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CANADA
DEPARTMENT OF MINES AND RESOURCES

MINES AND GEOLOGY BRANCH
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GEOLOGICAL SURVEY
WATER SUPPLY PAPER No. 245

GROUND-WATER RESOURCES
OF THE
RURAL MUNICIPALITY OF CUTKNIFE
NO. 439
SASKATCHEWAN

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



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Map - Rural Municipality of Cutknife, No. 439,
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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 or treasurer of each municipality in Saskatchewan and Alberta will be supplied with the information covering that municipality. Copies of the reports will also be available for study at offices of the Provincial and Federal Government Departments. Further assistance in the interpretation of the reports may be obtained by applying to the Chief Geologist, Geological Survey, Ottawa. Technical terms used in the reports are defined in the glossary.

How to Use the Report

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

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

GLOSSARY OF TERMS USED

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Edmonton Formation

The name Edmonton formation was first applied to the beds containing coal in the Edmonton area, and later to the same beds in adjoining areas. The formation has a total thickness of 1,000 to 1,150 feet, but is bevelled off eastward and the east edge of the formation

follows a northwest line from Coronation through Tofield to a point on North Saskatchewan River about midway between Edmonton and Fort Saskatchewan. No Edmonton beds occur northeast of this line, but the formation becomes progressively thicker to the southwest due to the fact that the beds incline in that direction and the surface bevels across them.

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

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

Bearpaw Formation

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

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

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

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

Pale and Variegated Beds

Underlying the Bearpaw formation is a succession of bentonitic sands, shales, and sandy shales containing a few coal seams. The upper part of this succession, due to the bentonitic content, is commonly light coloured and has been described as the Pale Beds, whereas the lower

part is darker, and is known as Variegated Beds. In part, dark shales are present in both Pale and Variegated Beds; others are greenish, grey, brown, and dark chocolate, carbonaceous types. The sands may also be yellow, but where bentonite is present it imparts a light colour to the beds. Both Pale and Variegated Beds are characterized by the presence of thin seams of ironstone, commonly dark reddish, but in part purplish, Selenite (gypsum) crystals are, in places, abundant in the shales.

The best sections of Pale Beds exposed in the region are in the Tit Hills, southwest of 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 Pale and Variegated Beds occur over a wide area from Maclin and Kerrobert northeast through Wilkie to the Eagle Hills, south of Battleford. Numerous outcrops occur in the area south of Unity at Muddy Lake, but south and east around Biggar these beds are almost wholly concealed by glacial drift.

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

Birch Lake Formation

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

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

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

Grizzly Bear Formation

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

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

Ribstone Creek Formation

The type area of the Ribstone Creek formation is on Ribstone Creek near its junction with Battle River in tp. 45, rge. 1, W. 4th mer. At this place the lower sand beds of the formation are well exposed. The upper part of the lower sand member of this formation outcrops on the north side of Battle River, in the northeast part of sec. 26, tp. 47, rge. 5, near the mouth of Grizzly Bear Coulee. Above it, higher on the bank and at a short distance from the river, there is a 12 foot zone of carbonaceous and coaly beds in two layers, each about 2 feet thick, separated by 6 feet of shale. Above this are 90 feet of dark shales that are thought to have been deposited in sea water, that is, they are marine shales. These marine shales in turn are overlain by a sandy zone about 20 feet thick containing oysters in the basal part. This sandy zone is the upper sand member of the Ribstone Creek formation.

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

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

Lea Park Formation

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

help to retain the surface waters. The area northeast of North Saskatchewan River in Saskatchewan is almost wholly within the Lea Park formation, where water can be found only in surface deposits.

WATER ANALYSES

Introduction

Analyses were made of water samples collected from a large number of wells in west-central Saskatchewan. Their purpose was to determine the chemical characteristics of the waters from different geological horizons, and thereby assist in making correlations of 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 (SO₄), chloride (Cl), and carbonate (CO₃) 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 (CaCO₃) and calcium sulphate (CaSO₄).

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 (MgSO₄) 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 (Na₂SO₄) combines with water to form "Glauber's salt" and excessive amounts make the water unsuitable for drinking purposes. Sodium carbonate (Na₂CO₃) 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 purposes¹. Sodium sulphate is less

1

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

harmful.

