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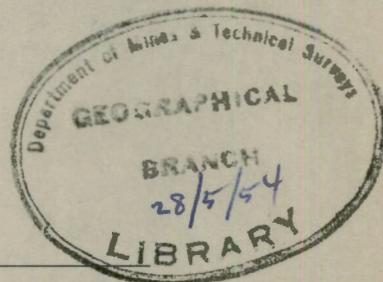
CANADA
DEPARTMENT OF MINES
AND
TECHNICAL SURVEYS

GEOLOGICAL SURVEY OF CANADA

WATER SUPPLY PAPER No. 319

GROUND-WATER RESOURCES
OF
TOWNSHIPS 11 to 14, RANGES 26 to 29,
WEST OF PRINCIPAL MERIDIAN
MANITOBA
(Elkhorne Area)

By
E. C. Halstead



OTTAWA

1953

Environment CANADA Environnement
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SUPPLY PAPER
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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.

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GROUND-WATER RESOURCES
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PART I

INTRODUCTION

The present report is an attempt to assemble the data on ground-water resources in a form that will be useful to well drillers, farmers, municipal authorities, and others interested in obtaining adequate water supplies.

Publication of Results

The essential information pertaining to ground-water conditions is being issued in reports that, in Manitoba, cover a square block of sixteen townships lying between the correction lines and beginning at the Saskatchewan boundary. The reports on the most southerly strip of the province include in addition the two townships lying north of the International Boundary. The secretary-treasurer of each municipality will be supplied with the information covering that municipality, and copies of the reports will also be available for study at offices of the Provincial and Federal Departments. Further assistance in interpreting the reports may be obtained by applying to the Chief Geologist, Geological Survey of Canada, Ottawa.

How to Use the Report

Anyone desiring information concerning ground-water in any particular locality will find the available data listed in the well records, and other pertinent information on the maps of the area. For those unfamiliar with these reports it is, perhaps, advisable that that part dealing with the area as a whole be read first, so as to be in a better position to understand the more particular descriptions of each township that follow. Also, the map accompanying the report should prove a useful source of reference when reading the text.

The map consists of two figures. Figure 1 shows bedrock and surface geology. The water-bearing properties of the bedrock change from formation to formation, and are referred to in subsequent pages. The type of glacial deposit at the surface may be determined from the map, and its possibilities as an aquifer are also discussed in this report.

Figure 2 shows the location and types of wells in the area, the land relief (topography), and the drainage pattern. Not every well is plotted on the map, but most of those giving pertinent information are shown, and probably include 90 per cent of the wells in the area. Where ground water is not readily available, or carries too much dissolved salts to be used, dugouts often form the only means of supply. The topography is shown by contours, or lines of equal elevation, spaced at vertical intervals of 50 feet.

The well records are compiled from data obtained by interviewing farmers, and in many cases their accuracy depends upon the farmer's memory. Wherever possible data were checked by plumb-line measurement to the nearest foot. The wells are tabulated by townships and sections, and the total depth of the well, depths to the water level at high and low stages, and, where possible, the depth at which the water-bearing horizon occurs, are all listed. The general character of the water is stated, and the use to which it can be put. Wells from which samples were taken for analysis are indicated on the well-record sheets. An idea of how much water a well can be expected to yield is suggested by the number of stock (cattle and horses only) that can be watered at it. One head is assumed to consume between 8 and 10 gallons of water a day. Unless followed by the word "only"

the figure for the number of stock watered is not necessarily the maximum yield of the well, but simply the greatest amount that the present user has required. The word "only" indicates that the figure given is the maximum yield of the well. To obtain the position of an aquifer at any given point, the elevation of the point should be determined from the contours on Figure 2 of the map. Elevations of adjacent wells may be found in the well records and the depth to the aquifer can usually be determined from them. By comparing elevations the depth of the aquifer below the unknown point may be estimated. This method is particularly applicable to bedrock wells, but may not be successful where information is too limited, or where the glacial drift is thick and of an irregular character. In such instances a person searching for water should refer to the text for information on the nature of the deposits in that area.

GLOSSARY OF TERMS USED

Alkaline. The term 'alkaline' or 'alkali' water has been applied rather loosely to waters having a peculiar and disagreeable taste, and commonly a laxative effect. The waters so described in the Prairie Provinces are those heavily charged with sulphates of magnesium and sodium (respectively Epsom salts and Glauber's salts) and are more correctly termed sulphate waters. Truly 'alkaline' waters owe that property to the presence of calcium carbonate and calcium bicarbonate. In this report an attempt to adhere to local terminology is made by referring to sulphate waters as 'alkali' in the well records, and the term 'alkaline' is avoided.

Alluvium. Deposits of clay, silt, sand, gravel, and other material in lake beds and in flood plains of modern streams. The term also includes the material in river terraces, which once formed part of the flood plain but are now above it.

Aquifer. A porous bed, lens, pocket, or deposit of material that transmits water in sufficient quantity to satisfy pumping wells and springs.

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.

Bentonite. and bentonitic clays have the property of swelling when water is added to them. They occur as white beds as much as 2 feet thick, but usually much thinner, and are probably formed by the weathering of volcanic ash.

