CANADA

DEPARTMENT OF MINES

AND

TECHNICAL SURVEYS

GEOLOGICAL SURVEY OF CANADA

WATER SUPPLY PAPER No. 256

GROUND-WATER RESOURCES OF THE RURAL MUNICIPALITY OF MERVIN NO. 499 SASKATCHEWAN

Records Collected by C. O. Hage

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

OTTAWA

1947

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MINES AND GEOLOGY BRANCH
BUREAU OF GEOLOGY AND TOPOGRAPHY

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INTRODUCTION

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

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

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

The water records were obtained mostly from the well owners, some of whom had acquired the land after the water supply had been found, and hence had no personal knowledge of the water-bearing beds that had been encountered in their wells. Also the elevations of the wells were taken by aneroid barometer and are, consequently, only approximate. In spite of these defects, however, it is hoped that the publication of these water records may prove of value to farmers, town authorities, and drillers in their efforts to obtain water supplies adequate for their needs.

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

Publication of Results

The essential information pertaining to ground-water conditions is being issued in reports that in Saskatchewan cover each municipality, and in Alberta cover each square block of sixteen townships beginning at the 4th meridian and lying between the correction lines. The secretary treasurer of each municipality in Saskatchewan and Alberta will be supplied with the information covering that municipality. Copies of the reports will also be available for study at offices of the Provincial and Federal Government Departments. Further assistance in the interpretation of the reports may be obtained by applying to the Chief Geologist, Geological Survey, Ottawa. Technical terms used in the reports are defined in the glossary.

How to Use the Report

Anyone desiring information concering ground water in any particular locality will find the available data listed in the well records. These should be consulted to see if a supply of water is likely to be found in shallow wells sunk in the glacial drift, or whether a better supply may be obtained at greater depth in the underlying bedrock formations. The wells in glacial drift commonly show no regional level, as the sands or gravels in which the water occurs are irregularly distributed and of limited extent. As the surface of the ground is uneven, the best means of comparing water wells is by the elevations of their water-bearing beds. For any particular well this elevation is obtained by subtracting the figure for the depth of the well to the water-bearing bed from that for the surface elevation at the well. For convenience both the elevation of the wells and the elevation of the water-bearing bed or beds in each well are given in the well record tables. Where water is obtained from bedrock, the name of the formation in which the water-bearing sand occurs is also listed in these tables, and this information should be used in conjunction with that provided on bedrock formations, pages 4 to 8, which describes these formations and gives their thickness and sequence. Where the level of the water-bearing sand is known, its depth at any point can easily be calculated by substracting its elevation, as given in the well record tables, from the elevation of the surface at that point.

With each report is a map consisting of two figures. Figure 1 shows the bedrock formations that will be encountered beneath the unconsolidated surface deposits. Figure 2 shows the position of all wells for which records are available, the class of well at each location, and the contour line or lines of equal surface elevation. The elevation at any location can thus be roughly judged from the nearest contour line, and the records of the wells show at what levels water is likely to be encountered. The depth of the well can then be calculated, and some information on the character and quantity of water can be obtained from a study of the records of surrounding wells.

GLOSSARY OF TERMS USED

Alkaline. The term "alkaline" has been applied rather loosely to some ground waters that have a peculiar and disagreeable taste. In the Prairie Provinces, water that is commonly described as alkaline usually contains a large amount of sodium sulphate and magnesium sulphate, the principal constituents of Glauber's salt and Epsom salts respectively. Most of the so called alkaline waters are more correctly termed sulphate waters, many of which may be used for stock without ill effect. Water that tastes strongly of common salt is described as salty.

Alluvium. Deposits of earth, clay, silt, sand, gravel, and other material on the flood plains of modern streams and in lake beds.

Aquifer or Water-bearing Horizon. A porous bed, lens, or pocket in unconsolidated deposits or in bedrock that carries water.

Buried pre-Glacial Stream Channels. A channel carved into bedrock by a stream before the advance of the continental ice-sheet, and subsequently either partly or wholly filled in by sands, gravels, and boulder clay deposited by the ice-sheet or later agencies.

Bedrock. Bedrock, as here used, refers to partly or wholly consolidated deposits of gravel, sand, silt, clay, and marl that are older than the glacial drift.

Coal Seam. The same as a coal bed. A deposit of carbonaceous material formed from the remains of plants by partial decomposition and burial.

Contour. A line on a map joining points that have the same elevation above sea-level.

Continental Ice-Sheet. The great ice-sheet that covered most of the surface of Canada many thousands of years ago.

Escarpment. A cliff or a relatively steep slope separating level or gently sloping areas.

Flood Plain. A flat part in a river valley ordinarily above water but covered by water when the river is in flood.

Glacial Drift. The loose, unconsolidated surface deposits of sand, gravel, and clay, or a mixture of these, that were deposited by the continental ice-sheet. Clay containing boulders forms part of the drift and is referred to as glacial till or boulder clay. The glacial drift occurs in several forms:

(1) Ground Moraine. A boulder clay or till plain (includes areas where the glacial drift is very thin and the surface uneven).

(2) Terminal Moraine or Moraine. A hilly tract of country formed by glacial drift that was laid down at the margin of the continental ice-sheet during its retreat. The surface is characterized by irregular hills and undrained basins.

(3) Glacial Outwash. Sand and gravel plains or deltas formed by streams that issued from the continental ice-sheet.

(4) Glacial Lake Deposits. Sand and clay plains formed in glacial lakes during the retreat of the ice-sheet.

Ground Water. Sub-surface water, or water that occurs below the surface of the land.

Hydrostatic Pressure. The pressure that causes water in a well to rise above the point at which it is first encountered.

Impervious or Impermeable. Beds, such as fine clays or shale, are considered to be impervious or impermeable when they do not permit of the perceptible passage or movement of ground water.

Pervious or Permeable. Beds are pervious when they permit of the perceptible passage or movement of ground water, as for example porous sands, gravel, and sandstone.

