CANADA
DEPARTMENT OF MINES
AND
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GEOLOGICAL SURVEY OF CANADA
WATER SUPPLY PAPER No. 262

GROUND-WATER RESOURCES OF THE LOCAL IMPROVEMENT DISTRICT NO. 532 SASKATCHEWAN

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

OTTAWA
1947

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DEPARTMENT OF MINES AND RESOURCES

MINES AND GEOLOGY BRANCH
BUREAU OF GEOLOGY AND TOPOGRAPHY

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Figure 1. Map showing bedrock geology;

2. Map showing topography and the location and types of wells.

INTRODUCTION

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

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

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

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

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

Publication of Results

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

How to Use the Report

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

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

GLOSSARY OF TERMS USED

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

The formations that outcrop in west-central Saskatchewan are an extension of similar formations that occur in east-central Alberta. They are of Upper Cretaceious age, and consist entirely of relatively soft shales and sands, with some bands of hard sandstone and layers of ironstone nodules. The succession, character, and estimated thickness of the formations are shown in the following table:

Formation	Character	Thickness Feet
Edmonton	Grey to white, bentonitic sands and sandstones with grey and greenish shales; coal seams prominent in some areas, as at Castor, Alberta.	1,000 to 1,150
Bearpaw	Dark shales, green sands with smooth black chert pebbles; partly non-marine, with white bentonitic sands, carbonaceous shales or thin coal seams similar to those in Pale Beds; shales at certain horizons contain lobster claw nodules and marine fossils; at other horizons are abundant selenite crystals.	300 to 600 thins rapidly to the north-west
Pale and Variegated Beds	Light grey sands with bentonite; soft, dark grey and light grey shales with selenite and ironstone; carbonaceous shales and coal seams; abundant selenite crystals in certain layers.	950 to 1,000 in Czar-Tit Hills area; may be thinner elsewhere
Birch Lake	Grey sand and sandstone in upper part; middle part of shales and sandy shales, thinly laminated; lower part with grey and yellow weathering sands; oyster bed commonly at base.	100 in west, but less to east and south
Grizzly Bear	Mostly dark grey shale of marine origin, with a few minor sand horizons; selenite crystals and nodules up to 6 or 8 inches in diameter	Maximum, 100
Ribstone Creek	Grey sands and sandstones at the top and bottom, with intermediate sands and shales; thin coal seam in the vicinity of Wainwright; mostly non-marine, but middle shale in some areas is marine.	Maximum, 325 at Viking; thins eastward
Lea Park	Dark grey shales and sandy shales with nodules of ironstone; a sand 70 feet thick 110 feet below the top of the formation in the Ribstone area, Alberta.	950 to 1,100

Edmonton Formation

The name Edmonton formation was first applied to the beds containing coal in the Edmonton area, and later to the same beds in adjoining areas. The formation has a total thickness of 1,000 to 1,150 feet, but is bevelled off eastward and the east edge of the formation follows a northwest line from Coronation through Tofield to a point on North Saskatchewan River about midway between Edmonton and Fort Saskatchewan. No Edmonton beds occur northeast of this line, but the formation becomes progressively thicker to the southwest due to the fact that the beds incline in that direction and the surface bevels across them.

The Edmonton formation consists of poorly bedded grey and greenish clay shales, coal seams, and sands and sandstones that contain clay and a white material known as bentonite. This material when wet is very sticky and swells greatly in volume, and when dry tends to give a white appearance to the beds containing it. Such beds are relatively impervious to water, and at the surface produce the "burns" of barren ground where vegetation is scanty or absent.