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

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

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

Hardness. The hardness of water is the total hardness, and has been determined by the amount of a standard soap solution required to form a lather that will stand up (persist) for 2 minutes. Hardness is of two kinds, temporary and permanent. Temporary hardness is caused by calcium and magnesium bicarbonates, which are soluble in water but are precipitated as insoluble normal carbonates by boiling, as shown by the scale that forms in teakettles. Permanent hardness is caused by the presence of calcium and magnesium sulphates, and is not removed by boiling. The two forms of hardness are not distinguished in the water analyses. Waters grade from very soft² to very hard, and can be classified according to the following system:

2

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

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

Hard waters are usually high in calcium carbonate. Almost all of the waters from the glacial drift are of this type, especially those 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 reaction¹.

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:

	SE. sec. 16, NE. sec. 3, SW. sec. 7, SE. sec. 21	tp. 38, rge. 21	tp. 39, rge. 25,	tp. 37, rge. 24,	tp. 38, rge. 23
Salts					
CaCO ₃	73	18	53	35	
CaSO ₄	-	-	-	-	
MgCO ₃	52	14	45	38	
MgSO ₄	-	-	-	-	
Na ₂ CO ₃	297	679	164	562	
Na ₂ SO ₄	297	158	266	437	

NaCl	31	45	45	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 ₂ CO ₃	-	-	-
Na ₂ SO 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. sec. 10, tp.35, rge. 20,
CaCO ₃	73	73	73	198	108	90
CaSO ₄	-	-	-	-	m-	-
MgCO ₃	38	38	38	52	69	52
MgSO ₄	-	-	-	-	-	-

Na ₂ CO ₃	129	119	129	11	106	125
Na ₂ SO 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 analyses suggests a common source bed. The distance between the Tramping Lake well and the Vera wells is about 40 miles. This water, which is thought to come from the basal sand of the Ribstone Creek formation, is not typical of water from the same stratigraphical horizon in the vicinity of Battle River, one reason being, possibly, that at Battle River the stream has cut through the Ribstone Creek formation exposing the sand members along its banks. This may cause a more rapid movement of the underground water in this area than farther south, and it is known that the rate of flow is a controlling factor that governs the change of calcium carbonate to sodium carbonate when the softening reagents of bentonite or glauconite are present in the sand.

Some of the soft waters from the Ribstone Creek formation cannot be distinguished from those of the Pale Beds, whereas others are quite different. The following analyses illustrate some of the different types of water from this formation:

	Se. sec. 11, tp. 46, rge.	Ind. Agent Little Pine I.R.	SW. sec. 24, tp. 46, rge.	NE. sec. 36, tp. 43, rge.	Se. sec. 26, tp. 43, rge.	NE. sec. 36, tp. 41, rge.	NW. sec. 22, tp. 42, rge.
Salts	28		21	18	18	24	23
CaCO ₃	90	90	410	73	35	73	125
CaSO ₄	-	-	-	-	-	-	-
MgCO ₃	97	59	168	38	31	38	97
MgSO ₄	-	-	64	-	-	-	-
Na ₂ CO ₃	217	392	-	283	592	129	196
Na ₂ SO 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 CUTKNIFE, NO.439, SASKATCHEWAN

Physical Features

Eagle Hills escarpment continues west into this municipality as far as Cutknife Creek; where it turns northward along the west bank of the creek to merge with the south bank of Battle River. It is here a prominent physical feature which rises rather abruptly for 200 feet and divides the lower sandy plain from the higher prairie level of most of the municipality. The branches of Cutknife Creek, with the main stream from the southeast and a tributary stream from the northwest, have cut deep and sharp valleys into glacial materials covering the higher prairies. In general, however, and particularly in the south part of the municipality, the prairie is fairly level, with a broad hill rising above an elevation of 2,200 feet in the northwest corner.

