CANADA

DEPARTMENT OF MINES

AND

TECHNICAL SURVEYS

GEOLOGICAL SURVEY OF CANADA

WATER SUPPLY PAPER No. 315

GROUND-WATER RESOURCES OF TOWNSHIPS 11 to 14, RANGES 22 to 25, WEST OF PRINCIPAL MERIDIAN, MANITOBA

(Hamiota Area)

By

E. C. Halstead

OTTAWA

1953

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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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 I 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 slopping 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 failing 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 purposes[1]. Sodium sulphate is less harmful.

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[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 brines 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 table[1] may be used to indicate the degree of hardness of a water:

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

Total Hardness

Parts per million	Character
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:

Parts per million	Character
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 22 TO 25, WEST PRINCIPAL MERIDIAN, MANITOBA (Hamiota area)

Introduction

An investigation of the glacial geology and the ground-water resources of tps. 11 to 14, rges. 22 to 25, W. Princ. mer., was carried on by the writer during the field season of 1950.

Physical Features

The general character of the topography is that of an uneven, undulating plain with elevations ranging from 1,800 feet above sea-level in tp. 14, rge. 22, to 1,250 feet above sea-level in the Assiniboine Valley, which crosses tps. 11 and 12, rge. 25. A belt of end moraine, from 1 mile to more than 5 miles wide, crosses the area, and its long narrow hills, the Arrow Hills, rise 40 to 50 feet above the surrounding plain. Undrained depressions in this end moraine may cover 25 acres or more and are occupied by permanent lakes. The lake west of Lenore occupies a depression 3 miles long and about $\frac{1}{4}$ mile wide that has been gouged out of the bedrock.

Assiniboine River crosses the western margin of the area. Its wide floor is bordered by gullied walls that rise 150 feet or more above the river. Oak River, an intermittent stream, flows south to the Assiniboine Valley and its branching tributaries have dissected and gullied the overburden in tp. 11, rges. 22 and 23.

Geology

Table of Formations

Age	Formation	Character	Thickness (Feet)
Recent	Alluvium	Stream-laid mud, silt, sand, and gravel	
Pleistocene	Lake beds	Silty clay, fine sand and silt, duned sand, assorted sand and gravel in beaches and deltas	0-50
	Glacial drift	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 shale (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 shale; comprising three members; Pembina (dark shale, numerous bentonite bands near base); Boyne (grey, calcareous shale, non-calcareous dark shale near base); and Morden (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 Cretaceous	Ashville	Dark grey to black shale with silt and sand	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 to brown shale, light grey limestone and sandstone	380±
Jurassic or earlier	Amaranth	Red beds and gypsum	220±

The map-area is underlain by Upper Cretaceous shale of the Riding Mountain formation. This shale outcrops along the walls of the Assiniboine Valley and on the margin of the lake west of Lenore. One water-bearing zone of the bedrock is its upper fractured and weathered surface, which yields a supply of hard, commonly alkali, watter with much iron. In the southwestern quarter of the area bedrock is overlain by an average of 20 feet of overburden.

End moraine occupies a belt in the west half of the area. It is made up of till pushed and piled by the continental ice mass, and outwash sand and gravel that was deposited by run-off streams. The outwash deposits are excellent aquifers. Ground moraine overlies the bedrock in the remainder of the area and varies in thickness from less than 15 feet in tp. 11, rge. 25, to 150 feet or more in the northeast corner. It is made up of blue, clay-rich till overlain by 20 feet or more of buff weathered till. This till is impervious and only limited supplies of water are available from discontinuous lenses or pockets of sand and gravel in it. Glacial Lake Souris covered the southern half of this block. In it silt and sand were deposited and wave action winnowed out the finer materials and modified the ground moraine. The lake bed deposits are too thin to be valuable as aquifers.

Water Supply

Water supply has been no problem in the north half of this area. Wells are dug into outwash gravel in the area of end moraine, and elsewhere a supply is obtained from wells drilled below the blue clay to layers of fine sand and gravel or to the upper fractured surface of the bedrock. The water is commonly alkali, but can be used for the household as well as for stock, although the concentration of iron that precipitates as the red iron hydroxide makes the water unsatisfactory for domestic use. The water may be filtered through a simple home-made filter of sand and charcoal.

South of Harding the search for water has been costly and many farms depend entirely upon dugouts. The impervious till lacks lenses of gravel or sand and the water that slowly entered the test holes contains enough alkali salts to be unfit for use. The shallow patches of outwash gravel along abandoned stream channels are the only source of potable water. Such aquifers as these are apt to fail in years of drought and to freeze in winter months.

Township 11, Range 22. Assiniboine River crosses sections 1 and 2. North of the river a broad valley floor, about 3 miles wide, is covered with lake-bed sand except for a long oval hill of outwash gravel about 5 miles long and in places more than a mile wide. This is an excellent aquifer and wells dug into it to depths of 20 to 30 feet yield an abundant supply of hard clear water.