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

Bearpaw Formation

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

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

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

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

Pale and Variegated Beds

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

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

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

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

Birch Lake Formation

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

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

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

Grizzly Bear Formation

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

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

Ribstone Creek Formation

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

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

The lower sand member of the Ribstone Creek formation also varies in thickness from a minimum of about 25 feet. On the banks of Vermilion Creek, north of Mannville, the basal sand is at least 60, and may be 75, feet thick. It is overlain by shaly sand and sandy shale beds, which replace the shale beds in the central part of the formation as exposed at the mouth of Grizzly Bear Coulée. In the Wainwright area, where the formation has been drilled in deep wells, the basal sand is 60 feet thick, with the central part composed of shale containing sand streaks. The upper sand member is about 20 feet thick in this area. The total thickness of the formation in the Wainwright area is 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 Coulée in tp. 47, rge. 5, and beyond to the Two Hills area in tp. 54, rge. 12, whereas the northeast boundary crosses North Saskatchewan River southwest of Elk Point and extends northwest to include an area slightly north of St. Paul des Metis and Vilna to tp. 60, rge. 14. Within this belt water wells are common in the Ribstone Creek sands, which are almost without exception water-bearing in some part of the formation. The limits of the belt to the northeast determine the limits of water from this source, but to the southwest of the belt, as here outlined, water may be obtained in this formation by drilling through the younger beds that overlie it. The Ribstone Creek sands are a prolific source of water in many places and hence the distribution of this formation is of considerable economic importance. Where the formation consists of upper and lower sands with a central shale zone only the sands are water-bearing, although thin sand members may occur in the shale. Where the formation is largely sand the distribution of water may be in any part of the formation, although the upper and lower sands are perhaps the better aquifers. To the east of Alberta, along Battle River and Big Coulée in Saskatchewan, the Ribstone Creek sands are marine. Marine conditions apparently become more prevalent to the southeast and it is believed that in this direction the sands are gradually replaced by marine shales. Thus at some distance southeast of Battleford the Ribstone Creek formation loses its identity and its equivalents are shales in a marine succession.

Lea Park Formation

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

WATER ANALYSES

Introduction

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

Discussion of Chemical Determinations

The dissolved mineral constituents vary with the material encountered by the water in its migration to the reservoir bed. The mineral salts present are referred to as the total dissolved solids, and they represent the residue when the water is completely evaporated. This is expressed quantitatively as "parts per million", which refers to the proportion by weight in 1,000,000 parts of water. A salt when dissolved in water separates into two chemical units called "radicals", and these are expressed as such in the chemical analyses. In the one group is included the metallic elements of calcium (Ca), magnesium (Mg), and sodium (Na), and in the other group are the sulphate (SO_4), chloride (Cl), and carbonate (CO_3) radicals.

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

Mineral Constituents Present

Calcium. Calcium (Ca) in the water comes from mineral particles present in the surface deposits, the chief source being limestone, gypsum, and dolomite. Fossil shells provide a source of calcium, as does also the decomposition of igneous rocks. The common compounds of calcium are calcium carbonate ($CaCO_3$) and calcium sulphate ($CaSO_4$).

Magnesium. Magnesium (Mg) is a common constituent of many igneous rocks and, therefore, very prevalent in ground water. Dolomite, a carbonate of calcium and magnesium, is also a source of the mineral. The sulphate of magnesia ($MgSO_4$) combines with water to form "Epsom salts" and renders the water unwholesome if present in large amounts.

Sodium. Sodium (Na) is derived from a number of the important rock-forming minerals, so that sodium sulphate and carbonate are very common in ground waters. Sodium sulphate (Na_2SO_4) combines with water to form "Glauber's salt" and excessive amounts make the water unsuitable for drinking purposes. Sodium carbonate (Na_2CO_3) or "black alkali" waters are mostly soft, the degree of softness depending upon the ratio of sodium carbonate to the calcium and magnesium salts. Waters containing sodium carbonate in excess of 200 parts per million are unsuitable for irrigation purposes[1]. Sodium sulphate is less

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

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harmful.

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

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

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

Hardness. The hardness of water is the total hardness, and has been determined by the amount of a standard soap solution required to form a lather that will stand up (persist) for 2 minutes. Hardness is of two kinds, temporary and permanent. Temporary hardness is caused by calcium and magnesium bicarbonates, which are soluble in water but are precipitated as insoluble normal carbonates by boiling, as shown by the scale that forms in teakettles. Permanent hardness is caused by the presence of calcium and magnesium sulphates, and is not removed by boiling. The two forms of hardness are not distinguished in the water analyses. Waters grade from very soft to very hard, and can be classified according to the following system[2]:

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

- A water under 50 degrees (that is, parts per million) of hardness may be said to be very soft.
- A water with 50 to 100 degrees of hardness may be said to be moderately soft.
- A water with 100 to 150 degrees of hardness may be said to be moderately hard.
- A water with more than 200 and less than 300 degress of hardness may be said to be hard.
- A water with more than 300 degrees of hardness may be said to be very hard.

Hard waters are usually high in calcium carbonate. Almost all of the waters from the glacial drift are of this type, especially those not associated with sand and gravel deposits that come close to the surface.