Buried pre-Glacial Stream Channel. A channel eroded into the surface of 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.

Coal Seam. The same as a coal bed. It is 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 relatively steep slope separating level or gently sloping areas.

Flood Plain. A flat part of a river valley ordinarily above water but submerged when the river is in flood. It is an area where silt and clay are being deposited.

Glacial Drift. A general term that includes all the loose, unconsolidated materials that were deposited by the ice-sheet, or by the waters associated with it. Clay containing boulders usually forms a large part of the glacial drift in an area, and is called glacial till or boulder clay, and is not to be confused with the more general term glacial drift, which occurs in the following several forms:

(1) Terminal Moraine or Moraine. A ridge or series of ridges formed by glacial drift that was laid down at the margin of a moving ice-sheet. The surface is characterized by irregular hills and undrained basins.

(2) Kame Moraine. Assorted deposits of sand and gravel laid down at or close to the ice margin. The topography is similar to that of a terminal moraine.

(3) Ground Moraine. Boulder clay (till) laid down at the base of an ice-sheet. The topography may vary from flat to gently rolling.

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

(5) Glacial-lake Deposits. Sand, silt, and clay deposited in glacial lakes during the retreat of the ice-sheet.

Shoreline. A discontinuous escarpment, with intervening gravel beaches and bars, which indicates the former margin of a glacial lake.

Ground Water. The water in the zone of saturation below the water-table.

Hydrostatic Pressure. The pressure that causes water in a well to rise above the point at which it was first encountered in the well, namely, at the level of the aquifer.

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

Pervious or Permeable. Beds are pervious or permeable when they permit the perceptible passage or movement of ground water, as in the case of sands and gravels.

Pre-Glacial Land Surface. The surface of the land as it existed before the ice-sheet covered it with drift.

Recent Deposits. Deposits that have been laid down by the agencies of water and wind since the disappearance of the continental ice-sheet; for example, alluvium in stream valleys.

Sand Point or Driven Well. A sand point is a piece of perforated and screened pipe 2 or 3 feet long, which ends in a sharp point. It is fastened to lengths of ordinary pipe and forced down into surface deposits of a sandy or gravelly nature. The depth of such a well rarely exceeds 30 feet.

Unconsolidated Deposits. The mantle or covering of alluvium, pre-glacial soils, and glacial drift consisting of loose, uncemented material that overlies the bedrock.

Variegated. Beds so described show different colours in alternating beds or lenses.

Water-table. The upper limit of the part of the ground saturated with water. This may be near the surface or many feet below it. A water-table is said to be perched when a zone of saturated material is separated from the main water-table below by a zone or zones of unsaturated material.

Water-worked Till. Glacial till or boulder clay that has been subjected to water action, usually near the margins of glacial lakes, so that the fine clay has been washed out and a deposit that may be composed mainly of sand and gravel is left behind.

Wells. The term refers to any hole sunk in the ground by any means for the purpose of obtaining water. If no water is obtained they are referred to as dry holes. Wells yielding water are divided into four classes:

(1) Flowing Artesian Wells. Wells in which the water is under sufficient hydrostatic pressure to flow above the surface of the ground at the well.

(2) Non-flowing Artesian (Sub-artesian) Wells. Wells in which the water is under sufficient hydrostatic pressure to raise it above the level of the aquifer, but not above the level of the ground at the well.

(3) Non-artesian Wells. Wells in which the water does not rise above the water-table or the aquifer.

(4) Intermittent Non-artesian Wells. Wells that are generally dry for a part of each year.

GENERAL DISCUSSION OF GROUND WATER

Almost all the water recovered from beneath the earth's surface for both domestic and industrial uses is meteoric water, that is, water derived from the atmosphere. Most of this water reaches the surface as rain or snow. Part of it is carried off by streams as run-off; part evaporates either directly from the surface and from the upper mantle of soil, or indirectly through transpiration of plants; and the remainder sinks into the ground to be added to the ground-water supplies.

The proportion of the total precipitation that sinks into the ground will depend largely upon the type of soil or surface rock, and on the topography; more water will sink into sand and gravel, for example, than into clay; if, on the other hand, the region is hilly and dissected by numerous streams, more water will be immediately drained from the surface than in a relatively flat area. Light, continued precipitation will furnish more water to the underground supply than brief torrential floods, during which the run-off may be nearly equal to the precipitation. Moisture falling on frozen ground will not usually find its way below the surface, and, therefore, will not materially replenish the ground-water supplies. Light rains falling during the growing season may be wholly absorbed by plants. The quantity of moisture lost through direct evaporation depends largely upon temperature, wind, and humidity. Locally these deposits may become very extensive. The water-bearing properties of alluvial deposits are variable, but, in general, such deposits form favourable aquifers. They are porous, and readily yield a part of their contained water, although in places their porosity may be greatly reduced by the presence of fine silt and clay. This type of deposit may be expected to yield moderate domestic supplies through shallow wells, and larger supplies if the deposits are extensive.

