraine. The Edmonton formation underlies the entire township but is overlain by the Paskapoo formation in the higher areas in the southwest, roughly the twelve southwestern sections. With few exceptions, wells obtaining water in the unconsolidated deposits draw from lake sands or from moraine near Ewing and Foxall Lakes. In every case the water is hard. Small supplies of hard water may occur in till in the terminal moraine areas or if pockets of gravel are encountered the supply may be considerable.

The Paskapoo formation in this township drains into Red Deer River and contains little water. No wells seen draw water from it. Wells in the southwestern part of the township may have to drill through 100 feet or more of dry Paskapoo before reaching the Edmonton.

The Edmonton formation everywhere seems to hold large amounts of water, in most places under enough pressure to force it fairly high in the wells. This water, at least in all fairly deep wells, is soft, and on rare occasions only contains a little iron. The average depth of the wells is about 130 feet, the deepest well seen being 310 feet, but the depth of even neighbouring wells may be very different. No single aquifer is prominent, but water is found at elevations ranging from 2,470 to 2,830 feet. In general, wells in the southern eighteen sections obtain their water from above 2,730 feet elevation, and those in the northern twelve sections from elevations lower than this.

Township 37, Range 22. The most important topographic feature of this township is Red Deer River, which runs through a valley 400 to 500 feet deep and 1 mile to 2 miles wide along its eastern edge. Two or three miles back from the river the land surface shows little or no slope towards it.

Except for a small area of glacial-lake sand in section 7 and a patch of ground moraine in sections 3 and 4 surrounding a lake in a valley trending southeast into Red Deer River, the entire township is covered by terminal moraine. This moraine shows the typical knob and kettle topography, with low relief near the river but more rugged in the centre and south where some hills rise to heights of over 100 feet. A few sloughs and lakes, fewer than might be expected, occur in it, the largest being Wood Lake.

The unconsolidated deposits are rarely over 20 feet deep near the river, but farther west may be as much as 50 feet deep. The Edmonton formation underlies the unconsolidated deposits in sections 3 and 4 and along a strip about a mile wide following Red Deer River, where it outcrops at many places. Elsewhere in the township the Paskapoo formation above the Edmonton underlies the unconsolidated deposits. It outcrops along a road in the northeast of section 8 and may form the base, and perhaps a large part, of some of the morainal hills.

The conditions of water supply in that part of this township east of the river are similar to those in the western part of township 37, range 21, and need no further description. Some springs, yielding a fair supply of water, are present along the west bank of the river valley, and others, yielding an excellent supply, occur along the slope into the lower land of sections 3 and 4. Most of this water is hard. There are a few wells in the glacial deposits, most of which yield poor supplies of hard water.

Water is obtained from both the Edmonton and Paskapoo formations in this township, but most wells tap the Edmonton even where it is necessary to pierce the Paskapoo to reach it. The average depth of a bedrock well is about 140 feet, but there is much variation, depending mostly upon the elevation at the surface where the well is drilled. Most of the wells draw their water from elevations between 2,750 and 2,820 feet, mostly near the lower elevation. Most of the water is soft, and the few wells that have hard water are found among those that draw from the higher aquifers. Iron is present in some of the water.

As the water naturally tends to drain down the westward dipping beds, there is a section about 1½ miles wide just west of the river in which water is difficult to obtain in any quantity. A well there was drilled to a depth of 300 feet but obtained only a little water at a depth of about 145 feet. It is evidently necessary to go deeper than this to find satisfactory supplies of water. It is advisable to drill as far back from the river as possible when searching for water in this area.

Apart from the strip west of the river, water supplies are good over the whole township.

Township 37, Range 23. Delburne Lake lies in the north-central part of this township in a fairly large, broad valley. The surface of the township slopes north and towards this valley, the highest points being in the south-central part. Lake sands, deposited when Delburne Lake stood higher, cover about 14 square miles in the northeast. The sands, later reworked by wind, have a generally rolling surface, which often reflects the surface of the underlying moraine. Sand also appears along a stream valley in the west. Knob and kettle moraine surrounds the sand areas and covers almost all the rest of the township and all the high areas. This moraine is thickest in the west and south, with some hills reaching a height of 50 or 75 feet. The till forming the moraine is fairly clayey, but sloughs are not plentiful.

The Paskapoo formation everywhere overlies the Edmonton, but no outcrops were seen, and in most places it is covered by at least 50 feet of unconsolidated material. The contact between the two formations is generally at an elevation of about 2,700 feet.

