CANADA

DEPARTMENT OF MINES

AND

TECHNICAL SURVEYS

GEOLOGICAL SURVEY OF CANADA

WATER SUPPLY PAPER No. 260

GROUND-WATER RESOURCES OF THE RURAL MUNICIPALITY OF GREENFIELD NO. 529 SASKATCHEWAN

Records Collected by C. O. Hage

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

OTTAWA

1947

Reprinted 1953

CANADA
DEPARTMENT OF MINES AND RESOURCES

MINES AND GEOLOGY BRANCH
BUREAU OF GEOLOGY AND TOPOGRAPHY

GEOLOGICAL SURVEY

WATER SUPPLY PAPER NO. 260

GROUND-WATER RESOURCES
OF THE
RURAL MUNICIPALITY OF GREENFIELD, NO. 529,
SASKATCHEWAN

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

OTTAWA
1 9 4 7

CONTENTS

Illustrations

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 (SO_4), 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

[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.

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]:

[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 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, especially those 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].

---

[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
Hardness	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	3[illegible]5	125
$CaSO_4$	-	-	-
$MgCO_3$	109	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. The 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	163	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	1,260	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 5,000 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 GREENFIELD, No. 529, SASKATCHEWAN

Physical Features.

The watershed between the two large drainage systems of Saskatchewan and Beaver Rivers trends easterly through township 55. The country is on the whole very flat, and has the appearance of a ground-moraine deposit. There are also several small recessional moraines, the largest of which lies west of Brightsand Lake and trends almost due north. A few surface sand deposits are exposed north of Brightsand Lake and west of Turtle Lake. The rest of the municipality is covered with a deposit of boulder clay. Brightsand and Turtle Lakes occupy large depressions in the glacial drift, and both have outlets to the south.

Geology

The surface deposit of boulder till completely masks all bedrock. It may vary in thickness from place to place, and is 265 feet thick where a deep test hole was drilled on sec. 21, tp. 53, rge. 21. The material below this level was a silty shale, but as the hole was drilled with a jetting rig the samples may not be representative of the strata passed through. Fragments of a hard sandstone similar to the Ribstone Creek formation were found on the surface close to the test hole, but as no similar sand was found in the samples it seems improbable that it came from this hole. The driller, J. Rabrick, was, however, quite certain that several hard sandstone bands were drilled. Elsewhere in the municipality no information was obtained that would give the thickness of the drift or the nature of the bedrock strata. The nearest outcrop is in the vicinity of Turtleford where the shale surface is higher than in the test well referred to above. This would favour the presence of Lea Park shale below drift if the strata are flat lying.

Water Supply

All the wells tap aquifers in the glacial drift. These wells are for the most part relatively shallow, and few holes were dry. Many of the aquifers are small sand and gravel deposits in the boulder till, but there appears to be an extensive sand deposit buried between boulder clays around Brightsand Lake, which extends north and northwest into tp. 53, rge. 20, and tp. 53, rge. 21. Possibilities of finding lower aquifers should be very good as the samples from the deep test hole of the Spruce Lake Holding Company, on sect. 21 tp. 53, rge. 21 show much coarse sand close to the base of the drift. It must, however, be remembered that lateral changes in the drift occur very abruptly and are also very common.

Possibilities of water in the strata below the drift will depend upon the presence of sand in the bedrock formation, and, as previously indicated, seem rather remote.

Township 53, Range 19. The land surface rises gently to the west from Turtle Lake and reaches a maximum height of more than 100 feet above the level of the lake along the west side of the township. The glacial drift that forms the surface deposit is a light-textured ground moraine and is quite rocky in places.

