CANADA
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PRELIMINARY REPORT

GROUND-WATER RESOURCES OF THE RURAL MUNICIPALITY OF .... NO. 140 SASKATCHEWAN

By

B. R. MacKay, H. N. Hainstock, & G. L. Scott

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INTRODUCTION

Lack of rainfall during the years 1930 to 1934 over a large part of the Prairie Provinces brought about an acute shortage both in the larger supplies of surface water used for irrigation and the smaller supplies of ground water required for domestic purposes and for stock. In an effort to relieve the serious situation the Geological Survey began an extensive study of the problem from the standpoint of domestic uses and stock raising. During the field season of 1935 an area of 80,000 square miles, comprising all that part of Saskatchewan south of the north boundary of township 32, was systematically examined, records of approximately 60,000 wells were obtained, and 720 samples of water were collected for analyses. The facts obtained have been classified and the information pertaining to any well is readily accessible. The examination of so large an area and the interpretation of the data collected were possible because the bedrock geology and the Pleistocene deposits had been studied previously by McLearn, Warren, Rose, Stansfield, Wickenden, Russell, and others of the Geological Survey. The Department of Natural Resources of Saskatchewan and local well drillers assisted considerably in supplying several hundred well records. The base maps used were supplied by the Topographical Surveys Branch of the Department of the Interior.

Publication of Results

The essential information pertaining to the ground water conditions is being published in reports, one being issued for each municipality. Copies of these reports are being sent to the secretary treasurers of the municipalities and to certain Provincial and Federal Departments, where they can be consulted by residents of the municipalities or by other persons, or they may be obtained by writing direct to the Director, Bureau of Economic Geology, Department of Mines, Ottawa. Should anyone require more detailed information than that contained in the reports such additional information as the Geological Survey possesses can be obtained on application to the director. In making such request the applicant should indicate the exact location of the area by giving the quarter section, township, range, and meridian concerning which further information is desired.

The reports are written principally for farm residents, municipal bodies, and well drillers who are either planning to sink new wells or to deepen existing wells. Technical terms used in the reports are defined in the glossary,

How to Use the Report

Anyone desiring information about ground water in any particular locality should read first the part dealing with the municipality as a whole in order to understand more fully the part of the report that deals with the place in which he is interested. At the same time he should study the two figures accompanying the report. Figure 1 shows the surface and bedrock geology as related to the ground water supply, and Figure 2 shows the relief and the location and type of water wells. Relief is shown by lines of equal elevation called "contours". The elevation above sea-level is given on some or all of the contour lines on the figure.

If one intends to sink a well and wishes to find the approximate depth to a water-bearing horizon, he must learn: (1) the elevation of the site, and (2) the probable elevation of the water-bearing bed. The elevation of the well site is obtained by marking its position on the map, Figure 2, and estimating its elevation with respect to the two contour lines between which it lies and whose elevations are given on the figure. Where contour lines are not shown on the figure, the elevations of adjacent wells as indicated in the Table of Well Records accompanying each report can be used. The approximate elevation of the water-bearing horizon at the well-site can be obtained from the Table of Well Records by noting the elevation of the water-bearing horizon in surrounding wells and by estimating from these known elevations its elevation at the well-site.[1] If the water-bearing horizon is in bedrock the depth to water can be estimated fairly accurately in this way. If the water-bearing horizon is in unconsolidated deposits such as gravel, sand, clay, or glacial debris, however, the estimated elevation is less reliable, because the water-bearing horizon may be inclined, or may be in lenses or in sand beds which may lie at various horizons and may be of small lateral extent. In calculating the depth to water, care should be taken that the water-bearing horizons selected from the Table of Well Records be all in the same geological horizon either in the glacial drift or in the bedrock. From the data in the Table

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[1] If the well-site is near the edge of the municipality, the map and report dealing with the adjoining municipality should be consulted in order to obtain the needed information about nearby wells.

of Well Records it is also possible to form some idea of the quality and quantity of the water likely to be found in the proposed well.

GLOSSARY OF TERMS USED

Alkaline. The term "alkaline" has been applied rather loosely to some ground-waters. In the Prairie Provinces, a water is usually described as "alkaline" when it contains a large amount of salts, chiefly sodium sulphate and magnesium sulphate in solution. Water that tastes strongly of common salt is described as "salty". Many "alkaline" waters may be used for stock. Most of the so-called "alkaline" waters are more correctly termed "sulphate waters".

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 water-bearing bed, lens, or pocket in unconsolidated deposits or in bedrock.

Buried pre-Glacial Stream Channels. A channel carved into the 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 struck.

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 the ground water.

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

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

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

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

<u>Water Table.</u> 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.

<u>Wells.</u> 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. These are called <u>Flowing Artesian Wells.</u>

(2) Wells in which the water is under pressure but does not rise to the surface. These wells are called <u>Non-Flowing Artesian Wells.</u>

(3) Wells in which the water does not rise above the water table. These wells are called <u>Non-Artesian Wells.</u>

NAMES AND DESCRIPTIONS OF GEOLOGICAL FORMATIONS, REFERRED TO IN THESE REPORTS

Wood Mountain Formation. The name given to a series of gravel and sand beds which have a maximum thickness of 50 feet, and which occur as isolated patches on the higher parts of Wood Mountain. This is the youngest bedrock formation and, where present, overlies the Ravenscrag formation.

