CANADA
DEPARTMENT OF MINES
AND
TECHNICAL SURVEYS

GEOLOGICAL SURVEY OF CANADA

WATER SUPPLY PAPER No. 250

GROUND-WATER RESOURCES OF THE RURAL MUNICIPALITY OF TURTLE RIVER NO. 469 SASKATCHEWAN

Records Collected by C. O. Hage
Compilation by G. S. Hume and C. O. Hage

OTTAWA
1947
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MINES AND GEOLOGY BRANCH
BUREAU OF GEOLOGY AND TOPOGRAPHY

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INTRODUCTION

Information on the ground-water resources of east-central Alberta and western Saskatchewan was collected, mostly in 1935, during the progress of geological investigations for oil and gas. The region studied extends from Edmonton in the west to Battleford in the east, and from township 32 on the south to township 59 in western Alberta, township 63 in eastern Alberta, and in part as far north as township 56 in western Saskatchewan.

This region is crossed by North Saskatchewan and Battle Rivers, and includes other more or less permanent streams. Most of the lakes within the area, however, are alkaline, and water is obtained in wells from two sources, namely, from water-bearing sands in surface or glacial deposits, and from sands in the underlying bedrock.

A division has been made in the well records, in so far as possible, between glacial and bedrock water-bearing sands. In investigations for oil and gas, however, the bedrock wells were used to trace the lateral extent of geological formations, with the result that the records deal more particularly with this type of well. No detailed studies were made of the glacial materials in relation to the water-supply, nor were the glacial deposits mapped adequately for this purpose. In almost all of the region investigated in Alberta, and in all but the northeast part of the region studied in Saskatchewan, water can be obtained from bedrock. In a few places, however, the water from the shallower bedrock sands is unsatisfactory, and deeper drilling may be necessary.

The water records 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 farmers, town authorities, and drillers in their efforts to obtain water supplies adequate for their needs.

In collecting this information several field parties were employed. These were under the direction of Professors R. L. Rutherford and P. S. Warren of the University of Alberta, C. H. Crickmay of Vancouver, and C. O. Hage, until recently a member of the Geological Survey. The oil and gas investigations of which these water records are a part were undertaken under the general supervision of G. S. Hume.

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 Government 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 reports are defined in the glossary.

How to Use the Report

Anyone desiring information concering 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 provided on bedrock formations, pages 4 to 8, 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 substracting its elevation, as given in the well record tables, from the elevation of the surface at that point.

With each report is a map consisting of two figures. Figure 1 shows the bedrock formations that will be encountered beneath the unconsolidated surface deposits. Figure 2 shows the position of all wells for which records are available, the class of well at each location, and the contour line or lines of equal surface 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 likely 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 or Water-bearing Horizon. A porous bed, lens, or pocket in unconsolidated deposits or in bedrock that carries water.

Buried pre-Glacial Stream Channels. 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 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 overlie 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 WEST-CENTRAL SASKATCHEWAN AND EAST-CENTRAL ALBERTA

The formations that outcrop in west-central Saskatchewan are an extension of similar formations that occur in east-central Alberta. They are of Upper Cretaceious age, and consist entirely of relatively soft shales and sands, 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:

Formation	Character	Thickness Feet
Edmonton	Grey to white, bentonitic sands and sandstones with grey and greenish shales; coal seams prominent in some areas, as at Castor, Alberta.	1,000 to 1,150
Bearpaw	Dark shales, green sands with smooth black chert pebbles; partly non-marine, with white bentonitic 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 are abundant selenite crystals.	300 to 600 thins rapidly to the north-west
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.	950 to 1,000 in Czar-Tit Hills area; may be thinner elsewhere
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 in west, but less to east and south
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	Maximum, 100
Ribstone Creek	Grey sands and sandstones at the top and bottom, with intermediate sands and shales; thin coal seam in the vicinity of Wainwright; mostly non-marine, but middle shale in some areas is marine.	Maximum, 325 at Viking; thins eastward
Lea Park	Dark grey shales and sandy shales with nodules of ironstone; a sand 70 feet thick 110 feet below the top of the formation in the Ribstone area, Alberta.	950 to 1,100

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 eastward and the east 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 incline in that direction and the surface bevels across them.

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

Water is relatively abundant in the Edmonton formation, which contains much sand, commonly in the form of isolated lenses distributed irregularly through the formation. Consequently, there is little uniformity in the depth of wells even within a small area. Water also occurs commonly with coal seams and, unlike the sand lenses, these beds 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 the water from the shallow surface deposits, may be "hard". The basal beds of the Edmonton formation usually contain fresh water, but this may become brackish locally where the underlying Bearpaw beds contain highly alkaline or salty water.

Bearpaw Formation

In southern Alberta, where the Bearpaw formation is thickest, the beds composing it are mainly shales that have been deposited in sea water. In the area north of township 32 the formation thins to the northwest and becomes a shoreline deposit composed of shales containing bentonite, impure sands, and thin coal seams. In some areas, as at Ryley and near Monitor, and in the Neutral Hills, the Bearpaw contains pebble beds. At Ryley these are consolidated into a conglomerate, but mostly the pebbles are loosely distributed in shale or sandy beds.

In the area immediately north of township 32 the Bearpaw occupies a widespread belt beneath the glacial drift, but farther northwest the belt narrows, and at Ryley and northwestward it is only a few miles wide. This belt crosses North Saskatchewan River about midway between Edmonton and Fort Saskatchewan. Bearpaw beds form the main bedrock deposits of the Neutral Hills. Farther south, where they have an exposed thickness of at least 400 feet, they contain green sands, and beds of marine shale interfinger with the bentonitic shales and sands of the underlying formation. To the north, on the banks of North Saskatchewan River, the division between the Bearpaw and the overlying and underlying formations is indefinite, and the thickness of beds of Bearpaw age is relatively small.

The water in the Ryley area is from the Bearpaw formation, and is salty. In other areas to the south the marine Bearpaw formation carries green sand beds that yield fresh water, but commonly a much better supply is found by drilling through the Bearpaw into the underlying Pale Beds.

In Saskatchewan, Bearpaw beds occur southeast of Maclin and south of Luseland and Kerrobert. Only the basal beds are present, and these contain green sands that are commonly water-bearing.

Pale and Variegated Beds

Underlying the Bearpaw formation is a succession of bentonitic sands, shales, and sandy shales containing a few coal seams. The upper part of this succession, due to the bentonitic content, is commonly light coloured and has been described as the Pale Beds, whereas the lower part is darker, and is known as Variegated Beds. In part, dark shales are present in both Pale and Variegated Beds; others are greenish, grey, brown, and dark chocolate, carbonaceous types. The sands may also be yellow, but where bentonite is present it imparts a light colour to the beds. Both Pale and Variegated Beds are characterized by the presence of thin seams of ironstone, commonly dark reddish, but in part purplish, Selenite (gypsum) crystals are, in places, abundant in the shales.

The best sections of Pale Beds exposed in the region are in the Tit Hills, southwest of Czar. These hills carry a thin capping of Bearpaw shales, beneath which, and around Bruce Lake, more than 200 feet of Pale Beds are exposed. The total thickness of Pale and Variegated Beds in the Tit Hills area is about 970 feet. Variegated Beds outcrop near Hawkins on the Canadian National Railway west of Wainwright, but no area exposes the complete succession, which is considered to comprise about 200 feet of beds.

Records of wells drilled into the Pale and Variegated Beds do not, in general, indicate lateral persistence of sands for long distances, nor any uniform average depth to water-bearing sands in a local area. This points to the conclusion that the sands are mainly local lenses, but as such lenses are numerous, few wells fail to obtain water. In the Cadogan area many flowing wells have been obtained from sands about midway in the succession. In western Saskatchewan Paleland Variegated Beds occur over a wide area from Maclin and Kerrobert northeast through Wilkie to the Eagle Hills, south of Battleford. Numerous outcrops occur in the area south of Unity at Muddy Lake, but south and east around Biggar these beds are almost wholly concealed by glacial drift.

