CANADA

DEPARTMENT OF MINES AND TECHNICAL SURVEYS

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WATER SUPPLY PAPER No. 188

PRELIMINARY REPORT

GROUND-WATER RESOURCES OF THE RURAL MUNICIPALITY OF SNIPE LAKE NO. 259 SASKATCHEWAN

By

B. R. MacKay, H. N. Hainstock & P. D. Bugg

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GROUND WATER RESOURCES OF THE RURAL MUNICIPALITY OF SNIPE LAKE, NO. 259 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 supplies 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.

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 Snipe Lake, No. 259, comprises an area of approximately 495 square miles in southwestern Saskatchewan. It consists of twelve full townships described as tps. 24, 25, 26, and 27, ranges 19, 20, and 21, and three partial townships described as tp. 23, ranges 19, 20, and 21, all W. 3rd mer. The town of Eston, in township 25, range 20, is situated near the centre of the municipality and lies approximately 48 miles east of the Saskatchewan-Alberta boundary and 148 miles north of the International Boundary line. The Eatonia Section of the Canadian National railways traverses the central part of the municipality in an east - west direction, and on it are located the hamlet of Snipe Lake, the town of Eston, and the village of Richlea. Another line of the same railway branches off at Eston and runs in a southeaterly direction, and on it are located the hamlets of Witley and Isham. A branch line of the Canadian Pacific railway occurs in the north-eastern part of the area, and on it are situated the hamlets of McMorran and Penkill.

South Saskatchewan river forms the southern boundary of the municipality. It lies at an elevation of 1,850 feet in the western part of the area and 1,815 feet above sea-level in the eastern part. The river is almost a mile wide in some parts, but its channel is choked by large sand-bars. The river valley is approximately 2 miles wide and the nothern slope rises abruptly to elevations of 2,100 to 2,200 feet above sea-level. This slope of the valley is cut by numerous, short, steep-sided valleys that contain intermittent streams. A narrow range of hills parallels the river on the north and from these hills the elevation decreases to the north. A flat plain occupies the greater part of the municipality and is the site of an old glacial lake. The elevation of this flat plain increases from an average of 2,100 feet in the south to a maximum of 2,300 feet above sea-level in some areas in the northern part. This large lake basin is mantled by a deposit of heavy, "gumbo", lake clay that varies in thickness from a few inches to probably 40 feet. The lake clay is underlain by glacial till which comes to the surface along the slopes of South Saskatchewan valley and in the belt of hills bordering the river. Glacial till also occurs in the three northern townships, in the eastern part of township 26, range 19, and in a narrow area along Snipe Lake valley. This valley runs in a southerly direction through townships 27 and 26, range 21, and extends into township 25, range 21. It is from 50 to 150 feet deep and is partly occupied by Snipe lake. The lake, however, does not contain water during drought periods. A small area in the northeastern corner of the municipality is mantled by moraine and is very rough and hilly. The moraine-covered area is not very suitable for cultivation, but most of the glacial till-covered areas and all of the glacial lake clay-covered area are under cultivation. The municipality is not thickly settled, but the farms are large.

Water-Bearing Horizons in the Unconsolidated Deposits

The supply of water in this municipality is obtained from South Saskatchewan river, from four springs, from a number of wells, and from artificial reservoirs. The water from South Saskatchewan river is used mostly for stock, and in some places farmers living several miles from the river haul water from it. If the water is used for domestic purposes it should be filtered and boiled.

The springs are situated along the slopes of South Saskatchewan valley. These springs are owned by the municipality and many people obtain water for both domestic and stock needs from this source.

The glacial lake deposits consist of a heavy clay that in some areas extends to a depth of 40 feet. The lake clay does not contain beds of water-bearing sand or gravel. In secs. 30 and 31, tp. 23, range 20, two shallow wells tap what is thought to be lake sands that underlie the glacial lake clay. Each of these wells yields a very large supply of water and the well in section 30 is used by many farmers and by some of the residents in the town of Eston. With the exception of these wells and two others, the water in the glacial lake clay-covered area is obtained from deep wells.

The glacial till and morainic deposits are similar in composition and consist of 1 to 3 feet of soil; 10 to 30 feet of yellow, oxidized boulder clay that is almost entirely free of pockets of water-bearing sand or gravel; and 100 to 240 feet of unoxidized or blue boulder clay. Discontinuous layers of sand and gravel occur near the base of the drift or between the drift and the underlying bedrock. Two or three wells have tapped pockets of sand and gravel in the yellow boulder clay and they yield moderate quantities of water that is usable for all farm purposes. As these aquifers are widely scattered it is advisable to locate them by means of a small hand auger before digging a well. A large supply is not to be expected from pockets in the upper part of the glacial drift.

At least seventy-four wells obtain water from sand and gravel pockets in the glacial drift at depths of 70 to 200 feet. Most of these sand or gravel aquifers probably occur at the contact of the drift and underlying bedrock. Most of the wells yield very large quantities of water, but a few yield inadequate supplies for local needs. The water in the wells that yield large supplies is under hydrostatic pressure and maintains constant levels. The water is highly mineralized and that from many wells is not usable for domestic purposes, whereas that from others is being used, as water of better quality is not obtainable. In general these wells are a very poor source of water for farm purposes.

Water-bearing Horizons in the Bedrock

The Bearpaw formation is thought to underlie the glacial drift throughout the greater part of the municipality. In some areas along the western side of the municipality the Bearpaw formation is very thin and in some localities it may be altogether absent. It does not appear to exceed 100 feet in thickness in any part of the municipality. It is mostly non-water bearing, but a few wells may be drawing water from porous beds in the shales of the Bearpaw formation. The water from these wells is very highly mineralized and is not satisfactory for domestic purposes, but it can be used if water of better quality is not obtainable. The water is under hydrostatic pressure and each well usually yields a large supply. The aquifers are not continuous, however, as deeper wells are known to penetrate the Bearpaw without striking water-bearing beds.

The Belly River formation immediately underlies the Bearpaw formation throughout the municipality and in some places it may immediately underlie the glacial drift. Approximately 95 of the 184 wells in the municipality are thought to tap sand aquifers in the Belly River formation. The wells vary in depth from 180 to 550 feet, and practically all of them tap aquifers of fine sand. The sand deposits are not continuous, but occur as lenses or small layers at various elevations. Most of the wells yield water that is very hard, "alkaline", contains a large amount of mineral salts in solution, and the water from many wells is not usable for domestic purposes. It contains a considerable amount of iron in solution and acts as a laxative on those not accustomed to its use. The water is usually under hydrostatic pressure and an individual well yields a very large supply of water, and many of the wells cannot be pumped dry by a large farm pump. Some of the deeper wells, particularly those in township 27, range 21, tap sand aquifers that yield an abundant supply of soft water. This water has a baking soda taste and is entirely different from that obtained at shallow depth in the Belly River formation. It is used for all farm purposes except irrigation. It is possible that water can be obtained from the Belly River formation at any locality in the municipality. Some difficulty is experienced, however, in keeping the fine sand from plugging the well casings. In some wells sand screens are used and it is reported that a coating of lime or some other mineral forms over the screen and shuts off the supply of water. The usual poor quality of the water, the difficulties of keeping the wells from plugging with sand, and the initial expense of drilling, are factors to be considered before drilling a deep well.