Cypress Hills Formation. The name given to a series of conglomerates and sand beds which occur in the southwest corner of Saskatchewan, and rests upon the Ravenscrag or older formations. The formation is 30 to 125 feet thick.

Ravenscrag Formation. The name given to a thick series of light-coloured sandstones and shales containing one or more thick lignite coal seams. This formation is 500 to 1,000 feet thick, and covers a large part of southern Saskatchewan. The principal coal deposits of the province occur in this formation.

Whitemud Formation. The name given to a series of white, grey, and buff coloured clays and sands. The formation is 10 to 75 feet thick. At its base this formation grades in places into coarse, limy sand beds having a maximum thickness of 40 feet.

Eastend Formation. The name given to a series of fine-grained sands and silts. It has been recognized at various localities over the southern part of the province, from the Alberta boundary east to the escarpment of Missouri coteau. The thickness of the formation seldom exceeds 40 feet.

Bearpaw Formation. The Bearpaw consists mostly of incoherent dark grey to dark brownish grey, partly bentonitic shales, weathering light grey, or, in places where much iron is present, buff. Beds of sand occur in places in the lower part of the formation. It forms the uppermost bedrock formation over much of western and southwestern Saskatchewan and has a maximum thickness of 700 feet or somewhat more.

<u>Belly River Formation</u>. The Belly River consists mostly of non-marine sand, shale, and coal, and underlies the Bearpaw in the western part of the area. It passes eastward and northeastward into marine shale. The principal area of transition is in the western half of the area where the Belly River is mostly thinner than it is to the west and includes marine zones. In the southwestern corner of the area it has a thickness of several hundred feet.

<u>Marine Shale Series</u>. This series of beds consists of dark grey to dark brownish grey, plastic shales, and underlies the central and northeastern parts of Saskatchewan. It includes beds equivalent to the Bearpaw, Belly River, and older formations that underlie the western part of the area.

WATER-BEARING HORIZONS OF THE MUNICIPALITY

Rural municipality, No. 140, covers an area of 324 square miles in southwestern Saskatchewan. It consists of nine townships described as tps. 13, 14, and 15, ranges 22, 23, and 24, W. 3rd mer. The main line of the Canadian Pacific railway traverses the SE. ¼, sec. 1, tp. 13, range 22. There are no trading centres in the municipality, and the residents are served by the village of Tompkins in township 13, range 21, and by the village of Piapot in township 12, range 23. The centre of the municipality is 55 miles west of the city of Swift Current.

Approximately the southwestern half of the municipality was covered by a glacial lake of which Crane lake, Bigstick lake, and several, smaller, unnamed lakes are remnants. The part of the municipality covered by this glacial lake is mantled by a deposit of glacial lake sands 3 to 25 feet thick. In some sections these fine glacial lake sands have been blown into dunes by wind action, and form the Great Sand Hills that extend across the central part of the municipality in a northwest-southeast direction. In some places the dune sand is at least 43 feet thick. The northeastern half of the municipality is largely covered by moraine and glacial till. The ground surface of the municipality is generally slightly undulating to rolling and is particularly uneven and rough in the moraine-covered districts, and in the southwestern part of township 13, range 22, and the southeastern corner of township 13, range 23. The maximum elevation of about 2,655 feet above sea-level is reached in a number of hills in township 13, range 22, and the minimum elevation of 2,326 feet is at the surface of Bigstick lake in township 15, range 24.

Undrained depressions are very common, the largest of these being occupied by Crane lake in the southern part of the municipality, and by Bigstick lake in township 15, range 24. In years of average rainfall the lakes retain 20 and 10 feet of water and are at elevations of 2,425 and 2,326 feet above sea-level, respectively, but during the drought period Crane lake was dry and Bigstick lake was nearly dry. The water in these lakes, and in nearly all the undrained depressions in the municipality, is highly mineralized and is not suitable for stock. Some stock that watered at Crane lake during the drought died from the effects of the highly mineralized water. Piapot creek flows into Crane lake in township 13, range 23, from the south, but the volume of water carried by this creek has been restricted due to the erection of a dam at Piapot by the Canadian Pacific Railway Company. Two smaller streams, locally designated as Skull creek and Sidewood creek, empty into two lakes in the southern part of township 13, range 22.

The soil in the areas covered by glacial lake sands and Recent dune sands is too light to be extensively cultivated. The Great Sand Hills are covered by small poplar and sage brush, which if removed would result in drifting of the sand in the direction of the prevailing winds. The northeastern third of the municipality, which is largely covered by glacial till and moraine, is overlain by a thin covering of silty loam. The soil in this area can be cultivated successfully in years of normal rainfall, but is not suitable for cultivation during drought periods. Most of the municipality is used as grazing land for stock.

Water-bearing Horizons in the Unconsolidated Deposits

Water in this municipality is largely derived from springs and from wells sunk into the Recent dune sands or into the glacial drift. A few dams and dugouts are utilized for collecting and conserving surface water. Approximately twenty-five farmers in the municipality reported a shortage of water.

Springs are quite common in the six northern townships, and they are usually found near the bases of hills or in small valleys. Two springs in particular yield very abundant supplies of water and their available supply was not noticeably decreased during the drought of 1930 to 1934. These two springs are located in the NW. $\frac{1}{4}$, sec. 12, tp. 14, range 22, and in sec. 8, tp. 14, range 24. The spring in sec. 8, tp. 14, range 24, yields sufficient water for 1,000 head of stock and the residents have considered developing the one in sec. 12, tp. 14, range 22, so that it could be used as a community watering place for stock. The water from the springs is not highly mineralized and it is used extensively by ranchers for stock.

