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GEOLOGICAL SURVEY OF CANADA  
WATER SUPPLY PAPER No. 249

GROUND-WATER RESOURCES  
OF THE  
RURAL MUNICIPALITY OF MEOTA  
NO. 468  
SASKATCHEWAN

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



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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 concerning ground water in any particular locality will find the available data listed in the well records. These should be consulted to see if a supply of water is likely to be found in shallow wells sunk in the glacial drift, or whether a better supply may be obtained at greater depth in the underlying bedrock formations. The wells in glacial drift commonly show no regional level, as the sands or gravels in which the water occurs are irregularly distributed and of limited extent. As the surface of the ground is uneven, the best means of comparing water wells is by the elevations of their water-bearing beds. For any particular well this elevation is obtained by subtracting the figure for the depth of the well to the water-bearing bed from that for the surface elevation at the well. For convenience both the elevation of the wells and the elevation of the water-bearing bed or beds in each well are given in the well record tables. Where water is obtained from bedrock, the name of the formation in which the water-bearing sand occurs is also listed in these tables, and this information should be used in conjunction with that 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 subtracting 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 Cretaceous 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:

<u>Formation</u>	<u>Character</u>	<u>Thickness</u> 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 Azar. 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 Pale and 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 Coulee 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 Coulee 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 Coulee, 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 Coulee 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 aquifer, 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 Coulee. 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 3 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 Coulee. 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 100 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 Coulee 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 Coulee 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 these 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<sub>4</sub>), chloride (Cl), and carbonate (CO<sub>3</sub>) 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<sub>3</sub>) and calcium sulphate (CaSO<sub>4</sub>).

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<sub>4</sub>) 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<sub>2</sub>SO<sub>4</sub>) combines with water to form "Glauber's salt" and excessive amounts make the water unsuitable for drinking purposes. Sodium carbonate (Na<sub>2</sub>CO<sub>3</sub>) 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<sup>1</sup>. Sodium sulphate is less

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"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 ( $\text{SO}_4$ ) salts referred to in these analyses are calcium sulphate ( $\text{CaSO}_4$ ), magnesium sulphate ( $\text{MgSO}_4$ ), and sodium sulphate ( $\text{Na}_2\text{SO}_4$ ).

Chloride. Chlorine (Cl) is with a few exceptions, expressed as sodium chloride ( $\text{NaCl}$ ), 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 ( $\text{CO}_3$ ) 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<sub>2</sub> to very hard, and can be classified according to the following system :

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

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- 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 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<sup>1</sup>.

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Piper, A. M. "Ground Water in Southwestern Pennsylvania", Penn. Geol. Surv., 4th series.

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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.  $\frac{1}{4}$  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:

	SE. sec. 16, NE. sec. 3, SW. sec. 7, SE. sec. 21	tp.38, rge. 21	tp.39, rge. 25,	tp.37, rge.24,	tp. 38,rge.23
Salts					
CaCO <sub>3</sub>	73	18	53	35	
CaSO <sub>4</sub>	-	-	-	-	
MgCO <sub>3</sub>	52	14	45	38	
MgSO <sub>4</sub>	-	-	-	-	
Na <sub>2</sub> CO <sub>3</sub>	297	679	464	562	
Na <sub>2</sub> SO <sub>4</sub>	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 <sub>3</sub>	250	305	125
CaSO <sub>4</sub>	-	-	-
MgCO <sub>3</sub>	1109	80	155
MgSO <sub>4</sub>	149	104	69
Na <sub>2</sub> CO <sub>3</sub>	-	-	-
Na <sub>2</sub> SO <sub>4</sub>	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. sec. 10, tp.35, rge. 20,
CaCO <sub>3</sub>	73	73	73	198	108	90
CaSO <sub>4</sub>	-	-	-	-	m-	-
MgCO <sub>3</sub>	38	38	38	52	69	52
MgSO <sub>4</sub>	-	-	-	-	-	-

Na <sub>2</sub> CO <sub>3</sub>	129	119	129	11	106	125
Na <sub>2</sub> SO <sub>4</sub>	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	3,866	4,460
Hardness	135	90	110	100	130	130

The similarity in these analyses 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 illustrate some of the different types of water from this formation:

	Se.sec. 11, tp. 46, rge.	Ind.Agent Little Pine I.R.	SW.sec. 24, tp. 46, rge.	NE.sec. 36, tp. 43, rge.	Se.sec. 26, tp. 43, rge.	NE.sec. 36, tp. 41, rge.	NW.sec. 22, tp. 42, rge.
Salts	28		21	18	18	24	23
CaCO <sub>3</sub>	90	90	410	73	35	73	125
CaSO <sub>4</sub>	-	-	-	-	-	-	-
MgCO <sub>3</sub>	97	59	168	38	31	38	97
MgSO <sub>4</sub>	-	-	64	-	-	-	-
Na <sub>2</sub> CO <sub>3</sub>	217	392	-	283	592	129	196
Na <sub>2</sub> SO <sub>4</sub>	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 ( $\text{Na}_2\text{CO}_3$ ), 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 MEOTA, NO. 468, SASKATCHEWAN

Physical Features

Jackfish Lake, which now occupies the greatest part of tp. 47, rge. 17, is the remnant of a much larger lake that extended to the west and south shortly after the ice-mass retreated from the area. The area once occupied by this lake is now a flat plain covered with the silts and clays that were laid down in the basin. The east shore of Jackfish Lake marks the western edge of a large, northwesterly trending terminal moraine, which rises to a height of 500 feet above the level of the lake within a few miles. Jackfish Creek enters the lake from the north in a deep, broad valley that at one time must have been one of the larger streams entering the glacial lake. Several large gravel deposits border the channel, indicating further that a large amount of water formerly flowed into the lake from this direction. To the east of Jackfish Lake, along the edge of the moraine, large deposits of coarse sand and gravel show that some of the water entered the lake from the east.

The south part of Meota municipality is a flat plain now partly covered by glacial lake silts, sands, and clay. It is cut by Crystal, Jackfish, and Turtle Rivers, with North Saskatchewan River forming the southwest boundary. The banks of this river are steep and more than 150 feet high. Turtle River, which joins the Saskatchewan in this municipality, also has steep banks enclosing a narrow valley, but in the vicinity of both Jackfish and Crystal Rivers the country is swampy, and the river banks are very low.

Geology

Known outcrops of bedrock are limited to two localities in this municipality. A section of shale, sandy shale, and fine green sand is exposed at the south end of Jackfish Lake on sec. 6, tp. 47, rge. 16. The shale is marine, but the sand contains small fragments of carbonaceous material. The sands are fine, and in this respect are unlike the Ribstone Creek sands in the vicinity of Paynton, and are placed within but near the top of the Lea Park formation. Shale outcrops were found on the east side of the lake in secs. 6 and 8, tp. 48, rge. 18. These are dark grey, and are typical of the Lea Park formation. Furthermore, as shale was everywhere encountered in wells penetrating the drift between the two locations mentioned above, it is reasonable to conclude that the Lea Park shale underlies the drift throughout the area. Northeast of Jackfish Lake, where the land rises 500 to 600 feet above the level of the lake, it is not known whether the rise is wholly owing to an increase in thickness of the glacial drift, or in part to a rise in the bedrock in that direction. In the latter case the higher beds stratigraphically would be expected to the northeast, and the Ribstone

Creek formation may thus underlie a part of the higher land. There appears to be no sands in the upper part of the bedrock in the northwest part of the municipality, as the deep dry holes encountered only shale below the drift. One hole was drilled to a depth of 415 feet on sec. 4, tp. 49, rge. 13, without striking either water or sand. The only indication of a bedrock sand is in a well on SE. sec. 14, tp. 48, rge. 13, where a good supply of water is obtained in a fine yellow sand at a depth of 100 feet, or an elevation of 1,713 feet. The material from this well was not available for examination, and, hence, it is impossible to state whether it represents glacial sand or a sand member in the bedrock. A plausible explanation appears to be that the well is in a pre-glacial drainage channel that has been filled with glacial sand.

Bedded silts and clays deposited by a glacial lake compose the surface materials of the south part of this area. They are underlain by glacial drift, below which are Lea Park shales. These shales outcrop along Turtle River, and have been encountered in several wells. An unusual feature of this area is a deep, pre-glacial channel in the vicinity of Scentgrass. A large terminal moraine lies northeast of this area, cutting across the corner of the eastern township, and in front or to the west of this is an outwash plain of sand carrying water. In one well at Scentgrass a sand lens believed to be in the Lea Park was encountered at a depth of 260 feet or an elevation of 1,532 feet. Such sand lenses are known elsewhere from the Lea Park, but are unusual.