Most of the wells in this municipality yield sufficient water for stock requirements. Farmers who do not have deep wells usually haul water from neighbouring wells for all purposes. Many farmers who have deep wells haul water for domestic purposes for long distances. To increase the supply of water for stock needs, deep wells will have to be drilled or surface water conserved by using dams or dugouts. The excavation of dugouts is recommended, and shallow wells dug near the impounded water will usually yield sufficient water for household purposes. Where deep wells yield sufficient water for stock it is advisable to build cement cisterns in which rainwater from the roofs of buildings can be stored. This water when filtered and boiled is suitable for drinking and other household purposes.

GROUND WATER CONDITIONS BY TOWNSHIPS

Township 23, Range 19

The southern sections of this township are dissected by South Saskatchewan river, and the parts of these sections lying to the south of the river are not covered by this report. Several large sand-bars occur in the river in this area, a particularly large one occurring in the southeastern corner. The elevation of the river averages 1,815 feet above sea-level, and the northern slope of the valley rises abruptly to an elevation of 2,100 feet above sea-level. The northern slope is cut by numerous, short, steep-sided ravines that contain intermittent streams. North of the area dissected by the tributary streams the land becomes very flat and is overlain by glacial lake clay. This area is very suitable for farming. The slopes of the valley and the hills along the river are mantled by boulder clay which in the lower areas has been modified by water action, the finer materials being washed away and stones and boulders left exposed on the surface.

Water supplies are obtained from South Saskatchewan river, two springs and three deep wells. The water from South Saskatchewan river is used mostly for stock, but may be used for household purposes if it is purified by filtering and boiling. The two springs are located in the NW.$\frac{1}{4}$, section 14, and the NW.$\frac{1}{4}$, section 17, and flow continuously, yielding very large quantities of water. Most of the residents of this township haul all water for domestic purposes from these springs. The water is moderately hard and usable for all farm purposes.

The glacial lake clay is non-water bearing and it is useless to attempt to locate water at shallow depths either in the lake clay or in the underlying glacial till. Two dry holes in the SW.$\frac{1}{4}$, section 24, and the SW.$\frac{1}{4}$, section 30, strike beds of dry, fine sand at depths of 100 and 120 feet, respectively, and the glacial till may not contain water-bearing deposits even at depth. The beds of dry sand are encountered at approximately the same elevations as the springs located in sections 14 and 17, and the sand bed may possibly be drained by springs that occur along the slope of South Saskatchewan valley.

The three wells yield large quantities of water and are situated in the NW.¼, section 28, the NW.¼, section 34, and the NW.¼, section 35, and tap sand aquifers at depths of 340, 420, and 218 feet, respectively. The first two derive water from a bed of sand that occurs at an elevation of approximately 1,700 feet above sea-level, and which appears to belong to the Belly River formation. This bedrock formation is probably overlain by a thin layer of Bearpaw, and the 218-foot well may be deriving water from either the Bearpaw or the upper part of the Belly River formation. The wells yield large supplies of water that is under sufficient hydrostatic pressure to cause it to rise to points 200 to 300 feet below the surface or to an average elevation of 1,830 feet above sea-level. The water is very highly mineralized and is not usable for domestic purposes. It is very hard, usually "alkaline", and has a strong laxative effect on humans is used for drinking. The iron content, is also high, and the iron settles as a red precipitate when the water stands in contact with the air. The water is used only for stock, and apparently has no ill effects on them. Despite the fact these wells are of different depths, and that the basal elevation of the 218-foot well is somewhat higher than the other two, the quality of the water, the character of the aquifers, and the common level to which the water rises, indicate that the wells tap a common and continuous aquifer that probably belongs to the Belly River formation. It is, therefore, quite possible that wells sunk to similar depths in other sections of the township would locate water-bearing beds at similar depths. The poor quality to be obtained, the initial expense of drilling, and the difficulty of keeping the casings free from sand, are factors to be considered in drilling deep wells into the bedrock.

The excavation of dugouts to retain surface water is recommended as a method of increasing the supply of water for stock needs.

Township 23, Range 20

An area of approximately 22 square miles of this township lying to the north of South Saskatchewan river, is in the municipality of Snipe Lake. The river flows in an easterly direction and occupies a wide, deep valley, the northern slope of which rises from an elevation of approximately 1,825 feet to 2,100 feet above sea-level in less than a mile. The steep-sided slope is cut by numerous, short, deep ravines that contain intermittent streams. From the belt of hills that border the river the elevation decreases slightly to a flat plain that is part of a glacial lake basin. It is mantled by several feet of black, "gumbo", glacial lake clay. The hills and slope of the valley are covered by glacial till or boulder clay, and in the lower part of the valley the glacial till has been modified by water action, and stones and large boulders are common.

Only a few sections in the northern part of the township, or in that part mantled by glacial lake clay, are suitable for cultivation, and the farmers reside in this area. Water supplies are obtained from South Saskatchewan river, from small artificial reservoirs, and from a few wells. The water from the river is mostly used for stock, and it is a permanent source of supply for this purpose. The artificial reservoirs are formed by excavating dugouts to retain surface water. These reservoirs should be at least 12 feet deep to retain a supply during the winter months.

No water is obtained from the glacial lake clay, but water is obtained from glacial lake sands underlying the clay in sections 30 and 31. Two wells in the NW.¼, section 30, and in the SE.¼, section 31, are 11 and 13 feet deep, respectively, and tap beds of sand 3 or 4 feet below the surface. These aquifers are only of small areal extent, as other wells failed to strike sand beds immediately below the glacial lake clay. Both wells yield very large quantities of water that is moderately soft as compared with water from other wells. The water from the 11-foot well is usable for all purposes and many people haul from it for domestic purposes. Several residents of the town of Eston haul water a distance of 12 miles from this well. The 13-foot well yields water that has a bad odour and it is not usable for domestic purposes. This odour is possibly caused by a faulty crib through which surface sewage water may enter. It is very possible that another well sunk in the vicinity of this well would yield usable water for farm purposes. A well in the SE.$\frac{1}{4}$, section 24, taps several feet of blue muck below the lake clay at a depth of 30 feet and obtains a small supply of water that is not usable for domestic purposes, as it is very hard, "alkaline", and bitter to the taste. This well is a very poor source of water.

Two wells in the NE.$\frac{1}{4}$, section 28, and the SE.$\frac{1}{4}$, section 34, tap sand aquifers in the glacial till at depths of 60 feet. These wells yield large quantities of water that is usable for all domestic purposes. The sand deposits are approximately 15 feet thick. The water in one well does not rise above the aquifer, but the water in the other is under sufficient hydrostatic pressure to rise to a point 35 feet below the surface. This sand deposit was penetrated in another deeper well in the vicinity of these two wells, but it was non-water bearing. It is possible, however, that other wells to similar depths may locate water. In section 36 dry sand beds were encountered at depths of 90 and 135 feet, and water-bearing deposits are apparently very scarce in the glacial drift in this area.

Two wells in the NE.$\frac{1}{4}$, section 32, and the SE.$\frac{1}{4}$, section 33, are thought to have tapped beds of water-bearing sand in the Belly River formation at depths of 275 and 320 feet, respectively, or at an elevation of 1,849 feet above sea-level. Bedrock is thought to be encountered at a depth of 150 to 200 feet below the surface, or at an elevation of 1,964 feet above sea-level. At this depth a fine-textured, dark clay occurs and it is overlain by blue clay that contains many small stones and boulders. The Bearpaw formation is not more than 100 feet thick, and is probably considerably less. The water derived from these two wells is very highly mineralized and is not suitable for domestic purposes, although that from the well in section 32 can be used for cooking. The water is under sufficient hydrostatic pressure to rise to points 215 and 150 feet below the surface. The well in section 33 is not used as it is plugged. It is very possible that wells sunk to similar depths in other sections of the township would encounter this water-bearing horizon. The excavation of dugouts to collect and retain surface water is recommended.