The water from the sands of the Pale and Variegated Beds is generally soft. The supply, apparently, is dependent in part on the size of the sand body that contains the water and in part on the ease with which water may be replenished in the sand. Small sand lenses surrounded by shales may be filled with water that has infiltrated into them, but when tapped by a well the supply may be very slowly replenished. In many instances such wells yield only a small supply, although this is commonly persistent and regular.

Birch Lake Formation

The Birch Lake formation underlies the Variegated Beds, but in many areas the division is not sharp. The type area of the formation is along the north shore of Birch Lake south of Innisfree, where a section 65 feet thick, composed mostly of sand, is exposed. The total thickness of the formation in this area is about 100 feet, and although this is dominantly sand a central part is composed of alternating thin sand and shale beds. At the base of the formation, in a number of places, is an oyster bed, and this is exposed in a road cut in a section 73 feet thick on the east side of Buffalo Coulée in sec. 3, tp. 47, rge. 7, W. 4th mer. In both upper and lower parts of the formation the sand is commonly massive and outcrops tend to consolidate into hard, nodular masses from a foot to a few feet in diameter. Apparently these are formed through the deposition of salts from the water that finds an outlet at the outcrops. In fact, in some areas the sand may be traced along the side of a hill by the presence of small springs or nodular masses of sandstone.

The Birch Lake formation occurs under the drift and in outcrops in a large area south of North Saskatchewan River and northeast of a line from Willingdon to Innisfree and Minburn. East of this area the southwest boundary is more irregular, but outcrops are persistent on the banks of Battle River from a few miles north of Hardisty to and beyond the mouth of Grizzly Bear Coulée in tp. 47, rge. 5. It is believed, too, that a large area near Edgerton and Chauvin is underlain by the Birch Lake formation and that it extends southeastward into Saskatchewan around Manitou Lake and southeast to Vera.

It is thought that the Birch Lake formation thins eastward from its type section at Birch Lake, and that it loses its identity in western Saskatchewan. Deep wells drilled at Czar, Castor, and elsewhere no longer show the Birch Lake as a clearly recognizable sand formation, so that its southern limit beneath younger formations is unknown. Wherever it occurs as a sand, however, it is water-bearing, although in some areas the sand is apparently too fine to yield any considerable volume of water. In other areas, however, it persistently yields good wells. There is no apparent uniformity in the character of the water, which is either hard or soft in different wells in the same general area. Direct contact with surface waters that contain calcium sulphates may in time change a "soft" water well to a "hard" water well, and many wells are not sufficiently cased to prevent the percolation of water from surface sands into the well, and hence into the deeper, soft water producing sands. In part this accounts for the change in character of the water in a well, a feature that has been noticed by many well owners.

Grizzly Bear Formation

The type locality for the Grizzly Bear formation, which underlies the Birch Lake beds, is near the mouth of Grizzly Bear Coulée, a tributary of Battle River with outlet in tp. 47, rge. 5. The formation is mainly composed of dark shales that were deposited in sea water. At the mouth of Grizzly Bear Coulée two shale sections, each about 100 feet thick, are separated by a zone of thin sand beds. It is now recognized that the upper section is the Grizzly Bear shale, and that the lower one, very similar in character and also deposited in sea water, occurs in the next lower formation, the Ribstone Creek. The Grizzly Bear shale contains a thin nodular zone about 50 feet above the base, that is, at about the centre of the formation. This zone is sandy, and is believed to yield water in various wells. Other thin sands, in places water-bearing, are also present. The impervious nature of the Grizzly Bear shales makes the overlying Birch Lake sand a strong acquifer, as water collects in the sand above the shale. The contact of the Birch Lake and Grizzly Bear formations can be traced in some places by the occurrence of springs issuing from the base of the Birch Lake sand even where this is not exposed.

Grizzly Bear shales occur in a road cut on the south side of Battle River near the highway bridge at Fabyan. The shales in this area are about 100 feet thick. It is thought they extend as far west as the Viking gas field, where they have been recognized in samples from deep wells. It is probable, however, that the shales thin westward and thicken eastward so that their general form is a wedge between both higher and lower sand beds. The position of the thin edge of the wedge to the west is unknown, but evidently the Grizzly Bear marine shale underlies a large area in east-central Alberta extending into Saskatchewan mainly in the area south of Battle River.

Ribstone Creek Formation

The type area of the Ribstone Creek formation is on Ribstone Creek near its junction with Battle River in tp. 45, rge. 1, W. 4th mer. At this place the lower sand beds of the formation are well exposed. The upper part of the lower sand member of this formation outcrops on the north side of Battle River, in the northeast part of sec. 26, tp. 47, rge. 5, near the mouth of Grizzly Bear Coulée. Above it, higher on the bank and at a short distance from the river, there is a 12 foot zone of carbonaceous and coaly beds in two layers, each about 2 feet thick, separated by 8 feet of shale. Above this are 90 feet of dark shales that are thought to have been deposited in sea water, that is, they are marine shales. These marine shales in turn are overlain by a sandy zone about 20 feet thick containing oysters in the basal part. This sandy zone is the upper sand member of the Ribstone Creek formation.

It thickens to the east and west from the Grizzly Bear area but is probably at no place much more than 50 feet thick.

The lower sand member of the Ribstone Creek formation also varies in thickness from a minimum of about 25 feet. On the banks of Vermilion Creek, north of Mannville, the basal sand is at least 60, and may be 75, feet thick. It is overlain by shaly sand and sandy shale beds, which replace the shale beds in the central part of the formation as exposed at the mouth of Grizzly Bear Coulée. In the Wainwright area, where the formation has been drilled in deep wells, the basal sand is 60 feet thick, with the central part composed of shale containing sand streaks. The upper sand member is about 20 feet thick in this area. The total thickness of the formation in the Wainwright area is 180 to 200 feet, but this increases to the west and in the Viking area exceeds 300 feet.

The Ribstone Creek formation is widely exposed in a northwest-trending belt in east-central Alberta. The southwest boundary of this northwest-trending belt passes through the mouth of Grizzly Bear Coulée in tp. 47, rge. 5, and beyond to the Two Hills area in tp. 54, rge. 12, whereas the northeast boundary crosses North Saskatchewan River southwest of Elk Point and extends northwest to include an area slightly north of St. Paul des Metis and Vilna to tp. 60, rge. 14. Within this belt water wells are common in the Ribstone Creek sands, which are almost without exception water-bearing in some part of the formation. The limits of the belt to the northeast determine the limits of water from this source, but to the southwest of the belt, as here outlined, water may be obtained in this formation by drilling through the younger beds that overlie it. The Ribstone Creek sands are a prolific source of water in many places and hence the distribution of this formation is of considerable economic importance. Where the formation consists of upper and lower sands with a central shale zone only the sands are water-bearing, although thin sand members may occur in the shale. Where the formation is largely sand the distribution of water may be in any part of the formation, although the upper and lower sands are perhaps the better aquifers. To the east of Alberta, along Battle River and Big Coulée in Saskatchewan, the Ribstone Creek sands are marine. Marine conditions apparently become more prevalent to the southeast and it is believed that in this direction the sands are gradually replaced by marine shales. Thus at some distance southeast of Battleford the Ribstone Creek formation loses its identity and its equivalents are shales in a marine succession.

Lea Park Formation

The Lea Park formation is largely a marine shale, and only in the upper 180 feet is there any water. In the Dina area south of Lloydminster the upper beds of the Lea Park consist of silty shales about 110 feet thick underlain by silty sands 70 feet thick. Below these sands are marine shales only, and these yield no fresh water either in east-central Alberta or west-central Saskatchewan. The sand in the upper Lea Park formation is thus the lowest freshwater aquifer within a very large area. The extent of this sand in the Lea Park, particularly to the northeast, is not known, but as the strata in east-central Alberta have a southwest inclination, progressively lower beds occur at the surface to the northeast. Thus at a short distance beyond the northeast boundary of the Ribstone Creek formation, as previously outlined, the sand in the upper Lea Park reaches the surface, and represents the last bedrock aquifer in that direction. Farther northeast water must be obtained from glacial or surface deposits only. In Alberta this area without fresh water in the bedrock includes the country north of North Saskatchewan River in the vicinity of Frog Lake and a large area extending to and beyond Beaver River. In this area, however, more fresh water streams are present than farther south, and bush lands help to retain the surface waters. The area northeast of North Saskatchewan River in Saskatchewan is almost wholly within the Lea Park formation, where water can be found only in surface deposits.