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

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

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

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

WATER ANALYSES IN RELATION TO GEOLOGY

Glacial Drift

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

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

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

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

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

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

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

Bearpaw Formation

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

Pale Beds

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

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

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

Variegated Beds

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

Salts	NW. sec. 21, tp.41, rge.26	NW. sec. 3, tp.41, rge.28	SE. sec. 28, tp.40, rge.28
$CaCO_3$	250	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 Deds, 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	1,200	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 andn3,000 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.

LOCAL IMPROVEMENT DISTRICT, NO. 532, SASKATCHEWAN

Physical Features

The main topographical features of this municipality are North Saskatchewan River, which forms part of the southern boundary, and the steep escarpment that trends northwesterly from the river bank in tp. 53, rge. 25, to Oldman and Onion Lakes. This escarpment divides the area into two parts. The northeastern part is about 100 feet higher than the plain along Saskatchewan River and is covered with a rocky boulder till. In township 55 the surface becomes more broken and is marked by recessional moraines. The lower plain is cut by several streams that enter the Saskatchewan. The largest of these, Pipestone Creek, at one time carried a large amount of water. There are also several areas of sand and gravel, huge outwash gravel deposits in the vicinity of Fort Pitt post office, and an area of sand, now blown into dunes, east of Harlan post office.

Geology

Outcrops of shale and sandy shale are found along Pipestone Creek and Saskatchewan River. An outcrop on the east bank of Pipestone Creek in sec. 34, tp. 53, rge. 26, is very sandy near the top at an elevation of 1,860 feet. The lower part of the section is dark grey, typical Lea Park shale. The upper sandy phase is suggestive of the upper part of the formation and its proximity to overlying Ribstone Creek sand. It may be present to the north of the escarpment face referred to above. The lower beds are underlain by the Lea Park shale.

Water Supply

The surface deposits of sand and gravel on the lower land yield a good supply of ground water at shallow depths. These glacial deposits, though relatively thin, are the only source of good water, as the supply from the underlying shale is scanty and of poor quality. Locating a good well will, therefore, depend upon finding a sand or gravel bed above the shale. On the higher land to the north the boulder till contains less sand and gravel, and water possibilities in it are not as good. The aquifers there are lenses or pockets of sand or gravel irregularly distributed through the boulder till, and finding one of them is largely a matter of chance. However, in tp. 54, rge. 25, where gravel deposits are commonly exposed, it is to be expected that water will be found in one of these at a shallow depth.

<u>Township 53, Range 25.</u> The chief topographical features in this township are Saskatchewan River and Frenchmans Butte. The river is entrenched in a valley about 400 feet below the level of the plain that occupies the eastern half of the township. In the west the erosion associated with the early stages of the river removed a large part of this plain, leaving an escarpment face that trends northwest where the river swings to the west in section 21. On the lower land are fairly large deposits of sand and gravel, whereas the higher plain is composed almost entirely of boulder clay. Frenchmans Butte, an isolated circular hill on sections 23 and 24, has the appearance of a drumlin with the steepest face towards the north. Several similar hills in the vicinity are very much smaller, and, so far as can be determined, they are all composed of boulder till.

A well dug on NE. section 15 encountered shale at 90 feet, indicating the approximate depth of the drift on the plain. The elevation of the top of the shale is 1,940 feet above sea-level, much higher than that of any outcrops of shale exposed along Saskatchewan River or Glenbogie Creek.

The ground-water supply is obtained from various horizons in the drift deposit at depths that range from only a few feet to 84 feet. On the plain along the east side of the township the elevations of the aquifers of most of the wells are between 1,988 and 2,022 feet, and, consequently, lack the uniformity of level that would be expected from a large single deposit. It would appear, therefore, that they represent a large number of small deposits of sand and gravel irregularly distributed throughout the drift. The elevation of the top of the shale in section 15 is 1,940 feet. This is considerably lower than the deeper aquifers in the wells, and together with the fact that no sand nor gravel was encountered in the lower part of the drift on section 15, may indicate a scarcity of sand in the lower part of the drift deposits. On the lower land to the northwest the drift is thinner, with more sand and gravel near the surface. Where no water is encountered in the drift a seepage supply may be obtained on top of the bedrock shale. This should be adequate provided the well is in a favourable location, where water accumulates in depressions on the surface of these impervious beds.