Township 23, Range 21

Only the part of this township that lies to the north of South Saskatchewan river is discussed in this report. The river, which forms the southern boundary of the municipality, flows in a southeasterly direction, entering the township in section 31 and leaving in section 13. The northern slope of its valley is cut by many, steep-sided, tributary valleys that contain small, intermittent streams that flow in the spring of the year or after heavy rains. The elevation at the river is approximately 1,850 feet, and that of the hills bordering the river at least 2,200 feet above sea-level. From the belt of hills bordering the river the elevation decreases to approximately 2,100 feet above sea-level in a flat plain area. The slopes of the valley are mantled by boulder clay that has been modified by water action, and the hills are covered by glacial till that has not been modified. The flat plain is part of a large lake basin and it is mantled by several feet of glacial lake clay.

The flat plain is well settled as the soil is suitable for cultivation. No water is obtained from the glacial lake clay and no wells have been drilled to depths in an attempt to locate water in the underlying glacial till. The supply of water in this township is derived from two sources. A flowing spring in the NE.$\frac{1}{4}$, section 28, is used by most farmers as a source of water for stock, and all the farmers in the area haul water for domestic needs from this spring. The spring is owned by the municipality and farmers in other townships haul water from it. A reservoir 6 by 6 by 7 feet has been dug where the spring issues from the ground, and it is estimated that 10,000 gallons of water a day could be taken from the reservoir. The water is moderately hard and usable for all farm purposes including irrigation, and an abundant growth of vegetation is noticeable at the site of the spring. The second source of water is South Saskatchewan river which is used as a source of water for stock by several of the farmers in that vicinity. This water is satisfactory for stock use, but it should not be used for domestic purposes unless it is filtered and boiled. In some sections small ravines could be dammed to retain surface water. In the lake clay-covered area, dugouts would probably be more satisfactory to collect and store surface water for stock use.

The Belly River formation is thought to underlie the glacial drift in this township. The bedrock does not outcrop along the river and it probably, therefore, is at an elevation below 1,850 feet above sea-level. It is possible that beds of water-bearing sand occur in this formation, but the poor quality of water to be obtained may not warrant the expense of drilling.

Township 24, Range 19

The ground surface of this township is slightly rolling, with several knolls, ridges, and small ravines. A narrow ridge runs across the township in an east-west direction approximately 1 mile north of the southern boundary. The township is mantled by glacial till or boulder clay, overlain by a deposit of glacial lake clay, which on the knolls and ridges is only very thin. The elevation of the township varies between 2,028 feet in the southern and eastern parts, to 2,138 feet in the western sections, and 2,100 feet above sea-level in the northern sections, the general rise being toward the west.

The glacial lake clay is non-water bearing and no wells have located water at shallow depth in the underlying glacial till. Three wells are thought to derive water from an aquifer that occurs at or very near the contact of the glacial drift and the underlying bedrock. These wells are situated in the NE.$\frac{1}{4}$, section 22, the NW.$\frac{1}{4}$, section 26, and the SE.$\frac{1}{4}$, section 28, and they tap gravel aquifers at depths of 228, 232, and 230 feet, respectively, or at elevations varying between 1,833 and 1,871 feet above sea-level. The wells yield an abundant supply of water that is usable for all farm purposes. It is under sufficient hydrostatic pressure to rise to points 150 to 170 feet below the surface where it maintains a constant level. This gravel aquifer is probably of local areal extent, and it is not probable that wells in other parts of the township will encounter this water-bearing horizon.

A well in the NW.$\frac{1}{4}$, section 26, was sunk by the Canadian National railways and it encountered a sand aquifer, at a depth of 275 feet, or at an elevation of 1,799 feet above sea-level, which is thought to occur in the Bearpaw formation. This well will yield 150 gallons of water an hour and the water rises to a point 215 feet below the surface where it maintains a constant level. The water is suitable for domestic and stock purposes, but the well is not used at present as there is no demand for the water. The 232-foot well in this quarter section, which was mentioned in the previous paragraph, will yield sufficient water for the residents of the hamlet of Isham. It is not probable that the aquifer of the 275-foot well is of large areal extent.

Three wells in the NW.¼, section 4, the SW.¼, section 16, and the SE.¼, section 18, tap aquifers of fine sand at depths of 327, 500, and 425 feet, respectively. The aquifers are assumed to occur in the Belly River formation, which underlies the Bearpaw formation. The wells yield a large supply of water that is very highly mineralized, but which can be used if necessary for drinking, cooking, and other domestic purposes. The water is under strong hydrostatic pressure and rises to points 177 to 200 feet below the surface where it maintains constant levels. Some difficulty is experienced in keeping these wells from becoming plugged with sand. Sand screens are used and approximately once every five years it is necessary to pull up the casings and clean or replace the sand-screens as they have become completely coated with a mineral deposit. Wells sunk to similar depths in other parts of the township should encounter this or other water-bearing horizons. A 1,225-foot dry hole, however, is reported to have been drilled in the NE.¼, section 23. The base of this hole is at an elevation of 834 feet above sea-level.

The seven wells recorded are the only wells in the township, and most of the residents either haul water from them, from South Saskatchewan river, or from a few springs near the river. In some sections small dugouts are used to retain surface water, but they are not large enough to retain water throughout the year. To be satisfactory a dugout should be at least 12 feet deep. Shallow wells dug near these reservoirs will yield usable water for domestic needs, but care must be taken to see that the water is not contaminated.

Township 24, Range 20

The elevation in the southeastern corner of this township is approximately 2,180 feet above sea-level. From this point it increases to 2,260 feet in the northwestern corner. The ground surface is gently undulating and is very suitable for cultivation.

The area is thickly settled, and a shortage of water is experienced on many of the farms. The township lies within an area that was the site of an old glacial lake, and it is mantled by glacial lake clay. This clay varies in thickness from a few feet to possibly 30 feet, and it is non-water bearing. The underlying glacial till is also non-water bearing.

Only six wells have been reported in this township and they are thought to derive water from the Belly River formation. Three of the wells, located in the NW.$\frac{1}{4}$, section 10, the NW.$\frac{1}{4}$, section 28, and the NW.$\frac{1}{4}$, section 35, tap sand aquifers at depths of 262, 279, and 332 feet, respectively, or at elevations varying between 1,921 and 1,964 feet above sea-level. Each well, when not clogged by sand, yields a large supply of water. The well in section 10 yields 3 gallons of water a minute, whereas the well in section 35, in 1935 yielded a very small amount of water as it was plugged with fine sand. The water is very highly mineralized and is not usable for domestic needs, although that from the 279-foot well is being used for such purposes. The water is under sufficient hydrostatic pressure to rise to points 179 to 257 feet below the surface. It is not thought that the aquifer tapped by these wells is continuous over a large area as the other three deeper wells apparently did not encounter it. Three wells located in the SW.$\frac{1}{4}$, section 20, the NE.$\frac{1}{4}$, section 24, and the NE.$\frac{1}{4}$, section 34, tap sand and gravel aquifers at depths of 307, 366, and 411 feet, respectively. These wells are thought to tap an aquifer that may be continuous throughout the township. The water is of better quality than that from the three shallower wells, as it is usable for drinking, cooking, and other domestic purposes. Two of the wells each yield large quantities of water, but the 411-foot well in 1935 did not yield sufficient water for local requirements as it needed cleaning. When this well was drilled it yielded an abundant supply of water.