Adequate supplies of water are easily obtained from the Recent dune sands at depths less than 45 feet. The usual method employed by ranchers is to drive a sand-point below the water table at some convenient locality where stock is watered. If a large herd of stock is to be watered, several sand-points are used. The drought of 1930 to 1934 did not affect the supply of water in the Great Sand Hills nearly so much as it did in other parts of the municipality, and all the farmers and ranchers in this area have an adequate supply of water. The quality of the water varies from very soft to hard and "alkaline", but there is no difficulty in securing water that is usable for drinking.

The glacial lake sands are not as thick as the Recent dune sands and they usually extend to depths less than 15 feet. These sands overlie boulder clay, usually blue boulder clay, and the small supply of water derived from the glacial lake sands is easily affected by variations in rainfall. The coarser lake sands underlie the top soil, but at the contact of the lake sands and boulder clay a very fine quicksand is found in many places.

Wells that tap the quicksand yield water, but great difficulty is experienced in keeping the wells free from sand. If the quicksand layer is more than 2 or 3 feet thick it is very difficult to dig through it into the underlying boulder clay in the hope of securing better supplies of water from sand or gravel pockets. In such places farmers dig more than one well into the quicksand and use them all in order to obtain sufficient water for local needs. The surface of the boulder clay is uneven, and consequently wells sunk in the glacial lake sands in hollows in the surface of the boulder clay yield better supplies of water in drought years than do those that are sunk at the top of a knoll or rise in the surface of the boulder clay.

Water is obtained from pockets of sand and gravel in the boulder clay at depths of 6 to 63 feet. The supply of water is usually not abundant, and the water is rarely under pressure. Some wells were affected by the drought of 1930 to 1934. Sand-points have been driven successfully to a depth of 55 feet in the glacial drift and five of these wells in township 15, range 23, yield abundant supplies of water under hydrostatic pressure. The sand-points are used to overcome the difficulty of digging through layers of quicksand. The water from the glacial lake sands and from the pockets of sand and gravel in the boulder clay is occasionally too highly mineralized for drinking.

Dry holes have been sunk to a depth of 80 feet in the glacial drift but no well in the municipality has been bored or drilled through the glacial drift into the underlying bedrock formation. However, from evidence obtained from adjoining municipalities the glacial drift is estimated to be approximately 100 to 200 feet thick. Rather than attempt to obtain water at depths of 100 to 200 feet in the glacial drift by boring or drilling, farmers are advised to thoroughly prospect the upper 30 to 40 feet of the drift with a small test auger. Large, deep dugouts to retain surface water for stock can be advantageously employed in the moraine and glacial till-covered areas. Excavating wells 10 to 20 feet deep and 10 feet in diameter at the point where springs issue from the ground will increase the amount of water available from these sources.

Water-bearing Horizons in the Bedrock

The drak grey shales of the Bearpaw formation immediately underlie the glacial drift throughout the municipality. No wells in this municipality have been drilled into the bedrock as an abundant supply of water is usually obtained from the upper part of the glacial drift. The Bearpaw formation is thought to be thin and is not a good source of water. The Belly River formation underlies the Bearpaw, and in many places it contains water-bearing horizons. In the adjoining municipalities a number of wells obtain water from the Belly River formation at depths of 300 to 500 feet, and it is possible that wells sunk to these depths in this municipality would also encounter water-bearing horizons in the Belly River formation.

GROUND WATER CONDITIONS BY TOWNSHIPS

Township 13, Range 22

Recent dune sands cover most of the northern half of this township and glacial lake sands overlie the boulder clay or glacial till in the southern sections and parts of sections 30 and 31. The glacial till occurs at the surface in parts of sections 34, 35, and 36. The northeastern tip of Crane lake is located in the western parts of sections 30 and 31, and several small lakes and large sloughs, the largest being about 800 acres in area, occur in the southern 2½ miles of the township. All these lakes and sloughs were dry at some period during the drought of 1930 to 1934. The ground surface is rolling and it is particularly uneven in the southwestern part of the township. The minimum elevation of 2,425 feet above sea-level occurs at the level of Crane lake, and the maximum elevation of 2,655 feet is reached on a hill in the SW. ¼, section 14. Skull creek, a small, intermittent stream, flows from the southwest into one of the larger lakes in the NE. ¼, section 5. A stream, locally termed Sidewood creek, flows in a westerly direction across section 12 and empties into a lake in the SE. ¼, section 11. The area covered by sand dunes is lightly wooded with scrub poplar, willow, and sagebrush.

Since the soil is sandy and light very little of the land is cultivated and most of it is used as grazing land for stock. Springs are quite common in the vicinity of Sidewood creek, and they are used for stock. A dam has been constructed across Sidewood creek in sec. 7, tp. 13, range 21, and the water impounded by the dam during the spring-run-off season is also used for stock needs in this township.