WATER ANALYSES

Introduction

Analyses were made of water samples collected from a large number of wells in west-central Saskatchewan. Their purpose was to determine the chemical characteristics of the waters from different geological horizons, and thereby assist in making correlations of the strata in which the waters occur. Although this was the main objective of the analyses, it was also realized that a knowledge of the mineral content of the water is of interest and value to the consumer. The analyses were all made in the laboratory of the Water Supply and Borings Section of the Geological Survey, Ottawa.

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 (SO4), chloride (Cl), and carbonate (CO_3) radicals.

The analyses indicate only the amounts of the previously mentioned radicals, thus neglecting any silica, alumina, potash, or iron that may be present. It will be noticed that in most instances the total solids are accounted for by the sum total of the radicals as shown by the analyses. Actually, the residue when the water is completely evaporated still retains some combined water of crystallization, so that the figures for the "total solids" are higher than the sum total of the radicals as determined. These radicals are also "calculated in assumed combinations" to indicate the theoretical amounts of different salts present in the water. The same method was followed in each analysis, so that the table presents a consistent record of the different compounds present.

Mineral Constituents Present

Calcium. 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. 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 magnesia ($MgSO_4$) combines with water to form "Epsom salts" and renders the water unwholesome if present in large amounts.

Sodium. Sodium (Na) is derived from a number of the 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 salt" and excessive amounts make the water unsuitable for drinking purposes. 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 purposes[1]. Sodium sulphate is less

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1 "The extreme limit of salts for irrigation is taken to be 70 parts per 100,000, but plants will not tolerate more than 10 to 20 parts per 100,000 of black alkali (alkaline carbonates and bicarbonates)" Frank Dixey in "A Practical Handbook of Water Supply", Thos. Murby & Co., 1931, p. 254.

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harmful.

Sulphates. The sulphate (SO_4) salts referred to in these analyses are calcium sulphate ($CaSO_4$), magnesium sulphate ($MgSO_4$), and sodium sulphate (Na_2SO_4).

Chloride. Chlorine (Cl) is with a few exceptions, expressed as sodium chloride (NaCl), that is, common table salt. It is found in all of the analyses, most of the waters containing less than 200 parts per million, but some as much as 2,000 or 3,000 parts. These waters have a brackish taste.

Alkalinity. The alkalinity determined in these water analyses is based on the assumption that the only salts present in the samples that will neutralize acids are carbonates, and that, consequently, the degree of alkalinity is proportional to the amount of the carbonate radical (CO_3) present.

Hardness. The hardness of water is the total hardness, and has been determined by the amount of a standard soap solution required to form a lather that will stand up (persist) for 2 minutes. 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. The two forms of hardness are not distinguished in the water analyses. Waters grade from very soft to very hard, and can be classified according to the following system[2]:

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2 The "Examination of Waters and Water Supplies", Thresh & Beale, page 21, Fourth Ed. 1933.

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 degress 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, especially 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 sand and clays. Bentonite and glauconite are two such reagents known to be present. Montmorillinite, one of the clay-forming minerals, has the same property of softening water, owing to the absorbed sodium that is available for chemical reaction[1].

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1 Piper, A. M., "Ground Water in Southwestern Pennsylvania", 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.

The amount of iron present in the water was not determined, owing to the possibilities of contamination from the iron casings in the wells. Iron is present in most waters, but the amount may be small. Upon exposure to air a red precipitate forms, the water becomes acid, and, hence, has a corrosive action. When iron is present in large amounts the water has an inky taste.

WATER ANALYSES IN RELATION TO GEOLOGY

Glacial Drift

The quality of the water from glacial drift depends largely on the nature of the deposit from which it comes and on the depth of the aquifer below the surface. Glacial deposits may be divided roughly into three types.

(1). Sand and gravel beds that form the surface deposit, such as outwash material and glacial lake sands.

(2). Buried outwash and interglacial deposits between two tills of boulder clay.

(3). Pockets or lenses of sand and gravel irregularly distributed through the till.

Water from surface sand deposits is normally low in dissolved salts, the total being generally less than 1,000 parts per million. Where large amounts of limestone occur in the glacial sand and gravel beds a characteristic constituent of the glacial water is calcium carbonate, the amount present varying from 300 to 700 parts per million.

Water from buried outwash deposits contains more dissolved salts than the surface sands, as the water in order to reach them has to percolate through overlying till. Rain water contains carbonic acid, which acts as a solvent and dissolves a great deal of calcium, magnesium, and sodium from the rock-forming minerals. Sulphate salts are commonly present, though their proportions vary greatly in the different waters. The shales that are incorporated in the drift are high in calcium sulphate, so that the amount of shale present will modify the quality of the water. The oxidized upper part of the drift contains less sulphate than the deeper, less oxidized boulder clay. The character of the water in the buried outwash deposits will, therefore, depend largely on the composition and amount of till that overlies it.

Water from irregularly distributed sand and gravel beds will vary in its content of dissolved salts depending upon the character of the material surrounding the reservoir beds. As the water in this type of deposit does not flow to any marked extent, it is apt to be more highly impregnated with soluble salts than where the underground movement is more rapid. Soft water in the drift is mostly confined to shallow wells in sands low in calcium carbonate. Waters from glacial lake clays are sometimes high in soluble salts. The sample from a well in glacial lake clay on N.W. ¼ sec. 27, tp. 42, rge. 17, has 11,040 parts per million of soluble salts, largely magnesium sulphate and sodium sulphate. The sample from SE. ¼ sec. 13, tp. 42, rge. 16, which is believed to come from glacial lake silts, has a very different composition. The total solids in it are only 440 parts per million, of which 250 are calcium carbonate. The great difference in these waters is due to the high soluble salt content that is associated with the lake clays but absent in the silts. Average drift water contains between 1,000 and 3,000 parts per million of dissolved mineral salts.

Bearpaw Formation

The Bearpaw formation consists of dark marine shales and beds of green sand. Water from these sands has a total solid count ranging from 300 to 1,600 parts per million and a hardness of more than 300 degrees. Calcium carbonate is very marked in all samples, due, perhaps, to the proximity of the water sands to the glacial drift. Sodium sulphate is the chief salt present, followed by calcium carbonate, magnesium sulphate, magnesium carbonate, and sodium chloride in decreasing amounts. These waters are distinguished from the overlying drift waters by being relatively low in total dissolved solids, and in containing no calcium sulphate and only moderate amounts of sodium sulphate, magnesium sulphate, and magnesium carbonate.

Pale Beds

Pale Beds underlie the Bearpaw formation. Total solids in waters from these beds vary from 700 to 1,300 parts per million. The water is, in most instances, soft, as it contains sodium carbonate in excess of calcium and magnesium carbonates, but when mixed with surface water high in calcium carbonate, it will become hard. The high concentration of sodium salts, especially sodium carbonate, in contrast with the calcium and magnesium salts distinguishes this water from that in Bearpaw sands. The Pale Beds include much bentonite, and it is this mineral that acts as a water softener within the formation. The following analyses are typical of waters from the Pale Beds:

Salts	SE. sec. 16, tp.38, rge. 21	NE. sec. 3, tp.39, rge. 25,	SW. sec. 7, tp.37, rge.24,	SE. sec. 21 tp. 38, rge.23
$CaCO_3$	73	18	53	35
$CaSO_4$	-	-	-	-
$MgCO_3$	52	14	45	38
$MgSO_4$	-	-	-	-
Na_2CO_3	297	679	464	562
Na_2SO_4	297	158	266	437

NaCl	31	45	46	130
Total solids	760	1,020	940	1,260
Harrdness	100	20	30	75

Variegated Beds

In Senlac Rural Municipality, Saskatchewan, are a number of wells that have water very similar in character to that found in the Bearpaw formation. These wells tap an horizon that corresponds with the Variegated Beds in Alberta, although they have not been separated from the Pale Beds. They are less bentonitic than the Pale Beds and darker in colour. The water is hard and has a low dissolved solid content. The three analyses given below show a great deal of similarity and suggest a common horizon.