The thickness of the drift has not been determined, and as there are no outcrops in the immediate vicinity the approximate elevation of the bedrock surface is not known. A dry hole on section 20 was in glacial clay at a depth of 70 feet, and is the deepest hole in the township. The water supply is obtained mainly from wells 60 feet or less in depth, with most of them less than 25 feet deep. Records of these wells give considerable information on the nature of the drift, but as this shows little regularity in deposition it is extremely difficult to determine the extent of the contained sand and gravel lenses. These pockets and lenses act as aquifers, and are usually found in the upper part of the drift, as indicated by the large proportion of shallow wells. They appear to follow the topography fairly closely, although the deep dry hole on section 20 is in the highest part of the township. Most of the deeper wells are also on the higher land, an exception being the one on SE. section 10, in which the water horizon has a depth of 52 feet, or an elevation of 2,102 feet. This is the lowest aquifer along the east side of the township, and indicates that aquifers at lower horizons than those tested may be present elsewhere. It is also important to note that most of the aquifers have a higher elevation than the one of Turtle Lake. The source of the water in the water-bearing beds is, therefore, not connected with the lake but is due directly to the annual precipitation. Consequently, if the upper part of the drift fails to yield the required amount of water it is quite possible that a good aquifer may be encountered at lower levels. As previously stated, the thickness of the drift is not known and for this reason the depth to the lowest possible horizon cannot be predicted. If the bedrock strata below the drift are shales, possibilities of finding an adequate supply in them are poor, and testing them to any great depth is not recommended.

Township 53, Range 20. Brightsand Lake occupies the greater part of a large depression that includes almost all of this township. The white sand beaches of the lake are indicative of the amount of sand that appears to be present in the drift material adjoining the lake. This large basin may be reflected in the bedrock surface, but as no outcrops of the underlying strata were found, and as no indications of bedrock were reported from wells, this assumption cannot be proved.

From an examination of the well records there appears to be a marked uniformity in the elevations of a large number of aquifers and that of Brightsand Lake, which is about 2,084 feet above sea-level, as determined by aneroid barometer. Along the east side of the Lake the elevations of the aquifers range between 2,081 and 2,106 feet, except for one on NE. section 12 that has a higher level. Conditions along the west side are somewhat similar, but on the south side the water horizon is lower suggesting a slight slope to the southwest. In this direction, too, the wells are much deeper, and the upper part of the drift does not contain very much sand or gravel.

The inferences that can be drawn from the information available suggests that a large buried sand deposit extends in all directions from Brightsand Lake, particularly to the north, and that this sand bed has a low dip to the south.

Lower aquifers may occur in the drift, but lack of information on the thickness and character of the lower part of the deposit renders it impossible to predict what may be expected at these depths.

Township 53, Range 21. This township has a topographic relief of about 200 feet. The lower areas to the southwest and southeast are well drained by deep gullies and valleys that carry the overflow waters from Spruce and Brightsand Lakes to the south into Turtlelake River. The long ridge, that parallels the valley in which Spruce Lake lies, broadens and shows more morainal characteristics in this township than it does farther south. This does not mean, however, that it may not have a core of bedrock, but the information from the test wells drilled by the Spruce Lake Holding Company does not lend much support to this possibility. The wells were drilled with a jetting rig and, therefore, no satisfactory samples were obtained for identification of the strata drilled. Fragments of coarse sandstone resembling Ribstone Creek sand were found beside the drill hole, but as the samples from the well did not show similar material the origin of the fragments is obscure.

A log of the well on SE. section 21, determined from samples supplied by Mr. L. Schunard, President of the Company, is as follows:

Surface elevation 2,198 feet

Depth (feet)	
30	- fine sand
50	- boulder clay
70-215	- coarse, glacial sand
245-255	- fine, silty clay
265	- coarse, glacial sand
270-540	- green, silty shale.

From the samples the sand at 265 feet is definitely of glacial origin and appears to mark the base of the surface deposit, at an elevation of about 1,928 feet. The samples below this were all of very similar shaly material.

The nearest known outcrop is a shale exposure in the vicinity of Turtleford. Material resembling shale, but thought to be glacial lake clay because glacial sand underlies it, occurs in a road-cut on the south side of section 3.