Most of the wells are located in the southern 4 miles of the township within the area covered by glacial lake sands. The lake sands vary from 3 to 25 feet in thickness and overlie blue clay. Small, but sufficient, supplies of water, are in many cases obtained from the glacial lake sands. Water is not difficult to find, but during the drought of 1930 to 1934 the water-level lowered in many of the wells. In most of the wells coarse sand underlies the light sandy soil and is usually followed by a very fine sand or quicksand. Small quantities of water are found in this quicksand, but the wells cannot be deepened to obtain a better supply of water as the quicksand washes into the wells. Residents usually use more than one of these shallow wells to obtain an adequate supply of water. The water from the glacial lake sands is hard and much of it "alkaline", but it is used for drinking. A 42-foot well in the SE. $\frac{1}{4}$, section 1, was bored through the glacial lake sands into water-bearing, sandy clay in the underlying boulder clay. The supply of water from this well is small and it decreased during the drought. The water is hard and slightly "alkaline".

Wells in the area covered by dune sands are from 8 to 16 feet deep and the quantity and quality of the water obtained are similar to that from the glacial lake sands. One well, however, located in a valley in the SW. $\frac{1}{4}$, section 25, was dug through sand into quicksand. The water level stands only 1 foot below the surface and the supply has been constant and adequate since 1901, the year the well was dug.

The supply of ground water is not particularly abundant in this township, but it is adequate for local needs, even during periods of drought. The water in lakes and sloughs is "alkaline", but it is sometimes used for stock.

Township 13, Range 23

The greater part of Crane lake, which lies at an approximate elevation of 2,425 feet above sea-level, occurs within this township. In years of normal rainfall the southern part of this lake contains 20 feet of water. During part of the drought of 1930 to 1934 this lake became dry and its bed was covered by sodium sulphate ("white alkali"). Piapot creek, a stream rising in the Cypress hills to the south, flows into Crane lake in the NE. $\frac{1}{4}$, section 3. The lake has no outlet and the water is highly mineralized. During the drought the decrease in the quantity of water in the lake caused a higher concentration of salts than usual and in 1934 it was reported that some stock had died after drinking the water.

The land surface of the township is covered by glacial lake sands and Recent dune sands. The ground is rolling, except in the vicinity of Crane lake where it is quite flat. Scrub poplar, willow, and sagebrush occur in parts of the areas covered by dune sand.

Most of the wells in this township are less than 15 feet deep and derive water either from the glacial lake sands or from the Recent dune sands. One 35-foot well in the NW. $\frac{1}{4}$, section 36, was bored through the glacial lake sands into sandy clay in the underlying blue boulder clay. The supply of water from the wells in the township is small, and most of them were readily affected by the drought of 1930 to 1934. Residents usually use more than one well to obtain an adequate supply of water. The water is hard. and some is "alkaline", but it is usable for drinking. No difficulty should be experienced in obtaining sufficient water for local needs in this township.

Township 13, Range 24

Part of Crane lake extends into the east-central part of this township. Most of the township is covered by glacial lake sands, which in small areas have been blown by the wind into Recent sand dunes. A long, narrow area covered by moraine extends across the central part of the township as far east as the NW. $\frac{1}{4}$, section 24. The land is gently rolling, unwooded, and the soil is a fine sandy loam.

The wells in this township are from 8 to 35 feet deep, and most of them derive water from the glacial lake sands or from the Recent dune sands. These sands overlie the blue boulder clay and are not more than 20 feet thick in this township. The sand layer immediately overlying the blue boulder clay is as a rule very fine and it forms the aquifer for a number of wells. This quicksand layer is from 2 to 3 feet thick and difficulty is experienced in digging wells through it as the sand washes in as fast as it can be excavated. Farmers in many cases dig a number of wells to the quicksand and use them all in order to obtain an adequate supply of water. The supply of water from the dune and glacial lake sands is small and was considerably decreased during the drought. The water varies from soft, to hard and "alkaline", but it is used for drinking.

A few wells have been dug or bored into small lenses or pockets of sand in the underlying boulder clay, but the supply of water from this source is very small and easily influenced by the variation in seasonal precipitation. A sand-point driven in the SW. $\frac{1}{4}$, section 32, passed through 3 feet of fine sandy loam, 12 feet light clay, 5 feet blue boulder clay, and 2 feet quicksand. The water obtained is hard, slightly "alkaline", contains iron, and in 1928 it had an "iodine" odour. The supply of water is small, but sufficient for local needs, and it is not under hydrostatic pressure. Seven farmers in the township have been unable to obtain an adequate supply of water. In years of normal rainfall adequate supplies are easily obtained from the thick deposit of sand that usually overlies the blue boulder clay, but in dry years the water table lowers and causes a slight shortage of water for stock.

Township 14, Range 22

The northern sections of this township are covered by moraine, the southern part is mantled by a deposit of Recent dune sands that attains a thickness of 43 feet in some places, and the central area is covered by glacial lake sand, glacial till, moraine, and a small area of dune sands in section 20. The ground surface is decidedly rolling and the southern sections are partly wooded with scrub poplar and willow. Large, shallow sloughs are common, but they were dry during the drought period. The water in these sloughs is highly mineralized.

A spring in the NW. $\frac{1}{4}$, section 12, feeds a large slough in sections 12 and 13, and yields an abundant supply of water from an aquifer of white gravel that underlies a thin layer of sandy loam. The spring has never gone dry, and it has been proposed that it be used as a source of water for stock in this community, as much of the land is used for ranching. A small but constant supply of water is delivered by a spring in the NE. $\frac{1}{4}$, section 27. Springs are also common in the vicinity of a large slough in sections 33 and 34.