Salts	NW. sec. 21, tp.41,rge.26	NW. sec. 3, tp.41,rge.28	SE. sec. 28, tp.40,rge.28
$CaCO_3$	250	305	125
$CaSO_4$	-	-	-
$MgCO_3$	1109	80	155
$MgSO_4$	149	104	69
Na_2CO_3	-	-	-
Na_2SO_4	98	132	386
NaCl	12	12	18
Total solids	640	640	780
Hardness	600	600	500

Ribstone Creek Formation

Chemical analyses of water from the Ribstone Creek formation vary more than in the Pale Beds, the reason being that at several different horizons the sediments show considerable lateral variation. Tha formation includes both marine and non-marine beds, thin coal seams being present in the basal part of the formation around Paynton, whereas south of Lashburn, on Battle River, marine fossils were found in strata considered to be at approximately the same horizon. The water analyses show similarities within limited areas, but long distance correlations cannot be made safely except for the saline waters that occur in the flowing wells at Vera, Muddy Lake, and at the south end of Tramping Lake. Analyses of these waters are given in the following table:

Salts	SE.sec.25, tp.41,rge. 24	SE.sec.22, tp.41,rge. 24,	NE.sec.36, tp.41,rge. 24,	SW.sec.7 tp.41,rge 24,	SE.sec.30, tp.38, rge. 22,	SW.sec10, tp.35. rge.20,
$CaCO_3$	73	73	73	198	108	90
$CaSO_4$	-	-	-	-	-	-
$MgCO_3$	38	38	38	52	69	52
$MgSO_4$	-	-	-	-	-	-

Na_2CO_3	129	119	129	11	106	125
Na_2SO_4	55	55	61	61	49	43
NaCl	2,929	3,036	2,690	2,863	3,531	3,861
Total solids	3,840	3, 460	3,120	3,200	3,860	4,460
Hardness	135	90	110	100	130	130

The similarity in these anlayses suggests a common source bed. The distance between the Tramping Lake well and the Vera wells is about 40 miles. This water, which is thought to come from the basal sand of the Ribstone Creek formation, is not typical of water from the same stratigraphical horizon in the vicinity of Battle River, one reason being, possibly, that at Battle River the stream has cut through the Ribstone Creek formation exposing the sand members along its banks. This may cause a more rapid movement of the underground water in this area than farther south, and it is known that the rate of flow is a controlling factor that governs the change of calcium carbonate to sodium carbonate when the softening reagents of bentonite or glauconite are present in the sand.

Some of the soft waters from the Ribstone Creek formation cannot be distinguished from those of the Pale Beds, whereas others are quite different. The following analyses illustratetsome of the different types of water from this formation:

Salts	Se.sec. 11, tp. 46, rge. 28	Ind.Agent Little Pine I.R.	SW.sec. 24, tp. 46, rge. 21	NE.sec. 36, tp. 43, rge. 18	Se.sec. 26. tp. 43, rge. 18	NE.sec. 36. tp. 41, rge. 24	NW.sec. 22. tp. 42. rge. 23
$CaCO_3$	90	90	410	73	35	73	125
$CaSO_4$	-	-	-	-	-	-	-
$MgCO_3$	97	59	168	38	31	38	97
$MgSO_4$	-	-	64	-	-	-	-
Na_2CO_3	217	392	-	283	592	129	196
Na_2SO_4	1,644	777	2,518	225	522	61	1,541
NaCl	249	63	76	12	83	2,690	71
Total solids	2,220	1,340	3,000	620	1,280	3,120	1,900
Hardness	280	160	750	110	35	110	600

The above chemical analyses show such a wide range in the dissolved salts present in the different waters in the Ribstone Creek formation that they cannot be used for correlation purposes over a large area.

Conclusions

(1) In most instances water from glacial drift is quite different from water from bedrock.

(2) Some of the bedrock horizons carry waters that show definite chemical characteristics.

(3) Most waters from glacial till carry total solids amounting to between 1,000 and 3,000 parts per million.

(4) Bedrock waters are commonly low in dissolved salts. Exceptions to this are to be found in water from the Ribstone Creek formation.

(5) Water from the Bearpaw formation is hard. An average of ten wells gave a total solid content of 1,100 parts per million.

(6) Water from the Variegated Beds resembles that from the Bearpaw formation.

(7) Waters from the Pale Beds is mostly soft. An average of ten wells gave a total solid of 1,000 parts per million.

(8) All soft waters contain sodium carbonate (Na_2CO_3), which is present in water from the Pale Beds and Ribstone Creek formations but absent from the Bearpaw formation and Variegated Beds.

RURAL MUNICIPALITY OF TURTLE RIVER, NO. 469, SASKATCHEWAN

Physical Features

The chief topographical features in this municipality are Saskatchewan and Turtlelake Rivers. The former, which serves as the western boundary of the municipality, has entrenched itself in a valley about 150 feet deep and flows in a straight course to the southeast. Turtlelake River is a small stream that flows almost parallel with the Saskatchewan to join the latter a few miles below the southern boundary of the area. Its banks are low, but large, flat plains on either side indicate that at one time it must have been a very large stream. The bordering plains carry a surface deposit of sand and sandy soil of fluvioglacial origin that originated from debris left by the melting ice and was spread by the resulting water. The current carrying the material could not have been swift, as the sand is fine and little gravel is associated with the deposits along the river. Another physical feature of interest is the abandoned drainage channel of Dry Gully, in tps. 48 and 49, rge. 21. This valley, about 100 feet deep and nearly half a mile wide, was at one time the course of Englishman River, which now enters the Saskatchewan in tp. 50, rge. 21.

The surface deposits in this municipality have been modified by the large amount of water that at one time flowed from the north, covering large parts of the area. The largest are those of the sand areas bordering the drainage channels previously mentioned. The mantle of glacial drift that caps the higher hills and underlies the sand and sandy areas is, on the whole, very thin, though somewhat thicker on the ridge between the two drainage systems. In a well on sec. 2, tp. 48, rge. 20, the drift is more than 80 feet thick, whereas to the south, in the Langmeade district, it has a depth of only 15 to 20 feet.

Geology

The bedrock strata beneath the surface deposits outcrop at various places along the drainage channels, particularly along Turtlelake River and Dry Gully. These are all shale, except for a bed of fine-grained sandstone exposed in a road-cut south of sec. 14, tp. 49, rge. 21, at an elevation of 1,781 feet. This sand is very fine grained and only 6 feet thick, and it is believed to be a lens within the Lea Park formation. The only indications of the higher, Ribstone Creek sandstone were some loose fragments found along Turtlelake River in sec. 30, tp. 47, rge. 19, and it appears that this formation has been wholly removed by erosion prior to the deposition of the glacial material. The shale that underlies the drift rises in elevation towards the north at a rate of 6 to 10 feet to the mile.

Water Supply

The surface deposit of glacial material yields the required water supply from comparatively shallow wells, with the exception of one or more in tp. 49, rge. 21, that are in a sand in the Lea Park formation. The exceedingly shallow depths are owing chiefly to the thin deposit of glacial drift that overlies the impervious shale. In the sand and light soil areas the water supply is usually very good. Also where the surface deposits have been reworked and contain a considerable amount of sand and gravel, as in tp. 49, rge. 19, the supply is sufficient to meet requirements. But where the drift contains only small bodies of sand and gravel the water supply affords a serious problem. This is especially true for a number of farmers in tp. 47, rge. 20, who must haul water from springs several miles distant. Similar conditions prevail along the north side of tp. 48, rge. 19. In the very shallow wells the supply falls off very noticeably with any decrease in annual precipitation, such conditions having affected several wells during dry years. The only remedy is to try to locate new sources of water, either by digging deeper wells or by locating bodies of sand and gravel that have hitherto not been tapped. Unfortunately, the Lea Park formation does not, as a rule, contain suitable water-bearing sands. The sandstone located on sec. 14, tp. 49, rge. 21, is very fine grained, and its possibilities as an aquifer are, therefore, considered to be very limited.

