CANADA

DEPARTMENT OF MINES AND RESOURCES

MINES AND GEOLOGY BRANCH

BUREAU OF GEOLOGY AND TOPOGRAPHY

GEOLOGICAL SURVEY

WATER SUPPLY PAPER No. 229

GROUND-WATER RESOURCES OF THE RURAL MUNICIPALITY OF GRANDVIEW NO. 349 SASKATCHEWAN

Records Collected by C. O. Hage

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

OTTAWA

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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 (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

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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 acuifer 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. $\frac{1}{4}$ 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. $\frac{1}{4}$ 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 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. 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	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 GRANDVIEW, NO. 349, SASKATCHEWAN

Physical Features

The west boundary of Grandview municipality is the deep valley occupied by Tramping Lake and Eaglehill Creek. The valley, apparently, is part of the early post-glacial drainage when the melting ice provided a great deal of water that drained to the southeast. The valley lies 200 to 250 feet below the level of the plain, and in most places is only about a mile wide. The sides are steep, and the valley, although in part occupied by Tramping Lake, is flat bottomed. Bedrock occurs on both sides, but owing to the steep valley walls and the softness of the bedrock the slopes are slumped and grass covered. The entire trench has relatively few tributary valleys of any size, but there are small side gullies. To the east, on the prairie level, are a number of very shallow lakes that trend southeast but that are obviously different from Tramping Lake in origin in that they occupy depressions in the surface resulting from the irregular distribution of glacial materials.

Geology

In a prospect for coal dug into the bank on the east side of Tramping Lake, in SE. sec. 29, tp. 36, rge. 20, an 18-inch seam of coal is reported to have been found in the Pale Beds, which here consist of soft, light grey sands with carbonaceous partings alternating with dark shales. Also, southwest of Kelfield, on the west side of Eaglehill Creek, some coal has been mined from a seam that is probably somewhat higher stratigraphically than that on Tramping Lake. It is thus safe to infer that the whole municipality is underlain by Pale Beds containing sands that yield water in a number of wells.

Water Supply

Most of the wells in this municipality obtain their water from glacial sands and gravels. There is here, as in other municipalities to the east of Tramping Lake, a zone of outwash gravels and sands at elevations of between 2,030 and 2,090 feet above sea-level. Mostly this is a very persistent zone and yields water wherever it is penetrated. In this municipality, however, it is apparently not quite as continuous as in some other places, although a number of wells obtain water from it. It may be that this zone is here at elevations slightly higher than to the east, although the data are not sufficient to be conclusive. Most of the wells in the drift are obtained from irregularly distributed sands and gravels above this zone. In a few places it has been possible to trace gravel beds over a considerable area, but generally all such water-bearing beds appear to be of local extent and probably are in the nature of lenticular deposits surrounded by boulder clay. All the water in the drift originates from rain and reaches the individual water-bearing beds by downward percolation.

Beneath the drift the Palo Beds contain sands that are water-bearing in many places. These sands, although more extensive than those in the ground moraine, are not persistent over very large areas, and commonly two wells only a few miles apart will obtain water at different levels. The individual sand members are at most only a few feet thick, and apparently grade laterally into shales. In places the sand in them is so fine that it rises with the water when encountered in a well and may even block the water flow. In the wells it is often reported as quicksand, and is no doubt partly responsible for the occurrence of mud springs where these beds outcrop. The water from many horizons in the Palo Beds is soft, but owing to the large amount of ironstone in the formation, hard water with an iron content is by no means uncommon.