The supply of water in this township is largely obtained from wells 8 to 43 feet deep that are sunk into the glacial lake sands, dune sands, or into water-bearing pockets of sand or gravel in the underlying boulder clay. No wells yield water under hydrostatic pressure, and the supply obtained in most of the wells in the township is small and easily decreased by drought conditions. Farmers usually use more than one well, each of which gives an insufficient supply but together yield an adequate supply. The most productive well in the township is in the NE. $\frac{1}{4}$, section 31. At this locality a sand-point was driven 9 feet through sand, clay, and into water-bearing gravel. The water-level stands at a point 5 feet below the surface, the supply is very abundant, and the water is soft. Most of the wells in the township yield hard water that is in some cases "alkaline", but it is used for drinking. Only two farmers in the township, one in the SE. $\frac{1}{4}$, section 16, and the other in the NE. $\frac{1}{4}$, section 21, reported an inadequate supply of water.

Township 14, Range 23

The greater part of the township is covered by Recent dune sands that form a part of the Great Sand Hills. Smaller areas covered by glacial till and moraine occur in the northern and eastern sections, and areas mantled by glacial lake sands and glacial till are located in the western part of the township. The ground surface is undulating to rolling and the Great Sand Hills are covered with a growth of small poplar and sagebrush. The land is not cultivated, as the sand dunes would soon begin to migrate by wind action if the grass and brush were removed. The land is used entirely for grazing purposes.

The wells in this township are from 9 to 30 feet deep and most of them are sand-points that have been driven past the level of the water table in the sand. In some areas the sand extends only 3 feet below the surface, whereas in others it is at least 30 feet thick. Where the sand is thin it is usually underlain by yellow boulder clay, but where the sand is thick it overlies blue boulder clay. A few wells have penetrated the dune and lake sands and derive water from sand or gravel in the underlying boulder clay. Adequate supplies of water are easily obtained at depths less than 30 feet in this township, and the supply was not greatly affected by the drought of 1930 to 1934. The water varies from soft, to hard and "alkaline". As the township is devoted to ranching, the wells are used almost entirely for stock. No difficulty should be experienced in obtaining sufficient water for local needs.

Township 14, Range 24

The greater part of this township is mantled by Recent dune sands and lies within the Great Sand Hills. Smaller areas covered by glacial lake sands occur in the southern mile of the township, the eastern sections, and in the northern part of section 32. Glacial till covers parts of sections 23, 25, 26, and 31. The ground surface is undulating to rolling and the soil is too sandy for cultivation. Several large sloughs occur in the eastern sections, but they are of little use to the ranchers as the water is "alkaline". These sloughs become dry in drought years. The sand dunes are covered with a growth of grass and sagebrush, which if removed by cultivation would result in the sand shifting due to wind action. The land is used entirely for stock grazing purposes.

A spring in section 8 yields sufficient water for 1,000 head of stock, even in drought years. This spring has not been used to its full capacity as water is so easily obtained by wells. Most of the wells derive water from either the glacial lake sands or from the dune sands. Two wells, 30 and 25 feet deep, in the SW. $\frac{1}{4}$, section 11, and the NE. $\frac{1}{4}$, section 28, obtain abundant supplies of water from deposits of sand and gravel that underlie 6 to 8 feet of clay. The 25-foot well penetrated the following materials in descending order: 8 feet clay, 10 feet quicksand, 6 feet blue clay, and 1 foot gravel. The 30-foot well has never been pumped dry since 1930, the year the sand-point was driven. The wells in this township are from 9 to 30 feet deep and with the exception of the two mentioned above, they have been sunk in sand that extends from the surface to the base of the well. Sand-points are used extensively. The supply of water is abundant and it was little affected by the drought of 1930 to 1934. The water varies from soft, to hard and "alkaline", and that from most of the wells is quite suitable for drinking. There is no shortage of water in this township.

Township 15, Range 22

Glacial till covers portions of sections 6, 7, 17, and 18, and glacial lake sands cover parts of sections 27, 28, 31, 32, 33, 34, and 35, whereas the remainder of the township is mantled by moraine. The ground surface is rough and rolling, and hills and large undrained depressions are common. The undrained depressions retain highly mineralized water in years of normal rainfall, but they are dry during drought periods.

Springs issue from sand and gravel aquifers near the base of some of the hills. These springs yield hard, slightly "alkaline" water, and they are used extensively for watering stock. No water is obtained from the glacial lake sands in this township, as they are not more than 2 or 3 feet thick. Dry holes have been dug to a maximum depth of 80 feet, however, in the glacial drift in the NE. $\frac{1}{4}$, section 13. Adequate supplies of water are not so easily obtained in this township as they are in the six southern townships of the municipality. The producing wells are from 13 to 63 feet deep and tap pockets of water-bearing sand and gravel that usually occur surrounded by boulder clay, but occasionally wells are dug in pockets of sand and gravel that extend from the surface to the base of the well. Many of the wells were affected by the drought of 1930 to 1934, but only eight farmers reported an insufficient supply of water.

One of the most productive wells in the township is a sand-point that is driven 22 feet to a bed of water-bearing gravel that underlies dark blue boulder clay. This well is located in the SE. $\frac{1}{4}$, section 4, and the water rises under pressure to a point 2 feet below the surface. The supply has been constant and very abundant since the sand-point was driven in 1929. The only other well that yields water under hydrostatic pressure was sunk for a school in the SW. $\frac{1}{4}$, section 22. This well is 63 feet deep, the deepest producing well in the municipality, and the water rises from a sand and gravel aquifer to a point 53 feet below the surface.