Owing to the considerable relief in the township the water horizons have a wide range in elevation. In the valley near Spruce Lake they vary between 1,918 and 1,946 feet. Of these the lowest aquifer is reached at a depth of 60 feet below a deposit of glacial-lake clay. This level is very low for glacial material, but as it is in the valley it may represent a pre-glacial drainage channel, and the bedrock surface may be found at a higher level on the more elevated land to the east. The water supply on this higher land is quite variable. Wells on sections 20, 21, and 23 have yielded a limited supply, whereas the two deep wells on section 9 are reported to have encountered good supplies at elevations of 2,122 and 2,002 feet at depths of 70 and 85 feet respectively. This wide range in elevations and depths is typical of a glacial deposit in which no extensive sand or gravel deposits are present. The thickness of the drift in the deep test hole on section 21 is about 265 feet. A thick sand occurs between depths of 70 and 215 feet, and may have good water possibilities elsewhere on the higher land.

Township 54, Range 19. Medium-textured ground moraine forms the main surface deposit in this township. In the southeast is an area of sand that extends along the west side of Turtle Lake, and to the northwest is a small recessional moraine. The surface is relatively flat, sloping gently to the east and west from a higher area that trends northerly through the approximate centre of the township.

The thickness of the surface deposit of boulder till is not known as no wells have drilled through it. It is composed essentially of boulder clay, but contains sand and gravel beds that supply the required amount of water. In the townships to the west and southwest a uniformity in the level of the water horizons around Brightsand Lake is suggestive of a widespread deposit, and similar conditions are thought to prevail along the west side of this township where many wells have aquifers between elevations of 2,150 and 2,180 feet, about 100 feet higher than at Brightsand Lake. Most of these wells are very shallow, suggesting that the upper part of the drift contains much sand

and gravel.

Township 54, Range 20. The sandy plain that surrounds the north end of Brightsand Lake extends northward in a belt from 2 to 3 miles wide. Typical ground moraine, somewhat rocky in places, borders this area of sand. A few, small, northwest-trending recessional moraines are present along the west side of the township.

The ground-water supply all comes from sand and gravel beds in the glacial drift, a heterogeneous mixture of boulder clay, containing irregularly distributed lenses, pockets, and beds of sand and gravel. Extensive sand deposits lying between deposits of boulder clay may be of interglacial origin or may record only a local retreat and advance of the ice-front. The water horizons around Brightsand Lake, which extend northward into this township, are believed to be of this latter type. The height of land separating the two large drainage systems lies just to the north and, therefore, the water that deposited the sand and gravel beds flowed southward leaving a deposit sloping in that direction. The elevations of this aquifer, which lies between two boulder tills, is about 2,080 feet in the south and rises to 2,165 feet on section 34. It will be noted that there are variations within these limits, possibly due to incorrect elevation determinations made by the aneroid barometer.

Township 54, Range 21. The surface topography of this township is a gently rolling plain, with morainal ridges along the south and east sides. The thickness of the glacial deposit of boulder clay is not known, as no deep wells have penetrated it, but in the township to the south it is 265 feet deep on section 21, where the Spruce Lake Holding Company drilled their No. 2 test hole.

The water supply is obtained from wells that are in glacial sand and gravel deposits. These wells have an average depth of about 20 feet, with the deepest one 45 feet. The supply is fairly good, although in places where the sand lens is small the yield is limited. No dry holes, however, are reported, indicating that the boulder clay everywhere contains an appreciable amount of sand and gravel. The elevations of most of the aquifers are mainly between 2,080 and 2,116 feet, and the aquifers appear to be part of the same deposit that is believed to be present in the township to the east, but at a lower elevation. Englishman River has its source in this township, and a large amount of water flowed through its channel to the southwest subsequent to the retreat of the continental ice-sheet. The well on section 27 obtains a good supply of water at a depth of 45 feet, at an elevation of 2,067 feet. This is lower than the horizon described above and may indicate a lower aquifer, although this is not certain as the character of the boulder till varies greatly from place to place. Possibilities of finding aquifers below those already tapped should be fairly good.

Township 55, Ranges 20 and 21. These two townships are discussed together because the information on the surface deposits in both is very limited. The height of land separating Beaver River and Saskatchewan River drainage systems lies in the northern part of these townships. The country has little relief, the moraines present are small, and the surface deposits are best described as ground moraine.