A few farmers who do not have wells haul water from the above-mentioned wells, but most of them haul from South Saskatchewan river or from a well situated in the NW.$\frac{1}{4}$, sec. 30, tp. 23, range 20. If the water from the river is used for domestic purposes it should be filtered and boiled. Artificial reservoirs are recommended to conserve water for stock use. Drilling to depths of 300 to 400 feet should encounter water-bearing beds in the Belly River formation.

Township 24, Range 21

South Saskatchewan river flows through section 6 at an elevation of 1,850 feet above sea-level. The area bordering the river is very rough and is cut by short, steep-sided ravines. The hills in this area attain an elevation of approximately 2,300 feet above sea-level. From this locality the elevation gradually decreases to an average of 2,240 feet above sea-level in a gently undulating plain which is mantled by glacial lake clay. Glacial till or boulder clay underlies the lake clay and is exposed at the surface along the north slope of the valley, on some of the higher hills and on a ridge that extends in a northwest-southeast direction in the northwestern corner of the township. The glacial till has been eroded by water action, and stones and boulders are common on the surface and render the areas very unsuitable for cultivation. The lake clay-covered area is very good farming land.

The supply of water in this township is derived from a spring and from seven deep drilled wells. The spring is used by the municipality and is situated in the NW.$\frac{1}{4}$, section 8. It yields at least 1,500 gallons of water a day, and has been dug out to form a reservoir which the water overflows. The water is moderately hard and usable for all farm purposes, and practically all water for drinking and household needs in this township is hauled from this spring.

The seven wells are located in widely separated sections of the township and are thought to have been sunk through the glacial drift and to have tapped beds of water-bearing sand in the Belly River formation. The drift is thought to be approximately 150 to 200 feet thick, and the wells are from 305 to 330 feet deep and apparently tap a common aquifer in the Belly River formation. Most of the wells yield sufficient water for local stock requirements, but the yield is often reduced by sand plugging the casings and it is necessary to clean the wells every few years. Sand screens are used to keep the sand from entering the casings, but the screens become coated by a mineral deposit and the water supply shut off. The water is under sufficient hydrostatic pressure to rise to points 175 to 270 feet below the surface. The water from all the wells except one is too highly mineralized to be used for drinking or any other household use and it is very hard and acts as a strong laxative. This water-bearing horizon should be encountered at approximately the same depth in other sections of the township, but the water will not be suitable for domestic purposes, and difficulty will be experienced in keeping the wells from plugging with sand. In some areas dugouts can be excavated to retain surface water for stock use. Shallow wells dug near the reservoirs should yield sufficient water for household purposes. Care must be taken to see that the water is not contaminated by polluted surface water.

Township 25, Range 19

The township is a gently rolling plain and although few farmers reside in the area practically the whole township is under cultivation. The elevation in the southeastern corner is slightly below 2,100 feet, but it rises to 2,200 feet above sea-level in the western and northern sections. Glacial lake clay overlies the glacial till throughout the greater part of the township, but in the northeastern corner the till comes to the surface.

The glacial lake clay consists of 1 to 2 feet of clay loam soil and 10 to possibly 40 feet of heavy black clay that does not contain deposits of water-bearing sand or gravel. The glacial till consists of blue, stony clay in which a few thin layers of sand, usually non-water bearing, occur at various elevations. A 173-foot well drilled in 1916 in the NE.¼, section 36, tapped a sand bed that at first yielded a fair supply of usable water, and the water was used until 1933, at which time the supply decreased and the water became too highly mineralized. If the well were cleaned it might possibly yield a supply of usable water. The aquifer is thought to be of local extent, and it is not probable that water will be derived at this depth throughout the township.

Three wells situated in the SE.¼, section 6, the SE.¼, and NW.¼, section 7, obtain water from gravel deposits that are thought to occur at or near the contact of the drift and the underlying Bearpaw formation. The wells are 200, 225, and 243 feet deep, respectively, and yield fairly large supplies of water that are sufficient for local requirements. The water is hard, but usable for all farm purposes. It contains a relatively large amount of iron in solution, and the water from the 200-foot well, which may be partly derived from the Bearpaw formation, has a laxative effect on those not accustomed to its use, and has a salty taste. The hydrostatic pressure is low and the water rises only 12 to 40 feet above the top of the aquifers. Other wells sunk in the vicinity of the producing wells may encounter the aquifers, but they are not continuous throughout the township, as deeper wells failed to encounter water at this depth.

Five wells from 380 to 551 feet deep pass through the glacial drift and Bearpaw formation, and tap a sand aquifer in the Belly River formation. The areal extent of the aquifer is unknown, but the wells are located in widely separated sections of the township and the horizon may be continuous throughout the area. The wells when first drilled yielded large quantities of water, but after a time the fine sand plugged the well casings and reduced the available supply. The water is very highly mineralized and that from some wells is not usable for household purposes, whereas that from others is used, although it is very unsatisfactory. It has a strong laxative effect on those not accustomed to the use of such water, and its continued use may prove injurious to the human system.

Good drinking water is scarce in this township. Some of the residents haul water from a spring in the E.½, sec. 12, tp. 25, range 18, and a few use cisterns in which they store rainwater that runs off the roofs of buildings. Some have excavated dugouts and sink shallow wells beside the impounded surface water, and these shallow wells yield intermittent supplies of water. The conservation of surface water is highly recommended in this township, but a dugout should be at least 12 feet deep to be satisfactory.

Township 25, Range 20

The ground surface of this township is gently rolling and the elevation averages slightly more than 2,200 feet above sea-level. The area is very suitable farming land and practically the whole township is under cultivation. Glacial lake clay mantles the entire township and consists of 1 to 3 feet of clay loam soil, and black clay that may attain a thickness of 40 feet. The lake clay is underlain by glacial till or boulder clay, which is probably 200 feet thick. The glacial till is composed of blue, stony clay and contains a few thin layers of non-water bearing sand. Three wells are thought to tap water-bearing gravel that occurs at the contact of the drift and the underlying bedrock. These wells are located in the SE.¼, section 6, the NW.¼, section 10, and the NW.¼, section 16, and are 225, 288, and 225 feet deep, respectively. The gravel deposits occur at elevations varying between 1,950 and 2,013 feet above sea-level. Each of the wells yields an abundant supply of water that is usable for drinking, cooking, and other domestic purposes. The water is not under great hydrostatic pressure, but it rises a few feet in the well and maintains a constant level. Many farmers haul water from the well in the NW.¼, section 16, and this well will stand continuous pumping. The aquifers of these wells are apparently of small areal extent, as deeper wells in the immediate vicinity do not encounter an aquifer at the above depths. A well in the SW.¼, section 4, however, taps an aquifer at a depth of 337 feet or an elevation of 1,882 feet above sea-level. This well is thought to have tapped a bed or lens of gravel in the Bearpaw formation. The water is very hard and although used for drinking and cooking it is not suitable for laundry purposes. It is under sufficient hydrostatic pressure to rise to a point 237 feet below the surface, where it maintains a constant level.

Seven wells from 280 to 410 feet deep tap sand aquifers in the Belly River formation. The shallower wells are found in the northwestern corner of the township as the bedrock apparently rises in this locality. The water is very highly mineralized and although that from some wells is used for domestic purposes it is not suitable for such use. It is usually "alkaline" and contains iron that precipitates as a reddish sediment and also stains the water containers. The hydrostatic pressure varies with the individual well, but the water usually rises to points 150 to 270 feet below the surface. It is very probable that wells sunk to similar depths in any part of the township would encounter this or a similar water-bearing horizon. No dry holes were reported in the bedrock. The poor quality of the water, the necessity of cleaning out the well once every few years, and the initial expense of drilling, are factors to be considered before a deep well is drilled. The conservation of surface water by the use of dugouts or other artificial reservoirs is highly recommended. Shallow wells sunk near the impounded water usually yield an adequate supply for domestic needs. Many of the residents are short of water for domestic purposes and at present are hauling for long distances. The residents of the village of Eston haul some water from a well in the NW.$\frac{1}{4}$, sec. 30, tp. 23, range 20, a distance of 10 miles.