In some areas of relatively steep slopes, valleys have been partly filled with sand and gravel, which, in turn, have been covered with impervious clay and silt. These circumstances commonly give rise to artesian conditions in the lower part of the valley.

DISCUSSION OF WATER ANALYSES

Both the kind and quantity of mineral matter dissolved in a natural water depend upon the texture and chemical composition of the rocks with which the water has been in contact. Pollution is caused by contact with organic matter or its decomposition products. Analyses of well waters for mineral content are made by the Department of Health and Public Welfare, Winnipeg, and by the Bureau of Mines, Department of Mines and Resources, Ottawa.

As the ground-water survey of Manitoba progresses an effort is made to secure samples representative of each major aquifer encountered; the purpose of this is to compare the chemical characteristics of waters from the various geological horizons and, thereby, assist in making correlations of the strata in which the waters occur. The mineral content of natural waters is also of interest to the consumers, though the effects of the constituents are usually already apparent. The quantities of the various constituents for which tests are made are given as 'parts per million', which refers to the proportion by weight of each constituent in 1,000,000 parts of water. A salt when dissolved in water separates into two chemical units called 'radicals', and those are expressed as such in the chemical analyses. In one group are included the metallic elements of calcium (Ca), magnesium (Mg), sodium (Na), and iron (Fe), and in the other group are the sulphate (SO_4), chloride (Cl), bicarbonate (HCO_3), carbonate (CO_3), and nitrate (NO_3) radicals. The radicals listed in the analyses tabulated in the second part of this report can be combined to give the actual quantity of the particular salts present in the water, but this is not done here as the radicals alone give enough information to identify the water types. In fact, the sulphate, chloride, and carbonate radicals, plus the hardness, serve to identify a water, and crude field tests on the basis of these constituents were used in some areas to outline more completely zones of the various water types.

The following mineral constituents include all that are commonly found in natural waters in quantities sufficient to have any practical effect on the value of waters for ordinary uses:

Silica (SiO_2) is dissolved in small quantities from almost all rocks. It is not objectionable except in so far as it contributes to the formation of boiler scale.

Iron (Fe) in combination is dissolved from many rocks as well as from iron sulphide deposits with which the water comes in contact. It may also be dissolved from well casings, water pipes, and other fixtures in quantities large enough to be objectionable, but separates as the hydrated oxide upon exposure of the water to the atmosphere. Excessive iron in water causes straining on porcelain or enamelled ware, and renders the water unsuitable for laundry purposes. Water is usually considered not potable if the iron content is more than 0.5 part per million.

Calcium (Ca) in the water comes from mineral particles present in the surface deposits, the chief sources being limestone, gypsum, and dolomite. Fossil shells provide a source of calcium, as does also the decomposition of igneous rocks. The common compounds of calcium are calcium carbonate (CaCO_3) and calcium sulphate (CaSO_4), neither of which have injurious effects on the consumer, but both of which cause hardness.

Magnesium (Mg) is a common constituent of many igneous rocks and, therefore, very prevalent in ground water. Dolomite, a carbonate of calcium and magnesium, is also a source of the element. The sulphate of

magnesia ($MgSO_4$) combines with water to form 'Epsom salts,' and renders the water unwholesome if present in large amounts.

Sodium(Na) is derived from a number of the important rock-forming minerals, so that sodium sulphate and carbonate are very common in ground waters. Sodium sulphate (Na_2SO_4) combines with water to form 'Glauber's salt' and excessive amounts make the water unsuitable for drinking purposes. Sodium carbonate (Na_2CO_3) or 'black alkali' waters are mostly soft, the degree of softness depending upon the ratio of sodium carbonate to the calcium and magnesium salts. Waters containing sodium carbonate in excess of 200 parts per million are unsuitable for irrigation purposes¹. Sodium sulphate is less harmful.

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

Sulphates (SO_4) referred to in this report are those of calcium, magnesium, and sodium, and have been mentioned above in referring to these radicals. They are also formed by oxidation of iron sulphides, and, hence, it is not uncommon to find iron in sulphate waters. Sulphates cause permanent hardness in water, and injurious boiler scale. Sodium and magnesium sulphates are laxative when present in quantities of more than 900 parts per million. The writers found that acclimatized people could drink water containing as much as 2,000 parts per million of all three of the principal sulphates, but that when all were present in quantities over 1,500 parts per million the water was commonly laxative to those not accustomed to it.

Chloride (Cl) is a constituent of all natural waters and is dissolved in small quantities from rocks. Waters from wells that penetrate brine or salt deposits contain large quantities of chloride, usually as sodium chloride (common salt) and less commonly as calcium chloride and magnesium chloride. Sodium chloride is a characteristic constituent of sewage, and any locally abnormal quantity suggests pollution from this source. However, such abnormal quantities should not, in themselves, be taken as positive proof of pollution in view of the many sources from which chloride may be derived. Chlorides impart a salty taste to water if present much in excess of 500 parts per million. In southwestern Manitoba waters with as much as 3,000 parts per million of chloride are used domestically, though more than 1,500 parts per million is generally considered undesirable. The following figures apply to chlorides: stock will require less salt if the water bears 2,000 parts per million; more than 5,000 parts per million is unfit for human consumption; more than 8,000 parts per million is unfit for horses; more than 9,500 parts per million is too much for cattle; and more than 15,500 parts per million is excessive for sheep. Magnesium chloride, less common than sodium chloride, is very corrosive to metal plumbing.