Shallow wells yield a good supply of water, except in the well on sec. 7, tp. 55, rge. 21. All are in the upper part of the drift. From the information at hand it would appear that these upper aquifers represent numerous sand deposits instead of a single extensive bed. If these deposits are small the amount of water in them will show signs of depletion during periods of dry years, especially if the sand lies near the surface. Deeper wells will, however, no doubt reach other sand and gravel beds that will yield the required amount of water. It is impossible to predict what conditions will be encountered from place to place, but as this area is so near the watershed, which may be due to an accumulation of drift, it is quite probable that the lower part of the drift also contains water-bearing horizons.

ANALYSES OF WATER SAMPLES FROM RURAL MUNICIPALITY OF GREENFIELD, NO. 529, SASKATCHEWAN

						CONSTITUENTS AS ANALYSED							CONSTITUENTS AS CALCULATED IN ASSUMED COMBINATIONS							
No.	Sect.	Tp.	R.	Depth of well in ft.	Total diss'd solids	Ca	Mg	Na	SO_4	Cl	Alka- linity	Total hard- ness	$CaCO_3$	$CaSO_4$	$MgCO_3$	$MgSO_4$	Na_2CO_3	Na_2SO_4	NaCl	Remarks
1	NW 4	53	21	48	660	57	65	68	369	7	165	580	142		19	297		194	12	Glacial

WELL RECORDS—Rural Municipality of Greenfield No. 529, 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	NE	4	53	19	3	dug	20	2163			5	2158	Glacial	soft		D.S.	Good supply in sand
2	NW	5					55	2242			55	2187	"	hard		D.S.	Good supply in sand and gravel
3	SE	7					22	2209			22	2187	"	"		D.S.	Limited supply in blue clay
4	SW	8					22	2225			22	2203	"	"		D.S.	Limited supply in clay
5	SW	9					18	2214	- 8	2206	18	2196	"	"		D.S.	Good supply in sand
6	SE	10					52	2154			52	2102	"	"		D.S.	Good supply in sand
7	SE	15					14	2176			14	2162	"	"		D.S.	Good supply in fine sand
8	NW	16					15	2226			15	2211	"	"		D.S.	Limited supply in clay
9	SW	18				bored	32	2211			32	2079	"	"		D.S.	Limited supply in gravel
10	SW	19				dug	10	2152			10	2142	"	"		D.S.	Good supply in gravel
11	SW	20				"	70	2230									Dry hole in blue clay
12	SE	20				"	35	2230			35	2195	"	hard		D.S.	Good supply
13	SE	21				"	25	2204			25	2179	"	"		D.S.	Good supply in sand
14	NW	23				"	15	2158			15	2143	"	"		D.S.	Good supply in clay
15	NE	25				"	14	2139			14	2125	"	"		D.S.	Good supply in sand
16	SW	25				"	7	2146			7	2139	"	"		D.S.	Good supply in sand
17	NE	28				"	16	2223			16	2207	"	"		D.S.	Good supply in clay
18	NW	30				"	40	2202			40	2162	"	"		D.S.	Good supply in fine sand
19	NE	31				"	8	2190			8	2182	"	"		D.S.	Good supply in sand and gravel
20	NW	32				"	60	2225			60	2165	"	"		D.S.	Good supply in gravel
21	NE	33				"	12	2211			12	2199	"	"		D.S.	Sufficient in clay
22	SW	34				"	10	2203			10	2193	"	"		D.S.	Good supply in clay
	SE	1	53	20	3	dug	80	2161			80	2081	Glacial	hard		D.S.	Good supply in fine sand
1	SW	2				"	16	2099	- 12	2087	16	2083	"	"		D.S.	Good supply in sand
2	SW	5				"	80	2138	- 77	2061	80	2058	"	"		D.S.	Good supply in sand
3	SE	5				"	33	2101	- 31	2070	33	2068	"	"		D.S.	Good supply in sand
4	NW	6				bored	95	2145	- 85	2060	95	2050	"	"		D.S.	Good supply
5	SE	6				"	85	2143	- 72	2071	78	2065	"	"		D.S.	Good supply in sand
6	NW	7				dug	22	2118	- 21	2097	22	2096	"	"		D.S.	Good supply in sand
7	NW	8				"	48	2130	- 40	2090	48	2082	"	"		D.S.	Good supply in sand
8	NE	12				"	49	2176			49	2127	"	"		D.S.	Limited supply in sand
9	SW	12				"	48	2154	- 42	2112	48	2106	"	"		D.S.	Good supply in gravel
10	SE	19				bored	54	2126	- 52	2074	54	2072	"	"		D.S.	Good supply in sand
11	NE	19				dug	33	2092	- 20	2072	33	2059	"	"		D.S.	Good supply
12	SE	23				"	14	2094	- 8	2086	14	2080	"	"		D.S.	Abundant supply in gravel
13	SW	24				"	9	2097			9	2088	"	"		D.S.	Good supply in gravel and sand
14	SE	26				"	30	2125	- 28	2097	30	2095	"	"		D.S.	Good supply in fine sand
15	NE	26				"	14	2114	- 11	2103	14	2100	"	"		D.S.	Good supply in gravel
16	NW	30				"	23	2099	- 18	2081	23	2076	"	"		D.S.	Good supply in gravel
17	NW	36				"	16	2100			16	2084	"	"		D.S.	Good supply in sand