Geology

Lea Park shales do not outcrop in the municipality, but are believed to underlie the drift along Battle River. To the west, within and west of Little Pine and Lucky Man Indian Reserve, are outcrops of sandstone, probably of the Ribstone Creek formation, along the river. Presumably, also, if the drift mantle was stripped off, Grizzly Bear shales would be found along the south bank of Battle River and down the west side of Cutknife Creek to the point where the escarpment turns east. The available information suggests that between the main branch of Cutknife Creek in the south part of tp. 44, rge. 20, and the edge of the escarpment in the north part of the township, Grizzly Bear shales may underlie the drift. Farther south, and also west and south of the escarpment elsewhere, the drift is underlain, presumably, by Variegated Beds, and Pale Beds may be present in the extreme southwest corner of the municipality. A well 980 feet deep drilled by jetting at Cutknife bottomed in Lea Park shale, and is thought to have

reached this formation at a depth of about 540 feet or an elevation of 1,555 feet.

Water Supply

Most of the wells in this municipality obtain their water supply from sand and gravel beds in the glacial drift. For the most part these are isolated deposits of no great lateral extent and have only a slight degree of uniformity in level locally. They are fairly numerous, however, and in most areas are encountered in the drift, although some wells had to be sunk more than 100 feet before reaching an aquifer. Consequently, a few wells have been abandoned without finding water. As already outlined, various formations lie beneath the drift in different parts of the municipality, and water-bearing sands occur in both the Variegated Beds and the Ribstone Creek formation. In many places, however, the fineness of the sand in some of these horizons has led to trouble in drilling the wells, and in a few instances has plugged the well casings. Other wells, apparently from the same horizon, have obtained an abundant supply of water.

Township 43, Range 20. All wells for which records are available in this township obtain water from sands in the glacial drift. Some degree of continuity to these sands seems evident, especially at elevations between 2,005 and 2,015 feet and 1,950 to 1,980 feet. Also, three wells obtain their supply at an elevation of about 2,035 to 2,040 feet. It is not certain, however, how far these horizons persist, but the lowest one would appear to be the most widespread. This may, however, be due to the fact that part of the land surface lies below the elevations of the upper horizons, and, hence, more wells have been sunk to the lowest horizon. So far as known no wells in this township have reached the Variegated Beds beneath the drift, although water could be expected from sands in this formation.

Township 43, Range 21. Much less regularity is evident in the elevations of water-bearing beds in the drift in this township than in the township to the east. Apparently, also, many wells penetrate the drift without securing an adequate supply of water, and reach beds as low stratigraphically as the Ribstone Creek formation. Much trouble has been experienced in these deep wells due to heaving of the fine sand in the well, thereby shutting off the water supply. For this reason a number of the deep wells have been abandoned, although in every instance an adequate supply of water was encountered until sealed off by the fine sand. Sands in what are considered to be Variegated Beds were found to be water-bearing beneath a reported coal seam 350 feet below the surface, at an elevation of 1,797 feet in a well 670 feet deep drilled on NE. section 19. This well must have reached the Ribstone Creek formation, but no data are available on any lower water horizons that may have been encountered. Another well was drilled in the town of Cutknife to a depth of 980 feet. The record of this well is poor, as it was drilled with a jetting rig. It is certain, however, that the bottom of the well is in Lea Park shales. A sand is reported to have been encountered at a depth of 440 feet, or an elevation of 1,655 feet, and is possibly the top of the Ribstone Creek formation. Another sand is reported to have been reached at a depth of 506 feet. It is not known how thick the Ribstone Creek formation is in this area, but as it is thinning south and eastward and is believed to be 120 feet thick in the vicinity of Prongua, it is thought it must be at least 100 feet in this area, and on this assumption the base of the Ribstone Creek formation would lie at an elevation of about 1,555 feet. Below this, in the Lea Park shales, no water would be expected to occur.

Township 43, Range 22. All wells for which records are available in this township obtain water from the glacial drift at variable elevations. This seems to point to the absence of widespread, continuous aquifers, and indicates that water-bearing beds are irregularly distributed through the drift. No well has reached

the Pale and Variegated Beds beneath the drift, and though it is expected that water-bearing sands would be encountered in these formations as well as in the deeper, Ribstone Creek beds, it is probable that, as in the township to the east, trouble would result from the extreme fineness of the sand.