Nitrates (NO_3) found in ground water are decomposition products of organic materials; they are not harmful in themselves, but they do point to probable pollution. It is recommended that a bacterial test be made on water showing an appreciable nitrate content, if it is to be used for domestic purposes.

Carbonates (CO_3) in water are indicated in the table of analyses as 'alkalinity'. Calcium and magnesium carbonate cause hardness in water, which may be partly removed by boiling. Sodium carbonate causes softness in waters, and is referred to under 'Sodium' above.

Bicarbonates (HCO_3). Carbon dioxide dissolved in water renders the insoluble calcium and magnesium carbonates soluble as bicarbonates. The latter are decomposed by boiling the water, which changes them to insoluble carbonates.

Hardness is a condition imparted to waters chiefly by dissolved calcium and magnesium compounds. It here refers to the soap-destroying power of water, that is, to the amount of soap that must first be used to precipitate the above compounds before a lather is produced. The hardness of water in its original state is its total hardness, and is classified as 'permanent hardness' and 'temporary hardness'. Permanent hardness remains after the water has been boiled. It is caused by mineral salts that cannot be removed from solution by boiling, but it can be reduced by treating the water with natural softeners, such as ammonia or sodium carbonate, or with many manufactured softeners. Temporary hardness can be eliminated by boiling, and is due to the presence of bicarbonates of calcium and magnesium. Waters containing large quantities of sodium carbonate and small amounts of calcium and magnesium compounds are soft, but if the latter compounds are present in large quantities the water is hard. The following table¹ may

¹Thresh, J.C., and Beale, J.F.: The Examination of Waters and Water Supplies; London, 1925, p. 21.

be used to indicate the degree of hardness of a water:

Total Hardness

<u>Parts per million</u>	<u>Character</u>
0-50.....	Very soft
50-100.....	Moderately soft
100-150.....	Slightly hard
150-200.....	Moderately hard
200-300.....	Hard
300 +	Very hard

The above table gives the generally accepted figures for hardness, but the people of southwestern Manitoba have become accustomed to harder waters, and the following table, based on about 800 field determinations of hardness, by the soap method, is more applicable:

<u>Parts per million</u>	<u>Character</u>
0-100.....	Very soft
100-150.....	Soft
150-250.....	Moderately hard
250-350.....	Hard
350-500.....	Very hard
500+	Excessively hard

Waters having a hardness of up to 300 parts per million are commonly used for laundry purposes. In southwestern Manitoba, hardness ranges from less than 50 parts per million to more than 2,500 parts per million.

PART II

TOWNSHIPS 11 to 14, RANGES 26 to 29,
WEST PRINCIPAL MERIDIAN, MANITOBA
(Elkhorn Area)

Introduction

An investigation of the glacial geology and the ground-water resources of townships 11 to 14, ranges 26 to 29, W. Princ. meridian, was carried on by the writer during the field season of 1949.

Physical Features

A marked topographic feature of this area is the valley of Assiniboine River, which is about a mile wide and 150 feet deep. The valley walls are gullied by short streams with narrow channels and the river itself follows an irregular course along a flat valley floor. Niso Creek flows east across the area and joins the Assiniboine in sec. 18, tp. 13, rge. 26. Gopher and Bosshill Creeks cross the southwestern part to join the Assiniboine near the town of Virden. The general character of the topography is that of an undulating plain with undrained depressions and isolated hills rising some 60 feet above the surrounding plain.

Geology

Table of Formations

Age	Formation	Character	Thickness (Feet)
Recent	Alluvium	Stream-laid mud, silt, sand, and gravel	
Pleistocene	Lake deposits	Silty clays, fine sands and silts, duned sands, assorted sands and gravel in beaches and deltas	0-50

Age	Formation	Character	Thickness (Feet)
	Glacial deposits	Till, clay, sand, gravel, boulders, assorted sand, and gravel in outwash plains	0-300
Upper Cretaceous	Riding Mountain	Upper beds of medium to light grey, hard, siliceous shales (Odanah shale), with some thin layers of fine, blue sand and bentonite beds; lower beds of slippery clay shale that tends to slump	1,000-
	Vermilion River	Dark grey and black shales comprising three members: <u>Pembina</u> (dark shale, numerous bentonite bands near base); <u>Boyne</u> (grey, calcareous shale, non-calcareous, dark shale near base); <u>Morden</u> (calcareous, speckled shale, overlying dark grey, non-calcareous, blocky shale with thin partings of white sand)	80- 140- 190-
	Favel	Grey shale with white, calcareous material; some bands of limestone; some bentonite	150-
Lower and Upper Cre- aceous	Ashville	Dark grey to black shales with silt and sands	40-
Lower Cretaceous	Swan River	White to green sandstone, black shale, and silt	50-
Jurassic		Light grey to red shale, calcareous sandstone, grey to buff-brown shales, light grey limestone and sandstone	380-
Jurassic or earlier	Amaranth	Red beds and gypsum	220

Upper Cretaceous shale of the Riding Mountain formation underlies the area and outcrops along Assiniboine Valley and Nisco Creek. The bedrock surface is irregular, fractured, and weathered, and is overlain by some 25 feet of drift in the central part of the area. It forms a widespread aquifer that yields abundant alkali water with much iron.