Township 34, Range 18. The deepest well in this township, in NE. section 6, is down 275 feet, and the elevation at the bottom is 2,082 feet. At 225 feet, or an elevation of 2,132 feet, fine gravel was reported. It is uncertain whether the bottom is in glacial materials or in Palo Beds. Directly east of this well, on NW. section 3, is another well 240 feet deep, the aquifer of which at this depth has an elevation of 2,114 feet. Here again it is uncertain whether the aquifer is in glacial materials or Palo Beds. The fact that the water in this well was soft might suggest Palo Beds, but this seems not to be significant as hard water was reported from the 275-foot well. All other wells in the township are probably in glacial materials and show considerable variation in the elevation of the water-bearing beds. Three wells, in sections 7, 17, and 20, obtained water at elevations of 2,184, 2,181, and 2,171 feet respectively, suggesting a locally productive aquifer of several miles extent in the western part of the township. Also several, mostly shallow wells, but up to 70 feet deep, obtain water from elevations of 2,230 to 2,250 feet, suggesting that this level also offers a somewhat persistent water-bearing zone. Other wells in which the aquifers occur at various elevations are undoubtedly lenticular sand or gravel deposits scattered fortuitously through the drift.

Township 34, Range 19. Eaglehill Creek cuts across the southwest corner of this township, and on its west bank, in section 7, Palo Beds carrying coal outcrop at an elevation of about 2,085 feet. To the northeast of this, in SW. section 16, a well 260 feet deep reached a water-bearing sand at an elevation of 2,039 feet, also presumed to be in the Palo Beds. The sand was very fine and sufficient of it rose in the casing to plug the well. Two wells in Kelfield, one belonging to the town and the other to the hotel, got water at an elevation of about 2,144 feet, and another well, in NE. section 12, obtained water in gravel at a depth of 168 feet and an elevation of 2,148 feet. A well 107 feet deep, in NE. section 9, reached an elevation of 2,156 feet and found no water. The above information points to the occurrence of a gravel bed between elevations of 2,144 and 2,148 feet, and suggests that the well in section 9 should encounter this bed if sunk a few feet deeper. With the exception of a very deep well in NE. section 6 all other wells in this township for which records are available obtain their water from sands at various horizons in the glacial drift. In instances where the supply is inadequate it can be increased by sinking to the deeper water-bearing zones referred to above.

East Half Township 34, Range 20. Eaglehill Creek cuts across the northeast corner of this township, and the valley is more than a mile wide and more than 200 feet deep. The land in it is relatively poor, and farming is mostly confined to the prairie level. Wells on NE. section 3, NW. section 12, and NE. section 14 are believed to obtain their water from the Pale Beds underlying the drift. All other wells are in glacial gravels or sands irregularly distributed through the drift.

Township 35, Range 18. The deepest well, 220 feet, in SW. section 25, obtains water from an aquifer at an elevation of 2,032 feet. It is not known whether this is in a glacial sand or in Pale Beds. In either case it is likely to be a fairly continuous aquifer under the whole township. All other wells are in glacial materials, which contain numerous though irregularly distributed sands. Apparently all these wells in glacial deposits, the aquifers of which, with one exception, fall within elevations of 2,135 to 2,214 feet, obtain their supply from the water-table. It is significant that the elevations of the numerous lakes in this area all fall within the same limits, as, for example, Little Tramping Lake in the next township west, elevation 2,132 feet; Eins Lake, 2,157 feet; an un-named lake in the west-central part of the township, 2,165 feet; and another un-named lake in the southeast corner of the township, 2,223 feet. The wells in sections 4, 9, and 10 obtain their water from a gravel bed of several miles extent, and gravel occurs elsewhere in the township. The presence of gravel or sand beds in the drift of most areas is not predictable, and hence it is impossible to forecast the depths of wells except below the water-table where sand and gravel beds are numerous though irregularly distributed.

Township 35, Range 19. All wells in this township for which records are available are less than 100 feet deep, and all obtain their water from sands below the water-table. Gravel deposits are relatively scarce. There are no continuous aquifers within the limits of the depths of present wells, and very little is known concerning deeper water-bearing horizons.