Pre-Glacial Land Surface. The surface of the land before it was covered by the continental ice-sheet.

Recent Deposits. Deposits that have been laid down by the agencies of water and wind since the disappearance of the continental ice-sheet.

Unconsolidated Deposits. The mantle or covering of alluvium and glacial drift consisting of loose sand, gravel, clay, and boulders that overlie the bedrock.

Water-table. The upper limit of the part of the ground wholly saturated with water. This may be very near the surface or many feet below it.

Wells. Holes sunk into the earth so as to reach a supply of water. When no water is obtained they are referred to as dry holes. Wells in which water is encountered are of three classes:

(1) Wells in which the water is under sufficient pressure to flow above the surface of the ground.

(2) Wells in which the water is under pressure but does not rise to the surface.

(3) Wells in which the water does not rise above the water table.

BEDROCK FORMATIONS OF WEST-CENTRAL SASKATCHEWAN AND EAST-CENTRAL ALBERTA

The formations that outcrop in west-central Saskatchewan are an extension of similar formations that occur in east-central Alberta. They are of Upper Cretaceoius 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 Macklin 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 associated with sand and gravel deposits that come close to the surface.

In soft water the calcium carbonate has been replaced by sodium carbonate, due to natural reagents present in the sand and clays. Bentonite and glauconite are two such reagents known to be present. Montmorillinite, one of the clay-forming minerals, has the same property of softening water, owing to the absorbed sodium that is available for chemical reaction[1].

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

If surface water reaches the lower sands by percolating through the higher beds it may be highly charged with calcium salts before reaching the bedrock formations containing bentonite or glauconite. The completeness of the exchange of calcium carbonate for sodium carbonate will, therefore, depend upon the length of time that the water is in contact with the softening reagent, and also upon the amount of this material present. The rate of movement of underground water will, consequently, be a factor in determining the extent of the reaction.

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

WATER ANALYSES IN RELATION TO GEOLOGY

Glacial Drift

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

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

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

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

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

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

Water from irregularly distributed sand and gravel beds will vary in its content of dissolved salts depending upon the character of the material surrounding the reservoir beds. As the water in this type of deposit does not flow to any marked extent, it is apt to be more highly impregnated with soluble salts than where the underground movement is more rapid. Soft water in the drift is mostly confined to shallow wells in sands low in calcium carbonate. Waters from glacial lake clays are sometimes high in soluble salts. The sample from a well in glacial lake clay on N.W. $\frac{1}{4}$ 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 a great deal of similarity and suggest a common horizon.

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

Ribstone Creek Formation

Chemical analyses of water from the Ribstone Creek formation vary more than in the Pale Beds, the reason being that at several different horizons the sediments show considerable lateral variation. 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 MERVIN, NO. 499, SASKATCHEWAN

Physical Features

Turtlelake River, with several of its tributaries, provides a well-developed drainage system in this municipality. These streams are indicative of the large amount of water that flowed to the south from the front of the retreating continental glacier that at one time covered the whole of the western Plains. The material transported by the ice was left as deposits of boulder clay, sand, and clay, and these were modified to a varying degree by the action of the water from the melting ice. The water, following the natural slope to the south, continued to flow over a large plain, and eroded channels, such as that of the deep, broad valley of Turtlelake River, where the gradients were steeper. Large gravel deposits are found adjacent to some of these old drainage channels, where the drift was subjected to erosion and not subsequently covered, leaving a concentration of boulders on the surface. This is the case in the southeastern part of tp. 50, rge. 21, and in many other similar areas. The thick, drift-covered areas of tp. 52, rge. 19, also show evidence of this erosion. Where the waters were dammed to form lakes, deposits of silts and clays were left on top of the boulder till. A deposit of this type, found along Turtlelake River in the vicinity of Turtleford, affords a medium-textured soil.

Geology

A few natural exposures of a dark grey marine shale occur along Turtlelake River in the vicinity of Mervin and Turtleford. The shale surface has also been reached in numerous wells, especially in the thin drift-covered areas of tp. 50, rge. 21. This shale resembles that of the Lea Park formation. The elevation of the shale surface rises to the north as far as Turtleford, beyond which no information is available on the elevation of the base of the drift, or the top of the shale. The top of the shale is an erosional surface and, therefore, irregular, and may show fully as much relief as the present surface. Higher beds stratigraphically may underlie the drift on the higher land, but there is no proof of this as none of the wells is known to have penetrated the drift where it is more than 100 feet thick.

Water Supply

All the water-bearing deposits in this municipality are in the glacial drift. These deposits are of various types. The more extensive sand and gravel beds are known as outwash deposits and interglacial sands. The latter are always to be found between two tills, whereas the former may or may not be buried. Most of the wells, however, are in isolated deposits of sand and gravel that are irregularly distributed through the drift. Outwash gravels occupy an area in the southern part of tp. 50, rge. 21. The drift is comparatively thin in tp. 50, rge. 20, and where no sand or gravel is encountered in it the only remaining source of water is a seepage supply at the shale and drift contact.

Township 50, Range 19. The gently southward-sloping ground moraine deposit of this township lies between two old drainage channels that at one time carried a large volume of water from the retreating ice-mass to the north and northeast. The thickness of the boulder till deposit increases from south to north, as the deeper wells in the north are still in glacial material.

The ground-water supply is obtained from wells in the glacial drift. The aquifers reached at depths ranging from 10 to 80 feet can be grouped mainly into two horizons, which in a general way follow the surface topography. The highest horizon found on the high land trending north and south between the creeks through the central part of the township has an elevation between 1,964 and 1,975 feet. Most of the wells to this horizon are shallow, and yield a good supply of water in gravel and sand. The well on SW. section 21 is 80 feet deep and the aquifer has an elevation of 1,967 feet. The aquifers represented by the wells in this group may be a series of small deposits of sand and gravel instead of a single large deposit.

The lower horizon varies in elevation from 1,871 feet in the south to 1,955 feet in the north. At intermediate points the elevations are between these levels. This aquifer follows the surface topography fairly closely and is encountered at shallow depths. The water supply is usually very good.