A few shallow wells draw fair supplies of hard water from the unconsolidated sand and moraine deposits. Most of them are in valleys and low areas, and it is unlikely that much water can be obtained from these deposits in higher areas.

The bedrock wells are all from about 50 to 200 feet deep. About four-fifths of them supply water that is soft or of medium hardness, the others hard or very hard water. Some of the water contains a fair amount of iron. The supply in all the bedrock wells is good, and with few exceptions, mainly in the east, the water rises high in the wells.

It is commonly difficult to determine whether the aquifer supplying the water is in the Edmonton or Paskapoo formation. Most wells obtain their water at elevations of between 2,705 and 2,765 feet. A few, mainly in the northwest, obtain it from lower elevations, and some, mostly in the south and the east, from higher. No special distinction in elevation between hard and soft water aquifers was noticed, the well using the lowest aquifer drawing hard water, and some in the highest aquifers doing the same. The hard-water wells can probably obtain softer water at slightly greater depth, and any well into the Edmonton should obtain soft water.

Township 37, Range 24. The surface of this township generally slopes north, with more than 400 feet difference in elevation between the highest point in the far southwest and the lowest point in the northwest. Small lakes and sloughs are common, and a few streams flow northward towards Red Deer River, which is only a mile or so beyond the north boundary. Almost the entire surface of this township shows the knobs and kettles of typical terminal moraine with hills 50, 75, and, in a few instances, 100 feet high. It is thickest in the west and southeast. In a small, flattish area in sections 5 and 6 the till has the character of ordinary ground moraine. Deposits of sand border several small lakes and occur along some streams.

The layer of unconsolidated material varies in thickness from perhaps 25 to 50 feet in the north to nearly 75 to 100 feet in the south, being greater on the hills and less in the valleys. The till is sandy in a few areas, but it generally is very clayey. Two tills were observed in the northwest; a rare, dark blue, sticky till overlain by the common light grey till.

A few shallow wells, mainly in the northwest, obtain from glacial deposits a fair to good supply of hard water that may be of inferior quality. Water may, perhaps, be found in the sandy areas near lakes and streams, and in valleys and lower areas in the moraine, but is not apt to be satisfactory in either quantity or quality.

Most wells draw their water from bedrock, and all of these, so far as can be determined, from the Paskapoo formation, which directly underlies the surface deposits everywhere in the township. As the Edmonton is covered by 100 feet or more of the Paskapoo in the north and perhaps 200 to 300 feet of it in the south, wells into it would have to be deeper than those obtaining water from the Paskapoo, but should encounter large supplies of soft water.

More than two-thirds of the bedrock wells supply water that is soft or of medium hardness and in satisfactory amounts. The wells average about 140 feet in depth, and most of them are within 40 feet of this depth. This is rather remarkable for a terminal moraine area, with its great relief. Water is drawn mostly from two zones in the Paskapoo, at elevations of 2,660 to 2,720 and 2,770 to 2,800 feet respectively, with a few wells drawing from higher aquifers. In general, the southern eighteen sections obtain water from the higher zone, and the northern eighteen sections, where the surface is lower and where the upper aquifers have been eroded away, from the lower zone. Two exceptions to this were noted, one well in section 18 using the lower zone and one in section 28 the higher.

Although the rise of water in the wells varies greatly, even in a small area, it is generally greater in the north, where water nearly reaches the surface, than in the south where the pressure is usually slight.

Township 38, Range 21. About 20 square miles of this township, mainly in the east and north, are covered with sand. This sand was deposited from glacial lakes and streams, and later reworked by wind, being removed from some areas and scattered farther south. The sand is commonly 20 or 30, and in places 40 to 50, feet thick. It generally has a mildly rolling surface, with many swampy depressions, and ground moraine shows through at intervals. This moraine underlies the sand, and some of the knolls seen in the sand are due to small hills in the till. Ground moraine overlies broad bedrock hills in the southwest and covers about 5 square miles. Though usually fairly smooth, in a few places it is slightly hilly. The knolls and depressions of typical terminal moraine cover about 9 square miles of the west. This is most rugged in the west where some hills reach a height of 50 feet. Gravel is present in the northern parts of sections 21 and 22, and may extend for some distance under the till.

