CANADA
DEPARTMENT OF MINES
AND
TECHNICAL SURVEYS

GEOLOGICAL SURVEY OF CANADA

WATER SUPPLY PAPER No. 72

# GROUND-WATER RESOURCES OF THE RURAL MUNICIPALITY OF MOUNT HOPE NO. 279 SASKATCHEWAN

by

B. R. MacKay, H. N. Hainstock and G. Graham

OTTAWA
1936

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BUREAU OF ECONOMIC GEOLOGY

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CONTENTS



Illustrations

# GROUND WATER RESOURCES OF THE RURAL MUNICIPALITY OF MOUNT HOPE, NO. 279 SASKATCHEWAN

## 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 age.

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.

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. These are called Flowing Artesian Wells.

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

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

## 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.

Belly River Formation. 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.

Marine Shale Series. 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

The rural municipality of Mount Hope, No. 279 comprises an area of 324 square miles consisting of nine townships described as tps. 28, 29, and 30, ranges 19, 20, and 21, W. 2nd mer. The centre of the municipality is approximately 180 miles west of the Manitoba border and 72 miles north of the city of Regina. Somans, near the centre of township 28, range 20, and on the main line of the Canadian National railways, is the largest settlement in the area.

A series of lakes, the largest of which are Kutawagan in the north, and Peter in the west, occur in a low-lying area in the northwestern half of the municipality. In this area the elevation varies from 1,700 to 1,750 feet above sea-level. The southeastern half of the municipality is undulating or gently rolling, and the elevation rises gradually, attaining 2,025 feet in the southeastern corner. Two, small, intermittent tributaries of Saline creek flow in a westerly direction through the southern townships.

A northeasterly trending strip of Glacial lake clay extends across the northwestern half of the municipality. This clay is bordered by two strips of boulder clay or till. Moraine covers large areas in the northwestern and southeastern corners of the municipality. The glacial drift is approximately 300 feet thick.

### Water-Bearing Horizons in the Unconsolidated Deposits

A water-bearing horizon occurs within the upper 35 feet of the glacial drift. This horizon is formed by scattered pockets of sand and gravel, or small layers of sand and gravel, within the weathered zone of the drift. The water contained in these pockets is derived by seepage from the surface and during periods of prolonged drought

their supply becomes somewhat depleted, and in many instances the wells tapping them become completely dry. Wells tapping this aquifer are found throughout the municipality, but they are more common in the southeastern half. In this area the supply from a number of wells is insufficient for local needs. Many of the shallower wells freeze during the winter, necessitating the hauling of water for stock. The water from this horizon varies from medium soft to hard, and is usually suitable for domestic purposes. Dugouts are used by some of the farmers in this area.

The sand and gravel deposits that occur as scattered pockets and thin layers in the lower unweathered zone of the glacial drift, form a second water-bearing horizon. These pockets are tapped at depths of 40 to 120 feet and their scattered occurrence is shown by numerous dry holes throughout the municipality, many of which are near producing wells. The wells tapping this horizon are not so directly affected by drought but in a number of wells the supply is very small and must be augmented by hauling water or by the use of dugouts. In a few wells, however, the supply is abundant and the water is under hydrostatic pressure. The water from one well located on the NE.$\frac{1}{4}$, sec. 23, tp. 30, range 20, flows above the surface. Most of the water from this horizon is hard and contains considerable amounts of salts in solution, but is used for both humans and stock without any noticeable ill effects.

The two water-bearing horizons mentioned above appear to be confined to a very limited area, but a third water-bearing horizon seems to be continuous within an area outlined by the boundary line "A" on the accompanying map. Wells in this area are obtaining their water from an horizon that is encountered at depths varying from 150 to 190 feet, or at elevations of 1,565 to 1,600 feet above sea-level. This horizon extends northward into the next municipality,

but its areal extent to the east is not defined. It is thought that it may extend over a considerable area to the south and southeast. The water in the wells tapping this aquifer is under sufficient hydrostatic pressure to rise to a point 40 feet below the surface. In a few wells it rises nearer the surface, and in one well located in the SW.¼, sec. 31, tp. 30, range 20, the water flowed above the surface. This well has since been filled in as the water was too highly mineralized to be of use. The water from the above wells is invariably hard and contains iron and other mineral salts in solution, but is generally used for domestic purposes.