In the municipality to the south dark grey marine shales underlie the thin deposit of glacial drift. The surface of the bedrock rises to the north and northeast, and if it continues to rise in this municipality it will lie at no great depth below the lower water horizon referred to above. No continuous sand beds, such as might serve as good aquifers, are known to be present in the bedrock shales, and test wells into these are not recommended.

Township 50, Range 20. With the exception of a strip about a mile wide along its east side this township lies in the broad Turtlelake Creek Valley. This valley occupies a low area in the bedrock shale, an outcrop of which is exposed in a road-cut on the edge of the creek on section 19 at an elevation of 1,875 feet. Two miles to the west the shale is encountered in wells at an elevation of 1,925 feet. As a boulder till deposit occurs in the valley west of Mervin, this valley must have been a low area in the bedrock surface before the advance of the ice. The light, sandy, loam soil in the valley is derived from the river silts that were left by the glacial waters.

The ground-water supply is obtained from sand and gravel deposits in the glacial drift, the thickness of which varies considerably in different localities. In the valley of Turtlelake Creek the drift is considered to be very thin, but increases in thickness on the higher land to the east. The well on NW. section 32 obtains water in glacial material at a depth of 60 feet. This aquifer is considered to be very near the base of the drift, as the shale outcrops on section 19 at an elevation of 1,875 feet. Only one water horizon is known in the valley deposits, but an additional seepage supply may be obtained at the contact of the drift and with the underlying shale. The porosity of the sand in the drift varies greatly, resulting in both good poor wells in the same horizon. The elevation of the wells in the valley follow the surface topography very closely, being 1,882 feet on section 32 and 1,842 feet on section 4.

On the higher land to the east the water horizon rises, and a moderately good supply is obtained at comparatively shallow depths. The yield varies from well to well, and for this reason the aquifers are thought to be small, irregular bodies or lenses of sand and gravel; this idea is supported by the fact that few springs emerge along the bottom of the escarpment, indicating that the sand deposits on the higher land east of the valley are not large.

Township 50, Range 21. This township is underlain by the impervious shales of the Lea Park formation and, consequently, the water supply must be obtained from overlying glacial drift. This drift deposit is on the whole very thin. In the southern part of the township considerable has been removed by erosion along the old drainage channel of Englishman River, and a deposit of sand and gravel covering several square miles has been left on the flat plain. The northeast part of the township is covered by a deposit of boulder till from 15 to 25 feet thick.

In the area of outwash gravel north of the old drainage channel, water is easily obtained at shallow depths. Numerous springs occur in sections 16, 17, and 18, and it is believed that the shale lies only a few feet below the gravel deposit. In the northeast part water is not so easily obtained, and where the drift does not contain sand or gravel the only recourse is a possible seepage supply from the top of the shale. In this area the sand in the boulder till does not appear to be distributed at all uniformly, and a good well is only encountered by chance. The seepage supply from the shale surface varies in relation to the location of the well with respect to the altitude of this surface. As this surface is irregular, a low part or depression will yield more water than a high part where the drainage surface is small. In some places, where the drift is thin and does not contain too many boulders, these low areas can be located by means of auger test holes. Digging into the shale has failed to reveal a satisfactory aquifer, as a dry hole was drilled to a depth of 350 feet on NE. section 14.

Township 51, Range 19. Part of the early history of the surface deposits is revealed by the deep valleys now occupied by only small streams. Turtlelake River eroded a deep valley before it changed to its present course. The tributary that joins this dry channel in section 16 from the northeast drains a large basin on the east side of the township. The surface deposit of boulder till is considered to be more than 100 feet thick, especially on the west and north sides. The valley in section 19 is more than 130 feet deep, and as far as could be determined it has not cut through into the underlying bedrock, nor did dry holes, more than 100 feet deep, in section 35 penetrate the drift. In the southeast part of the township, on the lower land, the drift may be somewhat thinner, but the bedrock that underlies the drift is not known to contain any water-bearing sands. The nearest outcrop, in the vicinity of Turtleford, is shale, and drilling to a depth of several hundred feet in it did not reveal any water-bearing beds. It is, therefore, believed that a water supply exists only in the glacial drift.

Available data are insufficient to supply complete information on the water-bearing deposits in the drift. More sand and gravel may be present in the southeast part of the township, and hence the chances of obtaining water at shallower depths are better there than along the west and north sides. The deep dry holes on sections 26 and 35 reaching elevations of 1,980 and 1,975 feet respectively, indicate that the drift does not contain sand and gravel in sufficient quantities to act as reservoir beds for the required amount of water. The aquifers in the other wells on record have a higher level along the west and north sides of the township, and are considered to be local deposits with no great lateral extent, so that it is difficult to predict where others may be found.

Township 51, Range 20. Glacial lake silts form the surface soils along Turtlelake River. This deposit extends over most of the township, except the higher land through the central and eastern parts that have a covering of boulder till. The deposits of lake silts have an elevation range of about 200 feet. They are underlain by boulder till and may have been laid down when the lake stood at various levels.

Outcrops of the underlying Lea Park shale are exposed in the railraod cuts on section 6 at an elevation of about 1,920 feet. This shale has failed to yield any appreciable supply of good water. It is, therefore, concluded that the water supply is limited to sand and gravel beds within the drift deposit.

The relief in this township is in excess of 200 feet, and the elevations of the aquifers fall within this range. The depths of the wells vary from 8 to 85 feet, with most of them less than 50 feet. The water-table follows the surface topography fairly well, but sand and gravel must be encountered to yield the required supply for the average farm. These bodies of sand and gravel, as indicated by the wells, show some degree of uniformity within certain limits. In a boulder till deposit the amount of sand and gravel present depends on the amount of sorting and reworking that took place at the time of deposition. These deposits are usually in the form of pockets or lenses, and vary greatly in size. Widespread deposits are not as common as the smaller, isolated deposits but form better aquifers wherever encountered. The higher wells do not show any marked uniformity in the elevations of the water-bearing horizons, but the group of aquifers between elevations of 2,042 feet on section 8 and 2,078 feet on section 23 is indicative of an extensive sand and gravel deposit at this horizon, as shown by wells on sections 26, 27, and 28. On the lower land water is obtained from a lower source, and it is possible that this aquifer may extend to the east as the aquifer in the well on NW. section 22 has an elevation of 1,958 feet. Drilling into the shale south of the village of Turtleford has failed to produce more than a seepage supply of water.