Township 25, Range 21

The elevation in the eastern part of this township is 2,200 feet, and gradually rises to 2,270 feet above sea-level in the western part. The ground surface is flat to slightly rolling, and the area is very suitable for cultivation. An abrupt, narrow valley extends into sections 34, 35, 27, and 13 from the north. It is from 25 to 75 feet deep and is an extension of the valley that contains Snipe lake in the township immediately to the north. The township is mantled by glacial lake clay underlain by glacial till or boulder clay which is exposed along the valley.

The glacial lake clay is not more than 40 feet thick and is non-water bearing. The glacial till is approximately 200 feet thick, but the contact of it and the underlying Bearpaw formation is not definitely known. The glacial till apparently does not contain deposits of water-bearing sand or gravel as all the wells are from 274 to 418 feet deep and are thought to derive water from either the Bearpaw or Belly River formations.

A 277-foot well in the SW.$\frac{1}{4}$, section 6, taps a bed of water-bearing gravel at an elevation of 1,993 feet above sea-level. This gravel bed may occur at the contact of the drift and Bearpaw formation, but the depth of the well and the poor quality of water would appear to indicate that the water is coming from the Bearpaw formation. The well has never been pumped dry and the water is very hard, "alkaline", and not suitable for domestic purposes, although it is used, as water of better quality is not obtainable within reasonable hauling distance. It is probable that this water-bearing bed is of small areal extent, as other wells in the vicinity did not encounter a gravel aquifer.

The other wells in the township, eleven in number, are from 274 to 410 feet deep, and are thought to tap sand aquifers in the Belly River formation. The sand deposits are usually dark blue and lie between an elevation of 1,940 and 1,880 feet above sea-level. The water is very highly mineralized and that from some wells is not usable for domestic purposes, whereas that from others is used, although it is not suitable, but water of better quality is not available. Most of the wells yield very large supplies of water sufficient for large herds of stock. The water is under hydrostatic pressure and usually rises to a point 200 feet below the surface. It is very probable that wells to similar depths in any part of the township would encounter a water-bearing sand deposit in the Belly River formation. The poor quality of the water and the difficulties entailed in keeping the well from plugging with fine sand are factors to be considered before a deep well is drilled. Many of the residents in this township haul water from these wells. Cisterns are used to collect rainwater from the roofs of buildings. Those who have not deep wells experience an acute shortage of water. The excavation of dugouts to collect surface water appears to be the best method of increasing the water supply in this township. Shallow wells sunk near the dugouts will usually yield sufficient usable water for domestic purposes.

Township 26, Range 19

The elevation in this township increases from 2,181 feet in the southeastern corner to 2,290 feet above sea-level in the northwestern corner. Glacial lake clay mantles approximately three-quarters of the township and it is underlain by glacial till or boulder clay that outcrops in the southeastern part of the area. The lake clay varies in thickness from a few inches to approximately 30 feet and is composed of a clay loam soil and dark, heavy clay. The clay is non-water bearing.

The glacial till, where it comes to the surface, consists of a thin layer of soil, several feet of yellow or oxidized clay, which apparently does not contain any water-bearing deposits, and blue boulder clay that extends to bedrock and contains a few, discontinuous deposits of water-bearing sand near its base. The sand deposits are reported to be exceptionally thick in some wells and may lie between the drift and the underlying bedrock.

Five wells situated in the SW.$\frac{1}{4}$, section 10, the SW.$\frac{1}{4}$, section 22, the NW.$\frac{1}{4}$, section 24, the NE.$\frac{1}{4}$, section 30, and the NW.$\frac{1}{4}$, section 31, tap sand beds in the glacial drift at depths of 80, 130, 189, 190, and 135 feet, respectively. The wells in sections 22, 24, and 30 yield an abundant supply of water that is usable for drinking, cooking, and other domestic purposes. Several farmers haul water for all purposes from the well in the NW.$\frac{1}{4}$, section 24, and many farmers haul water for drinking and domestic needs from this well. The other wells yield smaller supplies of water, but the supply is sufficient for present local needs. The sand aquifers are not continuous throughout the township, as some deeper wells do not encounter water-bearing sand at this depth, but wells in sections 28 and 30 encounter a bed of sand that yields a small amount of water at approximately the same elevation as the aquifers in the above-mentioned wells.

The glacial drift is thought to be underlain by the Bearpaw bedrock formation, but this formation is not more than 100 feet thick, and in some wells it does not appear even to be present. Some of the deep wells in sections 6 and 30 are reported to penetrate dark, fine-textured clay, whereas others encounter soft shales that may be the Bearpaw formation. The well in the NE.$\frac{1}{4}$, section 28, taps a sand and gravel pocket in dark clay from which a fairly large quantity of water is obtained. This well may derive its water from the Bearpaw formation. The water is usable for domestic purposes, although it is very hard, "alkaline", and has a fairly high iron content. The hydrostatic pressure is sufficient to cause the water to rise to a point 140 feet below the surface where it maintains a constant level. The Bearpaw formation is not thought to contain much water in this township.

The glacial drift and the Bearpaw formation throughout the township are underlain by the Belly River formation. Twelve wells from 180 to 401 feet deep tap sand aquifers in this bedrock formation. The deeper wells are located in the western part of the area where the elevation is the greatest, and the aquifers lie at an average elevation of 2,000 feet above sea-level. Most of the wells yield very large quantities of water that is highly mineralized, very hard, "alkaline", and contains a large amount of iron that gives the water a reddish colour after it stands in contact with the air. The water from most of the wells is used for domestic purposes although it is not suitable, but water of better quality is not available. It will have a laxative effect on those not accustomed to the use of highly mineralized water. The hydrostatic pressure varies with the individual well; the water rises to points between 90 and 275 feet below the surface. These wells are the main source of water for the residents of the township and it is very likely that other wells sunk to similar depths in other parts of the township will encounter water. The water will be highly mineralized, however, and some difficulty may be experienced by sand plugging the well casings. Dugouts could be used to collect and retain surface water for stock use.

Township 26, Range 20

Glacial till or boulder clay mantles this township, but with the exception of parts of sections 33, 34, and 35, it is concealed by approximately 10 to 30 feet of glacial lake clay. The ground surface is flat to gently rolling and the elevation varies from 2,260 to 2,310 feet above sea-level. The area is suitable for cultivation and most of the land is being farmed.

The glacial lake clay does not contain water. The underlying glacial till consists of approximately 100 to 200 feet of blue boulder clay that contains thin lenses and pockets of non-water-bearing sand, but several wells may be deriving water from sand beds at the contact of the drift and the underlying bedrock.

The Bearpaw bedrock formation is thought to immediately underlie the glacial drift. It is not more than 100 feet thick and in the highlands may not be present at all, as the wells located there appear to pass from the drift directly into the Belly River bedrock formation that elsewhere lies stratigraphically beneath the Bearpaw formation. No wells appear to be deriving water from the Bearpaw formation.