Township 46, Range 19. An outwash deposit in tp. 46, rge. 18 extends westward and underlies tp. 46, rge. 19. Water in it is found at shallow depths, and where it is intersected by the valley of North Saskatchewan River springs occur, as on NW. sect. 23. Underlying the drift is Lea Park shale, and although a well 110 feet deep on SE. sect. 36 reached the top of this formation, it found a very poor supply of water. There are no known water sands in the Lea Park shale in this township, so that sands in the glacial drift are the only known beds containing a water supply.

Township 47, Range 19. Turtlelake River flows diagonally across this township from northwest to southeast in a broad valley with gently sloping banks. The river has eroded through the surface deposits of sand, silt, and boulder till into the underlying marine shales of the Lea Park formation, which are exposed at several places along the river bank. A strip of sand about a mile wide extends along either side of the valley across the township, except through sections 20 and 29, and is bordered by light-textured soils. This sand and sandy soil is a fluvioglacial deposit that was laid down by the river waters before the present channel was formed. Heavier soils, composed largely of boulder till, occur along the west side of the township and also in the northeast corner.

Glacial deposits are the only source of water supply in this township, as the Lea Park shales that underlie them are not known to contain beds of sand. For this reason the water supply is obtained mostly from shallow wells. Outcrops of shale along the river range in elevation from 1,755 to 1,645 feet. The top of the Lea Park, however, would be expected to be somewhat higher than the outcrops along the river, and the thickness of the drift cannot, therefore, be very great, especially on the lower, sandy areas. In a well on NE. section 31, shale was encountered at a depth of 10 feet at an elevation of 1,806 feet. On the higher land centering around section 18 the drift may be thicker, as a well on this section struck water in gravel at a depth of 40 feet, but the average thickness should be less than 50 feet. Saturated sands commonly overlie impervious clay or shale beds, and in such places, where the drift is thin, a good supply of water can be obtained at shallow depths, as illustrated by a well on NE. section 6, which, though only 6 feet deep, has yielded an abundant supply over a period of years. This condition exists on sections 6 and 7, and the dip of the aquifer follows the surface topography fairly closely. The impervious layer underlying the sheet of sand is thought to be shale, although the material was not available for examination.

East of Turtlelake River the well records indicate that the water horizon lies between elevations of 1,760 and 1,765 feet. The depth from this aquifer to the Lea Park shale is not known, but the possibilities for lower horizons are not considered to be good, as the bedrock is exposed at a higher elevation on sec. 7, tp. 48, rge. 18. The top of the shale is an uneven surface, and, hence, may be encountered at different levels within very short distances. Where sand in the drift is scarce any depression or small valley in the shale is considered very important, because the drainage surface provided by the top of these impervious rocks permits the assumption of seepage from the surface.

Township 47, Range 20. The part of this township in Turtle River municipality is a broad ridge between Saskatchewan River to the southwest and Turtlelake River to the northeast. Boulder till, with considerable gravel, forms the surface deposit. The Lea Park shale does not outcrop in this area, but as shale was struck in a deep dry hole on section 23 at an elevation of 1,788 feet, and as outcrops of shale are found along Turtlelake River to the northeast, it is thought that this formation underlies the drift over most of the area. Wells on sections 10 and 22 indicate that a bedrock sand may occupy a limited area paralleling Saskatchewan River. Other evidence supporting this possibility is the occurrence of springs along the river bank at an elevation of about 1,700 feet. Furthermore, an outcrop occurs on the west side of the river in section 19 at an elevation of 1,700 feet, indicating a west dip of about 20 feet to the mile. The drift deposits must, however, be wholly relied upon as a source for water. Their thickness is not considered to be very great, because on section 23, in the deep dry hole referred to above, it was only 15 feet thick. The seepage that occurred at the contact was insufficient to meet requirements, and several other wells have failed to yield an adequate supply of water. The drift along the crest of the ridge is about 25 feet thick, but is thicker to the southwest along Saskatchewan River.

There are two reasons why securing an adequate supply of water offers a serious problem for some of the farmers. First, the drift is thin and contains one or at most only two aquifers. Secondly, the bedrock stratum below the drift is an impervious shale that yields very little or no water. Except for wells along the river, water is obtained at depths ranging from 5 to 15 feet. The main aquifer is a sand below the surface deposit of boulder till, and, though fairly extensive, it is absent in some places, as has already been pointed out. When it is impossible to locate a sand bed above the shale a seepage supply may be obtained on top of the shale itself, especially if a low point on the drainage surface can be found. The main source of water comes from an extensive sand deposit, but in addition smaller sand and gravel beds occur as lenses and irregular bodies, and, in some instances, may be traced for considerable distances by following gravel showings on the surface. The usual trend is northwest and southeast. As the water table is near the surface, prospecting for sand and gravel deposits can commonly be greatly facilitated by using a small auger, and this method is also very useful in determining the slope of the shale surface.

Should the annual precipitation continue to be less than normal over a period of years a shortage of water in the shallow wells may result. A new source must, therefore, be sought, and, if the facts as previously stated are kept in mind, a systematic search will probably result in obtaining an adequate supply.

Township 48, Range 19. Turtlelake River flows northerly along the west side of the township. The banks are low, and the country rises gradually to the northeast. The sandy area that borders the river is joined from the northeast by a similar one, about 2 miles wide, that trends diagonally across the township. The sand area is bordered by light-textured soil that grades into boulder till in the southeast corner and along the north side.

The drift deposit is underlain by Lea Park shale, which is exposed in SW. section 6 at an elevation of about 1,750 feet, and is encountered in wells in the townships to the north and east at somewhat higher elevations. For these reasons it is concluded that the shale underlies all of the township at no great depth below the surface, and that drift is of variable but no great thickness.

In the vicinity of Edam and in a strip about 2 miles wide along the west side of the township water is obtained in a coarse sand at depths of 15 to 30 feet. This sand is an outwash or fluvioglacial deposit that was laid down by water and subsequently covered with boulder till. It forms a good aquifer in this region. In the town of Edam sandpoints are used very successfully in the wells. Similar conditions are prevalent in the sand and sandy areas trending diagonally across the township from the northeast. However, in northern and southern parts of the township, covered with boulder till, the usual amount of sand does not appear to be present between the drift and the underlying shale. Most of the water supply, which in places is insufficient to meet requirements, is from a seepage that forms on top of the shale. Under these conditions one of two things may be done: either the seepage supply may be increased by locating a low area on the drainage surface of the shale, a problem that may necessitate digging several wells or test holes to determine the slope of the shale surface; or it may be found that sand and gravel pockets in the drift will yield the required amount of water. Locating one of these lenses or pockets is, however, a matter of chance, as they are irregularly distributed through the drift and have no definite limits or shape. Possibilities of water in the underlying shale are very poor, as no sand beds are known to be present.

Township 48, Range 20. The broad ridge that parallels Saskatchewan River to the south continues northward into this township, trending almost diagonally from southeast to northwest. Boulder till covers the ridge, but is broken by a strip of sand on sections 14 and 15. Elsewhere in the township a surface deposit of sand rests on the glacial drift. The thickness of the drift is at least 84 feet on section 2, where the bottom of the well has an elevation of 1,751 feet, corresponding very closely to the level of the shale on Turtlelake River to the east. It appears, therefore, that the drift thins to the east and west from the crest of the ridge.