Township 35, Range 20, East of Tramping Lake. A well drilled in SE. section 10 by the Tramping Lake Park Board to a depth of 640 feet obtained a flow of salty water with sufficient gas to burn at the well head. The gas is presumed to come from the Ribstone Creek formation. A log of the materials passed through is not available, but as Pale Beds have been exposed by digging on the east side of Tramping Lake, the well probably encountered these beds at no great depth and continued in soft sands and shales to its present depth. Elsewhere within the Pale Beds and underlying Variegated Beds are many aquifers, and it is difficult to believe that some higher, unreported water horizons were not encountered in this well and sealed off by the method of jetting used in drilling. The well, therefore, gives little information on the water supply available in the bedrock and the bottom may be below the Ribstone Creek formation. The present water is too salty for domestic purposes. All other wells in this east part of township 35 are from sand and gravel beds irregularly distributed through the glacial drift, and none of these wells reaches the level of Tramping Lake. Several wells with aquifers between elevations of 2,090 and 2,100 feet seem to indicate that this may be a fairly persistent water-bearing horizon, in which case the drift is at least 90 feet thick and may be considerably more, as the elevation of its base is not known.

Township 36, Range 18. All wells in this township are believed to get their water from glacial materials, although one well, in NE. section 15, is 190 feet deep and reaches an aquifer with an elevation of 2,056 feet. This aquifer may persist under the whole township, but is thought to be part of a zone containing sand lenses rather than one continuous bed. The zone appears to have been encountered by several wells, the aquifers of which have elevations between 2,056 and 2,097 feet, with most about 2,090 feet. One of these wells reported a "black muck" horizon similar to that reported in sec. 34, tp. 35, rge. 17, in Bushville municipality. All other wells with aquifers at higher elevations are sands or gravels irregularly distributed in the drift, and their occurrence is not predictable.

Township 36, Range 19. There are two deep water wells in this township, the Canadian Pacific Railway well at Handel, 375 feet deep, and a well 320 feet deep in NE. section 12. From the available information it is inferred that both of these wells were completed in Pale Beds. Two aquifers were reported in the railway well, one at 260 feet, at an elevation of 1,963 feet, and the other at 306 feet, at an elevation of 1,917 feet. In the well in section 12 the water occurred in coarse gravel at 140 feet, or an elevation of 2,087 feet, and in sand presumably belonging to the Pale Beds at a depth of 320 feet and an elevation of 1,907 feet. It is known that the sands of the Pale Beds are very irregular and discontinuous laterally, but the records of these wells suggest that the aquifer at 1,917 feet in the Handel well is the same as that at 1,907 feet in the well in section 12. The coarse gravel at an elevation of 2,087 feet in the well in section 12 indicates that this is the outwash glacial gravel zone persistent over a large area. Apparently, however, in this area it has not been found to be a strong aquifer. It has, however, been tapped within the township by a well in NE. section 6 at an elevation of 2,083 feet and by a well in SW. section 20 at an elevation of 2,093 feet. All other wells in this township are from irregularly distributed sands and gravels in the drift at elevations of between 2,120 and 2,170 feet. Most of these wells are less than 100 feet deep.

Township 36, Range 20, East of Tramping Lake. A tunnel into the bank of Tramping Lake in SE. section 29 has disclosed Pale Beds containing a thin coal seam at an elevation of 2,014 feet. A well in the gully in NW. section 28 struck this coal seam at a depth of 60 feet, and a still deeper well on the same quarter section obtains its water from the Pale Beds at a depth of 394 feet, or an elevation of 1,746 feet. In this township the base of the drift can be fairly closely defined, as a well in SW. section 26 produces water from gravel at 2,047 feet, whereas Pale Beds are known on the edge of Tramping Lake up to an elevation of 2,025 feet. Two wells produce water at an elevation of 2,092 feet in glacial materials, and another at 2,067 feet. These beds are in the outwash sand plain to which reference has already been made. All other wells are from sands irregularly distributed through the drift.

ANALYSES OF WATER SAMPLES FROM RURAL MUNICIAPLITY OF GRANDVIEW, NO. 349, SASK.