#### Water Supply

As the surface deposits of glacial origin are so diverse, it is evident that possibilities for a good supply of water in them will vary accordingly. Sand beds suitable as aquifers are not known to be present in the bedrock, and, consequently, the glacial deposits must be relied upon to yield the necessary supply. In the area covered with lake silts west and south of Jackfish Lake the glacial material is not thick, several wells having encountered bedrock shale at a depth of 20 feet. Nor does the amount of boulder till below the lake deposit appear to be large. The water horizon in this area is in a sand below the lake silts, or, where this sand is absent, a seepage supply is commonly obtained on top of the shale, but does not always yield an adequate amount of water. In the morainal deposits north and east of Jackfish Lake, water is obtained in sand and gravel deposits irregularly distributed through the drift, which appears to be very porous judging from the character of the surface material. Small bodies of outwash gravels along the western edge of the moraine should yield a good supply at very shallow depths.

In the southeast part of the same area an outwash deposit of sand slopes westward. It probably resulted from deposition by water derived from melting ice at the same time as the terminal moraine to the northeast was accumulating. This outwash sand deposit is a good source of water. In some places, however, the drift is very thin, and wells at a shallow depth have reached the underlying Lea Park shales.

Much the greater number of wells that have tested the Lea Park shales have found no water, and drilling deep wells in them is not recommended.

Township 46, Range 16. In this township Crystal Creek flows northwesterly to Murray Lake, and along its low banks the adjoining land is marshy. All the wells in the township, with the exception of two deep wells drilled by the Canadian National Railway at Scentgrass, are less than 60 feet deep, and obtain water from an outwash deposit of gravel and sand at elevations of 1,740 to 1,760 feet. This deposit is the best and most constant source of water in the township, and no doubt could be tapped by other wells. It is probably supplied by water from the hills to the north-east. The deep wells in Scentgrass appear to be in a pre-glacial valley. In the well at the section house, sand and gravel is reported in the drift at a depth of 197 feet, or an elevation of 1,595 feet. Thus, it is inferred that the drift is at least 200 feet thick in this area, in spite of the fact that outcrops of Lea Park shale occur on the steep bank of Jackfish Lake only a few miles from the northwest corner of the township. In the range to the east, at Iffley, artesian water is found in a buried stream channel. The elevation of the surface of the flowing wells at Iffley is 1,760 feet, and the water will rise 35 to 40 feet above the surface. In the well at the Canadian National Railway section house at Scentgrass the water rises to 1,757 feet, but comes from a somewhat lower level than in the wells at Iffley. Obviously, therefore, the aquifers in the two areas have no direct connection, but both are probably in the same pre-glacial channel, which must have joined the pre-glacial, North Saskatchewan River Valley, although the place of junction is unknown. At present the elevation of North Saskatchewan River at Battleford is less than 1,550 feet, or below the level of the gravel deposit in the bottom of the Scentgrass well.

In another well, 283 feet deep, at the Stock Yards at Scentgrass, a fine sand was encountered at 260 feet, or an elevation of 1,532 feet, and continued to the bottom of the well at 1,509 feet. This sand is believed to be a sand within the Lea Park formation. Its extent is unknown.

Township 46, Range 17. Jackfish River cuts across the flat surface of this township between banks that are very low. The surface is believed to be a glacial lake deposit of stratified sands, silts, and clays. Where these sands are moderately coarse they form good aquifers, but the silts are too fine to serve as water-bearing zones. Several wells encountered shales of the Lea Park formation at shallow depths, and these are usually a poor source of water. In one well 107 feet deep, on SW. section 25, a fine, water-bearing sand was encountered. Unless this well is in a pre-glacial channel, as in the case of the Canadian National Railway well at Scentgrass, it must be in a sand in the Lea Park shales. Such sands are known from a number of places, but the prospects of striking one of them in a well are not considered good, as they are thought to be local sand lenses. Wells on NW. section 19, SW. section 28, and SW. section 30 are believed to have encountered the top of the Lea Park shale at

a shallow depth. The well on SW. section 30 was drilled to a depth of 170 feet, most of which was in shale. No sand body and, consequently, no water was encountered in this shale, although the well was sunk to an elevation of 1,590 feet. This is still 100 feet above the sand in the Lea Park at Scentgrass Stockyards' well. It is not known how extensive this Lea Park sand may prove to be, but a well 350 feet deep, on SW. section 25, apparently did not encounter it, although the well was sunk considerably below the level at which it would be expected to occur.