There are no outcrops of bedrock in the township. The Lea Park shale was struck below what was considered to be glacial sand in the well on SW. section 2, and it seems probable that this formation everywhere underlies the drift. However, pieces of sandstone resembling that from the Ribstone Creek formation were found along Turtlelake River to the southeast, so that the actual contact with the Lea Park must be very close to the top of the shale in this well. It is, therefore, possible that some Ribstone Creek sand may overlie the shale on the higher land to the north, especially if the drift thins in that direction, but for all practical purposes the water supply should be looked for in the overlying drift.

In the sand and sandy areas a good supply of water is obtained at shallow depths. Only a few records of these shallow wells are, however, available for study, and as the drift varies in character from place to place it is difficult to reach conclusions on the possibilities of obtaining water at specific well sites. Two aquifers may be present. The upper one is at the base of the surface deposit of sand and has yielded a good supply in the past, but dry years will decrease the supply very materially. The lower horizon, which is within the drift, has been encountered in several wells. On section 30 it has an elevation of 1,776 feet, and on SW. section 14, 1,794 feet. Both of these wells are 30 feet deep.

It has proved more difficult to obtain a good supply of water in the areas of boulder till. On section 2 water was encountered in sand so fine that it prevented the well from being completed satisfactorily. This horizon is placed at the base of the drift, as the material from the bottom was thought to be shale.

Township 49, Range 19. The surface of this township is a relatively flat plain sloping gently to the southwest. The mantle of glacial drift is composed of boulder till, except for a strip of sand that parallels Whitemud Creek and extends to the northwest as a belt 2 miles wide through sections 14, 15, 21, 22, 28, and 33.

The bedrock that underlies the drift is a shale, and was encountered in several wells at depths ranging from 20 to 50 feet. So far as known this shale is typical of the Lea Park formation. The elevation at which the shale was encountered rises towards the north from 1,783 feet on section 6 to 1,906 feet on section 31. This is believed to be due to a rise in the strata towards the north, unless the sands that form part of the Ribstone Creek formation in the south thin towards the north and are too impervious to act as an aquifer.

The water supply in this township is obtained from wells with an average depth of 23 feet, the deepest one being 50 feet. The aquifers are all sand or gravel deposits within the glacial drift, whose thickness varies from 20 to 50 feet. The water supply must be obtained within the drift, as the underlying shale is not known to contain any water-bearing sands.

In the area of sand and sandy soil water is easily obtained at the base of the sand on top of the boulder till. This sand deposit was laid down by running water from the melting ice-sheet to the north, and, therefore, would be expected to slope or dip to the south. The boulder till that underlies the sand may contain sand and gravel that would serve as aquifers should it be necessary to dig deeper. The combined thickness of sand and boulder till will not be in excess of 50 feet.

In the areas of ground moraine water has not always been obtained with the same degree of success. Most of the wells encountered sand and gravel, but the supply of water did not everywhere meet the required needs, leading to the conclusion that the aquifers were small. As the bedrock surface slopes to the south, it seems logical to conclude that whatever sand or gravel is present will slope in the same direction, as the water that deposited them must have come from the north or northeast. It is, therefore, difficult to correlate the different aquifers in this township on their respective elevations. It can, however, be said that the drift has two water-bearing horizons, one in the upper 25 feet and one near the base. These deposits are not continuous beds, as was demonstrated by the small supply of water in some of the deeper wells, and the presence of gravel in several of them suggests an outwash deposit bordering the sand area to the west. Such a deposit should also slope to the south, as the water that did the sorting came from the north or northeast.

Township 49, Range 20. A light-textured soil, derived from a river deposited silt or alluvium borders Turtlelake River for a mile or more on either side. West of the flat plain the land rises gently to a very pronounced hill centring in section 20. This elevated area is covered with a sandy boulder till, which may be part of a broken moraine trending northwest. However, in appearance the hill resembles one that might have a core of bedrock, and no great thickness of boulder clay can, therefore, be assumed. Several of these erosional remnants occur west of Saskatchewan River and are associated with varying amounts of morainal material. The only well that has penetrated the drift is one 28 feet deep on NW. section 6, which reached bedrock shale at an elevation of 1,823 feet. There are no outcrops of the underlying bedrock in the township, but from well records in the township to the east it is believed that Lea Park shale underlies the area. On the higher land to the north the drift may be considerably thicker, but the higher elevations in that direction may be due in part to a rise in the bedrock surface.

Shallow wells supply the required amount of water. They have an average depth of 15 feet, and the deepest one is only 28 feet. The aquifer is, almost without exception, a fine sand, and gravel is notably scarce in this township. These aquifers are, nevertheless, believed to be all within the glacial materials. On the flat plain adjoining Turtlelake River water is easily obtained at shallow depths. The elevation of the aquifer in the north is around 1,850 feet, but it slopes gradually towards the south. On the higher, drift-covered area to the west there is not the same degree of regularity, and although the wells are shallow they do not always yield sufficient water, particularly in sections 5, 6, and 9. Shale was reported in the well on section 6 at an elevation of 1,823 feet, and, therefore, other wells at higher elevations have better possibilities of striking an horizon above the shale. Further prospecting for water horizons near the surface should not be neglected, as a boulder till deposit is variable in character and in many places a good shallow well may be obtained a short distance from a dry hole.

Difficulty has been encountered in finding water on NW. section 20. Here the elevation is much higher than that of the neighbouring farms, so deeper digging is advisable as long as the material is boulder clay. This can be distinguished from the underlying shale by the presence of small granite and limestone pebbles. The thickness of the drift on the higher land is not known, but is assumed to be considerably greater than on the plain to the south and east. The upper 25 feet of the drift contains a large amount of sand, which is believed to be present as numerous small separate deposits rather than as a single bed. Because of this, two wells at no great distance apart and at approximately the same levels may tap two different sands. Therefore, if a well should go dry it may be possible to tap a different source nearby. The underlying shale does not as a rule contain any suitable water sands. A very fine sand and sandstone bed 6 feet thick is exposed at an elevation of 1,781 feet in a road-cut on the west bank of a dry gully on section 14 in the township to the west. This sand occurs, presumably, in the Lea Park formation, but is very fine, thereby limiting its possibilities as an aquifer. It may extend to the east, but owing to its limited possibilities as an aquifer, hardly justifies investigation.

<u>Township 49, Range 21</u>. The main physical features in this township are Saskatchewan River on the west and Dry Gully trending almost north close to the east side. Between these two drainage channels is a broad ridge that forms a very pronounced hill facing north. Dry Gully, at one time the bed of a large river, is believed to be the old channel of Englishman River. There is also the possibility that part of the Saskatchewan found its way through this channel before the river had entrenched itself very deeply in its present valley. The light sandy soil that covers the greatest part of the area, except the higher land to the north, is a silt deposit left by the flood waters from the adjoining river.

Several outcrops of dark grey marine shale are exposed along Dry Gully. One of these is on the south side of section 14 in a road-cut on the west bank, showing a bed of very fine sandstone 6 feet thick. This sand is underlain by dark grey, impervious shale, and is believed to be a sand lens within the Lea Park formation. The elevation of the top of this bed is 1,781 feet. On section 34 the top of an exposure of shale occurs at 1,825 feet. The whole township is, therefore, believed to be underlain by the Lea Park formation.

The drift deposit is not considered to be very thick, as several wells have encountered the top of the shale at depths of less than 30 feet. In the northwest part of the township, where the land is fairly high, the drift may be thicker.

The sorted material within the drift supplies most of the water in this township. One well, however, on section 11 obtains soft water in sand believed to be within the Lea Park formation, and several other soft-water wells are reported in blue clay or on top of shale that may represent the same stratum. Such wells on sections 26 and 29 have elevations of 1,793 and 1,796 feet respectively. This horizon may, therefore, be found at intermediate points below the deposit of drift. No strong flow can be expected because the sand is very fine grained.