The water from wells in this township varies greatly in quality. Some wells yield soft water that can be used for washing, whereas other wells deliver hard water that is too "alkaline" for drinking. A 60-foot well in the SE. $\frac{1}{4}$, section 34, yields water that is too mineralized for stock use.

The farmer in the SE. $\frac{1}{4}$, section 33, has excavated a dugout in order to collect surface water to supplement the deficient supply of water from wells. The use of dugouts to retain surface water for stock use is recommended in this township. The dugout must be at least 12 feet deep to be successful. Test augers should be used prior to digging a well in order to locate a water-bearing deposit and eliminate the possibility of digging dry holes. Boring or drilling to depths much in excess of 100 to 200 feet is not recommended, as the underlying Bearpaw formation in this municipality is not thought to contain many water-bearing deposits of sand and gravel. Farmers are well advised to thoroughly prospect the upper 35 to 40 feet of glacial drift, preferably on the slopes or near the bases of hills, or in or near depressions.

Township 15, Range 23

Glacial lake sands cover the boulder clay in parts of the northern row of sections, and in parts of sections 7, 8, 17, and 18. A strip of country $1\frac{1}{2}$ to $2\frac{1}{2}$ miles wide in the northern half of the township is covered by moraine, and smaller areas in the southeastern corner of the township are also covered by moraine. Part of the Great Sand Hills extends into the south-western corner of the township, whereas the remainder of the township is mantled by glacial till. The ground surface is undulating to rolling and in years of normal rainfall many depressions retain surface water that is invariably "alkaline". The largest undrained depression occurs in the centre of the township.

Springs were reported in the NE. $\frac{1}{4}$, section 19, and in the vicinity of the large, undrained depressions in the centre of the township. Most of these springs were unaffected or their supplies only slightly decreased during the drought period, and they are extensively used for stock.

The glacial lake sands are not very thick and no wells in the township obtain water from these deposits. The Recent dune sands are from 6 to 20 feet thick, and only one well, located in the NE. $\frac{1}{4}$, section 6, derives water from the dune sands. This well is a sand-point driven through fine sand, quicksand, and coarse sand, and its base is 20 feet below the surface. The water is hard and the supply has been sufficient for local requirements since 1931, the year the sand-point was sunk. All the other producing wells in the township either tap sand deposits that outcrop at the surface or pockets of water-bearing sand and gravel embedded in the boulder clay at depths of 8 to 58 feet. Sand-points are used extensively, as they can be driven through quicksand that washes into hand-dug wells and prevents them from being deepened. Blue boulder clay is usually struck at a depth of 20 to 30 feet anywhere in the township.

Adequate supplies of water are not particularly difficult to locate in the upper 60 feet of the glacial drift, and only four farmers in the township have been unable to derive a satisfactory supply. A few wells yield very abundant and constant supplies of water. Five wells, all sand-points, in the NW. $\frac{1}{4}$, section 14, the NW. $\frac{1}{4}$, section 22, the NE. $\frac{1}{4}$, section 23, the SE. $\frac{1}{4}$, section 25, and the SE. $\frac{1}{4}$, section 27, yield water under hydrostatic pressure. The wells are 47, 55, 12, 44, and 45 feet deep, respectively, and the water rises to points 23, 25, 4, 22, and 10 feet below the surface. The water from the 55-foot well overflowed the surface when the sand-point was first driven, but the sand-point was driven deeper in an attempt to obtain a more abundant supply and the water ceased to flow. The water in this well imparts a laxative effect to stock. The 12-foot sand-point was driven through 5 feet of silty loam, 4 feet blue boulder clay, and 3 feet gravel. The supply of water from the gravel is very abundant. The 45-foot well also yields an abundant quantity of water from a gravel aquifer. Most of the ground water in this township is suitable for drinking, although some of it is "alkaline".

Several dry holes have been sunk to a maximum depth of 60 feet in the glacial drift. Nine dry holes, approximately 25 feet deep, were dug in the NW. $\frac{1}{4}$, section 19. Prospecting for water should be confined to the glacial drift which is believed to be less than 200 feet thick. The compact shales of the Bearpaw bedrock formation contain few deposits of water-bearing sand and gravel and drilling into them is not recommended. The Belly River formation that underlies the Bearpaw should, however, contain usable water.

Township 15, Range 24

Part of Bigstick lake occupies the western part of the township. In years of normal rainfall this lake is about 10 feet deep and lies at an elevation of approximately 2,326 feet above sea-level, but during the drought of 1930 to 1934 it was almost dry. Part of the northern five sections and a large area in the vicinity of Bigstick lake are covered by glacial lake sands. Sand dunes of the Great Sand Hills cover a large area in the southeastern corner of the township and parts of sections 5 and 6. The remainder of the township is covered by moraine and glacial till. The ground surface is slightly undulating to rolling, and it is particularly uneven in those sections that are covered by moraine. There are very few wooded areas, but the sand hills are covered by sagebrush and a few patches of scrub poplar and willow. Undrained depressions are common, but they were dry during the drought, and the depressions were covered by a white precipitate and formed "alkali" flats. These sloughs in years of normal rainfall hold "alkaline" water that is unsuitable for stock. The water in Bigstick lake is highly mineralized and is of no use to the ranchers in this vicinity.