A fourth water-bearing horizon appears general over the area outlined on the accompanying map by the boundary line "B". It is tapped by wells at depths of 190 to 225 feet from the surface, or at elevations of 1,510 to 1,540 feet above sea-level. It is probable that other wells might tap this same horizon outside the area defined by the "B" line. It is possible that the water-bearing horizons in the areas "A" and "B" belong to the same aquifer, but this has not been proved. Three wells located in secs. 15, 16, and 22, tp. 29, range 20, may also be tapping this same horizon, but the aquifer they encounter is at a slightly higher elevation than those encountered in the outlined areas. In the southern part of township 28, range 21, a well drilled to a depth of 190 feet did not encounter any water-bearing horizons, but is not deep enough to encounter this fourth aquifer if it is present in that part of the municipality.

The water from the wells tapping this fourth aquifer is under sufficient pressure to rise to a point 50 feet below the surface in most of the wells, and to flow above the surface in the SE.¼, sec.22, tp. 29, range 21, where the topographic relief is low. The supply from these individual wells is abundant and more than

sufficient for local needs. The water is hard, contains iron and other mineral salts in solution, but with a few exceptions it is suitable for domestic purposes.

The fifth and lowest recognized water-bearing horizon is encountered at depths of 245 to 270 feet or at elevations of 1,470 to 1,510 feet above sea-level. The boundary line "C" outlines the area in which wells tapping this aquifer are located. This horizon is probably formed by deposits of sand and gravel occurring at the contact of the drift, and the underlying bedrock. In some of the wells, the bedrock may have been penetrated, but it is probable that the water obtained is being derived from the glacial drift. It is not known if this water-bearing horizon occurs outside of the area outlined, but it is believed that two wells located in township 30, range 19, tap this, or a similar aquifer, at depths of 300 and 335 feet. It cannot be said, however, that the water-bearing horizon is continuous over the intervening area. The water in the wells drawing from this horizon, is under hydrostatic pressure and with one exception the water rises to a point 70 feet below the surface. The water is hard and contains a considerable amount of mineral salts in solution. It is suitable for stock requirements and in most cases it is being used also for domestic purposes. Dugouts can be used as a means of storing run-off waters for stock use throughout this municipality, and this means of conserving a supply of water is recommended, especially in the southeastern half of the municipality where an adequate supply of water has not as yet been encountered.

## Water-bearing Horizons in the Bedrock

The Marine Shale series underlies the glacial drift throughout the municipality. In a well in township 30, range 19, the contact of the drift and bedrock is approximately 333 feet below the surface, or at an elevation of 1,466 feet above sea-level.

It is estimated, however, that the contact will be found at an average depth of 300 feet.

No water-bearing horizons have been encountered in the bedrock of this municipality unless the last horizon mentioned above under the unconsolidated deposits occurs in the upper part of the bedrock. Data on the municipalities to the west and northwest suggest that a water-bearing horizon may occur in the bedrock at an elevation of approximately 1,300 feet above sea-level. However, since fairly large supplies of water can be obtained from the glacial drift in this municipality, and since there is no information on the water-bearing horizons in the bedrock, it is considered inadvisable to drill into the Marine Shale series unless absolutely necessary. Farmers who are unable to derive an adequate supply of water from the drift are advised to excavate large, deep dugouts for the retention of surface run-off waters, rather than to attempt to locate water in the bedrock.

## GROUND WATER CONDITIONS BY TOWNSHIPS

### Township 28, Range 19

The ground surface of this township is characterized by undrained depressions and hills, and the eastern half of the area is densely wooded. Along the eastern boundary the elevation above sea-level is approximately 2,025 feet. From there it slopes towards the west to an elevation of 1,875 feet in the northwestern corner. All of the township is mantled by glacial drift that is in the form of a moraine.