Township 46, Range 18. The southwestern boundary of this township is North Saskatchewan River. The river valley slopes are steep, and more than 150 feet high. Turtle River, with a narrow, steep-sided valley, joins North Saskatchewan River from the northwest. Glacial lake silts, sands, and clays cover this area, and a moraine deposit lies along its northern side.

Mostly the water supply is obtained from wells less than 35 feet deep in sand and gravel beds in the drift below the glacial lake deposits. Most of the aquifers are at elevations of 1,720 to 1,740 feet, with a few at other altitudes. One well, on NW. section 16, was drilled in yellow sand to a depth of 100 feet or an elevation of 1,635 feet. The sand is thought to be glacial, and may be in a bedrock channel filled with glacial material. Another well, 170 feet deep on SW. section 24, struck the Lea Park shale and found no water. The depth to the base of the drift in this well is not known. Throughout the township Lea Park shales are thought to underlie the drift, as outcrops occur along Turtle River. These shales contain no widespread aquifers, and the prospects of finding water in them are very poor. Deep drilling for water is, therefore, of no use in this township, and dependence must be placed entirely on finding water-bearing sand and gravel deposits in the drift.

Township 47, Range 16. Murray Lake parallels the edge of the large terminal moraine that rises more than 300 feet in a short distance to the northeast. So far as known this rise is caused by a thick deposit of glacial drift, as no outcrops were found along the deeply eroded valleys. Bordering the lake on the south the drift is relatively thin. On section 5 it is 40 feet thick, and contains only a little gravel close to the base. An outcrop of the underlying strata, on section 6 along the bank of Jackfish Lake, exposes shale underlain by sandy shale and by a bed of very fine sand and sandstone. Marine fossils were found in the shales, and, hence, it was concluded that these beds represent the upper part of the Lea Park formation. The sand is too fine to be of any great value as an aquifer. These sands extend beneath the ridge between Jackfish and Murray Lakes. Northeast of Murray Lake the bedrock was not observed nor reported in any of the wells, and, lacking the information, it is difficult to determine the elevation of the bedrock surface in this direction. Most of the wells in this part of the township get a good supply of water at shallow depths. A typical well is the one recorded on section 27, which encountered a good water supply at a depth of 22 feet. Sand and gravel form irregular deposits in the

drift; they vary greatly in size, and are believed to be particularly numerous in the upper part of the deposit.

Township 47, Range 17. Much of this township is occupied by Jackfish Lake. The land surface surrounding the lake is covered with fine silts that were laid down under water when the lake extended over a large area to the south and west. These silts form the main glacial deposit above the underlying bedrock shale. Their thickness ranges from a few feet to 15 feet, and commonly a sand close to the base acts as an aquifer. When the sand is absent a supply of water may accumulate as seepage on top of the shale. Some of the farmers have, however, been unable to obtain sufficient water from wells and have had to haul part of their supply from Jackfish Lake. Drilling deep wells into the shale has failed to yield any water below the surface deposit. A hole was drilled to a depth of 1,100 feet in the village of Meota. Shale was encountered at a depth of 40 feet, and there appeared to be no change in the formation below this depth. The lake clays associated with the silts resemble the shale in appearance and may be easily mistaken for it. The importance in making a distinction between them lies in the fact that sand and gravel may be found below the lake clay, whereas it is highly improbable that sand will be found in the shale. The base of the lake deposit and the top of the shale, therefore, are the most important water-bearing horizons. If the water supply is a seepage on top of the shale it can, in places, be increased by locating a low position that has a fairly large drainage surface.

Township 47, Range 18. Almost all of this township was at one time the bed of a glacial lake. The silts and clays laid down in it form the surface deposits, except for the sandy area in the southwest corner that has a fluvio-glacial origin associated with Turtlelake River. These lake silts constitute almost the total thickness of the glacial deposits that overlie the bedrock shale, as such boulder till as may be present below the bedded silts seems to be very thin. No bedrock outcrops in the township, but several wells have struck shale below the drift, indicating that the Lea Park formation underlies the surface material.

As the water supply must be obtained in the surface deposits, all the wells are shallow. Records show that they range in depth from 10 to 40 feet, with most of them about 15 feet deep. This represents the thickness of the surface material, as a number of wells encountered the underlying, dark, impervious shale at elevations between 1,760 and 1,750 feet. These levels are higher than that of Jackfish Lake, indicating that the bedrock surface slopes towards the east.