Township 53, Range 26. The surface deposits in the part of this township within this district have been greatly modified by fluvioglacial streams from the west and north. Pipestone Creek, flowing from the north in a deep valley that was eroded by the glacial waters, enters the Saskatchewan in section 27. The west side of the township is covered with a large deposit of sand that now has been blown into dunes. This sand deposit is associated with the early stages of Saskatchewan River and the fluvioglacial waters from the north. Most of it was deposited before the channel of Pipestone Creek was eroded to its present level.

The water level in this sand area is near the surface, as the sand is underlain by relatively impervious boulder till and shale. Outcrops of shale are exposed at various places along Pipestone Creek. The upper parts, as exposed in section 34 along the road, are quite sandy, and appear to be near the top of the formation. The elevation of the top of this sandy shale is 1,860 feet. The well on NE. section 33 is reported to have obtained water in a sandy shale at an elevation of 1,855 feet, suggesting the same strata as those exposed along the road in section 34, although where it was examined the sand was too fine to form a good aquifer. It is probable, however, that these sandy shale beds grade upward into sand that would be more suitable for an aquifer. So far as can be determined, these higher beds are not present east of the creek in this township, as a thick boulder till overlies the shale. All the wells are in sand that is believed to be of glacial origin and that lies close to the shale surface. The elevation of the aquifer on SE. section 34 is 1,863 feet, and is at approximately the same level as the sandy shale along the creek bank. Prospects of finding water at greater depths are, consequently, poor, as no extensive sand deposit is known to be present within the shale in this area. Locating a suitable well will, therefore, be limited to sand and gravel deposits in the drift and the sandy phase of the upper part of the bedrock strata.

Township 53, Range 27. The part of this township north of Saskatchewan River is very much like the township to the east. The sand area includes almost all of the eastern half of the township. The western margin grades into a belt of light sandy soil that is cultivated around Harlan post office. Farther west, boulder till is the surface deposit and overlies bedrock shale.

Water is easily obtained at shallow depths in the sand area. The water-table is near the surface, as the sand is underlain by impervious boulder till and shale. In the area of boulder till the water supply is a greater problem, as the surface deposit of boulder clay is not thick and sand and gravel beds are not everywhere present in it. Finding one of these aquifers in the drift is, therefore, largely a matter of chance. A test auger is very useful for this purpose, provided the till isn't too rocky. In most places, too, a fair seepage supply of water can be obtained from the top of the shale. The wells on sections 33 and 34 obtain water in a sand bed below shale at elevations of 1,872 and 1,861 feet and depths of 52 and 69 feet respectively, and shale was encountered very near the surface. The thickness of the sand bed is not known, but as the water supply is good it is reasonable to expect a fairly extensive aquifer at this level. However, the sand bed is believed to be a lens within the Lea Park shale, and for this reason would probably not be as thick or extensive as if it were part of the succeeding Ribstone Creek formation. The water is hard and alkaline, but is used for domestic purposes. This horizon should serve as an aquifer for a considerable area, as it is believed to be the same as the one encountered in a well on section 33 in the township to the east at an elevation of 1,855 feet.

Township 54, Range 25. The escarpment face, referred to on describing the township to the south, cuts across the southwest corner of this township. The higher land to the northeast is a comparatively flat plain having as surface deposits ground moraine and a few small morainal hills and eskers. These eskers trend almost north and south in sections 10 and 15. A long esker occurs in a valley tributary to Monnery River. In sections 25 and 36 it is a ridge, broken in a few places but dividing the valley into almost equal parts. The esker continues to section 15 where it flattens into a gravel deposit that covers the valley bottom. On the lower land to the southwest the surface deposit is much thinner, but as it is also very sandy water is easily obtained from it at shallow depths. There are also several springs along the face of the escarpment.

The water supply on the higher land is obtained from glacial wells. These wells are all less than 30 feet deep, except one on SE. section 5 that has a depth of 41 feet. The thickness of the drift is not known, but is thought to be in excess of 100 feet. As the surface elevation rises quite appreciably towards the north the thickness of the drift is considered to increase in the same direction. Part of this rise may be due to the presence of higher stratigraphic beds. The present water supply is obtained from the upper part of the drift, but lower aquifers may be found at greater depths. The sand and gravel beds are irregularly dispersed within the drift and may be encountered at shallow depths in many places without any surface indications. In the northeast part of the township gravel is exposed more than elsewhere, and is a good indication of the character of the upper part of the drift in this area. Thick gravel deposits may not be saturated with water throughout, and it may be necessary, therefore, to reach the lower levels to obtain a good supply.