The wells in this township obtain their supply from scattered pockets of sand and gravel in the glacial drift. These pockets are widely scattered, as many dry holes up to 265 feet in depth have been drilled throughout the township. The producing wells range in depth from less than 15 feet to 150 feet.

The shallow wells in this township are dependant upon precipitation and with few exceptions their supply was insufficient for local needs during the drought period of 1930 to 1935. The water from these shallow wells is suitable for all purposes, but care should be taken to see that they are not contaminated by sewage. Dugouts can be used to advantage in this area, and if made deep enough will supply water for stock for most of the year. The deeper wells, 80 to 150 feet in depth, are not so directly affected by drought conditions. The quality of the water from these deeper wells is inferior to that from the shallow wells. It is rarely used for drinking and some of it unfit for stock.

In view of the ground water conditions in this township, residents are advised to obtain drinking water from shallow wells located near depressions or sloughs, and to use dugouts for stock, rather than to run the risk of obtaining highly mineralized water at depth.

Township 28, Range 20

The surface of this township slopes from approximately 1,900 feet above sea-level in the southeast to 1,750 feet in the northwest. Two, small, intermittent tributaries of Saline creek flow in a general southwesterly direction through the central part of the township.

The western two-thirds of this township is mantled by glacial till or boulder clay, whereas the eastern one-third is covered by moraine.

The most widely tapped water-bearing horizon in this township is formed by scattered pockets of sand and gravel in the upper weathered zone of the drift, within 30 feet of the surface. In periods of drought, the wells tapping this horizon do not yield a sufficient supply for local requirements, but in years of average rainfall some of them yield an adequate supply. The water varies from moderately soft to hard, and is usually suitable for all farm needs.

A second water-bearing horizon is formed by very widely scattered pockets of sand and gravel at depths of 45 to 85 feet in the glacial drift. These pockets are not continuous as many dry holes down to 109 feet have been drilled in the vicinity of producing wells. The water is hard, and some of it too highly mineralized to be used for drinking. It is, however, suitable for stock.

One well, located on the SE.$\frac{1}{4}$, section 30, is obtaining an over-sufficient supply of water from a depth of 180 feet. The water in this well is under sufficient hydrostatic pressure to rise to a point 30 feet below the surface. It is hard and suitable for stock requirements. The areal extent of the aquifer encountered by this well is not known.

The residents of this township are advised to use shallow wells for household supplies, and dugouts for stock, rather than to try and locate water at depth in the glacial drift.

Township 28, Range 21

This township is characterized by a comparatively level to slightly undulating surface, varying in elevation from 1,700 feet in the northwestern corner to 1,800 feet above sea-level in the southeastern corner. One branch of Saline creek, in the northwestern corner, occupies a wide, shallow depression, whereas its branches in the southern part of the area have cut valleys to a depth of 40 feet and a width of 100 yards.

With the exception of a small area in the northwestern corner that is mantled by glacial lake clays, and a small area in the southwestern corner that is mantled by terminal moraine, this township is covered by glacial till or boulder clay.

Only a few wells in the township are obtaining water from scattered pockets of sand and gravel in the upper weathered zone of the glacial drift. With two exceptions these wells are adequate for local needs and the water is suitable for all farm requirements.

The water-bearing horizon that is most commonly encountered is formed by scattered sand and gravel pockets in the lower part of the glacial drift at depths of 50 to 100 feet. The local distribution of these pockets is shown by dry holes in the vicinity of producing wells. Most wells tapping this horizon are adequate for local needs. The water is invariably quite hard, but very little is so highly mineralized as to be unfit for domestic use.

In an area outlined as "B" in the northern part of the township, a third water-bearing horizon has been encountered by a number of wells. The depths of the wells tapping this horizon vary from 195 to 245 feet and the horizon occurs at an elevation of from 1,540 to 1,500 feet above sea-level. The aquifer appears to slope slightly towards the south. A 190-foot dry hole, located

on the SW.¼, section 2, suggests that this horizon thins out or disappears in this direction. It is probable that the same aquifer would be encountered at similar depths outside of the area outlined. The water from this horizon is under sufficient hydrostatic pressure to rise to a point 35 feet below the surface. The water is hard and contains a considerable amount of salts in solution, but it is being used for domestic and stock purposes.