Township 51, Range 21. The large streams that resulted from the retreating ice-mass eroded deep channels into the drift deposit and left a topography very similar to the present. During the early stages of Turtlelake River the water, or part of it, flowed to the southwest into Englishman River. During these early stages of development of the river the lower land lost much of its surface soil by erosion, and silt deposits left in the old drainage channels has since been partly removed by erosion.

The drift deposit is very thin in the valleys and on the lower land along the south side of the township. The shale surface was encountered in a well on section 2 at an elevation of 1,982 feet. This surface slopes to the west, as water is found at lower elevations above the shale in that direction. The higher land along the west side of the township and between the two streams has a thicker deposit of glacial drift, and no wells have penetrated it.

The drift is the only known source for the ground-water supply in the area, as the underlying shales have failed to produce any water where they have been tested. The depths of the wells range from only a few feet to 60 feet, and most of them are less than 30 feet deep. The gravel deposits along the old stream beds yield a good supply at shallow depths, as illustrated by the well on SW. section 12, which supplies the town of Turtleford. In the areas of thicker drift the water horizons follow the surface topography fairly closely. Most of the sand and gravel present occurs in small pockets and lenses, and these appear to be more abundant in the upper 30 feet. The deepest wells, however, are found on these higher plains on sections 20 and 26, at depths of 60 and 70 feet and elevations of 2,031 and 1,943 feet respectively. The latter must be near the top of the shale, as outcrops occur at slightly lower elevations in the vicinity of Turtleford. If this is so there may be a bed of sand or gravel on top of the shale in the area where these wells occur. The other wells in the immediate vicinity have aquifers close to this elevation.

Township 52, Range 19. Rocky ground moraine forms the surface deposit in this township. Turtlelake River has its source in Turtle Lake and flows diagonally to the southwest. At present this stream is very small, but its large deep valley was eroded shortly after the retreat of the ice from this section of the country.

There are no outcrops in the township, and all water wells are in glacial materials. The records show only three wells more than 35 feet deep, the remainder having an average depth of 20 feet. The thickness of the drift is difficult to estimate. On section 13 it is at least 85 feet deep as a well at this depth is in glacial gravel. The elevation of the bottom of the well is 2,136 feet, and is much higher than that of the well on section 6 where water is obtained at a depth of 50 feet at an elevation of 1,967 feet. This is lower than the top of the shale surface 10 miles to the southwest, and is probably near the base of the drift.

Aquifers in the east half of the township show a marked uniformity in elevation, which suggests the possibility of a buried sand and gravel deposit. The elevations in most of the wells lie between 2,134 feet and 2,111 feet, which approximates that of Turtle Lake at 2,126 feet. Along the west side of the township the country is higher and shows more morainal deposits. The aquifers there have elevations between 1,967 and 2,225 feet, but the information available does not suggest any large, continuous sand deposits.

Township 52, Range 20. Thunderchild Indian Reservation occupies more than half of the eastern part of this township. It is covered with a rocky ground moraine deposit of boulder till cut by several deep gullies draining into Turtlelake River. Glacial-lake silts cover the southwest part of this township and extend southward along Turtlelake Creek.

The ground-water supply is obtained from wells varying in depth from 16 to 90 feet. These wells are all in sand and gravel beds in the glacial drift deposit, and though deeper than in the average drift-covered area yield a good supply of water. The elevations of the aquifer are in definite groups within certain restricted areas. Five wells in the northwest part of the township obtain water from an aquifer at elevations between 2,079 and 2,086 feet. This aquifer may slope to the south or southwest, as the well on NW. section 20 has an elevation of 2,069 feet. To the east of Island Lake the elevations of the aquifers are between 2,036 and 2,026 feet, but south of the lake the water horizon is deeper and its elevation correspondingly lower. On SW. section 6 the aquifer is reached at a depth of 90 feet or an elevation of 2,005 feet. This should be at no great depth above the base of the drift and may be the lowest aquifer. Possibilities of finding a good supply of water in the underlying marine shales are not considered good, as they have failed to yield water where they have been tested south of Turtleford. Bedded clay was reported in a well on SW. section 32 at an elevation of 2,086 feet. This material was not examined. It is either a lake clay or bedrock shale, and the occurrence of lake clay a few miles to the northwest suggests that it is of glacial origin.

Township 52, Range 21. The west branch of Turtlelake River lies in a broad north-south trending valley that has eroded deeply into the glacial drift deposit. To the west the land surface rises to form a broad plain or ridge between this valley and that of Englishman River. Likewise, to the east a north-south ridge forms the divide between this valley and the drainage basin of Island Lake. Surface sand deposits are found along the stream bottoms and along the west bank of the valley in sections 19, 30, and 31.

No outcrops of the underlying bedrock are exposed in this township, and so far as known no wells have penetrated the drift. From regional information the bedrock is considered to be an impervious shale of, or similar to, the Lea Park formation. The water supply must, therefore, be obtained from sand and gravel deposits in the drift.

Aquifers in the drift are reached at various depths, and on the whole yield a good supply of water. In the valley bottom and adjacent to it the wells tap an aquifer that has elevations between 1,979 feet on section 30 and 1,921 feet on section 4. This aquifer must be near the base of the drift deposit, and it is, therefore, questionable whether lower aquifers are present. The higher aquifers appear to follow the surface topography fairly closely with elevations varying accordingly. These aquifers are considered to be pockets and lenses of sand and gravel distributed irregularly throughout the drift, and for this reason it is difficult to predict where they will be encountered. It will be noted, however, that some gravel or sand has been struck in all wells, indicating the large amount of sorted material that is present in the drift, and lending some assurance to the success of any new wells.

