CANADA
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WATER SUPPLY PAPER No. 296

GROUND-WATER RESOURCES OF TOWNSHIP 39 TO 42, RANGES 17 TO 20, WEST OF 4th. MERIDIAN, ALBERTA

by

R. L. Rutherford;, A.M. Stalker, and H. W. Tipper

OTTAWA
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MINES, FORESTS AND SCIENTIFIC SERVICES BRANCH

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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].

[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 39 to 42, RANGES 17 to 20,

WEST FOURTH MERIDIAN, ALBERTA

Introduction

Information on the ground-water resources of this area was obtained from the records of water wells and by a study of both the surface deposits and the underlying bedrock in their relation to the ground-water supply. The well record information was collected by R.L. Rutherford in 1935 and by A.M. Stalker in 1947; the surface deposits were mapped by A.M. Stalker in 1947; and the report was compiled by H.W. Tipper in 1948.

Physical Features

The main topographic features of this area are the valley of Battle River in the northeast townships and Buffalo Lake in the western townships. Battle River flows through a narrow, southeast-trending valley 150 feet deep, and bedrock is exposed along this river and its tributary creeks. Buffalo Lake is shallow and alkaline, and occupies a depression in the glacial drift.

Many, low, broad hills and ridges lie between Battle River and Buffalo Lake but, in detail, the surface exhibits the characteristic knob and kettle topography of a terminal moraine. The southern and eastern townships occupy a rolling plain into which many gullies have been cut by creeks. The area includes many small lakes and creeks, but several of these are dry in summer.

Geology

Bedrock Formations

The Edmonton formation underlies the glacial drift throughout the area. Bedrock is only exposed in the eastern townships, where the drift is shallow, and the best exposures occur along Battle River, in some creek valleys, in road cuts, and on some of the higher hills.

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 the formation becomes progressively thicker to the southwest due to the fact that the beds dip in that direction.

The Edmonton formation consists of poorly bedded, grey and greenish clay shales, coal seams, and sand and sandstones that contain clay and a white material known as bentonite. This material when wet is very sticky and swells greatly in volume; when dry it 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.

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, which 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 surface covered to a variable depth with a mantle of glacial drift, which constitutes 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 impervious mass, and also lying above it, are beds, pockets, and lenses of sand and gravel that form the water-bearing members or aquifers of the drift.

Ground Moraine. This type of glacial drift is chiefly boulder clay and till laid down beneath the ice-sheet, and consists of a heterogeneous mixture of clay, boulders, and pebbles enclosing irregularly distributed lenses and pockets of water-laid sand and gravel. The matrix of such deposits varies in composition from a yellowish sandy clay to a grey or white clay. Boulders and pebbles contained in the ground moraine are generally less than 6 to 8 inches in diameter but may reach dimensions of 2 to 3 feet.

Terminal Moraine. Part of the load carried by the continental ice-sheet was dropped at its front or margin during pauses in the general retreat of the melting glacier. This load consisted of material gathered during the advance of the ice-sheet, and was deposited as a mixture of boulder clay, silt, sand, and gravel. Much of the clay, silt, and fine sand has been carried away by melt water from the glacier, the deposits now consisting mainly of coarse till, gravel, and sand arranged in characteristic hummocks and poorly drained hollows.

Reworked Moraine. During the final recession of the ice-sheet, great volumes of melt-water accumulated along the margin of the ice. The glacial lakes so formed were of irregular size, and in many places were shallow and contained small islands. The duration of the glacial lakes depended on the persistence of barriers that had to be removed either by stream erosion or by the melting of ice dams. In the drainage process many areas of terminal and ground moraine were greatly modified, depressions were filled with sand and silt, knolls and hills were eroded, and much of the till was reworked, sorted, or carried away. Areas so affected are now rolling plains consisting of irregular patches of silt and sand intermingled with patches of till and gravel.

Glacial-lake Deposits. Glacial-lake sand, together with silt and clay, forms the surface deposits of the low country around Buffalo Lake. The sand is dark buff and fine grained, and is poorly to well stratified. The silt and clay occupy small, discontinuous areas and are light buff to grey in colour. In some places they are varved, and in others the silt is quite sandy and the clay, silt, and sands grade into one another.

Water Supply

Within this area, most wells yield an adequate supply of water for present needs, although in some wells the supply is barely adequate. Most wells in the glacial drift yield hard water, and the supply of many varies with the seasonal rainfall, so that they are not as dependable as the bedrock wells. The porous lenses of sand and gravel in the till serve as the best aquifers, but it is not possible to predict where these lenses will occur, and their discovery is a matter of chance. The glacial-lake deposits usually yield sufficient supplies of hard water, and in township 41, ranges 17 and 18, four flowing wells obtain water from glacial-lake sand.