Township 29, Range 19

The ground surface of this township is gently undulating. The surface rises from 1,800 feet in the northwest corner to 2,000 feet above sea-level in the southeast corner. A few small creeks that flow only in the spring are encountered in some parts of the township. With the exception of the northwestern corner, which is mantled with glacial till or boulder clay, this township is covered by moraine.

A few residents are obtaining varying supplies of usuable water from wells tapping scattered pockets of sand and gravel in the upper 30 feet of the glacial drift. Many of these wells are dug in ravines and small depressions. The pockets tapped probably do not form a continuous aquifer. Many of these wells are sufficient only for household requirements, but the water of all of them is fit to drink.

An aquifer that appears to be more general is encountered at depths of 35 to 85 feet from the surface and is formed by scattered pockets of sand and gravel in the glacial drift. Many dry holes have been drilled, however, in the vicinity of producing wells, especially in the eastern part of the township. The yield from wells drawing from this horizon is more abundant than that from wells tapping the shallow sand pockets and they are affected

to a lesser degree by drought conditions. The water is generally hard, but most of it is suitable for drinking. The supply from most of the wells is adequate for local requirements.

A well located on the SE.¼, section 6, is obtaining an abundant supply of hard water from an aquifer occurring at a depth of 280 feet or at an elevation of 1,620 feet. The areal extent of this water-bearing horizon is not known. The water is under slight pressure and rises to a point 140 feet below the surface. The water, although high in mineral salts, is being used for domestic as well as stock purposes. The residents of this township would be well advised to consider the possibility of using shallow wells for domestic purposes, and dugouts for stock use, rather than to drill deep wells into the drift. The expense involved and the uncertainty of obtaining an adequate supply of suitable water does not warrant the drilling of deep wells.

Township 29, Range 20

The elevation of this township varies from 1,875 feet in the southeast corner to 1,725 feet above sea-level in the northwest area. Most of the township is mantled by glacial till or boulder clay. In the southeastern corner a small area is covered by moraine and in the north-central area the glacial till is overlain by glacial lake clays. This latter area is quite flat and alkali soils are not uncommon.

Throughout the upper 30 feet of the drift mantle, scattered pockets of sand and gravel form aquifers for a number of shallow wells. These wells are dependant upon seasonal precipitation for their supply. Dry holes in the immediate vicinity of producing wells show that these pockets do not form a continuous water-bearing horizon. The water varies from moderately soft to hard, and it is suitable for farm requirements.

A few wells obtain water at depths of 50 to 110 feet from the surface. The aquifers tapped by these wells are formed by pockets of sand and gravel in the lower part of the drift. They do not form a continuous horizon as dry holes are encountered throughout the township at similar depths and in the vicinity as producing wells. The yield from these wells varies, but the majority of the residents have a supply that is sufficient for farm needs. The water is very hard and some of it can be used only for stock.

Three wells located near the centre of the township, on sections 15, 16, and 22, are obtaining adequate supplies of hard, drinkable water at depths of 130 feet to 180 feet from the surface. The water-bearing horizon occurs at an elevation of 1,600 to 1,635 feet above sea-level, but outside the limits of these three wells its areal extent is not defined. As the possibilities of obtaining adequate supplies of good water at depth are uncertain, residents in this township are advised to use shallow wells for household requirements and large, deep dugouts for stock.

Township 29, Range 21

The surface of this township is flat to gently undulating. From Peter lake, at an elevation of 1,700 feet, the surface rises gradually towards the southeast and northwest, attaining a maximum elevation of 1,750 feet in these areas. The valley of Peter lake is mantled by Glacial lake clays. Glacial till or boulder clay covers the southeastern part of the township and occurs as a narrow strip on the northwest slope of the lake basin. The northwestern corner of the township is covered by drift that is in the form of moraine.