The sixteen wells reported in this township are thought to tap sand aquifers in the Belly River bedrock formation. They are from 182 to 600 feet deep and appear to tap three different water-bearing horizons in this formation. The uppermost and principal water-bearing horizon is encountered at depths of 182 to 295 feet, or at an average elevation of 2,050 feet above sea-level. It may be continuous as some deeper wells encounter a water-bearing sand at approximately the same elevation, but as the wells became plugged they were drilled to a greater depth. An individual well yields a very large quantity of water that is very highly mineralized, and that from some wells cannot be used for domestic purposes. It is mostly very hard, "alkaline", and contains a large amount of iron that settles as a reddish precipitate when the water stands in contact with the air. The water has a strong laxative effect on those not accustomed to its use. Some difficulty is experienced as the fine sand has a tendency to plug the wells. Sand screens are used, but a mineral coating forms on the screen and the flow of water is gradually closed off. It is usually necessary to clean the wells every three or four years.

Two wells situated in the SE.$\frac{1}{4}$, section 8, and the SE.$\frac{1}{4}$, section 17, pass through the uppermost water-bearing horizon and tap a sandy bed at a depth of 300 feet, from which large supplies of water are obtained. The water is hard and highly mineralized, but it appears to be of better quality than that from most of the other wells. It is used for all domestic purposes although it is not very suitable for laundry work. The hydrostatic pressure is sufficient to cause the water to rise to a point 200 feet below the surface, where it maintains a constant level. It is probable that this water-bearing horizon will be encountered in other sections, but it is thought to be of local extent as deeper wells did not strike a gravel aquifer at this depth.

A well in the SW.¼, section 1, taps a third water-bearing horizon at a depth of 400 feet or at an elevation of 1,860 feet above sea-level. The aquifer is a fine sand from which a large supply of water is obtained. The water is usable for all domestic purposes and is under sufficient hydrostatic pressure to rise to a point 220 feet below the surface. This water-bearing bed may be fairly continuous, as wells sunk to similar depths in adjoining townships tap sand beds that yield water of similar quality.

The residents of this township usually obtain sufficient water from deep wells for stock requirements. There is a shortage of good drinking water, however, and many use the water from deep wells, although it is not suitable. It is recommended that rainwater be collected for domestic needs. Cement or galvanized iron cisterns can be used to collect the rainwater that runs off the roofs of the farm buildings.

Township 26, Range 21

A deep, steep-sided valley enters the township in section 35 and extends in a southerly direction, leaving the area in section 3. This valley is from ½ to 1 mile wide and is approximately 100 feet deep at the deepest part. In years of normal rainfall Snipe lake occupies part of the valley, but in 1935 it was practically dry. The water in this lake is in most cases not usable for any purpose. The ground surface above the valley is slightly rolling and slopes from an elevation of 2,300 feet in the western and eastern areas to 2,200 feet above sea-level, at the top of the valley. Glacial lake clay overlies most of the township, and it is underlain by glacial till or boulder clay, which outcrops along the valley and in the northwestern corner of the township. The glacial lake clay varies in thickness from a few inches to not more than 40 feet, and it is non-water bearing.

The glacial till or boulder clay varies in thickness, but it is probably not more than 200 feet or less than 150 feet thick. It consists of nearly impervious blue clay that contains small pebbles, and in which thin layers of sand occur at or near its base. Wells in the northwestern corner of the township are from 108 to 162 feet deep and tap beds of sand in this blue clay. They yield fairly large quantities of water and supply from 20 to 30 head of stock. The water is hard and slightly "alkaline", but is usable for household purposes. It is under hydrostatic pressure and rises to points 103 to 135 feet below the surface. It is probable that the deposits of water-bearing sand are continuous in this part of the township, and other holes drilled to similar depths should encounter water.

Four wells located in the SE.$\frac{1}{4}$, section 2, the NE.$\frac{1}{4}$, section 4, the SW.$\frac{1}{4}$, section 13, and the NW.$\frac{1}{4}$, section 35, are thought to tap sand aquifers in the Belly River bedrock formation at depths of 305, 390, 400, and 250 feet, respectively. The 305-foot well passes through a gravel aquifer at a depth of 230 feet. This aquifer probably occurs at the contact of the drift and the underlying bedrock, which may be the Bearpaw formation. If this formation is present it is less than 100 feet thick and it apparently does not contain water-bearing deposits. The materials penetrated by the other three wells are not definitely known. An individual well yields a very large quantity of water and each well waters from 100 to 200 head of stock. The water is very highly mineralized and is not suitable for domestic purposes, although it is being used as water of better quality is not available. The water is "alkaline" and acts as a laxative on those not accustomed to its use. As no dry holes are reported it should be possible to locate water in the Belly River formation in almost any section of the township. Water of good quality is not to be expected, however, and the wells may become plugged with the fine sand.

Farmers who have no wells haul water from neighbouring wells that yield an abundant supply. Water should be obtained by drilling to depths of 250 to 400 feet. Water for stock needs can also be derived by collecting surface water in dugouts or dams. The slightly mineralized surface water is more beneficial for stock use than the highly mineralized water from deep wells. The artificial reservoirs should be constructed so that they well retain at least 12 feet of water. Shallow wells sunk near the impounded water should yield water that is usable for domestic purposes. Care must be taken to see that the water does not become contaminated and it should be examined regularly by the Provincial Analyst for bacterial content.

Township 27, Range 19

An area of approximately 16 square miles in the north-eastern corner of the township is mantled by moraine. The ground surface of this area is rolling and is characterized by many, small, rock-strewn knolls and several undrained depressions. The remainder is covered by glacial till or boulder clay, but in the southern part the till is overlain by a thin veneer of glacial lake clay. The surface of the lake clay-covered area is flat, free of stones, and is well adapted for cultivation. The lake clay is non-water bearing. The surface of the glacial till-covered area is rolling, but no well-developed drainage system occurs. The deposits of glacial till and moraine are similar in composition and in general consist of 1 to 3 feet of loamy soil; 10 to 30 feet of oxidized or yellow boulder clay that contains very few pockets of water-bearing sand and gravel; and 100 to 250 feet of unweathered or blue boulder clay that contains beds of sand and gravel at various horizons.

Only one well is reported to be deriving water from a pocket of gravel in the weathered or yellow boulder clay. It is a 22-foot well in the NE.¼, section 18, and it yields an abundant supply of water that is usable for all farm purposes. The water rises to a point 18 feet below the surface where it maintains a constant level. The well cannot be bailed dry. The aquifer for this well is of local extent, as wells nearby do not encounter it. Probably with further prospecting other pockets of sand and gravel would be encountered. It is advisable to locate a water-bearing pocket by means of a small hand auger prior to digging a well.

The principal water-bearing horizon is tapped at depths of 45 to 200 feet in the glacial drift. This horizon is formed by discontinuous beds of sand and gravel in the blue boulder clay, and probably the deeper wells tap aquifers that lie between the glacial drift and the underlying bedrock. Most of the wells are approximately 100 feet deep, one being less than 85 feet, and two being 196 and 200 feet. With few exceptions the wells yield abundant supplies of water sufficient for large herds of cattle. Some of the wells cannot be pumped or bailed dry and the water maintains a constant level in the wells. Two wells in the NW.¼, section 5, and the NW.¼, section 6, yield small and insufficient supplies of very highly mineralized water that is not under hydrostatic pressure. If these two wells were deepened they might possibly yield a large supply of water. The water from the wells yielding abundant supplies is hard and usually "alkalime", but is usable for domestic purposes. It contains a considerable amount of iron in solution which precipitates as a reddish sediment when the water is exposed to the air. It is very probable that with further prospecting water-bearing deposits should be located in the glacial drift.