Most wells in the area obtain water from bedrock at depths of less than 200 feet, the greatest recorded depth being 535 feet. In general these wells yield ample supplies of soft water under sub-artesian conditions. Shallow wells may yield hard water, possibly as a result of surface water seepage into the well. There are eight flowing wells within this area, and no dry holes have been recorded.

Water is relatively abundant in the Edmonton formation, which contains much sand, commonly in the form of isolated lenses distributed irregularly through the formation. Water occurs in these sands, and, hence, there is little uniformity in the depths of wells even within a limited area. Although no continuous aquifer has been traced over any great area, water has been obtained from several definite zones. It also occurs commonly with coal seams, which, unlike the sand lenses, are much more regular and persistent. In contrast with the water from the bentonitic sands, which is generally 'soft', water from the coal seams, as in the glacial deposits, may be 'hard'. The basal beds of the Edmonton formation commonly contain fresh water, but this may become brackish where the underlying Bearpaw beds contain highly alkaline or salty water.

Township 39, Range 17. Ground moraine forms the surface deposit of this township. The till contains much bentonite and pieces of coal derived from the Edmonton formation. The surface is comparatively flat, and the depth of drift is 30 feet or less for most of the township.

A few wells in glacial drift obtain hard water at depths of 30 feet or less. Porous lenses of sand and gravel in the till serve as aquifers, but these are of local extent and their discovery is a matter of chance.

Bedrock wells are the main source of water for this township. A water-bearing zone occurs between elevations of 2,485 and 2,525 feet, and the water supplied is soft and under pressure. Other wells obtain water at elevations above and below this zone, and shallower wells commonly supply hard water whereas that from deeper wells is generally soft. The supply of water from several wells is insufficient for local requirements and is augmented by creeks, but most wells yield a sufficient supply for domestic use and for stock. The water in a few wells is alkaline or contains iron. The supply of water of many wells has decreased in the past few years, due, perhaps to drier seasons or to additional demands of more recent wells.

Township 39, Range 18. This township has a surface deposit of glacial till, which is yellow or white, and contains much bentonite derived from the Edmonton formation. The surface is comparatively flat, but slopes gently northeast.

Hard water is obtained from wells in the glacial drift at depths of 30 feet or less. Porous sand lenses in the till serve as aquifers, and as the water is not under much pressure, it does not rise high in the wells. The supply is sufficient, although it is dependent on rainfall.

Two water-bearing zones occur in bedrock, a lower one between elevations of 2,420 and 2,455 feet, and an upper one between 2,515 and 2,535 feet. Wells less than 100 feet deep have reached the upper zone, and wells 100 to 180 feet the lower zone. Several shallow wells yield hard water, but this may be due to surface water seeping into the well. In general the deeper wells supply soft water under good pressure. The supply of water is usually sufficient for most requirements, and only two wells are known to have an insufficient supply. The water in some wells is not satisfactory for domestic use because of a high content of soda or alkali, but can be used for stock.

Township 39, Range 19. In this township, ground moraine forms the surface deposit except in the northwest sections where terminal moraine overlies a small area. The surface is rolling in the southern sections, but becomes hummocky in the terminal moraine country. The depth of drift is as much as 120 feet and as little as 35 feet for the township.

Only one well in glacial drift has been recorded in the township, and it provides a good supply of hard water. The glacial till would yield only a limited amount of water because the porous sand lenses that serve as aquifers are of local extent, and the supply of water is dependent on rainfall. On some farms irrigation is required, and a more dependable supply of water is necessary, so that bedrock wells are preferred.

Bedrock wells provide a good supply of soft, clear water in this township. Most wells are obtaining water from two water-bearing zones between elevations of 2,490 and 2,518 feet and 2,530 and 2,560 feet respectively. The water is under strong pressure in both zones so that it rises high in the wells, and three wells that reach the upper zone are flowing. Other wells have obtained water above and below these zones, and the supply and quality of water have been satisfactory. The water in a few wells contains soda, iron, or alkali, but not in sufficient quantity to make the water unsatisfactory for domestic use or for irrigation. Most wells are 80 to 150 feet deep, and the deepest is 290 feet.

Township 39, Range 20. The surface deposits of this township consist of ground moraine in the southern and eastern sections and terminal moraine in the northern and western townships. The surface is rolling in the southern sections and hummocky in areas of terminal moraine, with many small lakes. The drift is 80 to 120 feet deep for most of the township.

Few wells in this township obtain water from the glacial drift. Porous lenses of sand and gravel in the till may yield sufficient hard water for some requirements, but wherever a large, dependable supply is needed, it is preferable to drill into bedrock.