Township 54, Range 26. This township is divisible, roughly, into two parts, an upper flat plain of boulder till to the north and a lower erosional plain to the south between Oldman and Pipestone Creeks. These two plains are separated by a steep bank more than 100 feet high. The upper plain is fairly flat and has a surface deposit of rocky boulder till. The thickness of this till is not known, but as no outcrops of the bedrock strata were found along the escarpment it appears that this rise in the land surface is wholly in drift materials. On the lower plain the drift is not thick, as indicated by several outcrops of bedrock along Pipestone Creek. The elevation of the top of the sandy shale on section 34 in the township to the south is 1,860 feet. East of Pipestone Creek this shale is overlain by a strip of boulder till that parallels a sand and gravel deposit along Oldman Creek. The latter deposit forms a flat plain and has the appearance of an outwash deposit formed by the fluvioglacial waters that flowed down Oldman Creek Valley. South of Oldman Lake and separating it from the flat outwash plain are several large gravel hills that rise about 100 feet above the valley. These are remnants of a very large gravel deposit that was built up before the present plain to the south was formed. The material on the plain was thus formed from the reworking of the original deposit. Shale is reported below the gravel on section 2, but the material was not available for examination.

The water supply comes from wells in glacial deposits, most of which are less than 20 feet deep. On the lower plain and in the sandy area water is easily obtained in the surface deposit of sand and gravel. The water-level within the sand varies with the annual precipitation, and it may, therefore, be necessary to deepen the wells during the seasons of less than average rainfall. In the boulder till area bordering Pipestone Creek the aquifers are sand and gravel pockets and lenses distributed through the drift. Possibilities are not as good here as in the sand belt to the east, and two wells on sections 4 and 5 do not yield much water. Where water cannot be found in the drift a seepage supply can generally be obtained at the contact between the drift and the bedrock shale.

There are also water possibilities in the upper part of the shale where its surface has an elevation greater than 1,860 feet. Water was obtained in the shale at an elevation of 1,855 feet on NE. sec. 33, tp. 53, rge. 26, and also 6 miles farther west under very similar conditions. It is possible that this aquifer extends northward, but the quality of the water from it is not as good as that of water from the drift, and it should only be tested when the higher horizons have failed. On the higher land to the north, where the drift is thicker, the well records are not sufficient to allow definite conclusions to be drawn on the nature of the drift. No dry holes have been dug, but the supply in the wells on sections 27 and 34 is not large and it may be necessary to test lower horizons. The sand and gravel deposits in the drift in this area may be numerous and small rather than few and more extensive. Testing for water below the drift may necessitate drilling to a depth of 200 feet, the supply to be expected is not considered to be large, and possibilities of the water rising any great height in the hole are poor.

<u>Seekaskootch Indian Reservation.</u> The chief topographical feature on Seekaskootch Indian Reservation is the continuation in a northwest direction of the escarpment face described in the area to the east. North of Onion Lake, on the north of the Indian Reserve, near the Alberta boundary this escarpment swings slightly to the southwest and divides the reservation into lowland and highland areas. The highland is cut by numerous gullies, which form the headwaters of Pipestone Creek. The lowland to the south of the plateau is covered with a thin deposit of glacial material of various types. East of Onion Lake and paralleling the escarpment is an area of sand and gravel. Along Pipestone Creek the soil is heavy clay derived from the underlying shale, and in the southeast part of the reserve is a sandy plain, which is the northern extension of the sand area around Harlan post office. West of the sandy plain and extending northward to Onion Lake the surface material is a ground moraine deposit of boulder clay and sandy clay. In the southwest part of the reserve the till is very rocky, and a small recessional moraine extends northward along the west side of

the reserve.

At the Roman Catholic Mission school the drift is less than 30 feet thick, as a well 34 feet deep struck water in sand below bedrock shale. This aquifer yielded only a limited supply of poor water, so that it is not considered advisable to seek water at this horizon where it can be obtained in the drift.

The water supply in the drift will depend upon the presence of sand and gravel beds. As the drift is thin, it is quite possible to miss one of these deposits in sinking a well, but it is reasonable to expect an average amount of sand and gravel except in the immediate vicinity of Pipestone Creek.