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 Greenfield No. 529

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	4	53	21	3	bored	48	2043	- 43	2000	18	2025	Glacial	hard		D.S.	Limited supply in gravel
2	SW	6				dug	35	1980			35	1945	"	"		D.S.	Good supply
3	SE	7				"	60	1978	- 10	1968	60	1918	"	"		D.S.	Good supply below lake clay
4	NW	8				"	32	1978	- 30	1948	32	1946	"	"		D.S.	Good supply in sand
5	NE	9				bored	70	2192	- 40	2152	70	2122	"	"		D.S.	Good supply.
6	SW	9				"	85	2087	- 45	2042	85	2002	"	"		D.S.	Good supply.
7	SW	10				dug	38	2192	- 36	2156	38	2154	"	"		D.S.	Good supply in gravel
8	NE	13				"	41	2127	- 26	2101	41	2086	"	"		D.S.	Good supply in gravel
9	NW	13				"	20	2090			20	2070	"	"		D.S.	Good supply in sand
10	SW	16				bored	45	2117	- 42	2075	45	2072	"	"		D.S.	Good supply in sand
11	NW	17				"	45	2048			45	2003	"	"		D.S.	Good supply
12	SW	17				dug	10	2001	- 8	1993	10	1991	"	"		D.S.	Good supply in gravel
13	SW	19				bored	27	2012	- 25	1987	27	1985	"	"		D.S.	Good supply in gravel
14	NE	20				dug	65	2116									Dry hole in glacial clay and fine sand
15	NE	21				"	8	2160	- 6	2154	8	2152	"	"		D.S.	Limited supply in sandy clay
16	NW	21				"	25	2070	- 22	2048	25	2045	"	"		D.S.	Limited supply in fine sand
17	SE	23				"	35	2171	- 30	2141	35	2136	"	"		D.S.	Limited supply in fine sand
18	SE	26				"	40	2134			40	2094	"	"		D.S.	Good supply in fine sand
19	SW	31				bored	25	2044	- 22	2022	25	2019	"	"		D.S.	Limited supply in fine sand
20	NW	31				"	43	2074			43	2031	"	"		D.S.	Good supply
21	SW	33				dug	13	2142	- 10	2132	13	2129	"	"		D.S.	Limited supply in sandy clay
22	NE	36				"	22	2137	- 17	2120	22	2115	"	"		D.S.	Sufficient supply in sand and gravel
1	SE	1	54	19	3	dug	10	2145	- 8	2137	10	2135	Glacial	soft		D.	Sufficient supply in clay
2	NE	3				"	12	2189			12	2177	"	"		D.S.	Good supply in sand
3	NW	3				"	10	2189			10	2179	"	hard		D.S.	Good supply in gravel
4	SW	4				"	13	2269			13	2256	"	"		D.S.	Good supply in fine sand
5	NW	5				"	40	2231			40	2191	"	"		D.S.	Limited supply in clay
6	SW	6				"	20	2200	- 15	2185	20	2180	"	"		D.S.	Good supply in sand and gravel
7	NW	6				"	50	2200	- 30	2170	50	2150	"	"		D.S.	Good supply in small sand veins
8	NE	6				"	40	2199			40	2159	"	"		D.S.	Good supply in sand
9	SW	8				"	24	2193			24	2169	"	"		D.S.	Limited supply in gravel
10	NE	9				"	25	2210			10	2200	"	"		D.S.	Limited supply in sand
11	NE	10				"	10	2173			10	2163	"	"		D.S.	Limited supply in sand
12	SW	15				"	60	2217			60	2157	"	"		D.S.	Good supply in clay
13	SE	17				"	20	2251			20	2231	"	"		D.S.	Good supply in gravel
14	NE	18				"	26	2182			26	2156	"	"		D.S.	Good supply in sand and gravel
15	SE	19				"	24	2165			24	2141	"	"		D.S.	Poor supply in gravel
16	SE	20				"	14	2252			14	2238	"	soft		D.S.	Good supply in gravel
17	SW	20				"	24	2192			24	2168	"	"		D.S.	Good supply in gravel
18	SW	27				"	20	2213			20	2193	"	hard		D.S.	Limited supply in gravel
19	SW	28				"	20	2228			20	2208	"	soft		D.S.	Good supply in sand
20	NE	30				"	12	2207			12	2195	"	"		D.S.	Good supply in sand and gravel
21	NE	31				"	10	2198			10	2188	"	"		D.S.	Limited supply in fine sand
22	SW	32				"	15	2217			15	2202	"	"		D.S.	Good supply in sand and gravel