Overlying the bedrock is an impervious, blue, clay-rich till that may contain lenses and pockets of sand and gravel that are water bearing. Overlying the blue clay in turn is a buff weathered, stony till of variable thickness but with an average of 25 feet.

An embayment of glacial Lake Souris along Assiniboine Valley modified the ground moraine near the eastern margin of the area. Outwash sand and gravel along the valley north of Miniota was deposited when the advance of the continental ice mass was halted and the end moraine known as Arrow Hills was formed. Patches of outwash gravel have been formed in abandoned stream channels that trend southeast across the ground moraine. They are of local extent, but are favourable sources of hard, clear water.

Water Supply

Three possible sources of ground water are present in this area, but none is continuous and, therefore, in some sections, where all three are lacking, dugouts are necessary to supply water for stock.

A shallow source of water is the surface sand and gravel along abandoned channels or in outwash along the streams and the river. An abundant supply of good water is obtained from shallow wells in such material, but unfortunately they are only found in a few places.

A deeper source supplies water to wells dug through clay to pockets or lenses of sand or gravel within the ground moraine. These wells are not satisfactory as the supply fails in seasons of drought, and in seasons of excess rainfall the wells fill with water that, upon standing, absorbs sulphates and other constituents from the clays and hence becomes bitter. These wells should be pumped out as often as possible in such seasons.

A third source of water is the weathered and fractured surface of the bedrock. This zone commonly yields abundant water, but dry holes that penetrated it are on record. The chemical composition of the water varies and it may be salty or bitter. Chemical analyses show that the water of drilled wells that are properly cased is not contaminated by seepage from the surface material and commonly the water is soft.

Township 11, Range 26. The surface of this township is relatively even, but with a slope to the east. It is covered with ground moraine that, in the eastern half, has been reworked by waters of glacial Lake Souris.

Local patches of sand and gravel, deposited along the western edge of the reworked deposits, are sources of good water sufficient for domestic use. Shallow wells in sections 14, 23, and 24 are dug in such deposits. Elsewhere water is obtained at depths of 40 to 60 feet from an aquifer of sand, gravel, or boulders underlying the blue clay. These wells have never supplied much water, and dugouts are necessary for stock. The increased annual rainfall of the last 6 years, however, has raised the water-table and most of these wells are more than half full of water. As stock are watered at dugouts only small amounts are pumped out daily. Consequently, the mineral content of the water standing in the wells in contact with blue clay has increased until some of it is unfit for drinking.

Wells dug in section 2 reach shale at 50 feet. In NE. $\frac{1}{4}$ section 20, a well drilled 136 feet penetrates blue clay and yields a potable water that rises in the well to a point 20 feet from the surface of the ground.

Township 11, Range 27. Ground moraine covers the surface of this township. The upper 20 feet or more is weathered, buff-coloured till commonly known as yellow clay, and underlying this is a clay-rich, blue till. The uneven surface is broken by isolated knolls parallel with, and west of, the 1,600-foot contour. These knolls are made up of till, with some gravel on the tops where the finer materials have been washed away. An aquifer of sand and gravel, underlying the blue clay, supplies sufficient ground water for domestic use and dugouts have been installed for a stock supply. The water is commonly alkali with much iron. An average depth of the wells dug in this township is 45 feet, and during the season that the investigation was carried out the water rose 35 feet or more in most wells. These wells will water 15 head in the dry years. They are easily pumped dry but after a few hours will refill sufficiently to allow further pumping.

Township 11, Range 28. The rolling uneven surface of this township is accentuated by abandoned stream channels and numerous undrained depressions. Bosshill and Gopher Creeks flow across it in a southeast direction. Ground moraine covers most of the township, the upper 20 feet or more of which is a weathered, buff-coloured till.

A supply of hard, commonly alkali water is obtained from wells dug 25 to 30 feet to lenses of sand or gravel in the drift. These wells yield enough water for domestic use but dugouts are required for a stock supply. Outwash gravel, found along abandoned channels, is also a source of water at shallow depth.

Township 11, Range 29. The uneven, rolling surface of this township is dissected by abandoned drainage channels.

Ten drilled wells have been recorded, some of which are no longer in use. In NW. $\frac{1}{4}$ section 3, a well was drilled 215 feet to a layer of sand and gravel below 205 feet of blue, clay-rich till. The water from this aquifer rises to a point 27 feet below the surface of the ground. In SE. $\frac{1}{4}$ section 4 and SE. $\frac{1}{4}$ section 10 the same aquifer was encountered at depths of 197 and 130 feet respectively. Drilled wells 127, 105, and 145 feet deep in SE. $\frac{1}{4}$ section 12, SE. $\frac{1}{4}$ section 14, and SE. $\frac{1}{4}$ section 22 reach a similar aquifer. In NW. $\frac{1}{4}$ section 18, a well was drilled to a depth of 242 feet. At 180 feet shale was encountered and hard, salty water from it rose to within 40 feet of the surface.