On the plateau the water supply likewise must come from the glacial drift, and conditions are believed to be similar to those in the belt west of the reserve in tp. 55, rge. 28. Here water is found at shallow depths. Lower aquifers are no doubt present in the drift, and can be tested for if the upper horizons fail to yield a supply.

Township 55, Range 25. Most of this township lies within the boundaries of the forest reserve, and for this reason the well records are limited to a narrow belt along the east side. The surface deposit is a thick mantle of rocky boulder till that is comparatively flat in the southeast corner, but south and east of Sidney Lake are ridges and hills of a recessional moraine.

The ground-water supply is obtained from sand deposits in the upper 30 feet of the glacial drift. Records show that the yield is not very good, which may indicate the occurrence of only small bodies of sand and gravel. Deepening the present wells may discover further aquifers. As the glacial drift is a heterogeneous mixture of boulder till, sand, and gravel it is impossible to draw definite conclusions on the occurrence, elevation, or extent of water horizons in it. However, such a thick deposit probably contains sufficient sand and gravel deposits to provide suitable aquifers almost anywhere in the belt, although the depths to these may vary considerably.

Township 55, Range 27. Most of this township is within the Saddle Lake Indian Reservation as already described. There is, however, a narrow strip a mile wide between the Indian Reserve and the 4th meridian. In this, one well is thought to have reached the Lea Park formation underlying the glacial drift. Also two wells in sections 33 and 34 north of the Indian Reserve have reached the Lea Park formation. It is not known if the Lea Park is sufficiently sandy to contain water but this is presumed to be so. The occurrence is assumed to be local only.

ANALYSIS OF WATER SAMPLES FROM LOCAL IMPROVEMENT DISTRICT NO. 532, SASKATCHEWAN.

						Constituents as Analysed							Constituents as Calculated in assumed Combinations							
No.	¼ Sec.	Tp.	Rge.	Depth in feet	Total dissolved solids	Ca	Mg	Na	SO_4	Cl.	Alk.	Total Hardness	$CaCO_3$	$CaSO_4$	$MgCO_3$	$MgSO_4$	Na_2CO_3	Na_2SO_4	NaCl.	Source of Water
1	SE 34	53	26	36	5260	136	222	1287	3657	51	170	1900	170	231		1100		2870	84	Lea Park
2	NE 33	53	27	52	2640	36	20	962	1447	18	500	200	90		69		348	2140	297	Lea Park