Township 44, Range 20. North of Prongua the Eagle Hills escarpment trends westerly and cuts across the north end of Sweet Grass Indian Reserve and across this township. North of it is a sandy area of little agricultural value. Cutknife Creek cuts across the southern part of the township, and its valley contains thick deposits of glacial drift. Several springs issue along the south side of the valley, apparently from glacial drift. The deepest well of which a record is available, on NW. section 23, is 102 feet deep, and obtains its water from glacial materials. Another well, 100 feet deep on SE. section 21, ended as a dry hole in blue glacial clay. The thickness of the drift is not known, but may be as much as 175 feet at Cutknife. Judging from the well records, there are several water-bearing horizons, but it is suspected that these have very little persistence laterally. It is also impossible from present information to predict the depth or depths to these horizons at any specific location. For most of this township, no bedrock higher than Grizzly Bear shales is believed to be present, but beneath this, in the Ribstone Creek formation, water-bearing sands are probably present, although their capacity and character are unknown.

Township 44, Range 21. Two wells in this township, one 204 feet deep on SW. section 4 and the other 200 feet deep on SW. section 6, penetrate the drift and obtain water below it, probably in the Variegated Beds, at an elevation of about 1,850 feet. Most of the wells, however, get their water in glacial sands and gravels. A few of these may have a considerable lateral extent, but most of them are local deposits, in the nature of irregularly distributed lenses in the drift, and as such, as in the township to the east, their occurrence or position cannot be predicted.

Township 44, Range 22. Records of only eight wells are available in this township, and four of these obtain water at an elevation of about 1,975 feet. This would seem to point to an aquifer trending north or slightly northwest across the centre of the township, as a well on NW. sec. 34, tp. 43, rge. 22, also obtains water at 1,975 feet. The other wells in the township show no uniformity in level, but the available data are insufficient on which to base definite conclusions. Below the drift, as in the southern part of the township to the east, the Variegated Beds probably contain water-bearing sands.

Township 45, Range 20, South of Battle River. This township, south of Battle River, is almost wholly covered by a deposit of sand in which water is found at no great depth. This is undoubtedly rain water that has accumulated in the sand where the latter rests on rather impervious glacial clay. It is thought that Ribstone Creek beds underlie the sand and drift in the southern part of the township, although Lea Park shales are probably close to the surface along Battle River.

Township 45, Ranges 21 and 22, West of Poundmaker Indian Reserve. In this area one well 150 feet deep on NE. section 5 struck a small flow of water at a depth of 130 feet, or an elevation of 1,833 feet, in what are thought to be Variegated Beds. All other wells in the area are in glacial drift, and water comes from irregularly distributed sands and gravel. The southern part of the area is presumed to be underlain by Variegated Beds, and these, as well as shales of the Grizzly Bear formation, would probably outcrop along the steep south bank of Battle River were it not for the mantle of glacial materials covering them. Several sandstone outcrops, probably of the Ribstone Creek formation, occur along Battle River in and west of the Little Pine and Lucky Man Indian Reserve. So far as known, no wells in the area have tested this formation for water.

ANALYSES OF WATER SAMPLES FROM RURAL MUNICIPALITY OF CUTKNIFE, NO. 439, SASKATCHEWAN

No.	¼ Sec.	Tp.	Rge.	Depth in feet	Total dissolved solids	Constituents as Analysed					Total Hardness	Constituents as Calculated in assumed Combinations					Source of water		
						Ca	Mg	Na	SO4	Cl.		Alk.	CaCO3	CaSO4	MgCO3	MgSO4		Na2CO3	Na2SO4
32	SW	8	43	20	72	1220	172	74	114	529	15	410	950	410	27	366	321	25	Glacial drift
34	NE	24	43	20	85	1360	293	68	29	689	9	345	1100	345	528	337	71	15	Glacial drift
67	NE	19	43	21	670	2100	36	35	689	685	368	500	250	90		122	281	607	Pale Beds
41	NW	27	44	22	64	4460	529	342	107	2317	65	460	3000	460	1172	1692	202	107	Glacial drift
38	SW	4	44	21	204	2680	472	158	112	1361	20	635	2600	635	744	788	306	33	Glacial drift
37	NE	4	44	20	90	1340	229	89	n.d	435	41	325	1200	325	337	248		17	Glacial drift
39	NE	5	45	21	150	2700	422	122	214	1341	16	605	1900	605	612	604	632	26	Glacial drift
51	SE	32	45	21	35	1340	36	17	448	525	38	530	160	90		59	392	63	Ribstone Creek
40	SE	9	45	22	78	1900	336	118	67	955	13	460	1500	460	516	584	184		Glacial drift

RECORD OF WELLS IN RURAL MUNICIPALITY OF CUTKNIFE, NO. 439, SASKATCHEWAN.