Only a few wells are obtaining water in the upper 100 feet of the drift. These wells tap very widely scattered sand and gravel pockets in the boulder clay and the supply is very seldom more than

sufficient for local needs, and in a few cases it is only sufficient for household requirements. The water is hard and is usually suitable for all purposes.

The first general water-bearing horizon is located at depths of 165 to 205 feet, or at elevations of 1,540 to 1,510 feet above sea-level. The proved extent of this horizon is outlined by the "B" boundary line on the accompanying map, but it is not unlikely that the same aquifer would be encountered by wells drilled within short distances outside of this boundary line. All of the wells tapping this horizon yield a supply that is more than sufficient for local needs and the water is under sufficient pressure to rise to a point 50 feet below the surface. In one well, located on the SE.$\frac{1}{4}$, section 22, the water flows above the surface. The water from this horizon is hard and in most wells the concentration of salts in solution is sufficient to render the water unfit for drinking.

A second general water-bearing horizon is present in an area in the southwestern corner that is outlined by the boundary "C". It occurs at an approximate elevation of 1,480 feet above sea-level, and wells tapping it are approximately 260 feet deep. This aquifer is known to extend to the north and west, but its areal extent to the south and east are not defined. It is possible that it is formed by deposits of sand and gravel at the base of the drift immediately over the bedrock. The hydrostatic pressure is sufficient to cause the water to rise a considerable distance above its source, and in the southern part of the area, the water rises to a point 50 feet or less below the surface. The supply is more than sufficient for local needs, but due to a high concentration of salts in solution much of the water is suitable only for stock. One well, located on the NE.$\frac{1}{4}$, section 32, which tapped this aquifer, yielded only a little water under slight hydrostatic pressure.

Township 30, Range 19

Two intermittent creeks run in a westerly direction through the central part of the township into Kutawagan lake. The surface rises from 1,715 feet above sea-level in the northwestern corner to 1,965 feet in the southeastern corner. The northwestern corner of the township is mantled by glacial lake clays, an area in the southeastern corner is covered by a moraine, and the remainder is underlain by glacial till or boulder clay.

The uppermost water-bearing horizon is formed by scattered pockets of sand and gravel that occur within the upper 35 feet of the glacial lake and boulder clays. Most of the wells that tap this horizon are adequate for domestic and stock requirements. The water varies from moderately soft to hard, and it is almost invariably suitable for all farm needs.

A few wells are obtaining a varying supply of water from a second water-bearing horizon that occurs at depths of 50 to 85 feet. This horizon is formed by scattered sand and gravel pockets in the lower part of the drift. The pockets are very local in distribution as dry holes have been drilled in the vicinity of producing wells. The water from wells encountering this horizon is hard, and although it contains a considerable amount of salts in solution is suitable for drinking.

Three wells in section 36 are obtaining good supplies of hard water from depths of 172 to 216 feet, or at an elevation varying from 1,585 to 1,653 feet above sea-level. The areal distribution of this aquifer is not known but it does not appear to be extensive. The wells are non-flowing artesian, but the hydrostatic pressure is slight and the water rises only to a point 60 to 90 feet from the surface. The water is hard and contains a large amount of salts in solution, but is being used for both humans and stock.

Two wells located on the NW.$\frac{1}{4}$, section 16, and the SW.$\frac{1}{4}$, section 34, drilled to depths of 300 and 334 feet, respectively, encounter aquifers at 1,520 and 1,466 feet above sea-level. It is probable that the aquifer of the first well is formed by sand and gravel deposits at the base of the drift immediately over the bedrock. The water from this well is under hydrostatic pressure and rises to a point 50 feet below the surface. The water is hard, abundant, and is used for drinking and stock. The aquifer of the well in the SW.$\frac{1}{4}$, section 34, is believed to be the bedrock. The water from this well is under little pressure, is of small amount, and is used only for stock. It appears that this aquifer is of limited areal extent.