Dug wells 40 to 50 feet deep commonly yield a sufficient supply for domestic use from aquifers in the blue clay. Shallower dug wells in the southern part of the township supply adequate amounts of good water from local patches of surface gravel along abandoned stream channels. Dugouts are common throughout the township.

Township 12, Range 26. The relatively flat surface of this township slopes east to where Assiniboine River crosses sections 36 and 25. Ground moraine covers the entire township, but in the eastern half it has been modified by the waters of glacial Lake Souris. The ground moraine consists of an upper 20 feet or more of buff-coloured till overlying various thicknesses of clay-rich till. Water-bearing zones are present below the blue clay and sufficient water may also be obtained from lenses of sand or gravel within the till. The wells are commonly 39 to 40 feet deep and dugouts are needed to assure a supply for stock. In section 21, a well was drilled 100 feet through 90 feet of blue clay and 10 feet of boulders and gravel. Water rose 50 feet in the well and in a month the well was dry.

Township 12, Range 27. Drift with a flat to uneven surface covers the township to a depth of not more than 30 feet, and in places only about 15 feet. Niso Creek crosses sections 31 and 32. Wells are commonly dug to bedrock where abundant water is obtained from the fractured and weathered surface of the shale. Fine sand below the blue clay is also water bearing but forms quicksand that fills the wells. In test drilling it is common to find plenty of water, but it is of poor quality, suitable for stock only. Dugouts are common. In SW. $\frac{1}{4}$ section 1, a well drilled 85 feet yields an abundant supply of good water.

Township 12, Range 28. Isolated hills of glacial till rise 30 to 50 feet above the surrounding uneven surface of this township, and sloughs of considerable extent occur in many places. Bedrock lies within 25 feet of the surface in sections 2, 3, 9, and 16. In these sections wells were drilled to a common water-bearing zone at a depth of 87 feet. Although the water in this zone is abundant it is too salty for domestic use. Wells have also been drilled in sections 21, 24, and 25. Dug wells reach layers of sand in the drift and commonly yield water of poor quality. Dugouts are common and dams have been built in Niso Creek to retain water for stock during summer months.

Elkhorn is built on a deposit of outwash sand and gravel from which shallow, dug wells and sandpoints supply sufficient water for the town. Dug wells, 18 feet deep and 6 feet in diameter, at Elkhorn Creamery yield 10,000 gallons an hour.

Township 12, Range 29. A belt of end moraine trends southeast across the township with a hilly, uneven, and much wooded surface. The remainder of the township is covered by ground moraine with an uneven surface. Niso Creek crosses sections 35 and 36.

The supply of water in this township is not abundant and its quality is poor. All the wells are dug to layers or local pockets of sand or gravel in the blue clay and reach to depths of 35 to 60 feet. No wells have been drilled to bedrock, which would probably be reached at depths of over 150 feet, but it is doubtful if water encountered in it would be of good quality.

Township 13, Range 26. Assiniboine River meanders, in a valley about 1 mile wide, across the township from section 18 to section 1 and is joined by Arrow River in section 10. Outwash gravel occurs along Arrow River. Gravel is also common in that part of the end moraine that crosses sections 25 and 24, and a broad outwash plain of sand extends from Miniota south to the edge of the river valley. The town of Miniota is supplied with sufficient water from this aquifer. Elsewhere, in the area of ground moraine, wells are dug to lenses of sand and gravel excepting south of the Assiniboine where a supply is obtained in wells less than 25 feet deep from the weathered fractured surface of the bedrock.

Drilled wells are not common, but one in NE. $\frac{1}{4}$ section 35, 80 feet deep, reaches a bed of black sand below blue clay and yields good water but with too much iron for domestic use. Springs along the north side of the valley are used in sections 16 and 19.

Township 13, Range 27. Assiniboine River crosses the northeast quarter of the township in a broad valley over the floor of which it meanders, and some cut-offs have left ox-bow lakes. The bedrock is overlain by a buff weathered till, averaging 20 feet in thickness, with an uneven to flat surface.

Wells are dug to bedrock, from whose weathered and fractured surface an abundance of water is pumped. This water may be alkali but is commonly used for drinking as well as for stock.

Township 13, Range 28. The rolling to flat surface of this township is characterized by low undrained areas known as saline flats. These have little agricultural value but contain a concentration of the mineral constituents present in the ground water. The supply of water is not satisfactory in this township as it is neither abundant nor of good quality. Those wells in use are about 30 feet deep and commonly dug to bedrock, in the weathered, fractured surface of which water is available. No drilled wells have been recorded and the possibility of good water being found at depths of 50 feet or more in the bedrock is not too encouraging, as salt water is commonly found at such depths in the adjacent areas. Wells in patches of outwash gravel along abandoned stream channels are dug for household supplies, but not all such wells yield an abundance of water.