Well No.	LOCALITY	Sec. Tp. Rge. Mer.	Type of Well	Depth of Well	Altitude of Well	WATER LEVEL		PRINCIPAL WATER-BEARING LAYER	Charac-ter of water	Use to which water is put	Yield in barrels		
						Above or Below surface	Elev. Above or Below Sea Level						
1	N.W. 2	43	20	3	2072	-30	2042	2007	Fine sand	Hard	Fe.	D.S.	Sufficient
2	S.W. 2	"	"	"	2082	-20	2062	2014	Sand	"	"	"	"
3	S.E. 2	"	"	"	2092	-32	2060	2052	Flack	Hard	Alk.	"	Poor supply
4	N.W. 4	"	"	"	2055	-40	2015	1985	"	"	"	"	Sufficient
5	S.W. 6	"	"	"	2099	-54	2045	2039	Sand	Hard	Alk.	D.S.	Good supply; another well 30' in gravel, good water.
6	S.W. 8	"	"	"	2051	-37	2014	1979	Flack	"	Alk.	"	Poor supply.
7	N.W. 12	"	"	"	2065	-30	2035	2035	Sand & gravel	Hard	Alk.	D.S.	Sufficient
8	N.E. 14	"	"	"	2041	-20	2021	2013	Coarse sand	"	"	"	Sufficient
9	N.E. 23	"	"	"	2019	-30	1989	1986	Fine	"	"	"	"
10	S.W. 24	"	"	"	2037	-17	2021	2007	"	Soft	"	"	"
11	N.E. 24	"	"	"	2038	-17	2021	1953	Blue clay	Hard	Fe.	"	Good supply
12	N.W. 24	"	"	"	2038	-55	1961	2004	Fine sand	"	"	"	Poor
13	S.W. 25	"	"	"	2016	-55	1961	1951	"	"	Fe.	"	Sufficient
14	N.W. 32	"	"	"	2062	-20	2000	2036	Black	Hard	"	"	Sufficient
15	S.E. 32	"	"	"	2020	-20	2000	1987	Clay	"	"	"	Good supply, School Well
16	N.E. 33	"	"	"	2002	-34	1978	1957	Sandy	"	"	"	Limited supply
17	S.W. 34	"	"	"	2012	-34	1978	1972	Gravel	"	Alk.	D.S.	Good Supply
18	S.W. 34	"	"	"	2012	-34	1978	1972	"	"	"	D.S.	Sufficient
1	N.E. 6	43	21	3	2083	-32	2051	2041	Glacial	Hard	Alk.	S.	Good Supply
2	S.W. 14	"	"	"	2035	-33	2002	1990	Sand	"	"	D.S.	Sufficient
3	S.W. 15	"	"	"	2070	-30	2040	2030	Sand	Hard	"	"	Limited supply
4	N.E. 18	"	"	"	2110	-80	2067	2095	"	"	"	"	Waters 100 head stock.
5	N.E. 19	"	"	"	2147	-80	2067	1797	Variegated Beds?	"	"	"	Coal seam at 350'.
6	N.W. 21	"	"	"	2084	-20	2039	2024	Sand	"	"	"	Sufficient
7	N.W. 28	"	"	"	2059	-20	2039	2009	Fire sand	"	"	"	"

x - D.- Domestic Stock Fe. Iron

Well

No.