From the large number of wells reporting a gravel aquifer it would appear that an outwash deposit is present west of Dry Gully, extending from section 27 south to section 3. In the north the elevation of the aquifer is about 1,790 feet, but falls to 1,750 feet on section 3. On sections 26 and 27 it is reached at a depth of between 40 and 50 feet, and to the south the drift covering is thin and depths are less than 20 feet. This constitutes the main aquifer in the township, and appears to have a wide distribution. On the higher land to the north sand and gravel pockets occur in the upper part of the drift and yield water at shallow depths.

ANALYSES OF WATER SAMPLES FROM RURAL MUNICIPALITY OF **TURTLE RIVER, NO. 469, SASKATCHEWAN**

No.	¼ Sec.	Tp.	Rge.	Depth in feet	Total dis-solved solids	Constituents as Analysed: Ca	Mg	Na	SO_4	Cl.	Alk.	Total Hardness	Constituents as Calculated in assumed Combinations: $CaCO_3$	$CaSO_4$	$MgCO_3$	$MgSO_4$	Na_2CO_3	Na_2SO_4	NaCl.	Source of Water
1	NE 31	49	19	40	7360	408	286	1341	4390	64	445	3000	445	782		1415		4030	106	Lea Park
2	NW 6	49	20	28	1920	100	52	487	1053	27	390	600	250		118	89		1450	44	Glacial

Well No.	LOCATION ¼ Sec.	Tp.	Rge.	Mer.	Type of Well	Depth of Well	Altitude of Well	WATER LEVEL Above (+) or Below (-) Surface	Elev. Above Sea Level	PRINCIPAL WATER-BEARING BED Depth Ft.	Elev.	Geol. Horizon	Character of Water	Use to Which Water is Put[x]	Yield and Remarks
1	N.W. 23	46	19	3	Spring				1688						A small flow
2	S.E. 26	"	"	"	Dug	22	1733	-18	1715	22	1711	Fine Sand	Soft	D.S.	Good supply
3	N.E.28	"	"	"	"	33	1738	-27	1711	23	1715	Sand & Grav"	Hard Alk	""	Waters 30 head

x.- D.- Domestic, S.- Stock, Alk.- Alkaline.

WELL RECORDS—Rural Municipality of Turtle River No. 469, Saskatchewan

WELL No.	LOCATION ¼	Sec.	Tp.	Rge.	Mer.	TYPE OF WELL	DEPTH OF WELL	ALTITUDE WELL (above sea level)	HEIGHT TO WHICH WATER WILL RISE Above (+) Below (−) Surface	Elev.	PRINCIPAL WATER-BEARING BED Depth	Elev.	Geological Horizon	CHARACTER OF WATER	TEMP. OF WATER (in °F.)	USE TO WHICH WATER IS PUT	YIELD AND REMARKS
	SE	34	46	19	3	bored	32	1753	- 20	1733	32	1721	glacial	hard		D.S.	Good supply
	SE	36	46	19	3	bored	110	1725			30	1695	top of shale	very poor		N.	Seepage on top of shale. Present supply from shallow well and Turtle R.
	NW	6	47	19	3	dug	10	1780			10	1770	glacial	hard		D.S.	Good supply
	NE	6	47	19	3	dug	5	1790	- 4	1786	5	1785	glacial	hard		D.S.	Very good supply
	SW	6	47	19	3	dug	25	1755	- 19	1736	25	1730	glacial	hard		D.S.	Good supply in yellow sand
	SE	7	47	19	3	dug	8	1810			8	1802	glacial	hard		D.S.	Good supply in sand
	NE	12	47	19	3	dug	12	1773			12	1761	glacial	hard		D.S.	Good supply in sand
	NE	14	47	19	3	dug	16	1778	- 14	1764	16	1762	glacial	hard		D.S.	Good supply in sand
	SE	18	47	19	3	dug	40	1868	-	-	40	1828	glacial	hard		D.S.	Good supply in gravel
	SE	25	47	19	3	dug	18	1783	-15	1768	18	1765	glacial	hard		D.S.	Good supply in fine sand
	NE	31	47	19	3	dug	20	1818	- 10	1808	10	1808	glacial	hard		D.S.	Poor supply. Water hauled from river.
	NE	10	47	20	3	bored	80	1783	- 30	1753	80	1703	bedrock ?	hard		S.	Good supply in sand. Large spring on river bank at same elevation.
	SW	22	47	20	3	bored	50	1785	- 35	1750	50	1735	glacial ?	hard alk.		D.S.	Limited supply in dark sand.
	SE	23	47	20	3	bored	165	1803									Dry hole in Lea Park shale. Top of shale at 15' - Elev. 1788.
	SW	26	47	20	3	dug	15	1778	-		15	1763	glacial	hard		D.S.	Limited supply in fine sand
	SW	27	47	20	3	dug	16	1793	-		16	1777	glacial	hard		D.S.	Good supply in fine sand.
	SW	28	47	20	3	spring		1723					glacial	hard			Spring flows continuously.
	SW	35	47	20	3	dug	20	1800	-		20	1780	glacial	hard		D.S.	Good supply in sand
	SE	1	48	19	3	bored	60	1788	-	-	50	1738	glacial	hard alk.		D.S.	Limited supply on top of shale
	SE	2	48	19	3	bored	18	1783	- 15	1768	9	1774	glacial	hard alk.		D.S.	Seepage supply on top of shale
	NE	2	48	19	3	dug	20	1803	-	-	16	1787	glacial	hard alk.		D.S.	Seepage supply on top of shale
	NE	14	48	19	3	bored	23	1833	-	-	21	1812	glacial	hard		D.	Limited supply on top of shale
	SE	26	48	19	3	bored	21	1900	10	1890	21	1879	glacial	hard alk.		D.S.	Fair supply
	SW	2	48	20	3	bored	84	1833	-	-	82	1751	glacial	hard alk.		D.S.	Limited supply in yellow sand
	SW	3	48	20	3	dug	18	1804	- 16	1788	18	1786	glacial	hard		D.S.	Good supply in gravel
	NE	3	48	20	3	bored	75	1878	- 45	1833	74	1804	glacial	hard alk.		D.S.	Good supply in fine yellow sand
	NW	10	48	20	3	dug	16	1850	- 11	1839	14	1836	glacial	hard alk.		D.S.	Good supply in yellow sand
	SW	14	48	20	3	bored	30	1824	- 10	1814	30	1794	glacial	hard		D.S.	Good supply
	SW	23	48	20	3	bored	35	1834	- 25	1809	34	1800	glacial	soft		D.S.	Good supply
	SE	30	48	20	3	dug	30	1806	-	-	30	1776	glacial	hard		D.S.	Limited supply, Another well 10' deep
	SW	32	48	20	3	bored	40	1893	-	-	40	1853	glacial	hard		D.S.	Good supply

NOTE—All depths, altitudes, heights and elevations given above are in feet.

(D) Domestic; (S) Stock; (I) Irrigation; (M) Municipality; (N) Not used.
(#) Sample taken for analysis.