The soil is not cultivated and the entire township is used as grazing land and is very sparsely settled. Springs are common and are usually located near the base of hills or in small ravines. Many of the "alkaline" sloughs are fed by these springs, but the water from the springs themselves is not highly mineralized. The yield from these springs was not depleted by the drought and they were used extensively for stock.

Wells were reported in only three quarter sections, namely, the NW. $\frac{1}{4}$, section 10, the NW. $\frac{1}{4}$, section 23, and the SE. $\frac{1}{4}$, section 32. These wells are 6 to 24 feet deep and water is not difficult to locate in the upper 25 feet of the glacial drift or in the Recent dune sands, although some wells yield more constant and abundant supplies of water than others. During the drought period the water table was lowered, but the supply of water was not decreased to such an extent that a shortage was experienced. The water is hard, usually "alkaline", and it acts as a laxative on humans, but it is not harmful to stock. Sand-points and shallow, hand-dug wells are recommended rather than deep drilled or bored wells. The water in the Bearpaw formation that underlies the drift is unfit for drinking, but the underlying Belly River formation may contain water-bearing horizons. Wells necessary to tap these aquifers will probably have to be drilled to depths of 300 to 500 feet.

STATISTICAL SUMMARY OF WELL INFORMATION IN RURAL
MUNICIPALITY OF NO. 140, SASKATCHEWAN

West of 3rd meridian — Township / Range	13	13	13	14	14	14	15	15	15	Total No. in municipality
	22	23	24	22	23	24	22	23	24	
Total No. of Wells in Township	17	10	53	21	8	9	55	45	7	225
No. of wells in bedrock	0	0	0	0	0	0	0	0	0	0
No. of wells in glacial drift	15	6	49	19	2	2	55	44	6	198
No. of wells in alluvium	2	4	4	2	6	7	0	1	1	27
Permanency of Water Supply										
No. with permanent supply	17	9	40	21	8	9	37	27	7	175
No. with intermittent supply	0	1	10	0	0	0	0	3	0	14
No. dry holes	0	0	3	0	0	0	18	15	0	36
Types of Wells										
No. of flowing artesian wells	0	0	0	0	0	0	0	0	0	0
No. of non-flowing artesian wells	0	0	0	0	0	0	2	6	0	8
No. of non-artesian wells	17	10	50	21	8	9	35	24	7	181
Quality of Water										
No. with hard water	16	10	43	17	5	4	27	24	7	153
No. with soft water	1	0	7	4	3	5	10	6	0	36
No. with salty water	0	0	0	0	0	0	0	0	0	0
No. with "alkaline" water	9	1	22	7	3	2	10	2	4	60
Depths of Wells										
No. from 0 to 50 feet deep	17	10	53	20	8	9	52	41	7	217
No. from 51 to 100 feet deep	0	0	0	1	0	0	3	4	0	8
No. from 101 to 150 feet deep	0	0	0	0	0	0	0	0	0	0
No. from 151 to 200 feet deep	0	0	0	0	0	0	0	0	0	0
No. from 201 to 500 feet deep	0	0	0	0	0	0	0	0	0	0
No. from 501 to 1,000 feet deep	0	0	0	0	0	0	0	0	0	0
No. over 1,000 feet deep	0	0	0	0	0	0	0	0	0	0
How the Water is Used										
No. usable for domestic purposes	12	8	40	16	2	6	29	27	0	140
No. not usable for domestic purposes	5	2	10	5	6	3	8	3	7	49
No. usable for stock	17	10	47	21	8	9	35	30	7	184
No. not usable for stock	0	0	3	0	0	C	2	0	0	5
Sufficiency of Water Supply										
No. sufficient for domestic needs	17	9	40	21	8	9	37	27	7	175
No. insufficient for domestic needs	0	1	10	0	0	0	0	3	0	14
No. sufficient for stock needs	14	5	31	16	8	9	22	24	7	136
No. insufficient for stock needs	3	5	19	5	0	0	15	6	0	53

ANALYSES AND QUALITY OF WATER

General Statement

Samples of water from representative wells in surface deposits and bedrock were taken for analyses. Except as otherwise stated in the table of analyses the samples were analysed in the laboratory of the Borings Division of the Geological Survey by the usual standard methods. The quantities of the following constituents were determined; total dissolved mineral solids, calcium oxide, magnesium oxide, sodium oxide by difference, sulphate, chloride, and alkalinity. The alkalinity referred to here is the calcium carbonate equivalent of all acid used in neutralizing the carbonates of sodium, calcium, and magnesium. The results of the analyses are given in parts per million--that is, parts by weight of the constituents in 1,000,000 parts of water; for example, 1 ounce of material dissolved in 10 gallons of water is equal to 625 parts per million. The samples were not examined for bacteria, and thus a water that may be termed suitable for use on the basis of its mineral salt content might be condemned on account of its bacteria content. Waters that are high in bacteria content have usually been polluted by surface waters.

Total Dissolved Mineral Solids

The term "total dissolved mineral solids" as here used refers to the residue remaining when a sample of water is evaporated to dryness. It is generally considered that waters that have less than 1,000 parts per million of dissolved solids are suitable for ordinary uses, but in the Prairie Provinces this figure is often exceeded. Nearly all waters that contain more than 1,000 parts per million of total solids have a taste due to the dissolved mineral matter. Residents accustomed to the waters may use those that have much more than 1,000 parts per million of dissolved solids without any marked inconvenience, although most persons not used to highly mineralized water would find such waters highly objectionable.