A sufficient supply of water is provided in this township by bedrock wells. Two water-bearing zones occur between elevations of 2,530 and 2,560 feet and 2,570 and 2,625 feet respectively. The lower one is a continuation of a similar zone in tp. 39, rge. 19; it supplies soft water under strong hydrostatic pressure, and commonly contains iron. In general the upper zone provides an adequate supply of soft water under pressure, but in a few wells the water is hard, possibly as a result of surface seepage. Other wells have found water above or below these zones, and the supply in all wells has been sufficient and generally of satisfactory quality.

Township 40, Range 17. Ground moraine overlies bedrock in the southwest sections of the township; elsewhere the surface deposits consist of reworked moraine, with intermingled patches of till and glacial-lake deposits. The surface is comparatively flat, with a few small hills and knolls. The drift is 15 to 55 feet deep for most of the township, but decreases northward.

Wells in glacial drift are not a common feature of this township, and bedrock wells are preferred. However, a few wells are obtaining hard water from sand lenses in the till and from small areas of glacial-lake sand.

A water-bearing zone occurs in bedrock between elevations of 2,385 and 2,420 feet, and wells that reach this zone provide a good supply of soft water. The water is under strong hydrostatic pressure so that it rises high in the wells, and two of these wells are flowing. A few wells have obtained water at higher elevations, but commonly the water is hard, although in sufficient supply and under pressure. Several wells drilled below an elevation of 2,300 feet have encountered aquifers that have yielded a good supply of water under pressure. Most wells are less than 100 feet deep, and the deepest is 325 feet.

Township 40, Range 18. The surface deposits of this township consist essentially of glacial till, with small areas of glacial-lake sand. The surface is gently rolling in the eastern sections, becoming more uneven toward the west. The depth of drift is 50 feet or less for most of the township.

Several wells in glacial drift supply hard water. Porous sand and gravel lenses in the till as well as small areas of glacial-lake sand serve as aquifers, but the supply of water is dependent on rainfall, and bedrock wells have proved more satisfactory.

Many bedrock wells in this township are obtaining water from a zone between elevations of 2,385 and 2,415 feet. The water in this zone is generally soft and under pressure, so that it rises high in the wells. Other wells obtain water above or below this zone, and the deeper wells commonly provide a good supply of soft water. Many wells have been drilled through coal seams, and the water in these wells commonly contains iron or sulphur. Most wells are less than 150 feet deep, and the deepest is 325 feet.

Township 40, Range 19. Terminal moraine forms the surface deposit of this township except in the southeast sections, where there is a small area of ground moraine. The surface exhibits the typical, uneven knob and kettle topography of a terminal moraine. The depth of drift varies considerably throughout the township, and in some places it is believed to be as much as 260 feet.

Wells in glacial drift provide a limited supply of hard water. Porous lenses of sand and gravel in the terminal moraine serve as aquifers, and the water supplied is dependent on the rainfall. The water in several of these wells is under moderate pressure; it commonly contains much iron, though rarely in sufficient quantities to make it unfit for use.

Wells in bedrock are relied upon as the main source of water in this township. Water has been obtained at various depths throughout the township, and no water-bearing zone has been defined. The water is generally soft, under strong pressure, and in sufficient supply. Water in several wells contains iron or soda, but apparently not in sufficient quantities to make it unsatisfactory for domestic uses. Most bedrock wells are more than 100 feet deep, and the deepest is 465 feet.

Township 40, Range 20. Terminal moraine forms the surface deposits of this township except along Buffalo Lake where glacial-lake sand overlies it. Buffalo Lake occupies the northwest sections of the township. The topography of the township is typical of a terminal moraine, with its low hills and undrained depressions. The depth of drift is 200 feet or more for most of the township.

A few wells are obtaining hard water from the glacial drift. Porous sand lenses in the till are one source of water, and two shallow wells obtain water from the glacial-lake sand. In general, bedrock wells are preferred.

All bedrock wells in this township are more than 150 feet deep, and most of them more than 250 feet; the deepest is 535 feet. These wells have all obtained a sufficient supply of water, which is usually soft and commonly contains iron or soda. No water-bearing zones has been defined but, on the other hand, no dry holes have been reported. The hydrostatic pressure is strong, and the water rises high in the wells.

Township 41, Range 17. Glacial till overlies bedrock in this township, and in the southern sections sand and silt overlie small areas of till that has been reworked by glacial melt water. Battle River and Meeting Creek have cut deep valleys through the till into bedrock, so that the surface of the township is very uneven. Bedrock is exposed along Battle River and its tributaries, but elsewhere in the township is covered by a deposit of glacial drift as much as 200 feet deep.