No.	¼ Sec.	Tp.	Rge.	Depth in feet	Elev. of Aquifer	Total dissolved solids	Constituents as Analysed						Total Hardness	Constituents as Calculated in assumed Combinations							Source of Water
							Ca	Mg	Na	SO_4	Cl.	Alk.		$CaCO_3$	$CaSO_4$	$MgCO_3$	$MgSO_4$	Na_2CO_3	Na_2SO_4	NaCl.	
1	SW 25	35	18	220	2033	2480	272	113	348	1320	10	510	1300	510	231		559		1052	17	glacial
2	SW 10	35	20	640	1368	4460	36	15	1598	29	2340	270	130	90		52		125	43	3861	Ribstone Creek
3	NE 15	36	18	190	2056	800	29	72	107	344	6	235	560	73		136	163		317	10	Bedrock(?)
4	NW 28	36	20	384	1746	1300	7	11	490	21	400	540	25	18		38		505	31	660	Pale Beds

RECORD OF WELLS IN RURAL MUNICIPALITY OF GRANDVIEW, No. 349, SASK.

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 & Remarks
1	N.E. 3	34	18	3	Dug	35	2280			35	2245	Glacial Sand	Hard	D.S.M.	Limited
2	S.W. 4	"	"	"	"	25	2263	-23	2240	25	2238	" "	"	D.S.	Good supply
3	N.W. 5	"	"	"	Drilled	240	2354	-190	2164	240	2114	" "	Soft	"	" mixed with surface water.
4	N.E. 6	"	"	"	"	275	2357	-175	2182	275	2082		Hard	"	" supply.
5	S.E. 6	"	"	"	Bored	46	2350	-20	2330	46	2304	Glacial	"	S.	Fair "
6	N.E. 7	"	"	"	Drilled	150	2334	-120	2214	150	2184	Fine sand	" Fe.	D.S.	Good supply
7	S.W. 9	"	"	"	"	75	2314	-50	2264	75	2239	Glacial sand	" "	"	" "
8	S.W.13	"	"	"	Dug	16	2310	-		16	2294	Glacial	" Alk.	"	" "
9	S.W.17	"	"	"	Drilled	160	2341	-60	2281	160	2181	Fine sand	" Fe.	"	" "
10	N.E.18	"	"	"	Bored	110	2353	-70	2283	110	2243	Glacial gravel	"	"	Waters 40 head stock
11	S.W.18	"	"	"	Drilled	140	2358	-112	2246	140	2218	Glacial	" med.		Well abandoned
12	S.W.20	"	"	"	"	164	2335	-64	2271	164	2171	Fine sand	"	"	Good supply
13	S.E.24	"	"	"	Dug	19	2290			19	2271	Glacial sand	"	"	" "
14	S.W.27	"	"	"	"	25	2274	-23	2251	25	2249	Glacial gravel	"	"	Poor "
15	S.E.28	"	"	"	Bored	65	2253	-45	2208	65	2188	Sand	"	"	Good "
16	N.E.28	"	"	"	"	60	2272	-40	2232	60	2212	Glacial gravel	"	"	" "
17	S.W.30	"	"	"	"	45	2318	-35	2283	45	2273	" sand	"	"	" "
18	N.E.31	"	"	"	"	70	2293			50	2243	Glacial	"	"	Fair "
19	N.W.33	"	"	"	"	55	2268			25	2243	"	"	"	Waters 35 head stock
20	N.E.34	"	"	"	Dug	18	2268	-13	2255	18	2250	" gravel	"	"	Good supply
21	N.W.36	"	"	"	Bored	70	2273	-50	2223	70	2203	" "	"	"	" "
1	N.E. 6	34	19	3	Drilled	300	2146	-150	2096	300	1846	Pale Beds	Soft	D.S.	Good supply
2	N.E. 9	"	"	"	Bored	107	2263								Dry Hole
3	N.E.12	"	"	"	Drilled	168	2316	-118	2198	168	2148	Glacial gravel	Hard	"	Good supply
4	N.W.13	"	"	"	Bored	35	2317	-15	2302	35	2282	Glacial	" med.	"	" "
5	S.W.14	"	"	"	Dug	35	2309	-		35	2274	" Clay	"	"	Poor "
6	S.E.14	"	"	"	Bored	120	2313	-60	2253	80	2233	Glacial	"	"	" "
										120	2193	"	"	S.	Good supply hauls water for House.

x.- D.- Domestic, S.- Stock, Fe.- Iron, Alk.- Alkaline, M- Municipal.