WELL RECORDS—Rural Municipality of Turtle River No. 469, Saskatchewan

WELL No.	LOCATION ¼	Sec.	Tp.	Rge.	Mer.	TYPE OF WELL	DEPTH OF WELL	ALTITUDE WELL (above sea level)	HEIGHT TO WHICH WATER WILL RISE Above (+) Below (−) Surface	Elev.	PRINCIPAL WATER-BEARING BED Depth	Elev.	Geological Horizon	CHARACTER OF WATER	TEMP. OF WATER (in °F.)	USE TO WHICH WATER IS PUT	YIELD AND REMARKS
1	NW	2	49	19	3	dug	25	1911			25	1886	glacial	soft		D.	Poor supply in blue clay
3	NW	4	49	19	3	dug	32	1824			32	1792	glacial	hard		D.	Limited supply in gravel
4	NW	6	49	19	3	dug	16	1810			16	1794	glacial	hard		D.	Good supply in sand
5	SE	6	49	19	3	dug	20	1803			20	1783	Lea Park	hard		D.S.	Good supply on top of shale
6	SE	8	49	19	3	dug	40	1863			40	1823	glacial	hard		D.	Limited supply in sand
7	NW	8	49	19	3	dug	18	1862			18	1844	glacial	hard		S.	Water in sand vein
8	NE	9	49	19	3		17	1857			17	1840	glacial	hard		D.S.	Good supply in gravel
9	NW	10	49	19	3		12	1880			12	1868	glacial	soft		D.S.	Good supply in sand
10	SE	13	49	19	3	dug	5	1870			5	1865	glacial	hard		D.S.	Good supply
11	NW	14	49	19	3		50	1901			50	1851	Lea Park	hard		D.S.	Good supply on top of shale
12	SW	16	49	19	3	dug	15	1904			15	1889	glacial	soft		D.S.	Good supply in sand
13	SW	17	49	19	3	dug	20	1891			20	1871	glacial	soft		D.S.	Limited supply in gravel
14	NE	18	49	19	3	dug	20	1894			20	1874	glacial	soft		D.S.	Good supply in gravel
15	SE	22	49	19	3	dug	14	1912			14	1898	glacial	hard		D.S.	Good supply in sand.
16	NE	22	49	19	3	dug	15	1922			15	1907	glacial	soft		D.S.	Good supply in sand.
17	NE	24	49	19	3	dug	21	1894			21	1873	glacial	soft		D.S.	Good supply in sand.
18	NE	26	49	19	3	dug	18	1930			18	1912	glacial	hard		D.S.	Good supply in clay.
19	SW	27	49	19	3	dug	12	1886			12	1874	glacial	soft		D.S.	Good supply in fine sand.
20	SE	28	49	19	3	dug	9	1887			9	1878	glacial	hard		D.S.	Good supply in fine sand.
21	NE	30	49	19	3	dug	36	1912			36	1876	glacial	hard		D.S.	Good supply in fine sand.
22	NE	31	49	19	3	dug	40	1946			40	1906	Lea Park	hard alk.		S.	Good supply on top of shale
23	NE	32	49	19	3	dug	25	1907			25	1882	glacial	hard alk.		S.	Good supply in gravel
24	NW	34	49	19	3	dug	10	1946			10	1936	glacial	hard alk.		S.	Good supply in sand
25	NE	34	49	19	3	dug	50	1961			50	1911	glacial	hard alk.		D.S.	Limited supply
26	NE	35	49	19	3	dug	18	1950			18	1932	glacial	soft		D.	Poor supply in gravel and clay.
27	SW	36	49	19	3	dug	26	1937			26	1911	glacial	hard		D.	Poor supply in sand.
2	NW	2	49	20	3		14	1876			14	1862	glacial	hard		D.	Good supply in fine sand.
3	SW	3	49	20	3		12	1901			12	1889	glacial	hard		D.S.	Good supply in fine sand.
4	NW	4	49	20	3	dug	13	1875			13	1862	glacial	hard alk.		D.S.	Good supply in sand.
5	SE	4	49	20	3		17	1907	-12	1895	17	1890	glacial	soft		D.	Good supply in sand.
6	SW	5	49	20	3		15	1874			15	1859	glacial	hard		D.	Limited supply.
7	NW	6	49	20	3		28	1851			28	1823	glacial	hard alk.		D.S.	Limited supply on top of shale
8	NE	9	49	20	3		16	1907			16	1891	glacial	hard alk.		D.	Limited supply in blue clay
9	NE	16	49	20	3		8	1885	- 4	1881	8	1877	glacial	hard		D.	Good supply
10	SE	20	49	20	3		16	1862			16	1846	glacial	soft		D.	Good supply in sand.
11	NE	20	49	20	3		12	1863			12	1851	glacial	hard		D.S.	Good supply in sandy clay.
12	SW	20	49	20	3		22	1906			22	1884	glacial	hard		D.	Good supply. Similar well for stock.
13	NW	20	49	20	3		28	1991									Dry hole.
14	SW	22	49	20	3		12	1882			12	1870	glacial	hard		D.S.	Good supply in sand
15	NE	24	49	20	3		20	1842			20	1822	glacial	soft		D.	Good supply in fine sand.
16	SE	34	49	20	3		24	1866			24	1842	glacial	soft		D.S.	Good supply in gravel
17	NW	35	49	20	3		19	1860			19	1841	glacial	hard		D.	Good supply in blue sand.
18	NW	36	49	20	3		22	1875			22	1853	glacial	soft		D.S.	Good supply in fine sand.

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(#) Sample taken for analysis.

WELL RECORDS—Rural Municipality of Turtle River No. 469, Saskatchewan

WELL No.	LOCATION ¼	Sec.	Tp.	Rge.	Mer.	TYPE OF WELL	DEPTH OF WELL	ALTITUDE WELL (above sea level)	HEIGHT TO WHICH WATER WILL RISE Above (+) Below (−) Surface	Elev.	PRINCIPAL WATER-BEARING BED Depth	Elev.	Geological Horizon	CHARACTER OF WATER	TEMP. OF WATER (in °F.)	USE TO WHICH WATER IS PUT	YIELD AND REMARKS
1	SE	3	49	21	3	dug	12	1787	-10	1777	12	1775	glacial	soft		D	Good supply in fine sand
2	NW	3	49	21	3	dug	14	1770			14	1756	glacial	hard		D.S.	Good supply in gravel
3	NE	8	49	21	3	dug	14	1720			14	1706	glacial	hard		D.S.	Poor supply in clay
4	NE	9	49	21	3	bored	15	1780	-10	1770	15	1765	glacial	hard		D.S.	Poor supply in clay
5	NE	11	49	21	3	dug	20	1799			20	1779	Lea Park	soft		D.S.	Limited supply in very fine sand. Several wells required.-
6	NE	13	49	21	3		10	1830			10	1820	Lea Park	soft		D.	Water in fine sand
7	SW	15	49	21	3	bored	17	1859	-14	1845	17	1842	Lea Park	soft		D.	Limited supply
10	NW	16	49	21	3	dug	12	1785			12	1773	Lea Park	hard		D.S.	Sufficient supply in gravel.
11	NE	16	49	21	3	dug	10	1805	- 7	1798	10	1795	Lea Park	hard		D.S.	Good supply in sand
8	SE	17	49	21	3	dug	16	1738	-13	1725	16	1722	Lea Park	soft		D.S.	Good supply in blue clay
9	SE	20	49	21	3	dug	20	1788	-18	1770	20	1768	Lea Park	hard		D.S.	Good supply in sand
12	SE	21	49	21	3	dug	17	1802	-14	1788	17	1785	Lea Park	hard		D.S.	Good supply in clay
13	SE	22	49	21	3	dug	24	1820	-22	1798	24	1796	Lea Park	soft		D.S.	Good supply in gravel
14	SE	23	49	21	3	dug	20	1754			20	1734	Lea Park	soft		D.S.	Good supply in clay
15	NW	25	49	21	3	dug	34	1818	-14	1804	34	1784	Lea Park	hard		D.S.	Good supply in sand
16	SW	26	49	21	3	bored	30	1823	-18	1805	30	1793	Lea Park	soft		D.S.	Good supply on top of shale
17	SE	27	49	21	3	dug	12	1819	- 8	1811	12	1807	glacial	soft		D.S.	Good supply in clay
18	SE	28	49	21	3	dug	40	1837	-37	1800	40	1797	glacial	hard		D.S.	Limited supply in gravel
19	NE	28	49	21	3	bored	40	1829	-20	1809	40	1789	glacial	hard		D.S.	Good supply in gravel
20	SE	29	49	21	3	bored	48	1844	-15	1829	48	1796	glacial	soft		D.	Good supply in blue clay
21	NE	32	49	21	3	dug	10	1902	- 7	1895	10	1892	glacial	soft		D.S.	Good supply in sand
22	NW	33	49	21	3	dug	12	1925	- 9	1916	12	1913	glacial	soft		D.S.	Good supply in sand
23	SE	36	49	21	3	dug	16	1843			16	1827	glacial	soft		D.	Limited supply in fine sand.

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