Township 30, Range 20

This township is comparatively flat, with an elevation of approximately 1,720 feet, except in the southeastern corner, where it rises to 1,800 feet above sea-level. The surface is cut by small creeks and sloughs, and small lake beds are prevalent throughout. Kutawagan lake occurs in the north-central area and in times of drought is almost completely dry.

Three small areas located in the southeastern, southwestern, and northwestern corners, are covered by glacial till or boulder clay, and over the remainder of the township the till is covered with glacial lake clay. Most of the township is being used for pasture land and only a few wells have been dug.

In the southern part of the township a few wells are obtaining fair supplies of water from small pockets of sand and gravel in the upper 30 feet of the clay. The yield from these wells varies greatly, and some of them are inadequate for local needs. In some wells the water contains so much mineral salt in solution that it is unfit for drinking. Little difficulty

should be experienced in obtaining small supplies of water from these pockets in the upper part of the drift. A spring on the SW.¼, section 16, yields an abundant supply of hard water that is suitable for all farm needs.

Three wells located on the NW.¼, section 6, the NW.¼, section 18, and the NE.¼, section 23, are obtaining adequate supplies of hard, drinkable water from depths of 118, 94, and 96 feet, respectively. The aquifer tapped is at an elevation of 1,637 to 1,653 feet above sea-level. It is not known if this water-bearing horizon is continuous or if the wells are tapping isolated pockets of sand and gravel. The water in each well is under hydrostatic pressure, sufficient to raise the water to within 15 feet of the surface in two of the wells, and to flow above the surface in the other well where the surface is lower. This latter well yields an abundant supply of water.

Two other wells located on the SE.¼, section 7, and the SW.¼, section 31, are obtaining water from a water-bearing horizon at depths of 175 and 140 feet from the surface, or at an elevation of 1,585 and 1,600 feet above sea-level, respectively. It appears that this aquifer extends to the north and west, but its areal extent to the east has not yet been established. The water in these two wells is under hydrostatic pressure. It rises to a point 15 feet below the surface in one well, and overflows the surface in the other, where the surface is lower. Both wells yielded a supply of water that was more than sufficient for local needs, but only the well on section 7 is being used at the present time, the flowing wells having been choked.

## Township 30, Range 21

The surface of this township is gently undulating, the elevation being about 1,750 feet above sea-level, except in the southeastern corner where it drops to 1,700 feet. This corner is characterized by "alkali flats" that occur along the continuation of Peter Lake valley. Along the valley of Peter lake

the glacial covering is composed of glacial lake clays and on a narrow strip on each side of the valley the surface is mantled with glacial till or boulder clay. The remainder of the township is covered by moraine.

The first water-bearing horizon is encountered by a few wells in the southeastern part of the township. These wells are drilled to depths of 90 to 117 feet and the aquifer they encounter is located at elevations ranging from 1,660 to 1,627 feet above sea-level. It is not known if these wells tap pockets of sand and gravel or if the horizon is continuous. It is probable, however, that the wells tap pockets, as deeper wells have been drilled without encountering this horizon. The water in these wells is under hydrostatic pressure and rises to a point 50 feet below the surface. The water is hard, contains salts in solution, but is used for both drinking and stock. One well, located on the NW.$\frac{1}{4}$, section 12, encountered a small supply of water not under hydrostatic pressure at a depth of 126 feet.

A second water-bearing horizon, the eastern boundary of which is outlined by the "A" line on the accompanying map, appears to be continuous over most of the township. The wells in this outlined area are drilled to depths varying from 175 to 235 feet and the aquifer is encountered at elevations of 1,550 to 1,600 feet above sea-level. A few wells, however, vary somewhat from the above figures. This horizon extends to the north and a short distance to the east, but it does not seem to continue to the south. The water in these wells is under pressure and in all of them it rises to a point 60 feet or less below the surface. The water is hard, contains iron salts, in solution, but in almost all cases is drinkable,

A third water-bearing horizon is encountered by three wells. It is assumed that this horizon is formed by deposits of sand and gravel that occur at the base of the drift, and which immediately overlie the bedrock. The boundary "C" on the accompanying map outlines the area in which wells obtaining water from this source are located. The three wells are 247, 250, and 268 feet deep, and the aquifer pierced is at elevations of 1,503, 1,500, and 1,482 feet above sea-level, respectively. The water rises to a point 55 feet or less below the surface. It is abundant in quantity and is suitable both for stock and for all domestic purposes.