Well No.															
7	S.W.16	34	19	3	Drilled	260	2299	-180	2119	260	2039	Pale Beds ?	Hard	D.S.	Plugged by fine sand
8	N.E.19	"	"	"	Bored	50	2279	-35	2244	50	2229	**Glacial sand**	"	S.	Good supply
9	S.E.20	"	"	"	"	100	2320	-90	2230	100	2220	" mud	" Fe.	D.S.	Limited
10	N.E.20	"	"	"	"	30	2294	-28	2266	30	2264	Sand	"	S.	" "
11	N.W.25	"	"	"	"	70	2368	-40	2328	70	2298	Glacial	"	D.S.	Good "
12	S.E.27	"	"	"	Drilled	186	2330	-66	2264	186	2144	Blue sand	" Fe.	D.S.M.	" "
13	S.E.32	"	"	"	Bored	30	2274	-10	2264	30	2244	**Glacial sand**	"	D.S.	Waters 50 head of stock.
14	N.W.32	"	"	"	"	30	2250	-26	2224	30	2220	" gravel	Soft	"	Good supply
15	S.E.33	"	"	"	Dug	20	2276	-17	2259	20	2256	" sand, **Fine**	Hard	"	Fair "
16	S.E.34	"	"	"	Bored	98	2349	-58	2291	98	2251	" sand	"	"	Waters 20 head of stock
1	N.E. 3	34	20	3	Dug	160	2208	-140	2068	160	2048	Pale Beds	Soft	D.S.	Good supply
2	S.E.10	"	"	"	"	147	2264	-143	2121	147	2117	**Glacial gravel**	Hard	D.S.	Sufficient
3	S.E.11	"	"	"	"	12	2223			12	2211	" "	Soft	"	Good supply. Flowing spring
4	N.W.12	"	"	"	"	190	2289	-160	2129	190	2099	Pale Beds	Hard	"	" " Coal seam.
5	N.E.14	"	"	"	Drilled	230	2291	-130	2161	230	2061	" " sand	"	"	" "
6	N.E.22	"	"	"	Dug	30	2269	-15	2254	30	2239	**Glacial gravel**	"	"	" "
7	N.E.35	"	"	"	Drilled	140	2264	-100	2164	140	2124	Sand	" Fe.	"	" "
1	N.E. 4	35	18	3	Dug	58	2258	-48	2210	58	2200	**Glacial gravel**	Hard		
2	N.W. 9	"	"	"	"	60	2248	-40	2208	60	2188	" "	"		
3	S.W.10	"	"	"	"	40	2238	-32	2206	40	2198	" "	" Alk.	D.S.	Fair supply
4	N.W.12	"	"	"	Bored	50	2259			50	2209	" sand, **fine**	"	"	Good "
5	S.E.13	"	"	"	"	40	2243	-35	2208	40	2203	" "	"	"	" "
6	N.E.14	"	"	"	"	75	2280			75	2205	Glacial	Soft	D.	Poor " School well.
7	N.E.18	"	"	"	"	60	2227			60	2167	"	Hard	D.S.	Good supply
8	S.W.20	"	"	"	"	48	2231	-32	2199	48	2183	" sand	"	"	" "
9	S.E.21	"	"	"	"	95	2230			95	2135		" Fe.	"	" "
10	N.E.22	"	"	"	Dug	106	2275	-96	2179	106	2169	**Glacial sand**	"	"	" "
11	S.E.23	"	"	"	Bored	135	2324	-100	2224	135	2189	" gravel	"	"	" "
12	N.E.23	"	"	"	"	65	2257	-40	2217	65	2192	Glacial	"	"	" "
13	S.W.24	"	"	"	"	70	2284	-63	2221	70	2214	"	"	"	Fair "
14	N.E.24	"	"	"	"	100	2258	-75	2183	100	2158	" gravel	" Fe.	"	Good "
15	S.W.25	"	"	"	Drilled	220	2253	-120	2133	220	2033	Pale Beds ?	"	"	" "
16	S.W.27	"	"	"	Bored	125	2285			125	2160				" "
17	N.W.27	"	"	"	"	100	2295	-85	2210	100	2195	Glacial	"	"	Fair "