Only one water horizon occurs in the surface deposits, but an additional supply of water may be obtained in places from seepage on top of the shale. The horizon is a sand bed that appears to be continuous at or near the base of the deposit of bedded lake silts. This sand varies in texture and does not offer the same water prospects at all points. The elevation of the sand is close to 1,760 feet along the western side of the township, the surface of which

slopes gradually towards Jackfish Lake. The amount of water obtainable is in direct proportion to the amount and character of the sand. Where the sand is extremely fine a fair amount of water may be obtained at the contact between the shale and surface material. This source is expected to be much better along the eastern side of the township, as the drainage surface slopes in that direction, and if an old channel can be located a good supply should be obtained. Along the western side, where the bedrock surface may be more or less flat, seepage at the contact may not yield any large amount of water unless small drainage channels can be located on top of the shale. Digging into the shale any great depth has failed to produce water.

Township 48, Range 16. The rugged topography of this township is that typical of the western front of the terminal moraine. Numerous gullies and small streams that trend and flow to the southwest dissect the morainal deposit into a series of ridges along the western front. Associated with these streams are large gravel deposits that were formed when large streams of water from the retreating ice mass flowed into Jackfish Lake. The relief, as shown by the map, is more than 400 feet. Whether this relief is represented wholly by the morainal deposit cannot be definitely determined until tested by the drill, as no outcrops of the bedrock were seen anywhere in the moraine, but as a large number of moraines are controlled by a rise in the bedrock surface it seems very probable that similar conditions may be encountered with this moraine.

As most of the township is part of an Indian reserve, and as the remainder is poor agricultural land, very few wells have been dug. These are all shallow, typical of the one recorded on section 24. The sand and gravel deposits in the drift are irregularly distributed throughout the boulder till, and hence their occurrence is difficult to predict. It would appear from the character of the surface material that the upper part of the drift contains a large number of these lenses or pockets of sand and gravel.

Township 48, Range 17. The surface deposits in this township are reflected in the various topographical features. Jackfish Creek, which now is a small stream in a large deep valley, at one time was a large river that entered Jackfish Lake or its equivalent during glacial time. Bordering this channel are two moraines: the one on the east is a terminal moraine, dissected by numerous small streams in deep gullies coming from the northeast. West of Jackfish Creek a small morainal deposit trends in the same direction. Between this moraine and Jackfish Creek are several large gravel deposits, apparently associated with the old channel. The flat plain west of Jackfish Lake is part of the old lake bed, and bedded silts are also found on the higher hills in the vicinity of Jackfish Lake post office up to an elevation of 1,850 feet.

The water supply of the township varies with the different deposits. In the morainal deposits to the east and north water is obtained in gravel and sand at various depths. Several springs emerge along the base of the larger hills; these are associated with gravel deposits that are fairly extensive in some of the larger valleys. One of the

largest springs is on NW. section 23. On the higher land the sand and gravel may not be so uniformly distributed, and locating a good supply of water is largely a matter of chance.

In the flat area west of Jackfish Lake water is obtained in a fine sand. This sand is believed to lie below the bedded silts, and has a fairly large lateral extent. Farther north, in sections 8 and 17, the bedrock shale is near the surface. Very little sand is present, and the water supply must be obtained as a seepage on top of the shale. Locating a low area on the shale surface, which acts as a drainage basin, should yield a good supply of water as long as the annual rainfall remains normal. A decrease in precipitation will soon be reflected in the water supply.

Township 48, Range 18. The surface deposit in this township is made up almost entirely of ground moraine. The topography is rolling in character, becoming morainal in the northeast part. The drift is not very thick, as indicated by the large number of wells that have encountered the underlying shales at depths between 20 and 40 feet.

Outcrops of Lea Park shale occur on the east side of Jackfish Lake in sections 6 and 7. These shales are believed to underlie the drift everywhere in the township, and it is, therefore, essential that the water supply be obtained in the glacial material. Where the drift does not contain sand and gravel the only available source will be a seepage at the contact with the shale.