STATISTICAL SUMMARY OF WELL INFORMATION IN RURAL MUNICIPALITY OF MOUNT HOPE, NO. 279, SASKATCHEWAN

| Township | 28 | 28 | 28 | 29 | 29 | 29 | 30 | 30 | 30 | Total No. in Municip- |
|---|---|---|---|---|---|---|---|---|---|---|
| West of 2nd moridian Range | 19 | 20 | 21 | 19 | 20 | 21 | 19 | 20 | 21 | ality |
| Total No. of Wells in Township | 87 | 66 | 49 | 66 | 48 | 32 | 51 | 13 | 37 | 449 |
| No. of wells in bedrock | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 |
| No. of wells in glacial drift | 87 | 66 | 49 | 66 | 48 | 32 | 50 | 13 | 37 | 448 |
| No. of wells in alluvium | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Permanency of Water Supply | | | | | | | | | | |
| No. with permanent supply | 46 | 41 | 44 | 47 | 46 | 32 | 49 | 13 | 36 | 354 |
| No. with intermittent supply | 7 | 4 | 0 | 7 | 2 | 0 | 0 | 0 | 1 | 21 |
| No. dry holes | 34 | 21 | 5 | 12 | 0 | 0 | 2 | 0 | 0 | 74 |
| Types of Wells | | | | | | | | | | |
| No. of flowing artesian wells | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 2 | 0 | 3 |
| No. of non-flowing artesian wells | 17 | 10 | 35 | 17 | 14 | 20 | 16 | 3 | 32 | 164 |
| No. of non-artesian wells | 36 | 35 | 9 | 37 | 34 | 11 | 33 | 8 | 5 | 208 |
| Quality of Water | | | | | | | | | | |
| No. with hard water | 45 | 40 | 35 | 49 | 42 | 28 | 42 | 9 | 36 | 326 |
| No. with soft water | 8 | 5 | 9 | 5 | 6 | 4 | 7 | 4 | 1 | 49 |
| No. with salty water | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| No. with alkaline water | 13 | 6 | 6 | 9 | 9 | 9 | 10 | 2 | 17 | 81 |
| Depths of Wells | | | | | | | | | | |
| No. from 0 to 50 feet deep | 63 | 47 | 20 | 49 | 39 | 11 | 40 | 8 | 4 | 281 |
| No. from 51 to 100 feet deep | 14 | 12 | 19 | 16 | 5 | 4 | 5 | 2 | 3 | 80 |
| No. from 101 to 150 feet deep | 8 | 7 | 2 | 0 | 4 | 1 | 1 | 2 | 6 | 31 |
| No. from 151 to 200 feet deep | 1 | 0 | 3 | 0 | 0 | 8 | 2 | 1 | 19 | 34 |
| No. from 201 to 500 feet deep | 1 | 0 | 5 | 1 | 0 | 8 | 3 | 0 | 5 | 23 |
| 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 use | 42 | 39 | 41 | 48 | 41 | 26 | 45 | 11 | 37 | 330 |
| No. not usable for domestic use | 11 | 6 | 3 | 6 | 7 | 6 | 4 | 2 | 0 | 45 |
| No. usable for stock use | 51 | 43 | 44 | 54 | 47 | 30 | 49 | 12 | 37 | 367 |
| No. not usable for stock use | 2 | 2 | 0 | 0 | 1 | 2 | 0 | 1 | 0 | 8 |
| Sufficiency of Water Supply | | | | | | | | | | |
| No. sufficient for domestic needs | 50 | 41 | 44 | 53 | 46 | 30 | 48 | 12 | 37 | 361 |
| No. insufficient for domestic needs | 3 | 4 | 0 | 1 | 2 | 2 | 1 | 1 | 0 | 14 |
| No. sufficient for stock needs | 28 | 29 | 40 | 38 | 31 | 22 | 37 | 10 | 32 | 267 |
| No. insufficient for stock needs | 25 | 16 | 4 | 16 | 17 | 10 | 12 | 3 | 5 | 108 |