Well No.															
18	N.E.30	35	18	3	Bored	100	2200	-70	2130	100	2100		Hard med.	D.S.	Fair supply
19	S.W.32	"	"	"	"	90	2225			90	2135		Soft	"	Good "
20	N.W.36	"	"	"	"	93	2250	-73	2177	93	2157	Glacial sand	Hard	"	" "
1	S.E. 4	35	19	3	Dug	40	2266			40	2226	Glacial	Hard	"	" "
2	N.W. 4	"	"	"	Bored	90	2237			90	2147		"	S.	" " salty.
3	S.W. 5	"	"	"	"	30	2222	-20	2202	30	2192	Glacial sand	Soft	D.S.	Fair "
4	N.E. 9	"	"	"	Dug	25	2209			25	2184	Glacial	Hard	"	
5	S.E.12	"	"	"	Bored	60	2253			60	2193	"	"	"	Limited supply
6	S.E.13	"	"	"	"	45	2226	-35	2191	45	2181	" sand	"	"	" "
7	S.W.16	"	"	"	"	50	2202	-40	2162	50	2152	Sand	"	"	Good "
8	S.E.17	"	"	"	"	33	2189	-20	2169	21	2168	Glacial sand	"	"	Poor "
9	S.W.18	"	"	"	"	53	2167	-40	2127	53	2114	Blue soapstone	"	"	Limited "
10	N.E.21	"	"	"	"	90	2235	-50	2185	90	2145	Glacial sand	"	"	" "
11	N.W.22	"	"	"	"	55	2255	-50	2205	55	2200	" "	"	"	" "
12	N.E.24	"	"	"	"	84	2225	-50	2175	84	2141	" clay	"	"	Poor " Spring E. of House Elev 2190
13	N.W.27	"	"	"	"	45	2241			45	2196	" sand	"	"	Very poor supply
14	S.W.30	"	"	"	"	87	2184			87	2097	Sand	"	"	Fair supply
15	S.E.30	"	"	"	Dug	35	2238			35	2203	Glacial	"	"	" "
16	N.W.31	"	"	"	Bored	70	2248	-65	2183	70	2178	" sand	"	"	Waters 10 head
17	N.E.32	"	"	"	"	36	2205	-32	2173	36	2169		"	"	Poor supply
1	N.W. 1	35	20	3	Bored	80	2215	-60	2155	80	2135	Glacial gravel	Hard	D.S.	Good supply
2	S.E.10	"	"	"	Drilled	640	2028	Flows	2028+	600	1428	Sand	Soft	"	½" stream, Gas, Salty water
3	S.E.22	"	"	"	Bored	60	2159			60	2099	Glacial	Hard	"	Poor
4	S.E.22	"	"	"	"	120	2159								Dry Hole.
5	N.E.23	"	"	"	"	40	2163	-35	2128	40	2123	Glacial gravel	Hard Alk.	"	Limited supply
6	S.E.28	"	"	"	"	60	2152	-50	2102	60	2092	Sand	" Fe.	"	" "
7	N.E.28	"	"	"	"	56	2156	-44	2112	56	2100	Glacial gravel	Hard	"	Good "
8	N.E.32	"	"	"	"	90	2186		Low	90	2096	Sand	"	"	Fair " Sand Point.
9	N.E.34	"	"	"	"	25	2196	-22	2174	25	2171	Glacial sand, fine	"	"	Good supply
10	S.E.34	"	"	"	"	50	2170	-25	2145	50	2120	Glacial clay	"	"	"
11	S.E.35	"	"	"		30	2220	-20	2200	30	2190	" Gravel	Soft	"	" "
12	N.W.36n	"	"	"	"	90	2231	-85	2146	90	2141	Sand, coarse	"	"	" "
1	N.W. 4	36	18	3	Bored	61	2192	-48	2144	61	2131	Glacial gravel	Hard	D.S.	Good supply
2	N.E. 4	"	"	"	"	60	2236			60	2176	Sand, fine	"	"	Poor "
3	S.E. 4	"	"	"	"	129	2226	-80	2146	129	2097	Sand	Soft	"	Good "