Township 13, Range 29. The surface of this township is uneven and hilly, isolated hills being common east of the 1,650-foot contour. Niso Creek enters the township in section 18 and leaves in section 2. Ground moraine composed of glacial till covers the township with 20 feet of buff weathered till overlying more compact clay-rich till. Patches of outwash sand and gravel are found along small abandoned channels.

The wells in this township are deeper than in those to the east, most of them being more than 50 feet. These wells are dug to lenses and pockets of sand and gravel in the clay-rich till and commonly yield sufficient water for household use. Two or more wells may be needed to assure a supply if a dugout has not been built.

In NE. $\frac{1}{4}$ section 34, an abandoned well was drilled 103 feet to a layer of black sand below blue clay and the water obtained was under sufficient pressure to rise 100 feet in the well. A dug well 14 feet deep in NE. $\frac{1}{4}$ section 24 yields good water from a layer of gravel about 5 feet thick. This well supplies the neighbouring farms with drinking water. At Manson wells have been dug 60 to 72 feet and encountered only water too alkali to use.

Township 14, Range 26. The belt of end moraine forming the Arrow Hills crosses the northeast quarter of the township. The surface of the end moraine is hilly, some hills being till and others gravel. The central part of the township is relatively flat with lakes in undrained depressions in impervious clay.

Outwash plains of sand and gravel in sections 5, 6, and 30 are excellent aquifers that are tapped in many places by sandpoints. In the end moraine pockets of gravel are sources of water of good quality. In the ground moraine that covers the rest of the township wells are dug to lenses or pockets of sand or gravel. These are 20 to 30 feet deep and yield sufficient water for domestic and stock use. More than one well is, however, needed on a farm to assure an adequate supply. In sections 24, 25, 35, and 36 wells are drilled 80 feet to a layer of sand that yields hard, clear water with some iron, sufficient for 100 head. In SE. $\frac{1}{4}$ section 14, a dry hole was drilled 485 feet, reaching shale at 134 feet. A total of 29 holes were dug 28 to 32 feet deep on this quarter, of which only four remain. These have from 10 to 12 feet of hard, clear water but may go dry in seasons of less than normal rainfall.

Township 14, Range 27. Assiniboine Valley crosses this township from section 30 to section 2. The river meanders on a wide valley floor and some meanders are cut off to form ox-bow lakes. Minnewasta Creek joins the Assiniboine in section 28. Ground moraine covers the township except near the edge of the valley where outwash gravel and sand are present.

East of the valley wells are dug in outwash sand and yield a sufficient supply for farm use. Wells in ground moraine on either side of the valley reach lenses of sand or gravel in the till that yield a small supply not sufficient for farm use and dugouts are needed. In N.W. $\frac{1}{4}$ section 25 a well drilled 109 feet through blue clay reaches an aquifer yielding hard, clear water with some iron.

Township 14, Range 28. Ground moraine covers the entire township, although it is not more than 20 feet deep in part of the southeast quarter. Its surface is uneven with undrained depressions.

The water supply is rarely sufficient and dugouts are needed on most farms. In the southwest quarter wells are dug to bedrock and an abundant supply is available in its weathered and fractured surface, but elsewhere wells are dug into glacial drift and the supply commonly fails during the winter months. At Willen a well drilled 70 feet yields alkali water from an aquifer in blue clay.

Township 14, Range 29. A narrow belt of end moraine trends southeast across the township from section 33 to section 13. This has a hilly, rolling surface that grades into the more even surface of the ground moraine covering the remainder of the township. Patches of outwash gravel along abandoned stream channels in sections 7, 13, 18, 29, and 36 are excellent aquifers and wells less than 12 feet deep into them yield an abundant supply of water. The water for most of the township is pumped from an aquifer of fine black sand below blue clay at an elevation of about 1,580 feet above sea-level. Wells 50 to 70 feet deep reach this aquifer and yield a moderate supply of water, most of which is alkali. The supply may fail in seasons of less than normal rainfall and dugouts are built to assure that sufficient water will be available at such times. In SW. $\frac{1}{4}$ section 2, a well 103 feet deep obtains water at 100 feet through the fractured surface of the bedrock.

Analyses of Water Samples

Discussion of Water Analyses

Twelve samples of water from the Elkhorn area were analysed by the Mines Branch, Department of Mines and Technical Surveys, Ottawa. The numbers in the first column are for laboratory identification only and have no special significance.

Samples Nos. 4083, 4084, 4109, 4111, and 4112 are from wells 34 to 54 feet deep, dug to lenses of sand or gravel in blue clay. The five analyses are of water of much the same type. Each has a high concentration of the constituents analysed, and hence the waters are very hard. Sample No. 4112, in particular, is of water with an exceedingly high concentration of all the constituents, and in consequence has a bitter taste and precipitates a scale on pots and pans. These samples are typical of much of the ground waters of southwestern Manitoba.