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 Greenfield No. 529

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	1	54	20	3	dug	11	2092	- 8	2084	11	2081	Glacial	hard		D.S.	Good supply in gravel
2	SE	2				"	20	2113	-10	2103	20	2093	"	"		D.S.	Abundant supply in sand
3	NW	5				"	35	2147	-33	2114	33	2114	"	"		D.S.	Good supply in sand
4	SW	7				"	37	2146	-30	2116	37	2109	"	"		D.S.	Good supply in sand
5	NW	8				"	22	2154	-20	2134	22	2132	"	soft		D.S.	Good supply in gravel
6	NE	14				"	30	2172			30	2142	"	"		D.S.	Good supply in sand and gravel
7	SW	15				"	28	2139	-25	2114	25	2114	"	hard		D.S.	Good supply in sand
8	NW	15				"	35	2184			35	2149	"	soft		D.S.	Good supply in sand
9	NW	16				"	28	2158	-20	2138	28	2130	"	hard		D.S.	Good supply in sand
10	SE	16				"	40	2150	-37	2113	40	2110	"	"		D.S.	Good supply in sand
11	SW	16				"	14	2127	- 8	2119	12	2115	"	"		D.S.	Good supply in sand
12	NW	17				"	45	2150			45	2105	"	soft		D.S.	Good supply in sand
13	NW	19				"	39	2152			20	2132	"	hard		D.S.	Limited supply in blue clay
14	NE	20				"	12	2178			12	2166	"	"		D.S.	Good supply in sand
15	NE	23				"	28	2206			28	2178	"	"		D.S.	Good supply in sand
16	NW	25				"	20	2189	-18	2171	20	2169	"	"		D.S.	Good supply in sand
17	SE	26				"	25	2197	- 2	2195	25	2172	"	"		D.S.	Good supply in sand
18	NW	27				"	35	2182			35	2147	"	"		D.S.	Good supply in sand
19	SE	30				"	22	2159			22	2137	"	"		D.S.	Good supply in sand
20	NW	30				"	23	2150			23	2127	"	"		D.S.	Good supply in sand and gravel
21	SE	31				"	22	2142	-17	2125	22	2120	"	"		D.S.	Good supply in sand
22	SW	33				"	18	2159			18	2141	"	"		D.S.	Limited supply in sand
23	NW	34				"	16	2170			16	2154	"	"		D.S.	Good supply in gravel
24	SW	35				"	20	2185	-16	2169	20	2165	"	"		D.S.	Good supply in sand
25	SE	36				"	12	2201			12	2189	"	"		D.S.	Good supply in clay
1	SW	1	54	21	3	dug	30	2196			30	2166	Glacial	hard		D.S.	Good supply in gravel
2	SE	2				"	12	2181			12	2169	"	"		D.S.	Limited supply in clay
3	NW	2				bored	41	2227	- 18	2209	18	2209	"	"		D.S.	Limited supply in sand
4	SW	4				dug	35	2160			35	2125	"	"		D.S.	Limited supply in sand
5	NE	5				dug	16	2113			16	2097	"	"		D.S.	Good supply in sand
6	NW	7				"	48	2096			48	2048	"	"		D.S.	Good supply in sand lense.
7	NW	8				"	20	2095			20	2075	"	"		D.S.	Limited supply in sand
8	NE	9				"	14	2109			14	2095	"	"		D.S.	Good supply in gravel
9	NE	10				"	11	2142			11	2131	"	"		D.S.	Sufficient supply
10	SE	13				"	35	2164	- 33	2131	33	2131	"	"		D.S.	Good supply in sand
11	SE	15				"	15	2131			15	2116	"	"		D.S.	Good supply in gravel
12	SW	16				"	32	2115			32	2083	"	"		D.S.	Good supply in sand
13	NE	20				"	26	2116			26	2090	"	"		D.S.	Good supply in gravel
14	NW	21				"	26	2113			26	2087	"	"		D.S.	Limited supply in blue clay
15	NW	23				"	14	2130			14	2116	"	"		D.S.	Good supply in fine sand
16	SW	24				"	20	2136			20	2116	"	"		D.S.	Good supply in sand
17	SW	25				"	20	2116			15	2101	"	"		D.S.	Good supply in clay
18	SE	26				"	19	2118			19	2099	"	"		D.S.	Limited supply in clay
19	SW	27				"	45	2112			45	2067	"	"		D.S.	Good supply in clay
20	NW	28				"	20	2130			20	2110	"	soft		D.S.	Good supply in sand
21	SE	29				"	19	2123			19	2104	"	"		D.S.	Limited supply in sand
22	SE	32				"	20	2111			20	2091	"	"		D.S.	Good supply in sand
23	NW	33				"	7	2123			7	2116	"	"		D.S.	Good supply in clay
24	NW	34				"	30	2135			30	2105	"	hard		D.S.	Good supply in sand
25	SE	35				"	22	2126			22	2104	"	"		D.S.	Good supply in sand