Wells in glacial drift are the main source of water for this township. A few wells obtain hard water from porous sand and gravel lenses in the till. Most of such wells are shallow, and their water supply limited. Lenses and beds of sand in the glacial-lake deposits in the southwestern sections have yielded a good supply of water. Three wells that have reached these aquifers are flowing, and the water in other wells in the vicinity is under strong hydrostatic pressure.

Few bedrock wells have been recorded in this township. Two flowing wells in bedrock have been reported in the southwest sections, but as these are in an area of glacial artesian supply and produce hard water, it is probable that the main flow is from aquifers in the drift. Other wells have obtained soft water at depths of 200 feet or less.

Township 41, Range 18. The surface deposits of this township consist of terminal moraine in the western sections and ground moraine and reworked moraine in the eastern sections. The surface is rolling in the east, but becomes hummocky in the west. Meeting Creek crosses the northeast sections in a narrow valley 150 feet deep.

Glacial wells are obtaining hard water at shallow depths from porous sand and gravel lenses in the till and from glacial-lake sand that overlies the till. The supply is sufficient, and one well in section 1 is flowing.

Wells in bedrock 60 to 180 feet deep provide a sufficient supply of soft water. Most of these wells have encountered aquifers at an elevation of about 2,400 feet. The water is under strong hydrostatic pressure, and one well in section 30 is flowing. The deepest well is 325 feet.

Township 41, Range 19. The surface deposits of this township consist entirely of terminal moraine. The surface is very hilly, with characteristic knob and kettle topography of a terminal moraine, and contains many small lakes and ponds, some of which are dry in summer.

Bedrock wells are the main source of water in this township. All those recorded were drilled, and all are more than 100 feet deep; the deepest is 460 feet. These wells supply sufficient soft water under strong pressure.

Township 41, Range 20. The surface deposits of this township consist of glacial till overlain in the northwest sections by glacial-lake sand and silt. Buffalo Lake occupies the central and southern sections, and together with other small lakes, comprises more than half the surface area of the township. The surface is comparatively flat or gently rolling, except in the northeast where it is hummocky.

Information on the water supply of this township is inadequate to define any aquifers or water-bearing zones in either the glacial drift or bedrock. However, conditions of water supply are probably similar to those elsewhere in the area, so that water may be obtained from shallow wells in the glacial drift and from deep wells drilled into bedrock. As the drift is deep, bedrock wells probably would need to be drilled to a depth of 150 to 250 feet.

Township 42, Range 17. Bedrock is exposed in this township along Battle River, but elsewhere it is covered by ground moraine. Battle River flows south through the centre of the township, and it and its tributaries have cut deep valleys and gullies into the till, making the surface very uneven.

Water from the glacial drift is generally hard, and the supply is limited. Porous sand lenses in the glacial till serve as aquifers and are replenished by rainfall, so that in dry seasons they may not be dependable.

Township 42, Range 18. Ground moraine forms the surface deposits of this township except in the southwest sections where terminal moraine occupies a small area. The surface is rolling, with several small hills and knolls. Bedrock is exposed along Meeting Creek, which flows southeast through the southwest sections.

A water-bearing zone occurs in bedrock between elevations of 2,475 and 2,515 feet. Sufficient soft water is obtained by wells that reach this zone, several such having been drilled near Donalda. Other wells have obtained a sufficient supply of soft water below this zone. All water obtained from wells drilled into bedrock is under fairly strong pressure. Most of these wells are less than 100 feet deep, and the deepest is 145 feet.

Township 42, Range 19. Terminal moraine forms the surface deposits of most of this township. In the northeast sections bedrock is exposed along Meeting Creek, and on either side of this creek are small areas of ground moraine. In general the topography of the township is typical of terminal moraine, with low hummocks, undrained depressions, and many small lakes, most of which are dry in summer. The drift is 75 feet deep or less for most of the township.

Wells 20 to 70 feet deep in glacial drift provide a limited supply of hard water. Porous sand lenses in the till serve as aquifers, but these are of local extent and occur at various elevations. The water supply for these wells is dependent on rainfall and is not dependable.

Water supplied by bedrock wells is generally soft, and the supply is generally sufficient. No aquifer has been defined, but most wells have obtained water at depths of less than 100 feet, and the deepest well is 225 feet.

Township 42, Range 20. Glacial-lake sand occupies a small area in the southwest sections, but elsewhere in the township the surface deposits consist of terminal moraine, and exhibit the hummocks and undrained depressions typical of a terminal moraine. Most of the many small lakes and ponds are dry in summer.

Most bedrock wells in this township are obtaining water from a zone between elevations of 2,470 and 2,525 feet. The water is soft and under pressure, and the supply from most wells is sufficient for local requirements. Wells that reach this zone are 100 to 200 feet deep. Deeper wells have also obtained a supply of soft water, and the deepest is 468 feet.

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.