It is difficult to outline definite water horizons in this township, as records of only a limited number of wells are available for study. The top of the shale surface, however, gives a good indication of the dip or slope of the sand or gravel lenses that may be present in the boulder till, as these roughly parallel one another. The surface of the shale rises from 1,738 feet in section 4 to 1,865 feet in section 32, showing a marked slope to the southeast of about 15 feet to the mile. The wells penetrating the drift are chiefly confined to a strip trending diagonally across the township from the northwest corner. The water supply is commonly inadequate, and is obtained as a seepage on top of the shale, as there is very little sand in the drift. The quality of the water is also very poor. Similar conditions prevail along the south side. In areas such as these very few recommendations on how to improve the supply can be offered. When the surface material is glacial till there is always the possibility of striking a new sand or gravel deposit with a good supply of water. The seepage supply, however, may be improved by locating a well in a depression or drainage channel on top of the shale surface, though the quality of the water within the drift is generally better than that of the seepage water that has come in contact with the shale.

In the northeast part of the township water is obtained in sand and gravel within the boulder till. A typical well in the area is located on NE. section 23, which

yields a good supply at a depth of 16 feet.

A low water horizon was encountered in a well 100 feet deep on SE. section 14, at an elevation of 1,713 feet. This is doubtfully a sand in the shale, as none was encountered in the deep holes elsewhere in this district, but is more probably a glacial sand of an old drainage channel cut into the shale. Tracing such a channel is difficult until it has been identified at several definite locations. The elevation of this sand is lower than Jackfish Lake, which suggests an old outlet for the lake in this direction.

ANALYSES OF WATER SAMPLES FROM RURAL MUNICIPALITY OF MOOTA NO. 468, SASKATCHEWAN.

No.	† Sec.	Tp.	Rge.	Depth in feet	Total dis- solved solids	Constituents as Analysed					Total Hardness	Constituents as Calculated in assumed Combinations					Source of Water		
						Ca	Mg	Na	SO <sub>4</sub>	Cl.		Alk.	CaCO <sub>3</sub>	CaSO <sub>4</sub>	MgCO <sub>3</sub>	MgSO <sub>4</sub>		Na <sub>2</sub> CO <sub>3</sub>	Na <sub>2</sub> SO <sub>4</sub>
7	NW 10	46	16	283	1220	79	35	307	451	30	515	420	198		121	183	658	50	Lea Park

RECORDS OF WELLS IN RURAL MUNICIPALITY OF MEOTA NO. 468, SASKATCHEWAN.

Well No.	LOCATION				Type of Well	Depth of Well	Altitude of Well	WATER LEVEL		PRINCIPAL WATER-BEARING BED		Character of Water	Use to Which Water is Put <sup>x</sup>	Yield & Remarks
	Sec.	Tp.	Rge.	Mer.				Above (+) Elev.	Below (-) Sea Surface Level	Depth Elev. Ft.	Geol. Horizon			
1	N.W. 1	46	16	3	Dug	16	1800		16	1784	Hard Fe.	D.S.	Sufficient. Possibly in Shale.	
2	S.W. 2	"	"	"	"	30	1788	-27	1761	1758	Black sand	"	"	Sufficient
3	N.E. 2	"	"	"	Bored	50	1800	-40	1760	1750	Gl. gravel	"	"	"
4	S.W. 4	"	"	"	"	41	1783			1743	Coarse sand	"	"	"
5	N.W.10	"	"	"	Drilled	283	1792	-29	1763	1509	Fine Lea Park sand	S.	"	C.N.R. Stockyards Well
6	N.W.10	"	"	"	"	197	1792	-35	1757	1595	Sand & Grav.	"	"	Scankgrass
7	N.E.15	"	"	"	Dug	30	1788	-26	1762	1758	Fine sand	Hard Alk.	D.S.	C.N.R. Sectionman's "
8	S.W.26	"	"	"	Bored	43	1792	-37	1755	1752	Coarse "	"	"	Sufficient
9	S.W.30	"	"	"	Dug	55	1759			1705	" gravel	"	"	Poor supply. Dry Hole 110'.
1	S.E. 2	46	17	3	Dug	28	1772			1744	White sand	Hard Alk.	D.S.	Sufficient
2	N.W. 3	"	"	"	"	26	1752			1726	Yellow "	"	"	"
3	S.E. 4	"	"	"	"	25	1742	-15	1727	1724	" "	"	"	"
4	N.E. 5	"	"	"	"	35	1739	-28	1711	1704	Sandy clay	"	"	Limited
5	S.W.11	"	"	"	Bored	23	1752			1729	Fine sand	Soft	"	Sufficient
6	S.W.14	"	"	"	Dug	22	1759			1737	" "	Hard Alk.	D.M.	" Village of Prince.
7	N.W.14	"	"	"	"	20	1764	-17	1747	1744	Sand	Hard Alk.	D.S.	Poor supply
8	S.W.16	"	"	"	"	18	1759	-17	1742	1741	Fine sand	"	S.	Limited " Blue clay below sand.
9	S.E.17	"	"	"	"	26	1740			1716	Coarse sand	Hard Fe.	D.S.	Sufficient
10	N.W.19	"	"	"	"	95	1760						"	Dry Hole in Shale.
11	N.E.20	"	"	"	"	16	1745			1729	Blue clay	Hard	"	Sufficient
12	S.E.23	"	"	"	Bored	26	1765	-20	1745	1739	Fine sand	"	"	Limited. Sand underlain by blue clay or shale.