ANALYSES OF WATER SAMPLES FROM RURAL MUNICIPALITY OF MERVIN, NO. 499, SASKATCHEWAN

						CONSTITUENTS AS ANALYSED							CONSTITUENTS AS CALCULATED IN ASSUMED COMBINATIONS								
No.	Sect.	Tp.	R.	Depth of well in ft.	Total diss'd solids	Ca	Mg	Na	SO_4	Cl	Alka-linity	Total hard-ness	$CaCO_3$	$CaSO_4$	$MgCO_3$	$MgSO_4$	Na_2CO_3	Na_2SO_4	NaCl	Remarks
1	SE 31	52	20	31	200	14	37	23	57	5	170	200	35		113	20		61	8	(glacial sand)

WELL RECORDS—Rural Municipality of Mervin No. 499, SASKATCHEWAN.

WELL No.	LOCATION ¼	Sec.	Tp.	Rge.	Mer.	TYPE OF WELL	DEPTH OF WELL	ALTITUDE WELL (above sea level)	HEIGHT TO WHICH WATER WILL RISE Above (+) Below (−) Surface	Elev.	PRINCIPAL WATER-BEARING BED Depth	Elev.	Geological Horizon	CHARACTER OF WATER	TEMP. OF WATER (in °F.)	USE TO WHICH WATER IS PUT	YIELD AND REMARKS
	SW	2	50	19	3		24	1977			24	1953	glacial	hard		D.S.	Limited supply
1	NE	2					30	1936			30	1906	"	"		D.S.	Good supply in sand
2	SW	4					35	1906			35	1871	"	"		D.S.	Good supply in yellow clay
3	NW	4					80	1983									Dry hole
4	NE	6					10	1928			10	1918	"	"		D.S.	Good supply in gravel
5	NE	8					20	1989			20	1969	"	"		D.S.	Limited supply in clay
6	SW	10					14	1941			14	1927	"	"		D.S.	Good supply in gravel
7	NE	10				dug	30	1961			30	1931	"	"		D.	Limited supply
8	NW	12					14	1950			14	1936	"	"		D.S.	Good supply
9	SE	14				dug	14	1936			14	1922	"	"		D.S.	Limited supply in gravel
10	SE	16					14	1986			14	1972	"	"		D.S.	Good supply in sand
11	NE	20					50	2039			50	1989	"	soft		D.S.	Good supply in gravel
12	SW	20					20	1954			20	1934	"	hard		D.S.	Good supply in gravel
13	SW	21				bored	80	2047			80	1967	"	"		D.S.	Good supply in gravel
14	NE	22				dug	31	1995	- 29	1966	31	1964	"	"		D.S.	Limited supply in sand
15	NW	23				bored	58	1975	- 55	1920	58	1917	"	"		D.S.	Limited supply in blue clay
16	NW	24					18	1954			18	1936	"	"		D.S.	Good supply in fine sand
17	SW	25				dug	11	1956	- 2	1954	11	1945	"	"		D.S.	Good supply in gravel
18	NE	25				"	10	1981	- 6	1975	10	1971	"	"		D.S.	Good supply in fine sand
19	SW	26				"	33	1994	- 25	1969	33	1961	"	soft		D.S.	Good supply in gravel and sand
20	SW	27					25	1982			25	1957	"	hard		D.S.	Good supply in fine sand
21	SE	28				dug	34	1974			34	1940	"	"		D.S.	Good supply
22	NE	31					18	2063			18	2045	"	"		D.S.	Good supply in gravel
23	SE	33				dug	22	1999			22	1977	"	"		D.S.	Good supply in fine sand
24	SW	34					20	1995			20	1975	"	"		D.S.	Good supply in gravel
25	NE	34				dug	20	1972	- 18	1954	20	1952	"	"		D.S.	Good supply in gravel
26	NW	35				bored	39	1988	- 31	1957	32	1956	"	"		D.S.	Good supply in sand
28	SE	36				dug	19	1994	-. 15	1979	19	1975	"	hard		D.S.	Good supply in sand
2	SW	2	50	20	3		20	1851			20	1831	glacial	hard		D.S.	Good supply in fine sand
3	NE	2					19	1896	- 15	1881	9	1887	"	"		D.S.	Poor supply in sand
4	SE	4					10	1852			10	1842	"	soft		D.S.	Good supply in fine sand
5	SW	6					40	1890			40	1850	"	hard		D.S.	Good supply in sand and blue clay
6	NW	7					18	1880			18	1862	"	"		D.S.	Good supply in sand and gravel
7	SE	9					20	1875			20	1855	"	"		D.	Poor supply in blue clay
8	NW	10					55	1906			55	1851	"	"		D.S.	Limited supply in clay
9	NW	12				bored	72	1988	- 52	1936	40	1948	"	"		D.	Limited supply in sand vein
10	SW	12				"	15	1930	- 11	1919	15	1915	"	"		D.	Limited supply in sand and gravel
11	SW	13				"	30	1969	- 20	1949	30	1939	"	soft		D.S.	Good supply in clay and gravel
12	SW	14				dug	14	1920	- 11	1909	14	1906	"	hard		D.S.	Good supply in sand
13	SE	15				"	12	1915	- 6	1909	12	1903	"	"		D.S.	Good supply in clay
14	NW	16					18	1905			18	1887	"	"		D.S.	Sufficient supply in gravel
15	SE	17					20	1884			20	1864	"	"		D.	Limited supply in sand and gravel
16	SE	18					50	1910									Dry hole in blue clay
17	NE	20					25	1911			25	1886	"	soft		D.S.	Good supply in sand and gravel
18	SW	21					22	1911			22	1889	"	hard		D.S.	Good supply in clay
19	SW	22				bored	30	1921	- 20	1901	30	1891	"	soft		D.	Limited supply in sandy clay
20	NW	23				dug	28	2005	- 19	1986	28	1977	"	hard		D.S.	Poor supply in gravel vein
21	SW	24				"	25	2004			25	1979	"	"		D.S.	Limited supply in clay
22	NW	24					25	2039			25	2014	"	"		D.	Limited supply in gravel
23	NW	25					30	2068			30	2038	"	"		D.S.	Good supply