The unconsolidated deposits vary greatly in thickness, from perhaps 20 feet in the ground moraine areas to 50 or 60 feet in the sand areas, and being mostly over 50 feet in the terminal moraine areas. The Edmonton formation underlies the unconsolidated deposits everywhere.

A few wells draw water from the sand deposits, which are nearly always a good source of hard water. In many cases the water has collected in sand-filled hollows in the underlying till. One well in section 21 obtains its water from gravel at a depth of 75 feet, and although this aquifer may continue elsewhere, it would probably be better to drill a little deeper and ensure a bedrock water supply. Water supplies from ground moraine are unlikely to be satisfactory, and even the lower areas in the terminal moraine offer little hope of adequate supply.

The Edmonton formation in this township contains large amounts of soft water in several aquifer zones. As the land surface slopes northward, wells in that direction tap progressively deeper aquifers. Similarly to the west, where the upper aquifer zones drain into Red Deer River, lower zones must be drilled into to ensure an adequate water supply. The highest of the zones, from elevations of 2,610 feet to over 2,640 feet, is used in the six southernmost sections only where it is the main source of water. The next zone, present over all the township, includes several aquifers ranging in elevation from 2,515 to 2,585 feet, but mainly between 2,515 and 2,560 feet. The lowest zone is between elevations of 2,445 and 2,475 feet and is believed to underlie the entire township. Although only a few wells in the southwest draw from this aquifer, it is everywhere a possible source of water if none is found at higher elevations.

This is a township of deep wells, the average depth of those into bedrock being about 175 feet. The deepest are in the higher areas in the west and southwest where several are over 300 feet deep and where the average is about 245 feet. Elsewhere the average depth is about 130 feet.

The water has a fair rise over all the township. A few flowing wells are present in the southeast and others could be found in that vicinity.

Township 38, Range 22. Red Deer River runs south through the centre of this township, in a valley about one mile wide and from 200 to 400 feet deep. Away from the valley the land surface shows very little slope towards the river or other evidence of the river's nearness. Its general slope is towards the north.

Gently rolling ground moraine covers about 4 square miles in the northwest of the township. Towards the south this grades into terminal moraine that covers the rest of the township. The latter is nowhere very rugged, only east of the river do hills reach heights of 50 feet. The unconsolidated material is 10 to 30 feet thick near the river and in the northwest, and perhaps 40 to 60 feet in the higher morainal areas. Gravel is present in the northern half of the township on both sides of the river back from the valley. That on the east bank is unsorted, dirty, and probably of glacial origin whereas that to the west is cleaner and better sorted, and was probably laid down by the river. The deposits are of a fair size, generally 10 to 30 feet thick, but at some points 50 or 60 feet thick.

Except where covered by the Paskapoo formation in section 2 and in about 9 square miles of the southwest, the Edmonton formation everywhere directly underlies the unconsolidated material, and is widely exposed in the river valley.

A few wells draw hard water from the unconsolidated deposits. Most of these are in gravel areas where the supply is good but some draw

water from the moraine where, even in the low-lying areas, the supply is generally not satisfactory.

The water-bearing zones described in township 38, range 21, continue into the part of the township east of the river, and the conditions of water supply are much the same. A few wells, mostly in higher areas, obtain water from above 2,620 feet elevation, and a few others from about 2,580 feet, but most of the wells draw from an aquifer zone between 2,520 and 2,555 feet elevation that underlies the part of the township east of the river. Several wells in section 14 obtain water from another zone between 2,290 and 2,350 feet that probably holds a good supply over all the township, if higher aquifers are not adequate. Nearly all the wells have good supplies of soft or medium hard water. The water has only a slight rise in the wells, probably owing to the drainage into the river. The deepest well into the bedrock east of the river is 382 feet deep, the shallowest 38, with an average about 165 feet.

The Paskapoo formation supplies water for a number of wells in the southwest of the township at various elevations above 2,740 feet. This water is nearly always very hard, and has considerable iron, but, except at highest elevations, the supply is good. However, most of the wells west of the river draw water from the Edmonton formation between 2,620 and 2,690 feet elevation, and largely from the zone 2,620 to 2,665 feet. The water in about half these wells is hard and in the others soft, and it sometimes contains iron. The amount is generally satisfactory. An aquifer zone from 2,590 to 2,610 feet elevation supplies large amounts of soft water to several wells. It probably extends over all the township and can be used if higher aquifers are not adequate. The average depth of these wells west of the river is about 110 feet, and the water rises a fair distance in them. Several springs lie along Red Deer Valley, but have only a fair supply. The wells in the vicinity of the river do not usually have as good a supply of water as those farther back.