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

Well

No.

13	N.W.24	46	17	3	Dug	23	1749	-18	1731	23	1726	Fine sand	Hard Alk.	D.S.	Sufficient
14	S.W.25	"	"	"	Drilled	350	1749					Fine sand	Hard Alk.		Dry Hole in Lea Park Shale
15	S.W.25	"	"	"	Bored	107	1749			107	1642	Fine sand	"		Sand trouble
16	S.W.28	"	"	"	Dug	18	1750			16	1734	Sandy clay	"	D.S.	Sufficient
17	S.W.30	"	"	"	Brilled	170	1761			17	1744	"	"		Very poor supply. On top of Shale.
18	S.W.33	"	"	"	Bored	110	1757								Dry hole, shale below 30 ft.
1	S.E.9	46	18	3	Dug	22	1745	-20	1725	16	1729	Fine sand	Hard Alk.	D.S.	Sufficient
2	N.E.11	"	"	"	"	32	1750	-28	1722	30	1720	Sand	Hard	"	"
3	N.W.11	"	"	"	"	25	1735	-21	1714	25	1710	Glacial gravel	" Alk.	"	"
4	S.E.12	"	"	"	"	19	1739			19	1720	Sand & Yellow sand	Hard	"	Poor supply
5	N.W.16	"	"	"	Bored	100	1735			100	1635	Fine sand	Hard Alk.	S.	Shallow Well 18' in Gravel.
6	S.W.16	"	"	"	Dug	39	1758	-33	1725	34	1724	Fine Clay	Hard Alk.	"	Sufficient
7	S.E.16	"	"	"	"	25	1753	-23	1730	25	1728	Clay	Hard Alk.	"	Poor supply
8	S.E.20	"	"	"	"	20	1728	-17	1711	20	1708	Fine sand	Hard Alk.	D.S.	Sufficient
9	N.W.21	"	"	"	"	21	1738			21	1717	Sand & Grav.	Hard	"	"
10	S.W.24	"	"	"	Drilled	170	1750								Dry Hole in Shale
11	S.W.24	"	"	"	Dug	23	1750†			23	1727	Fine sand	Hard	D.S.	Good supply
12	N.W.24	"	"	"	Bored	40	1760			20	1740	Coarse "	" Alk.	"	Sufficient

WELL RECORDS—Rural Municipality of Meota No. 468, Saskatchewan.