The Bearpaw formation is thought to immediately underlie the glacial drift, but it may be very thin in some sections or absent in others. The Belly River formation underlies the Bearpaw and three wells obtain water from sand deposits that are thought to occur in this formation. These wells are located in the SE.$\frac{1}{4}$, section 6, the SW.$\frac{1}{4}$, section 12, and the NW.$\frac{1}{4}$, section 26, and are 285, 252, and 448 feet deep, respectively. Each well yields a very large supply of water; that from the first two wells can be used for domestic purposes, but that from the 448-foot well is too highly mineralized for household use. The water is very hard, "alkaline", and contains a large amount of iron. This water will act as a laxative on those not accustomed to the use of such water. Wells should find water in the Belly River bedrock formation at similar depths throughout this township.

The residents of the township, with few exceptions, have b- able to derive sufficient water from wells. Dams could be constructed in some sections to conserve surface water, and dugouts can be used throughout most of the area. Shallow wells sunk beside the impounded surface water should yield water that would be usable for domestic needs.

Township 27, Range 20

The average elevation of this township is 2,300 feet above sea-level. The area is mantled by glacial till, but in the southern corner the till is overlain by a thin deposit of glacial lake clay. The ground surface of this area is very flat and suitable for cultivation, whereas that of the glacial till-covered area is more rolling, and in the western sections it is very hilly. Only a small area in the western part of the township is under cultivation.

No water-bearing sands or gravels occur in the glacial lake clay or in the upper part of the underlying boulder clay. The upper 30 feet of glacial till is composed of yellow boulder clay. Unoxidized blue boulder clay underlies the yellow clay, and it contains thin layers and pockets of sand at various depths. In some sections water-bearing deposits occur at or near the contact of the glacial drift and underlying bedrock. Nine wells scattered throughout the township are thought to derive water from these sand and gravel beds. The wells are from 100 to 192 feet deep and each well yields a large quantity of water. The water-level in some of the wells cannot be lowered by continuous pumping. The water is highly mineralized but is mostly usable for domestic purposes. With one exception the water is under hydrostatic pressure and rises to points 75 to 150 feet below the surface. This water-bearing horizon does not appear to be continuous as deeper wells failed to encounter it. A 110-foot dry hole was also sunk in the NE.$\frac{1}{4}$, section 36. If this hole were deepened it might encounter a water-bearing horizon.

The Bearpaw formation underlies the glacial drift, but it is probably not more than 100 feet thick in any part of the township. A soft, clay shale is reported at the base of some of the wells that derive water from the glacial drift, and the deeper wells pass through shale into the underlying Belly River formation. The Bearpaw formation appears to be non-water bearing in this township.

Nine wells from 200 to 480 feet deep tap sand aquifers that appear to be in the Belly River formation. Most of the wells yield abundant supplies of water under sufficient hydrostatic pressure to rise to points 80 to 240 feet below the surface. The fine sand of the aquifers in many places plugs the well casings and it is usually necessary to clean out the wells every four or five years. The water is very highly mineralized and that from some wells is not usable for domestic purposes. It is usually very hard, "alkaline", and contains a considerable amount of iron, which settles as a red precipitate when the water stands in contact with the air. It is very possible that water can be located in the Belly River formation at similar depths in any part of the township. The poor quality of water obtained and the difficulty of keeping the well casings free from sand are factors to be considered before drilling a deep well.

A few farmers are forced to haul water from neighbouring wells, and the most inexpensive method of increasing the supply of water in this township is by collecting surface water in dugouts or dams. The slightly mineralized surface water is more suitable for stock than the water from deep wells.

Township 27, Range 21

A deep valley extends in a north-south direction through the eastern part of this township. It is an extension of the valley in township 26, range 21, that contains Snipe lake. The valley is considerably more than 100 feet deep and is from one-half to one mile wide. The elevation at the top of the west bank of the valley is 2,300 feet above sea-level, from where it rises in a north-westerly direction to approximately 2,380 feet above sea-level in the northwestern corner. A shallower depression occurs in the southwestern part of the township. The township is mantled by glacial till or boulder clay, but in the southeastern sections a thin deposit of glacial lake clay overlies the glacial till. The slopes of the valley are covered by till that has been modified by water action. The surface of the glacial lake clay-covered area is flat and the land is suitable for cultivation, whereas the glacial till-covered area is more rolling, becoming somewhat hilly in some sections, but the greater part is also under cultivation.

Water supplies are obtained from sloughs, artificial reservoirs, and from wells. The sloughs are small and supply only sufficient water for a few head of stock during part of the year. The artificial reservoirs can be formed by the excavation of dugouts or by the construction of dams. Some of these reservoirs are of sufficient size to retain water even in drought periods. For example a dam in the NE.$\frac{1}{4}$, section 11, impounds a body of water 100 by 600 feet in size and 14 feet deep and a 5-foot well dug near the dam yields a permanent supply of soft water that is sufficient and suitable for all household purposes. This method of increasing water supplies is highly recommended where good water cannot be obtained from wells. Care must be taken, however, to see that the water in the well does not become contaminated. It is advisable to have the water tested regularly for bacteria content.

Some wells in this township derive water from the glacial drift and other wells obtain it from the underlying bedrock. The glacial drift consists of 1 to 4 feet of loamy soil, 20 feet or less of oxidized or yellow boulder clay, and probably 85 to 160 feet of nearly impervious, blue boulder clay. No deposits of water-bearing sand are known to occur in the yellow clay or in the upper part of the blue boulder clay. Wells from 85 to 150 feet deep tap sand and gravel aquifers that occur either at the contact of the drift and bedrock, or very near the base of the drift. The wells are scattered throughout the township and the aquifers appear to be fairly continuous. The wells in the southwestern corner of the township tap thin aquifers, and the yield from an individual well is small, being only sufficient for 10 to 15 head of stock. The water is not under pressure and the supply is insufficient for local needs. The other wells in the glacial till in the northern part of the township tap aquifers that yield an abundant supply of water, and some of the wells cannot be pumped dry. The water is very highly mineralized and acts as a laxative, and that from some wells cannot be used for domestic purposes. The water from some wells is being used, although it is not satisfactory, but water of better quality cannot be obtained.

Five wells obtain water from the Belly River formation at depths of 280 to 490 feet. These wells pass through the glacial drift and the underlying non-water-bearing Bearpaw formation. Shale, which is thought to be part of the Bearpaw formation, was encountered at depths of 180 and 140 feet in two wells located in the NW.$\frac{1}{4}$, section 15, and the NE.$\frac{1}{4}$, section 22. This formation is not more than 100 feet thick and is underlain by the Belly River formation. Sand beds in the Belly River formation usually yield very large quantities of water and several wells in this township that tap these deposits cannot be pumped dry by a large farm pump. The water is very highly mineralized and soft, due to the large amount of sodium carbonate in solution and the absence of calcium and magnesium salts, and it has a baking soda taste. The water is usable for domestic purposes, but it is very unsatisfactory for cooking. The water is under sufficient hydrostatic pressure to rise to points 100 to 200 feet below the surface where it maintains a constant level. It is probable that wells sunk to similar depths in any part of the township will encounter water-bearing beds in the Belly River formation.

STATISTICAL SUMMARY OF WELL IN
MUNICIPALITY OF SNIPE LAKE, NO.