WELL RECORDS - LOCAL IMPROVEMENT DISTRICT NO. 532, SASKATCHEWAN

WELL No.	LOCATION					TYPE OF WELL	DEPTH OF WELL	ALTITUDE WELL (above sea level)	HEIGHT TO WHICH WATER WILL RISE		PRINCIPAL WATER-BEARING BEDS			CHARACTER OF WATER	TEMP. OF WATER (in °F.)	USE TO WHICH WATER IS PUT	YIELD AND REMARKS
	¼	Sec.	Tp.	Rge.	Mer.				Above (+) Below (−) Surface	Elev.	Depth	Elev.	Geological Horizon				
1	SE	10	53	25	3		33	2027			33	1994	Glacial	hard		D.S.	Good supply in sand
2	SW	13				dug	48	2036	- 40	1996	48	1988	"	"		D.S.	Good supply in gravel
3	SE	13				"	23	1945	- 17	1928	23	1922	"	"		D.S.	Good supply in sand
4	NE	13				"	55	2010			55	1955	"	"		D.S.	Good supply in sand
5	SE	14				"	20	2040	- 13	2027	20	2020	"	soft		D.S.	Good supply
6	NE	14				"	60	2055			60	1995	"			D.S.	Good supply
7	NE	15				"	45	2039	- 31	2008	45	1994	"	soft		D.S.	Good supply in sand. Dry hole 110' Shale at 90 feet.
8	SW	21				"	16	1689	- 4	1685	16	1673	Top of shale	hard		D.S.	Good supply on top of Lea Park shale.
9	NE	22				"	58	2040	- 36	2004	18	2022	Glacial	soft		D.S.	Limited seepage supply
10	NW	23				"	35	2050			28	2022	"	"		D.S.	Limited supply in blue clay
11	SW	24				"	41	2072	- 30	2042	41	2031	"	hard		D.S.	Good supply in sand
12	NE	27				"	47	2052	- 43	2009	47	2005	"	"		D.S.	Good supply in sand
13	SE	28				"	12	1908			12	1896	"	"		D.S.	Good supply in sand
14	NW	28				"	24	1891			24	1867	"	"		D.S.	Good supply in clay
15	NE	30				"	12	1823			12	1811	"	"			Seepage supply on top of shale
16	NW	33				"	30	1970			30	1940	"	"		D.S.	Good supply in clay
17	SE	34				bored	84	2053	- 80	1973	84	1969	"	"		N.	Caved and abandoned
18	SW	36				dug	46	2063	- 26	2037	46	2017	"	"			Good supply in sand
1	SE	19	53	26	3	dug	14	1764			14	1750	Glacial	hard		D.S.	Good supply in gravel
2	NW	25				"	23	1890			23	1867	"	"		D.	Poor supply in sand
3	SW	26				"	40	1882	- 35	1847	40	1842	Lea Park	"		D.S.	Limited supply on top of shale
4	SW	32				"	15	1878	- 12	1866	15	1863	Glacial	soft		D.S.	Good supply in clay
5	NE	33				bored	35	1890			35	1855	Lea Park	hard		D.S.	Good supply in shale
6	NE	34				dug	15	1920	10	1910	15	1905	Glacial	soft		D.S.	Good supply in sand
7	SE	34				"	36	1899			36	1863	"	hard		S.	Good supply in blue clay
8	NW	34				"	16	1885	- 15	1870	16	1869	"			D.	Limited supply in sand
9	NW	36				"	15	1912			15	1897	"	soft		D.S.	Good supply in sand
1	SE	21	53	27	3	dug	21	1855	- 16	1839	21	1834	Glacial	hard		D.S.	Good supply in Lea Park shale
2	SW	26				"	25	1924	- 20	1904	25	1899	"	soft		D.S.	Good supply in sand and gravel
3	NW	26				"	15	1924			15	1909	"	"		D.S.	Limited supply in sand
4	NW	27				"	20	1922	- 17	1905	20	1902	"	"		D.S.	Good supply on top of shale
5	SE	27				"	8	1886			8	1878	"	hard		D.S.	Good supply in sand
6	SW	27				"	10	1866	- 7	1859	10	1856	"	"		D.S.	Limited supply in sand
7	SE	28				"	15	1904	- 13	1891	15	1889	"	"		D.S.	Limited supply in sand
8	NE	33				bored	52	1924	- 48	1876	52	1872	Lea Park	"		D.S.	Good supply in shale
9	NW	34				"	69	1930	60	1870	69	1861	" "	"		D.S.	Good supply in shale

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 - LOCAL IMPROVEMENT DISTRICT NO. 532, 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 BEDS Depth	Elev.	Geological Horizon	CHARACTER OF WATER	TEMP. OF WATER (in °F.)	USE TO WHICH WATER IS PUT	YIELD AND REMARKS
1	NW	2	54	25	3	dug	6	1997	- 5	1992	6	1991	Glacial	hard		D.S.	Good supply in sand
2	SE	5				"	41	1972	- 39	1933	41	1931	"	"		D.S.	Good supply in gravel
3	NW	6				"	20	1890	- 19	1871	20	1870	"	"		D.S.	Limited supply in clay
4	SW	7				"	18	1958			18	1940	"	"		D.S.	Good supply in clay
5	SE	8				"	30	2054			30	2024	"	"		D.S.	Good supply in gravel
6	SW	9				"	12	2038	- 10	2028	12	2026	"	"		D.S.	Good supply in yellow clay
7	SE	9				"	16	2004	- 10	1994	16	1988	"	"		D.S.	Good supply in clay
8	SE	12				"	25	2120			25	2095	"	"		D.S.	Good supply in clay
9	SE	14				"	20	2091			20	2071	"	"		D.S.	Good supply in clay
10	NE	15				"	14	2041			14	2027	"	soft		D.S.	Good supply in gravel
11	SE	17				"	20	2039	- 11	2038	20	2019	"	hard		D.S.	Good supply in gravel
12	NW	18				"	6	2060	- 4	2056	6	2054	"	soft		D.S.	Good supply in clay
13	NW	20				"	20	2130			20	2110	"	"		D.S.	Good supply in sand
14	NE	21				"	17	2085			17	2068	"	"		D.S.	Good supply in clay
15	SE	22				"	27	2087	- 25	2062	27	2060	"	"		D.S.	Limited supply
16	NE	27				"	20	2143	- 19	2124	20	2123	"	"		D.S.	Limited supply in sand
17	NE	28				"	15	2121			15	2106	"	hard		D.S.	Limited supply in sand
18	NE	34				"	24	2123	- 21	2102	24	2099	"	"		D.S.	Good supply in gravel
19	NW	35				"	18	2124	- 15	2109	18	2106	"	"		D.S.	Good supply in sand
20	NE	36				"	20	2106	- 15	2091	20	2086	"	soft		D.S.	Good supply in sand and gravel