Mineral Substances Present

Calcium and Magnesium

The calcium (Ca) and magnesium (Mg) content of water is dissolved from rocks and soils, but mostly from limestone, dolomite, and gypsum. The calcium and magnesium salts impart hardness to water. The magnesium salts are laxative, especially magnesium sulphate (Epsom salts, $MgSO_4$), and they are more detrimental to health than the lime or calcium salts. The calcium salts have no laxative or other deleterious effects. The scale found on the inside of steam boilders and tea-kettles is formed from these mineral salts.

Sodium

The salts of sodium are next in importance to those of calcium and magnesium. Of these, sodium sulphate (Glauber's salt, Na_2SO_4) is usually in excess of sodium chloride (common salt, NaCl). These sodium salts are dissolved from rocks and soils. When there is a large amount of sodium sulphate present the water is laxative and unfit for domestic use. Sodium carbonate (Na_2CO_3) "black alkali", sodium sulphate "white alkali", and sodium chloride are injurious to vegetation.

Sulphates

Sulphates (SO_4) are one of the common constituents of natural water. The sulphate salts most commonly found are sodium sulphate, magnesium sulphate, and calcium sulphate ($CaSO_4$). When the water contains large quantities of the sulphate of sodium it is injurious to vegetation.

Chlorides

Chlorides are common constituents of all natural water and are dissolved in small quantities from rocks. They usually occur as sodium chloride and if the quantity of salt is much over 400 parts per million the water has a brackish taste.

Iron

Iron (Fe) is dissolved from many rocks and the surface deposits derived from them, and also from well casings, water pipes, and other fixtures. More than 0.1 part per million of iron in solution will settle as a red precipitate upon exposure to the air. A water that contains a considerable amount of iron will stain porcelain, enamelled ware, and clothing that is washed in it, and when used for drinking purposes has a tendency to cause constipation, but the iron can be almost completely removed by aeration and filtration of the water.

Hardness

Calcium and magnesium salts impart hardness to water. Hardness of water is commonly recognized by its ~~soap-destroying~~ powers as shown by the difficulty of obtaining lather with soap. The total hardness of a water is the hardness of the water in its original state. Total hardness is divided into "permanent hardness" and "temporary hardness". Permanent hardness is the hardness of the water remaining after the sample has been boiled and it represents the amount of mineral salts that cannot be removed by boiling. Temporary hardness is the difference between the total hardness and the permanent hardness and represents the amount of mineral salts that can be removed by boiling. Temporary hardness is due mainly to the bicarbonates of calcium and magnesium and iron, and permanent hardness to the sulphates and chlorides ~~of calcium and magnesium. The permanent hardness~~

can be partly eliminated by adding simple chemical softeners such as ammonia or sodium carbonate, or many prepared softeners. Water that contains a large amount of sodium carbonate and small amounts of calcium and magnesium salts is soft, but if the calcium and magnesium salts are present in large amounts the water is hard. Water that has a total hardness of 300 parts per million or more is usually classed as excessively hard. Many of the Saskatchewan water samples have a total hardness greatly in excess of 300 parts per million; when the total hardness exceeded 3,000 parts per million no exact hardness determination was made. Also no determination for temporary hardness was made on waters having a total hardness less than 50 parts per million. As the determinations of the soap hardness in some cases were made after the samples had been stored for some time, the temporary hardness of some of the waters as they come from the wells probably is higher than that given in the table of analyses.

Water from the Unconsolidated Deposits

No analyses of water from the unconsolidated deposits in this municipality are available. Much of the water from the thick deposits of Recent dune sand is soft, and twenty-seven wells that tap these deposits in this municipality yield soft water. Most of the wells that tap aquifers of sand and gravel in the glacial drift yield water that is hard and in places "alkaline", but it is rarely too mineralized to be unfit for stock use. Forty-nine wells in the municipality yield water that cannot be used for drinking as it acts as a laxative. Analyses of the well waters in this municipality will probably reveal the presence of the following mineral salts, their abundance decreasing in the order given: magnesium sulphate, sodium sulphate, calcium sulphate, calcium carbonate, and sodium chloride. The first two salts mentioned are the most objectionable in drinking water and their magnitude nearly always determines the usability of the water.

The character of the glacial deposits encountered within 40 feet of the surface varies considerably within small areas. Similar variations occur in the quality of the water even from shallow wells sunk to the same depth and only a short distance apart. In general, however, the water from the glacial drift in this municipality can be used for stock and that from many of the wells is usable for domestic needs.

Water from the Bedrock

No water is being obtained from the Bearpaw formation in this municipality. Several analyses have been made of water from this source in adjoining areas and any water that might be obtained from this formation in this municipality will probably be of very poor quality, and the sulphates of magnesium and sodium, and common salt, will no doubt occur in large amounts. The total solid content of the water usually exceeds 2,000 parts per million and may exceed 5,000 or 6,000 parts per million. Such water is unfit for drinking and will cause scour in stock. Should wells be drilled into the Belly River formation water of better quality should be obtained. It will be suitable for stock, but may not be usable for drinking.

NOTE:

Because of difficulties involved in reproduction, the tables of well records referred to are not included with this report. Information regarding individual wells may be obtained by writing to the Director, Geological Survey of Canada, Ottawa.