Well No.															
4	N.W. 5	36	18	3	Bored	87	2196	-67	2129	87	2109	Glacial sand	Hard	D.S.	Limited
5	N.E. 7	"	"	"	"	60	2188	-20	2168	60	2128	" "	"	"	Sufficient
6	S.E. 7	"	"	"	"	87	2220	-60	2160	87	2133	" "	"	"	"
7	S.W. 9	"	"	"	"	80	2228	-60	2168	80	2148	" gravel	"	"	"
8	N.E.10	"	"	"	"	53	2231			53	2178	" sand	"	"	"
9	N.W.10	"	"	"	"	47	2231			47	2184	" " ,fine	"	"	"
10	N.E.12	"	"	"	"	87	2240			87	2153	" clay	"	"	Poor supply
11	S.W.14	"	"	"	"	63	2236			60	2176	" sand	Soft	"	Sufficient
12	S.E.14	"	"	"	"	60	2190			60	2130	" "	Hard	"	"
13	N.E.15	"	"	"	Drilled	190	2246	-80	2166	190	2056	Sand fine	" med.	"	Sand plugged the well.
14	N.W.16	"	"	"	Bored	80	2228	-72	2156	80	2148	Glacial sand	Hard	"	Limited
15	S.E.18	"	"	"	"	60	2204	-40	2164	60	2144	" "	"	"	Sufficient
16	S.E.19	"	"	"	"	70	2202	-50	2152	70	2132	" "	"	"	"
17	S.E.20	"	"	"	"	80	2212	-60	2152	80	2132	" gravel	"	"	"
18	N.E.20	"	"	"	"	35	2199	-27	2172	35	2164	" sand	" med.	"	"
19	N.E.21	"	"	"	"	85	2168			85	2083	Sand, fine	"	"	"
20	N.W.22	"	"	"	"	94	2172	-80	2092	83	2089	" "	"	"	"
										94	2078	" "	Salty		Shut off
21	S.W.22	"	"	"	"	105	2210	-93	2117	105	2105	" "	Hard	"	Sufficient supply
22	N.E.24	"	"	"	"	47	2130	-37	2093	47	2083	Sand	"	"	" "
23	S.W.24	"	"	"	"	60	2150	-30	2120	56	2094	"	"	"	" "
24	N.E.27	"	"	"	"	47	2156			47	2109	" ,.fine	"	"	" "
25	N.W.28	"	"	"	"	65	2183	-45	2138	65	2118	Gravel	Soft	"	" "
26	S.E.30	"	"	"	"	40	2168			40	2128	Glacial gravel	Hard	"	" "
27	S.E.32	"	"	"	"	40	2167	-30	2137	40	2127	Sand	"	"	" "
28	N.E.33	"	"	"	"	103	2114	-35	2079	103	2011	Blue muck	"	"	" "
29	N.W.34	"	"	"	Dug	22	2118	-19	2099	22	2096	" "	"	"	Limited
30	S.E.34	"	"	"	"	18	2126			18	2108	Sand, fine	"	"	Sufficient "
1	S.W. 2	36	19	3	Bored	60	2230	-55	2175	60	2170	Glacial gravel	Hard	D.S.	Limited supply
2	S.E. 4	"	"	"	"	95	2247	-80	2167	95	2152	" sand	"	"	" "
3	S.E. 6	"	"	"	Drilled	375	2223	–		260	1963				Poor " C.P.R.
								–		306	1917				" "
4	S.E. 6	"	"	"	Bored	95	2223			95	2128	Glacial	Hard	D.S.	Sufficient
5	N.E. 6	"	"	"	"	140	2223		Low	140	2083	Sand	"	"	Poor supply
6	N.W. 7	"	"	"	"	40	2191	-35	2156	40	2151	Glacial sand	"		Limited
						120	2191								Dry hole