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				
NW 31	46	18	3	dug	20	1755	-16	1739	16	1739	glacial	med. soft	D.S.	Good supply in blue clay			
NE 32	46	18	3	dug	20	1785			20	1765	glacial	hard alk.	S.	Limited supply in blue clay			
NW 33	46	18	3	dug	36	1780	-11	1769	36	1744	glacial	hard alk.	S.	Good supply. Water comes through rock.			
NW 34	46	18	3	bored	36	1790			36	1754	glacial	hard		Well incomplete at time of visit. Water in gravel.			
NE 34	46	18	3	bored	29	1785			29	1756	glacial	hard alk.	S.	Water in sand			
SW 35	46	18	3	bored	57	1790	-18	1772	57	1733	glacial	hard	S.	Good supply			
SW 5	47	16	3	bored	90	1752									Dry hole. Shale below 40 feet.		
NE 16	47	16	3	bored	69	1877			51	1826	glacial	hard	D.S.	Limited supply in coarse sand			
SE 27	47	16	3	dug	22	1892			22	1870	glacial	hard	D.S.	Good supply in fine sand.			
NW 2	47	17	3	bored	200	1773									Dry hole. Shale below 40 feet.		
SW 4	47	17	3	bored	26	1786			24	1762	glacial	soft	D.S.	Good supply in coarse red sand			
SE 6	47	17	3	bored	100	1801			94	1707	glacial	hard	D.S.	Limited supply in white sand			
SW 18	47	17	3	dug	16	1753			16	1737	glacial	hard	D.S.	Good supply in fine sand			
SW 8	47	17	3	drilled	1100	1761									Dry hole. Shale below 40 feet		
NW 31	47	17	3	bored	40	1778			30	1748	glacial ?	soft	D.S.	Limited supply in fine sand.			
NW 3	47	18	3	dug	14	1773	- 10	1763	14	1759	glacial	hard	D.S.	Good supply in sand.			
NE 4	47	18	3	dug	14	1778	- 10	1768	10	1768	glacial	hard	D.S.	Limited supply in gravel and sand.			
NE 8	47	18	3	dug	12	1773	- 8	1765	10	1763	glacial	hard	D.S.	Water on top of shale.			
NW 10	47	18	3	dug	16	1768			12	1756	glacial	soft	D.S.	Good supply in sand bed 2 feet thick			
SW 11	47	18	3	dug	25	1833									Dry hole. Shale below 20 feet.		
NE 16	47	18	3	dug	22	1783			20	1763	glacial	hard alk.	D.S.	Limited supply on top of shale.			
NW 16	47	18	3	dug	17	1773	- 14	1759	16	1757	glacial	hard alk.	D.S.	Limited supply in fine sand.			
SE 20	47	18	3	dug	17	1773	- 12	1761	12	1761	glacial	hard alk.	D.S.	Limited supply in sand below bedded silts.			
SE 23	47	18	3	dug	22	1765			20	1745	glacial	hard alk.	D.S.	Good supply in fine sand.			
NE 26	47	18	3	bored	58	1773	- 28	1745	40	1733	glacial	hard	D.S.	Good supply on top of shale			
NW 27	47	18	3	bored	16	1778			16	1762	glacial	hard alk.	S.	Limited supply on top of shale			
SW 33	47	18	3	bored	37	1779			36	1743	glacial	hard alk.	D.S.	Good supply on top of shale			
NW 33	47	18	3	dug	16	1779			12	1767	glacial	hard alk.	D.S.	Good supply in coarse grey sand			
SW 35	47	18	3	dug	14	1748	- 8	1740	14	1734	glacial	hard alk.	D.S.	Good supply in fine 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 Meota No. 468, Saskatchewan.

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				
SE	24	48	16	3	dug	12	2180	- 9	2171	12	2168	glacial	hard		D.S.	Good supply in gravel and sand	
SE	6	48	17	3	dug	27	1760	-22	1738	27	1733	glacial	hard		D.S.	Good supply in fine sand	
NW	7				bored	60	1833			60	1773	glacial	hard alk.		S.	Limited supply on top of clay	
SW	23				dug	45	1777	-17	1760	45	1732	glacial	hard alk.		D.S.	Good supply in sand and gravel	
NW	23				spring		1750+						hard		S.	Very large continuous flow.	
SE	4	48	18	3	dug	50	1808			40	1768	glacial	hard		S.	Limited supply on top of shale	
NW	4				dug	22	1798			20	1778	glacial	hard		D.S.	Good supply in fine grey sand	
NW	5				dug	22	1783			18	1765	glacial	hard		D.S.	Good supply. Top of shale at 20 feet.	
NE	7				bored	35	1813	-25	1788	33	1780	glacial	hard		D.S.	Limited supply on top of shale	
NW	12				bored	44	1813			38	1775	glacial	soft		D.S.	Limited supply in yellow sand	
SE	13				bored	70	1753			35	1718	glacial	hard alk.		D.	Seepage on top of shale	
SE	14				bored	100	1813			100	1713	glacial ?	hard		D.S.	Good supply in fine yellow sand.	
SW	14				bored	30	1783			30	1753	glacial	soft		D.S.	Limited supply in fine sand.	
NW	14				bored	28	1798			40	1758	glacial	hard alk.		D.S.	Good supply	
SW	22				dug	35	1823									D.S.	Dry hole. Shale below 35 feet. Good supply in well. 9 feet deep in gravel.
NE	23				dug	16	1741			16	1725	glacial	soft		D.S.	Good supply in fine sand	
SW	28				bored	35	1860	-25	1835	35	1825	glacial	hard alk.		D.S.	Limited supply on top of shale	
NW	32				dug	23	1873			19	1854	glacial	hard alk.		D.S.	Limited supply on top of shale	
NW	32				bored	100	1883									D.S.	Dry hole. Shale below 20 feet.

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.