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WELL RECORDS—Rural Municipality of Mervin No. 499, 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				
24	SE	26	50	20	3		15	1999			15	1984	glacial	hard		D.S.	Limited supply in gravel
25	SW	27					26	1922			26	1896	"	"		D.S.	Limited supply in gravel
26	NW	28				dug	17	1934			17	1917	"	"		D.S.	Good supply in sand and gravel
27	SE	30					18	1920			18	1902	"	"		D.S.	Limited supply in sand and gravel
28	NW	32				dug	60	1942			60	1882	"	"		D.	Limited supply in gravel
29	SW	33				bored	42	1934	- 28	1906	42	1892	"	"		S.	Good supply in sand
30	SE	34				"	50	2045	- 42	2003	50	1995	"	"		D.	Limited supply in clay
31	SW	34				"	30	1967	- 26	1941	30	1937	"	"		D.	Limited supply. Dry hole 90 feet in blue clay.
32	SE	35				dug	16	2043	- 12	2031	16	2027	"	soft		D.S.	Good supply in gravel
33	SW	36				"	20	2054			20	2034	"	"		D.S.	Good supply in gravel
1	NE	3	50	21	3	dug	40	1909	- 30	1879	40	1869	glacial	hard		D.S.	Limited supply
2	SE	10				"	2	1803			2	1801	"	soft		D.S.	Good supply in sand
3	NW	13				"	25	1945			25	1920	Lea Park	hard		D.S.	Poor supply
4	NE	14				drilled	350	1955					Lea Park				Dry hole in shale
5	SE	15				dug	4	1832			4	1828	glacial	soft		D.S.	Good supply in sand
6	SW	16				"	4	1837			4	1833	"	"		D.S.	Good supply in sand
7	SE	16				spring		1852									Continuous flow
8	NE	16				dug	16	1895			16	1879	"	hard		D.S.	Good supply in shale
9	SW	17				spring		1842					"				Continuous flow
10	NE	17				dug	10						"	soft		D.S.	Good supply
11	SW	18				"	18	1811			18	1793					Water on top of shale
12	NW	20					60	1905			30	1875	glacial	hard		D.S.	Seepage supply on top of shale
13	SE	21				bored	83	1920			15	1905		alkaline		D.S.	Seepage supply on top of shale
14	SW	22				dug	20	1928			20	1908	glacial	hard		D.S.	Limited supply in sand
15	SE	22				"	40	1940			40	1900				S.	Limited supply of poor water
16	NW	22				"	18	1932			18	1914	"	"			Limited supply in sand and gravel
17	NE	22				"	27	1965	- 14	1951	27	1938	"	"		D.S.	Good supply in sand and gravel
18	NW	23				"	20	1947									Dry hole in shale
19	SW	24				drilled	370	1945					Lea Park				Shale below 20 feet
20	SE	26				dug	40	1990	- 14	1976	18	1972	glacial	hard		D.S.	Good supply in sand and gravel
21	SE	28				"	18	1957			18	1939	"	soft		D.S.	Good supply
22	NE	28				"	27	1983					"				Dry hole in blue clay
23	SW	32				"	12	1905	- 6	1899	8	1897	"			D.S.	Abundant supply in sand
24	NE	32				"	24	1930	- 14	1916	20	1910	"	hard		D.S.	Good supply in sand and gravel
25	NW	34				"	30	1992	- 10	1982	15	1977	"	"		D.S.	Limited supply on top of shale
26	SW	34				"	60	1972									Dry hole in shale
27	NW	36				"	15	1920			15	1905	glacial	soft		D.S.	Limited supply in clay
1	NW	2	51	19	3		28	1982			28	1954	glacial	hard		D.S.	Good supply in fine sand
2	SE	4				bored	45	2005			45	1960	"	"		D.S.	Good supply in sand
3	SW	4					60	1994			60	1934	"	"		D.S.	Good supply in gravel
4	SE	5					25	2014									Dry hole
5	SE	6				bored	90	2165			90	2075	"	"		D.S.	Good supply in fine sand
6	NE	7				dug	18	2114			18	2096	"	soft		D.S.	Good supply in fine sand
7	NW	15				"	25	2001	- 22	1979	25	1976	"	hard		D.S.	Good supply
8	NE	20					100	2117			100	2017	"	"		N.	Well abandoned. Poor well
9	NW	26					80	2055									Dry hole

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WELL RECORDS—Rural Municipality of Mervin No. 499, SASKATCHEWAN.