Township 38, Range 23. Red Deer River flows through the west and north parts of this township in a general northeasterly direction. It occupies a valley about a mile wide and 150 to 200 feet deep, towards which the surface of the township generally slopes.

The unconsolidated deposits are rarely much more than 30 feet thick, and in many places, especially near the river, much less. A thin layer of river, stream, and lake sand, in places overlain by till, has been deposited in sections 28, 29, 32, and 33. Fairly coarse gravel is present on both sides of Red Deer River in the western part of the township. Mostly it is 10 to 20 feet thick and, although probably widespread, much of it is hidden by a covering of till. In the northeast and centre about 10 square miles are covered by rolling ground moraine, with knolls and depressions that increase in size to the south, east, and west. This ground moraine grades into a terminal moraine of low relief that covers the rest of the township. Only a few hills in this moraine are over 30 feet high, but sloughs and ponds occupy many of the depressions.

Two tills are commonly present; some 10 feet of a blue-black till appearing under the more common light grey one. Gravel is generally present under the lower till.

The Paskapoo formation lies under the surface deposits and over the Edmonton formation throughout the township except for an area near the river, where the latter formation directly underlies the unconsolidated material. Wide exposures of the Edmonton and some outcrops of Paskapoo are present along the river.

Although a few wells obtain hard water from the surface material, it is generally an unsatisfactory source, even in the sand and gravel areas, largely because of drainage into the nearby river.

Water is obtained from both the Edmonton and Paskapoo formations, and it is often difficult to determine from which a well is drawing. The wells average about 105 feet in depth, but vary greatly even in neighbouring parts of the township. They range from 30 to 200 feet in depth. Most wells draw from aquifers between 2,700 and 2,760 feet elevation, and these usually have a sufficient supply of hard water. These wells are mostly in the southeast, for nearer the river the land surface is lower and is in places below these elevations. Here wells have to depend on lower aquifers, largely between 2,570 and 2,670 feet, being generally lowest near the river. These wells have mainly soft water, but the supply may be poor, largely because of drainage into the nearby river valley that lessens the pressure. In this area a good reservoir for collecting water in the well would help to compensate for the small rise.

Northwest of the river most wells supply soft water and draw from an aquifer zone between 2,500 and 2,565 feet elevation.

In this township the rise of water in the wells is fair to poor, being poorest near the river.

Township 38, Range 24. Red Deer River runs from west to east through the southern part of this township, and its valley, which is about 200 feet deep and a mile wide, is the most important topographic feature. The surface of the township has a general slope towards the valley.

Small areas of sand border some streams, and till, sand, and gravel cover Red Deer Valley except where bedrock outcrops. Otherwise practically the whole surface of the township is overlain by terminal moraine of low relief. Its hills are low and gentle, and the swamps and sloughs, which are numerous away from the river, shallow and broad.

Both the Edmonton and Paskapoo formations are widely exposed along the valley. Elsewhere the covering of unconsolidated deposits varies in thickness from perhaps 10 to 20 feet near the river to a maximum thickness of 40 to 50 feet back from it. The Edmonton lies directly under this unconsolidated cover in a narrow belt along the river; elsewhere the Paskapoo overlies the Edmonton.

No wells were seen in the unconsolidated material, and this offers little chance of satisfactory water supply in the area south of the river. North of the river it may at times give fair supplies of hard water, especially from near its contact with the bedrock.

The Paskapoo formation is the chief bedrock source of water, as the Edmonton formation lies at a depth of 150 to 250 feet everywhere but near the river, and is too deep to be generally used. Nevertheless, the Edmonton should contain a fairly large amount of soft water if a suitable supply cannot be found at higher elevations.

Little information is available about the water-supply north of the river. In general, near the river water does not rise high in the wells as it drains into the river, and sufficient supplies are somewhat difficult to obtain. A larger reservoir for collecting water in the well would be helpful in many instances. In the higher areas of the

township north of, and a mile or two back from, the river most wells should draw their water from between 2,700 and 2,780 feet elevation. The water is mostly hard, but in some cases, which are more common towards the west, it is softer. The water is in sufficient supply, and, being under some pressure, rises fairly high.

Conditions described for the northern part of tp. 37, rge. 24, and for that part of tp. 38, rge. 23, south of the river are similar to those in this township south of the river.

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.