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 Greenfield No. 529

WELL No.	LOCATION					TYPE OF WELL	DEPTH OF WELL	ALTITUDE WELL (above sea level)	HEIGHT TO WHICH WATER WILL RISE		PRINCIPAL WATER-BEARING BED			CHARACTER OF WATER	TEMP. OF WATER (in °F.)	USE TO WHICH WATER IS PUT	YIELD AND REMARKS
	¼	Sec.	Tp.	Rge.	Mer.				Above (+) Below (−) Surface	Elev.	Depth	Elev.	Geological Horizon				
1	NW	4	55	20	3	dug	15	2151	-12	2139	15	2136	Glacial	hard		D.S.	Good supply in sand
2	SE	4				"	13	2158			13	2145	"	soft		D.S.	Limited supply in sand vein
3	SE	8				"	15	2139	- 9	2130	15	2124	"	hard		D.S.	Sufficient supply
4	SW	19				"	16	2172			16	2156	"	"		D.S.	Good supply in gravel
1	SW	2	55	21	3		15	2136			15	2121	Glacial	hard		D.S.	Good supply in clay
2	SW	3					9	2092			9	2083	"	"		D.S.	Good supply in sand
3	SW	7				dug	60	2131	-57	2074	60	2071	"	"		D.	Good supply in sand. Dry hole 60 feet
4	NE	10				"	30	2115			30	2085	"	"		D.	Good supply in clay and gravel
5	NE	13					12	2158			12	2146	"	"		D.	Good supply in clay
6	SE	15					14	2097			14	2083	"	soft		D.	Good supply in blue clay
7	SE	23				dug	37	2139	- 27	2112	37	2102	"	hard		D.	Good supply in clay

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.