Samples Nos. 4082, 4081, and 4108 are from wells along Niso Creek that are dug 30 to 60 feet to aquifers in the bedrock. Sample No. 4082, from a drilled well 60 feet deep, is of soft water with a concentration of sodium and chlorine. Sample No. 4108, from a dug well, shows a more balanced concentration of each constituent and the water is very hard. Sample No. 4081, also from a dug well, is excessively hard water and shows a greater concentration of every constituent than in the other two samples. All three wells apparently reach the same soft-water aquifer, but only in the drilled well, which is cased, is contamination from higher, hard-water aquifers prevented.

Sample No. 4107 is of relatively soft water from an aquifer in bedrock. The well is drilled 242 feet and reaches shale at 180 feet. This is a good quality water.

Samples Nos. 4110 and 4079 are taken from wells that reach aquifers in bedrock. The wells are about $1\frac{1}{2}$ miles apart and have elevations of 1,628 and 1,634 feet respectively. Sample No. 4079 is taken from a drilled well 103 feet deep. The water is very soft, the large amounts of sodium, chlorine, and bicarbonate combining to form natural softeners for the water. This well is cased and not contaminated by the water from the overburden. Sample No. 4110 is from a dug well. Most of the water comes from the shale, but there is sufficient contamination by water from the overburden to render the water hard and alkali.

Sample No. 4080 is taken from a dug well 45 feet deep that reaches an aquifer of black sand underlying blue clay. Bedrock is about 50 feet from the surface of the ground. This water is very hard with a high concentration of sulphates.

ANALYSES OF WELL WATERS FROM Townships 11-14, Ranges 26-29, W.P.M., Manitoba

Sample Number	Section	Township	Range	Meridian	Owner	Depth of well * (feet)	Aquifer	Total dissolved solids (parts per million)	Constituents as Analysed (parts per million)								Hardness as (CaCO ₃) (parts per million)		
									Calcium (Ca)	Magnesium (Mg)	Alkalis (as Na)	Sulphate (SO ₄)	Chloride (Cl)	Nitrate (NO ₃)	Bicarbonate (HNO ₃)	Alkalinity (as CaCO ₃)	Ca hardness	Mg hardness	Total hardness
4111	NW 5	11	26	WPM	R. Stephenson	54		1658	252.0	125.0	59.0	765.0	18.2	0	536.8	440.0	628.7	514.4	1143.1
4084	SW 8	11	26	WPM	R. Sinclair	50	gr.	5258	425.0	509.3	196.0	2209.0	143.3	165.6	819.8	672.0	1257.5	2095.8	3353.3
4083	SE 22	11	26	WPM	L. Tapp	35		2220	239.0	155.6	36.0	232.9	107.3	797.4	378.2	310.0	738.5	640.3	1378.8
4109	SE 16	11	27	WPM	H. Odell	34	gr.	3914	302.5	248.7	535.0	1708.7	247.8	230.4	593.2	499.0	754.7	1023.4	1778.1
4112	SE 19	11	27	WPM	C. Dunkin	34	cl.	7978	397.3	621.7	1040.0	4365.2	572.6	0	237.9	215.0	991.3	2558.3	3549.6
4082	NE 31	12	27	WPM	R. Watson	60	sh.	3754	33.7	13.3	1430.0	641.6	1299.6	7.1	745.7	616.0	84.1	54.7	138.8
4081	SE 6	13	27	WPM	G. Cole	30	sh.	3560	257.0	281.7	224.0	563.3	280.1	886.0	872.8	715.4	984.3	1139.2	2143.5
4108	SE 34	12	28	WPM	H. Drake	50	sh.	1468	114.8	55.7	288.0	526.3	163.8	65.6	322.1	264.0	286.4	229.2	515.6
4107	NW 18	11	29	WPM	W. Goethe	242	sh.	1224	47.0	18.0	404.0	425.5	65.8	0	551.4	452.0	117.3	77.4	194.7
4110	NE 36	13	29	WPM	W. J. Kirby	45	sh.	3574	212.0	213.9	660.0	1557.2	304.5	79.7	641.7	526.0	528.9	880.2	1409.1
4029	SW 2	14	29	WPM	G. Fowler	103	sh.	2700	17.0	9.4	1040.0	44.4	1200.2	4.4	719.8	618.0	42.4	38.7	81.1
4080	NE 28	14	29	WPM	A. Elliot	45	sd.	5475	330.0	564.4	258.0	2169.6	235.4	255.2	602.2	493.6	1127.7	2322.5	3450.2

* Symbols used for aquifers: gr. - gravel
cl. - clay
sh. - shale
sd. - sand

Record of Wells

The well records of this area follow in tabulated form. A commentary on these has been made on page 1 of this report.

As a rule the depth to the 'principal water-bearing bed' has been taken as the total depth of the well, and its elevation is given as such. This commonly applies to wells drilled in bedrock or those obtaining water from sub-artesian or artesian aquifers in glacial material or bedrock formations. For these wells digging or drilling is continued until a good supply is obtained and then operations are stopped. In shallow surface materials, not over 30 feet deep, wells are usually dug a short distance below the water-table during a dry season and thereafter water may enter or leave the well at any point below the water-table. The height to which water will rise in the well depends on the amount of rainfall received during the season. For the season in which the survey was conducted the rainfall was more than normal for the district and the figures given for the height of water in the dug wells is, consequently, above average.