WELL No.	LOCATION ¼	Sec.	Tp.	Rge.	Mer.	TYPE OF WELL	DEPTH OF WELL	ALTITUDE WELL (above sea level)	HEIGHT TO WHICH WATER WILL RISE Above (+) Below (−) Surface	Elev.	PRINCIPAL WATER-BEARING BED Depth	Elev.	Geological Horizon	CHARACTER OF WATER	TEMP. OF WATER (in °F.)	USE TO WHICH WATER IS PUT	YIELD AND REMARKS
10	SW	26	51	19	3		40	2020					glacial				Dry hole in blue clay
11	NW	27					40	2071			40	2031	"	hard		D.S.	Good supply in fine sand
12	SE	27				dug	8	2015			8	2007	"	soft		D.S.	Good supply in fine sand
13	SE	28				"	35	2111			35	2076	"	hard		D.	Limited supply in sand
14	NW	30				bored	95	2105			95	2010	"	"		D.S.	Good supply in gravel
15	NW	35					96	2132			96	2036	"	"		D.S.	Good supply. Village well.
																	Dry holes 100 and 115 feet.
16	NW	36					40	2113			40	2073	"	"		D.S.	Good supply in sand
1	NE	2	51	20	3		17	2146			17	2129	glacial	hard		D.S.	Good supply in gravel
2	SE	4				dug	28	1952	- 23	1929	28	1924	"	"		D.S.	Good supply in sand
3	SW	5				bored	32	2001	- 22	1979	32	1969	"	"		D.S.	Good supply in sand
4	SE	8				dug	24	2066	- 16	2050	24	2042	"	soft		D.S.	Good supply
5	NW	9				"	15	2068	- 5	2063	15	2053	"	hard		D.S.	Good supply in sand
6	SW	10				"	22	2094	- 17	2077	22	2072	"	"		D.S.	Limited seepage supply
7	NW	12					55	2176			55	2121	"	"		D.S.	Good supply in clay
8	SW	15					30	2129	- 15	2114	30	2099	"	soft		D.S.	Good supply in sand
9	SE	16				dug	20	2133			20	2113	"	hard		D.S.	Good supply in fine sand
10	SE	17				bored	72	2168			72	2096	"	"		D.S.	Good supply in gravel
11	NE	18				"	52	2014	- 32	1982	52	1962	"	soft		D.S.	Good supply in gravel
12	NW	20				dug	8	2021	- 2	2019	8	2013	"	hard		D.S.	Good supply in fine gravel
13	NE	21					60	2125			60	2065	"	soft		D.S.	Good supply in sand
14	NW	22					76	2034			76	1958	"	hard		D.S.	Good supply in gravel
15	NE	23					11	2089			11	2078	"	"		D.S.	Good supply in sand
16	SW	24					73	2152			73	2079	"	"		D.S.	Good supply in gravel
17	SE	26					14	2063			14	2049	"	"		D.S.	Good supply in sand
18	SW	27					20	2069			20	2049	"	"		D.S.	Good supply
19	SE	28					70	2102			70	2032	"	"		D.S.	Good supply
20	NW	28				dug	46	2078	- 30	2048	46	2032	"	"		D.S.	Good supply in gravel
21	NE	31				"	41	1993	- 30	1963	41	1952	"	"		D.S.	Good supply in gravel
23	NE	32				bored	30	2031			30	2001	"	soft		D.	Limited supply in sand
24	NW	33				"	85	2069			85	1984	"	"		D.S.	Good supply in gravel
25	NE	36				"	60	2085			60	2025	"	hard		D.S.	Good supply in gravel
1	NW	2	51	21	3	dug	24	2006			16	1990	glacial			D.S.	Poor supply in sand above shale.
2	SW	3				"	25	1973			25	1948	"	hard		D.S.	Good supply in sand and gravel
3	NE	4				"	22	1968	- 18	1950	18	1950	"	"		D.S.	Limited supply in sand above clay
4	SE	5				"	34				34		"	soft		D.S.	Good supply in sand and gravel
5	SE	6				"	8	1917	- 4	1913	8	1909	"	hard			Good supply in sand
6	NE	6				"	33	1989	- 25	1964	33	1956	"	"		D.	Limited supply
7	SE	7				bored	35	2053	- 20	2033	35	2018	"	"		D.S.	Good supply in sand and gravel
8	NE	7				"	32	2085			32	2053	"	soft		D.S.	Good supply
9	SW	8				"	36	2000	- 28	1972	36	1964	"	hard		D.S.	Limited supply in gravel vein
10	NW	8				"	57	2048	- 45	2003	57	1991	"	"		D.S.	Good supply in sand
11	NE	10				dug	18	1970	- 14	1956	18	1952	"	"		D.S.	Good supply in sand and gravel
																	shale below
12	SW	12				"	32	1935			32	1903	"	"		D.S.	Abundant supply in gravel
13	NE	15				"	8	1950	- 4	1946	8	1942	"	"		D.	Poor supply in sand
14	SW	16				bored	29	2030	- 17	2013	29	2001	"	"		D.S.	Good supply
15	SW	17				"	16	2005			16	1989	"	"		S.	Poor supply.

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WELL RECORDS—Rural Municipality of Mervin No. 499, SASKATCHEWAN.