West of 3rd meridian — Township	23	23	23	24	24
Range	19	20	21	19	20
Total No. of Wells in Township	7	9	1	8	7
No. of wells in bedrock	3	2	0	5	7
No. of wells in glacial drift	4	7	1	3	0
No. of wells in alluvium	0	0	0	0	0
Permanency of Water Supply					
No. with permanent supply	5	7	1	7	7
No. with intermittent supply	0	0	0	0	0
No. dry holes	2	2	0	1	0
Types of Wells					
No. of flowing artesian wells	0	0	0	0	0
No. of non-flowing artesian wells	3	3	0	7	7
No. of non-artesian wells	2	4	1	0	0
Quality of Water					
No. with hard water	3	6	1	7	7
No. with soft water	2	1	0	0	0
No. with salty water	0	0	0	0	0
No. with "alkaline" water	0	1	0	1	1
Depths of Wells					
No. from 0 to 50 feet deep	2	3	1	0	0
No. from 51 to 100 feet deep	1	3	0	0	0
No. from 101 to 150 feet deep	1	0	0	0	0
No. from 151 to 200 feet deep	0	1	0	0	0
No. from 201 to 500 feet deep	3	2	0	7	7
No. from 501 to 1,000 feet deep	0	0	0	0	0
No. over 1,000 feet deep	0	0	0	1	0
How the Water is used					
No. usable for domestic purposes	2	4	1	7	5
No. not usable for domestic purposes	3	3	0	0	2
No. usable for stock	5	6	1	7	7
No. not usable for stock	0	1	0	0	0
Sufficiency of Water Supply					
No. sufficient for domestic needs	5	7	1	7	7
No. insufficient for domestic needs	0	0	0	0	0
No. sufficient for stock needs	5	5	1	7	5
No. insufficient for stock needs	0	2	0	0	2

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.

Chloride s

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 Snipe Lake, No. 259, Saskatchewan

No.	LOCATION Qtr.	Sec.	Tp.	Rge.	Mer.	Depth of Well, Ft.	Total dis'vd solids	HARDNESS Total	Perm.	Temp.	CONSTITUENTS AS ANALYSED Cl.	Alkalinity	CaO	MgO	SO_4	Na_2O	CONSTITUENTS AS CALCULATED IN ASSUMED COMBINATIONS Solids	$CaCO_3$	$CaSO_4$	$MgCO_3$	$MgSO_4$	Na_2CO_3	Na_2SO_4	NaCl	$CaCl_2$	Source of Water
1	SW.	16	24	19	3rd	500	2,643												(2)		(4)	(3)	(1)	(5)		x3
2	NE.	24	24	20	3rd	366	3,300	1,600	1,500	100	105	495	450	310	1,840	607	3,198	495	420		924		1,186	173		x3
3	SE.	34	24	21	3rd	309	3,800	2,400	2,000	400	106	465	630	420	2304	513	3,774	465	912		1,258		904	175		x3
4	SW.	4	25	20	3rd	337	2,580	1,100	1,050	50	102	120	110	216	1,443	636	2,297	120	105		644		1,200	168		x2 ?
5	NW.	24	26	19	3rd	189	2,860	2,200	2,000	200	25	500	530	370	1542	170	2,590	500	608		1,105		336	41		x1
6	SW.	20	26	19	3rd	401	2,760	120	15	105	48	470	30	36	1426	1161	2,663	54		75		345	2,110	79		x3
7	NE.	32	26	21	3rd	139	1,206		B.	Coli	present							(3)	(1)		(2)		(4)		(5)	x1
8	NW.	26	27	19	3rd	448	2,694												(4)		(5)	(2)	(1)		(3)	x3
9	NW.	34	27	19	3rd	196	3,220	2,400	2,300	100	37	490	620	331	1,758	272	2,928	490	841		986		550	61		x1

Water samples indicated thus, x 1, are from glacial drift.
Water samples indicated thus, x 2, are from bedrock, Bearpaw formation.
Water samples indicated thus, x 3, are from bedrock, Belly River formation.
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 ($CaCO_3$).

Analyses Nos. 1, 7, and 8 by Provincial Analyst, Regina.
For interpretation of this table read the section on Analyses and Quality of Water.

Water from the Unconsolidated Deposits

Three samples of water from the glacial drift in the municipality of Snipe Lake were analysed and the results are listed as samples 5, 7, and 9 in the accompanying table. These samples were taken from wells 189, 139, and 196 feet deep, respectively, and the aquifers probably occur at or near the contact of the drift and the underlying Bearpaw bedrock formation. The total dissolved solid content varies from 1,206 to 3,220 parts per million, and it is probable that most of the water derived at depth in the glacial drift will be similar to that represented by these samples. The mineral salts present in the greatest concentration are the sulphate salts of sodium, magnesium, and calcium, with smaller amounts of sodium carbonate and sodium chloride (common salt). The water is a sulphated water, or as it is commonly termed, "alkaline". It is very hard and as a rule is not good for domestic purposes, but that from many wells is used, as water of better quality is not obtainable. Bacilli coli are present in sample 7 and this water is contaminated by human or animal refuse.

Several springs and a few shallow wells are located in this municipality, but no samples of water obtained from them were analysed. The water from the springs is reported as soft or moderately hard, and as being usable for all farm purposes including irrigation. The total dissolved solid content is low, as compared with water from deeper wells, and it probably does not exceed 1,000 parts per million. The principal mineral salts in solution are probably the sulphate salts of sodium, calcium, and magnesium, with smaller amounts of calcium carbonate and either sodium chloride or calcium chloride. The water from the shallow wells probably has a higher total dissolved solid content than that from the springs, but it contains the same mineral salts in solution in different proportions. Water from the springs and shallow wells is the best water for domestic purposes in the municipality.

Water from the Bedrock

Sample No. 4 is taken from a well that is thought to be deriving water from an aquifer in the Bearpaw formation. The water has a total dissolved solid content of 2,580 parts per million. The principal mineral salts in solution are sodium sulphate (Glauber's salt), magnesium sulphate (Epsom salts), and sodium chloride (common salt), with smaller amounts of calcium sulphate and calcium carbonate. The water is hard, slightly "alkaline", and is usable for household use as well as for stock.

Samples 1, 2, 3, 6, and 8 are taken from wells 309 to 500 feet deep that tap sand aquifers in the Belly River formation. The total dissolved solid content varies from 2,694 to 3,800 parts per million. Samples 2 and 3 are taken from wells 309 and 366 feet deep that tap sand beds in the upper part of the formation. The mineral salts present in these samples are the sulphates of calcium, sodium, and magnesium, and calcium carbonate and sodium chloride. The water, although not suitable for domestic purposes, is used as water of better quality is not obtainable within reasonable hauling distance. The water from a few wells of similar depth cannot be used for domestic purposes. Samples 1, 6, and 8 are from wells that tap an aquifer at lower depth in the Belly River formation. The wells are 401 to 500 feet deep and the aquifers are sand. The average total dissolved solid content of the water from these wells is 2,700 parts per million. The water is soft and usable for domestic purposes. Sodium sulphate (Glauber's salt) is the most abundant mineral salt in solution, with sodium carbonate or calcium sulphate being next in abundance. The water from the aquifers in the lower part of the Belly River is distinguished from that of the upper aquifers by the fact that it contains a large amount of sodium carbonate. The water has a baking soda taste, is very poor for cooking as it turns vegetables black, but it is an excellent water for laundry work. The water from deep wells in the Belly River bedrock formation is of better quality for domestic purposes than that from the shallower wells. The water from most of the other wells, besides being highly mineralized, contains a large amount of iron that settles as a red precipitate of iron oxide when the water stands in contact with the air. Much of the iron, however, can be removed by aerating and filtering the water.

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.