## 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.

Analyses of Water Samples from the Municipality of Mount Hope, No. 279, Saskatchewan.

| LOCATION | | | | | | Depth of Well, Ft. | Total Dis'vd Solids | HARDNESS | | | CONSTITUENTS AS ANALYSED | | | | | | CONSTITUENTS AS CALCULATED IN ASSUMED COMBINATIONS | | | | | | | | Source of Water. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No. | Qtr. | Sec. | Tp. | Rge. | Mer. | | | Total | Perm. | Temp. | Cl. | Alkalinity | CaO | MgO | $SO_4$ | $Na_2O$ | Solids | $CaCO_3$ | $CaSO_4$ | $MgCO_3$ | $MgSO_4$ | $Na_2CO_3$ | $Na_2SO_4$ | NaCl | $CaCl_2$ | |
| 1. | SW. | 5 | 30 | 21 | 2 | 268 | 3,400 | 1,300 | 1,200 | 100 | 270 | 250 | 550 | 169 | 1,911 | 753 | 3,381 | 250 | 996 | | 504 | | 1,185 | 446 | | * 1 |
| 2. | NE. | 36 | 28 | 21 | 2 | 80 | | | | | | | | | | | | (3) | (1) | | (2) | | (4) | | (5) | * 1 |

Water samples indicated thus, * 1, are from glacial drift.
Analyses are reported in parts per million; where numbers (1), (2), (3), (4), and (5) are used instead of parts per million, they represent the relative amounts in which the five main constituents are present in the water.
Hardness is the soap hardness expressed as calcium carbonate ($CaCO_3$).

Analysis No. 1, by Provincial Analyst, Regina.
For interpretation of this table read the section on Analyses and Quality of Water.

Water from the Unconsolidated Deposits

The quality of ground water obtained from the unconsolidated deposits varies considerably. The water from the shallow wells in this municipality is comparatively soft to hard, depending upon the amount of mineral salts it has encountered and taken into solution as it seeped downard from the surface. Where the aquifers are overlain by thick deposits of clay it is probable that the water obtained from them will contain more "total dissolved solids" than where only a thin mantle of clay covers the aquifer. No samples from shallow water-bearing horizons were analysed, but two samples were analysed from wells obtaining water at 80 and 268 feet from the surface, respectively. The prominent salts in the water from the shallower well are $CaSO_4$ (calcium sulphate) and $MgSO_4$ (magnesium sulphate or Epsom salts), whereas $Na_2SO_4$ (sodium sulphate or Glauber's salt) is the predominant salt present in the water from the deeper well. However, these three salts are common in most waters obtained from the glacial deposits and although, in many cases, their high concentration might cause ill effects on humans not used to such water,,they do not appear to have any such effect on those using them continually. In a number of wells throughout the municipality, the water is not drinkable for humans and can only be used for stock. It is very probable that $MgSO_4$ and $Na_2SO_4$ are the most abundant salt in these waters. The water from the deep well (Sample 1) is excessively hard and very little of its hardness can be eliminated by boiling. It is probable that most of the water from the deeper horizons in this area will be just as hard. In all the deeper wells, iron salts appear to be present, but if water containing iron is allowed to stand for a considerable time before using, much of this iron will be oxidized and precipitated.

## Water from the Bedrock

No well in this municipality is known to be definitely obtaining its water from a bedrock aquifer. In the municipalities of Wreford to the east and Usborne to the northeast, the water from the bedrock is soft to hard and is high in "total dissolved solids". Sodium sulphate (Glauber's salt) is the most abundant salt present and NaCl (common salt) is also present in considerable concentration. If water were obtained from a deeper bedrock horizon it would probably contain $Na_2CO_3$, (black alkali) besides $Na_2SO_4$ and NaCl. It would probably also be soft, but not always drinkable.

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.