8	S.E.30	43	21	3	Drilled	380	2125	-50	2075	323 377 440 506	1802 1748 1655 1589	Fine sand Variegated Beds ? sand Ribstone Ck.	Sand trouble
9	S.W.32	"	"	"	"	980	2095						Well abandoned. Cutknife Town
10	N.E.33	"	"	2	Dug	110	2055	-27	2004	30	2001	Fine sand	Dry Hole
11	N.W.34	"	"	"	Bored	30	2031			87	1953		Poor supply
12	N.E.35	"	"	"	"	87	2040			70	1960		Good
13	N.E.36	"	"	"	"	70	2030	-55	1975	70	1960	Sand	Limited "
1	N.W. 6,	43	22	3	Bored	78	2215 [±]	-69	2146	78	2137	Dark sand	Sufficient
2	S.W. 6	"	"	"	Dug	20	2201			20	2081	Blue clay	Limited
3	S.W.12	"	"	"	Bored	38	2115	- 2	2113	38	2077	" "	Good supply
4	N.W.16	"	"	"	"	85	2231			75	2156	Sandy "	Limited
5	S.W.25	"	"	"	Drilled	500	2172	-72	2119	490	1682	Ribstone Creek	Well abandoned
6	S.W.28	"	"	"	Bored	80	2191			80	2111	White sand	Limited supply
7	S.W.33	"	"	"	"	65	2074	-57	1983	65	2009	Glacial Gravel	Good
8	N.E.34	"	"	"	"	65	2040			65	1975	"	"
1	N.E. 4	44	20	3	Bored	90	1980	-78	1902	90	1890	Gray sand	Good supply
2	S.W. 6	"	"	"	"	70	2015			70	1945	Gravel	Limited supply
3	N.W. 9	"	"	"	"	70	1980	-49	1931	60	1920	Sand	Sufficient
4	N.E.10	"	"	"	Dug	16	1978	-12	1866	16	1962	Fine "	Limited
5	S.E.10	"	"	"	"	35	1981	-30	1951	35	1946	Gravel	Sufficient
6	N.E.12	"	"	"	"	10	1978	- 6	1972	10	1968	"	"
7	S.E.15	"	"	"	"	15	1955	- 9	1946	15	1940	Sand	"
8	S.E.16	"	"	"	Bored	70	1960	-50	1910	70	1890	"	"
9	S.W.17	"	"	"	"	80	1965	-60	1905	80	1885	Clay	Poor supply
10	S.W.18	"	"	"	"	75	1977	-10	1967	75	1902	"	"
11	N.E.20	"	"	"	"	60	1770	-50	1720	57	1713	Fine sand	Sufficient
12	S.E.21	"	"	"	"	40	1890			40	1850	"	Poor supply, Dry Hole in Blue Clay 100'.
13	N.W.21	"	"	"	Dug	30	1758			30	1728	Fine sand	Sufficient
14	N.E.22	"	"	"	"	15	1863	- 3	1860	15	1848	"	"
15	N.E.23	"	"	"	"	20	1921	-16	1905	20	1901	Glacial Gravel	Poor supply
16	N.W.23	"	"	"	Bored	102	1953	-94	1859	102	1851	Gravel & sand	Sufficient
17	S.E.24	"	"	"	Dug	24	1952	-20	1932	24	1928	Sand	Sufficient

Well

No.

1	N.E. 5	45	21	3	Bored	150	1963	-130	1833	130	1833	Sand	Hard Fe.	S.	Poor supply, piece of wood found at 100'.
2	N.E. 6	"	"	"	Dug	16	1974	-12	1962	16	1958	Sand	Hard	D.S.	Sufficient
3	S.E.32	"	"	"	"	35	1704			35	1669	Red sand	Soft	"	" Indian Agent's Well.
1	N.W. 3	45	22	3	Bored	52	2033	-44	1992	52	1981	Sand	Hard Alk.	D.S.	Sufficient
2	N.E. 4	"	"	"	"	74	2036	-30	2010	74	1962	Stratified Clay	" Fe.	"	Waters 100 head
3	S.E. 9	"	"	"	"	78	2040	-22	2022	78	1962	Sand	" Fe.	"	" 200 " stock.
4	S.W.10	"	"	"	"	52	2044	-11	1997	52	1992	Fine sand	Soft	"	Limited
5	S.E.13	"	"	"	Dug	14	2008	-30	2108	14	1994	Dark "	Hard Fe.	S.	Sufficient
6	S.E.19	"	"	"	Bored	100	2138	-40	2052	100	2038	Fine "	"	D.S.	Limited supply
7	S.W.21	"	"	"	"	80	2092			80	2012	Fine "	"	"	"
8	S.E.30	"	"	"	Dug	30	2119			30	2089	Glacial sand	"	"	Dry Hole in Blue Clay
9	S.E.36	"	"	"	Bored	90	1734			90			"	"	Indian Mission School