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 BEDS Depth	Elev.	Geological Horizon	CHARACTER OF WATER	TEMP. OF WATER (in °F.)	USE TO WHICH WATER IS PUT	YIELD AND REMARKS
1	NW	1	54	26	3	dug	25	1880			25	1855	Glacial	hard		D.S.	Good supply in clay
2	NW	2				"	10	1936	- 8	1928	10	1926	"	soft		D.S.	Good supply in sand
3	SE	4				"	25	1900			25	1875	"	hard		D.S.	Limited supply
4	NE	5				"	12	1866	- 7	1859	12	1854	"	"		D.S.	Limited supply in blue clay
5	NE	9				"	8	1901	- 7	1894	8	1893	"	"		D.S.	Limited supply in sand
6	NW	12				"	12	1913			12	1901	"	"		D.S.	Good supply in gravel
7	NE	12				"	45	2021			45	1976	"	"		D.S.	Limited supply in fine sand
8	SW	13				"	16	1931			16	1915	"	"		D.S.	Poor supply
9	SW	14				"	15	1938	- 12	1926	15	1923	"	soft		D.S.	Good supply in sand
10	SW	15				"	14	1948	- 10	1938	14	1934	"	"		D.S.	Good supply in sand and gravel
11	NE	16				"	12	1962	- 11	1951	12	1950	"	"		D.S.	Good supply in sand and gravel
12	SE	17				"	10	1895			10	1885	"	hard		D.S.	Good supply in fine sand
13	NW	21				"	26	2125	- 23	2102	26	2099	"	"		D.S.	Good supply in sand
14	SE	27				"	14	1979			14	1965	"	"		D.S.	Limited supply in gravel
15	SE	34				"	52	2128			52	2076	"	"		D.S.	Limited supply in sand

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 BEDS Depth	Elev.	Geological Horizon	CHARACTER OF WATER	TEMP. OF WATER (in °F.)	USE TO WHICH WATER IS PUT	YIELD AND REMARKS
Approx.		12	54	27	3	dug	14	1892	- 7	1885	14	1878	Glacial	hard		D.S.	(Anglican Mission Onion L. Ind. Reserve) Good supply in sand
	SW	8				Spring		1880					"	"		D.S.	Continuous flow - R.C. Mission on Onion L. Indian Reserve. Dug well 34' in shale. Limited supply of poor water.

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— LOCAL IMPROVEMENT DISTRICT NO. 532, 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	HEIGHT TO WHICH WATER WILL RISE Elev.	PRINCIPAL WATER-BEARING BED Depth	PRINCIPAL WATER-BEARING BED Elev.	PRINCIPAL WATER-BEARING BED Geological Horizon	CHARACTER OF WATER	TEMP. OF WATER (in °F.)	USE TO WHICH WATER IS PUT	YIELD AND REMARKS
	SE	1	54	28	W3	dug	8	1885	- 6	1879	8	1877	Glacial	soft		D.S.	Good supply
	SW	1	55	25	3	dug	30	2130	- 29	2101	30	2100	Glacial	hard		D.	Poor supply in clay
	NE	2				"	16	2103	- 14	2089	16	2087	"	"		D.S.	Good supply in sand.
	SW	13				"	10	2048	- 9	2039	10	2038	"	soft		D.S.	Poor supply in sand.
	SE	5	55	27	W3	dug	30	1998			30	1968	Glacial	hard		D.S.	Good supply in gravel
	SE	7				"	14	2036			14	2022	"	"		D.S.	Good supply in sand.
	NE	7				"	14	2053			14	2039	"	soft		D.S.	Good supply in clay.
	SE	18				"	8	2034			8	2026	"	hard		D.S.	Just sufficient in sand.

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

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