Well No.															
7	N.W. 8	36	19	3	Dug	28	2205	-24	2181	28	2177	Glacial gravel	Soft	D.S.	Sufficient
8	S.W.10	"	"	"	Bored	50	2192	-30	2162	50	2142	" sand	Hard	"	"
9	N.E.10	"	"	"	"	75	2208	-25	2183	75	2133	" "	"	"	"
10	S.E.12	"	"	"	"	112	2241	-80	2161	112	2129	" "	"	"	"
11	N.E.12	"	"	"	Drilled	320	2227	-70	2157	140	2087	" gravel	"		
										280	2007	Pale Beds	"		
										320	1907	" " sand		S.	Plugged with sand
12	S.W.15	"	"	"	Dug	10	2154	- 3	2151	10	2144	Glacial	"	D.S.	Limited supply
13	S.E.16	"	"	"	Bored	37	2168	-34	2134	37	2131	" sand	"	"	" "
14	S.W.16	"	"	"	"	30	2157	-26	2131	30	2127	" " , fine	"	"	Poor "
15	S.W.20	"	"	"	"	65	2158	-35	2123	65	2093	Black clay	"	"	Sufficient
16	N.W.22	"	"	"	"	96	2220	-86	2134	96	2124		"	"	Limited
17	S.E.22	"	"	"	"	50	2211	-45	2166	50	2161	Glacial sand	"	"	"
18	S.E.24	"	"	"	"	70	2178	-10	2168	70	2108	" "	"	"	Sufficient
19	S.E.25	"	"	"	"	40	2208	-35	2173	40	2168	" "	"	"	"
20	S.W.26	"	"	"	"	90	2211	-80	2131	90	2121		"	"	"
21	N.W.32	"	"	"	Dug	20	2153	-16	2137	20	2133	" gravel	Soft	"	"
22	S.E.34	"	"	"	Bored	35	2200	-31	2169	35	2165	" sand, fine	Hard	"	Limited
23	N.E.34	"	"	"	"	35	2173	-34	2139	35	2138	" " "	"	"	"
24	S.E.36	"	"	"	Dug	12	2170	- 6	2164	12	2158	" "	"	"	"
25	N.W.36	"	"	"	Bored	50	2157	-25	2132	50	2107	" "	" med.	"	Sufficient
1	N.E. 2	36	20	3	Bored	90	2240±	-85	2155	90	2150	Glacial sand	Hard	D.S.	Limited supply
2	S.E. 2	"	"	"	"	75	2219		Low	75	2144	Glacial	"	"	" "
3	S.W. 4	"	"	"	"	50	2215	-48	2167	50	2165	" sand	Soft	"	Poor "
4	N.W. 9	"	"	"	"	40	2220		Low	40	2180	Glacial		"	Waters 3 head of stock.
5	N.E.10	"	"	"	"	40	2200	-20	2180	40	2160	" sand	Hard	"	Sufficient
6	S.E.13	"	"	"	"	65±	2191			65	2126			S.	"
7	S.E.15	"	"	"	"	55	2201	-25	2176	55	2146	Glacial	Hard	D.S.	"
8	S.E.21	"	"	"	"	35	2173	-16	2157	35	2138	" sand	Soft	"	"
9	N.E.22	"	"	"	"	82	2174			82	2092	Blue clay	Hard	"	"
10	N.W.22	"	"	"	"	102	2169	-57	2112	102	2067	Sand	"	"	"
11	S.W.23	"	"	"	"	90	2197	-55	2142	90	2107	Glacial	"	"	"
12	S.E.24	"	"	"	"	40	2186	-25	2161	40	2146	Glacial sand	"	"	"
13	S.W.26	"	"	"	"	120	2167	-35	2132	120	2047	" gravel	"	"	"
14	N.W.28	"	"	"	Drilled	394	2130			384	1746	Pale Beds	Soft	"	" Coal.

Well No.															
15	N.W.28	36	20	3	Bored	60	2072	-40	2032	60	2012	Pale Beds sand	Hard	D.S.	Sufficient Coal above water.
16	N.E.34	"	"	"	"	42	2120	-26	2094	28	2092	Glacial sand,fine	"	"	Sufficient.
17	S.W.36	"	"	"	"	50	2185	-45	2140	50	2135	" "	"	"	Limited supply
18	S.E.36	"	"	"	"	57	2250±	-22	2228	57	2193	" "	"	"	" "