WELL No.	LOCATION ¼	Sec.	Tp.	Rge.	Mer.	TYPE OF WELL	DEPTH OF WELL	ALTITUDE WELL (above sea level)	HEIGHT TO WHICH WATER WILL RISE Above (+) Below (−) Surface	Elev.	PRINCIPAL WATER-BEARING BED Depth	Elev.	Geological Horizon	CHARACTER OF WATER	TEMP. OF WATER (in °F.)	USE TO WHICH WATER IS PUT	YIELD AND REMARKS
16	NE	18	51	21	3	bored	50	2044	- 25	2019	50	1994	glacial	hard		D.S.	Poor supply
17	NW	19				dug	30	2149			30	2119	"	soft		D.S.	Good supply in sand
18	SW	20				bored	60	2091	- 40	2051	60	2031	"	hard		D.S.	Good supply
19	SW	24				dug	27	1971	- 25	1946	27	1944	"	hard		D.S.	Good supply in sand
20	SE	26				bored	70	2013	- 35	1978	70	1943	"	hard		D.S.	Good supply
21	SE	27				dug	5	1967	- 3	1964	5	1962	"	"		D.S.	Good supply in fine sand
22	SE	28				"	10	1920			10	1910	"	soft		D.S.	Good supply in sand
23	NW	28				bored	14	1971			14	1957	"	soft		D.S.	Good supply in fine sand
24	SE	30				dug	14	2094	- 12	2082	14	2080	"	"		D.S.	Good supply in sand and gravel
25	NE	30				"	30	2123	- 20	2103	30	2093	"	hard		D.	Limited supply in sand
	NE	32				"	35	1950	- 33	1917	35	1915	"	"		D.	Sufficient for domestic use
	NE	34				"	75	2106			15	2091	"	"		D.S.	Poor seepage supply
1	NE	2	52	19	3	dug	65	2181	- 45	2136	65	2116	glacial	hard		D.S.	Good supply in sand
2	SE	4				"	34	2157			34	2123	"	"		D.	Limited supply in gravel
3	NW	6				"	50	2017			50	1967	"	"		D.S.	Good supply
4	NE	12				"	20	2175			20	2155	"	"		D.S.	Good supply in gravel
5	SE	13				"	85	2221	- 65	2156	85	2136	"	"		D.S.	Good supply in gravel
6	NW	14				"	16	2147			16	2131	"	"		D.S.	Good supply in sand and gravel
7	SE	15				"	33	2144			33	2111	"	"		D.S.	Good supply in sand and gravel
8	NW	18				"	30	2158			30	2128	"	soft		D.S.	Poor supply in sand and clay
9	NE	19				"	10	2230	- 3	2227	10	2220	"	"		D.S.	Good supply in coarse sand
10	NW	21				"	20	2190	- 18	2172	20	2170	"	hard		D.S.	Good supply in gravel
11	SE	22				"	20	2147			20	2127	"	"		D.S.	Good supply in clay
12	NW	22				"	7	2159			7	2152	"	"		D.S.	Good supply in sand and gravel
13	SW	23				"	16	2141			16	2125	"	"		D.S.	Good supply in gravel
14	SE	30				"	12	2237			12	2225	"	soft		D.S.	Poor supply in gravel
15	SE	32				"	18	2214	- 15	2199	18	2196	"	"		D.S.	Good supply in sand
16	NE	34				"	16	2153			16	2137	"	hard		D.S.	Good supply in coarse sand
17	NW	35				"	20	2154			20	2134	"	"		D.S.	Good supply in clay
1	1.R. No.115B Agts. Res						80	2083			80	2003	glacial	hard		D.S.	Limited supply in sand
2	SW	4	52	20	3		52	2079	- 25	2054	52	2027	"	"		D.S.	Good supply in gravel
3	NW	5	52	20	3		50	2069			50	2019	"	"		D.S.	Good supply in gravel
4	SW	6					90	2095			90	2005	"	"		D.S.	Good supply
5	SW	17					15	2041			15	2026	"	soft		D.S.	Good supply in sand
6	NW	17					17	2053	- 12	2041	17	2036	"	hard		D.S.	Good supply in blue clay
7	NE	18				dug	20	2050	- 12	2038	20	2030	"	"		D.S.	Good supply in sand
8	NW	20				"	24	2093	- 15	2078	24	2069	"	"		D.S.	Good supply in sand
9	NE	28				"	75	2160			75	2085	"	"		D.S.	Good supply in sand
10	NW	30				"	16	2119	- 13	2106	16	2103	"	"		D.S.	Good supply in gravel
11	SE	31				"	31	2138			31	2107	"	"		D.S.	Limited supply in sand and gravel
12	SW	32				"	50	2137	- 42	2095	50	2087	"	"		D.S.	Good supply in gravel
13	SW	32				bored	42	2128	- 36	2092	42	2086	Lea Park ?	"		D.S.	Good supply in bedded clay
14	NE	33				dug	40	2124			40	2084	glacial	"		D.S.	Good supply in [redacted] clay
15	NW	34				"	42	2121			42	2079	"	"		D.S.	Good supply in sand

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1	SE	1	52	21	3		40	2069			40	2029	glacial	hard		D.S.	Good supply in clay
2	NE	2					20	2078			20	2058	"	"		D.S.	Good supply in gravel
	SE	3				dug	18	2091	- 12	2079	18	2073	"	"		D.S.	Good supply in gravel
3	NW	4				"	27	1948	- 26	1922	27	1921	"	soft		D.	Limited supply in sand
	SE	6				bored	70	2090	- 50	2040	20	2070	"	hard		D.S.	Seepage sunply in sand
4	SW	6				"	40	2039			40	1999	"	"		D.S.	Good supply
5	NE	7					12	2035			12	2023	"	"		D.S.	Good supply in sand
6	SW	8				bored	92	2037	- 42	1995	92	1945	"	"		D.S.	Good supply in gravel and sand
7	NW	9				dug	27	2008	- 25	1983	27	1981	"	"		D.S.	Good supply in gravel
8	NW	10				"	30	2101			30	2071	"	"		D.S.	Poor supply in sand
9	SW	12					50	2044			50	1994	"	"		D.S.	Good supply in sand
10	NW	16				bored	50	2002	- 25	1977	50	1952	"	"		S..	Good supply in fine sand
11	NW	17				"	30	2008			30	1978	"	"		D.S.	Good supply in gravel
12	SE	18				dug	12	2034			12	2022	"	"		D.S.	Good supply in sand above clay
13	SE	19				bored	24	2050	- 21	2029	24	2026	"	"		D.S.	Good supply in sand
14	NW	25					33	2085			33	2052	"	"		D.S.	Good supply in clay
15	NW	26					14	2042			14	2028	"	soft		D.S.	Good smpply in clay
16	NW	27				dug	12	2076			12	2064	"	"		D.S.	Poor supply in clay
17	NE	28				bored	55	2070			55	2015	"	hard		D.S.	Poor supply in sand
18	NE	30				dug	12	1991	- 4	1987	12	1979	"	"		D.S.	Good supply in fine sand
	NE	32				bored	92	2021	- 20	2001	92	1929	"	"		D.S.	Good supply in sand
19	SE	33				dug	21	2101			21	2080	"	soft		D.S.	Good supply in sand
	NW	33				bored	70	2040	- 35	2005	70	1970	"	hard		D.S.	Good supply in fine sand
	NE	33				dug	15	2060	- 10	2050	15	2045	"	"		D.S.	Good supply in clay
20	SW	34				"	20	2070			20	2050	"	"		D.S.	Just enough in sand and clay
21	SW	35					40	2109			40	2069	"	"		D.S.	Good supply in clay
	NE	36				bored	80	2100	- 60	2040	80	2020	"	"		D.S.	Good supply
22	SW	36				dug	23	2119	- 11	2108	23	2096	"	"		D.S.	Good supply in clay

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

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