North of the broad valley the surface is dissected by Oak River and its three branching tributaries. Many of the gullies and channels so formed have cut 100 feet or more into glacial till, the surface of which has been reworked by waters of glacial Lake Souris. Wells are dug 15 to 30 feet deep to discontinuous lenses of sand or gravel in the glacial till, or in patches of outwash or windblown sand. The supply is commonly sufficient. In sections 19, 20, 21, 29, and 30 the wells are dug from 60 to 72 feet deep, to a layer of black sand that yields hard, clear water having much iron. A well tapping this aquifer will yield enough water for 100 head or more. In NW.$\frac{1}{4}$ section 25, a well 114 feet deep reached a layer of fine sand that filled it in to a depth of 98 feet. It is now dry.

Township 11, Range 23. Impervious blue clay of the ground moraine underlies the silts deposited on the surface by waters of glacial Lake Souris. The branching tributaries of Oak River have dissected the township leaving a rolling channelled surface conducive to rapid runoff. In consequence there is little replenishment of the ground water reservoir and supply of ground water is inadequate, so that dugouts are necessary for a stock supply. Everywhere wells have been dug, bored, or drilled to a depth of 50 to 120 feet only to prove dry or to obtain water that was too alkali for stock. Black alkali water, with a high concentration of sodium carbonate, is common in the test holes dug in the south part of the township.

In SE.$\frac{1}{4}$ section 29, a well bored 85 feet reaches a layer of fine sand below blue clay. Its water is alkali and contains much iron, but has been a constant supply for 15 to 20 head of stock. In SW.$\frac{1}{4}$ section 35 a well dug 74 feet to a layer of gravel now supplies 25 head of stock, but, during the years of drought, would supply only 4 head of horses. On the same quarter section another well drilled 150 feet deep reaches a layer of fine sand and yields only a barrel of water a day. Shallow dug wells along the creeks are commonly a source of drinking water.

<u>Township 11, Range 24</u>. Arrow Hills, with a width of 1 mile to 4 miles, are formed in a belt of end moraine trending south across the township. Their elongate hills and undrained depressions are made up of glacial till and outwash gravel. The overburden is only 10 to 24 feet thick, as bedrock is encountered in wells between those depths. That part of the end moraine not included in the Arrow Hills was modified by waters of glacial Lake Souris and it and the ground moraine are covered by a thin layer of lacustrine silt.

A supply of good water is available in the sand and gravel of the end moraine. Elsewhere wells are dug through ground moraine to bedrock, where sufficient supplies are obtained at an average depth of 30 feet. In NE.$\frac{1}{4}$ section 4, a layer of sand in blue clay at 97 feet, yields soft, clear water, but in section 6, no water, other than black alkali water, was encountered in any test holes.

<u>Township 11, Range 25</u>. Assiniboine River crosses the township from section 31 to section 4 and meanders over a broad valley floor that is, in places, about a mile wide. The walls of the valley, 200 feet high, are gullied and dissected by short streams. Beyond the valley the uneven to flat surface is formed on ground moraine

modified by waters of glacial Lake Souris. Bedrock is 10 to 30 feet from the surface and wells dug to it yield a supply of hard, clear water. Wells may be deepened if the supply should fail during seasons of drought. A sufficient supply of water is found everywhere in this township.

Township 12, Range 22. Oak River enters this township in section 36 and leaves in section 6. It and its abandoned channels dissect the otherwise gently rolling surface. An intermittent tributary of Oak River also crosses sections 12, 1, and 2. The overburden consists of ground moraine much of which has been modified by wave action of waters of glacial Lake Souris. Patches and low ridges of sand and gravel are also present, many of which were deposited along the abandoned channels of Oak River and along the shores of the glacial lake as its level dropped.

Patches of outwash sand and gravel are the chief but very localized aquifers in the township. The village of Bradwardine, for instance, is on an outwash plain and has an abundant supply of good water from shallow wells. Elsewhere wells are dug 30 to 50 feet into the blue clay but yield a supply of water that is commonly not sufficient and dugouts are needed. There are however exceptions, and in SE.$\frac{1}{4}$ section 33, a well drilled 180 feet, supplies hard, iron-bearing water that is under sufficient pressure to rise to the surface and overflow.

Township 12, Range 23. This township is covered by ground moraine whose surface is uneven to undulating with undrained depressions and wooded areas. The southern half has been modified by waters of glacial Lake Souris. Dug wells are 25 to 60 feet deep through blue clay to lenses of sand and gravel. The supply is commonly sufficient for domestic uses and dugouts are built for a stock supply. Several wells, 12 to 60 feet deep, were dug on the NW.$\frac{1}{4}$ section 11, and in each the water was too alkali to use. At Harding, five dug wells average 40 feet in depth and yield alkali water.

One of the first wells drilled was in SW.$\frac{1}{4}$ section 27, to a depth of 150 feet. Water was first encountered at a depth of 25 feet in a layer of gravel 10 feet thick, but drilling continued and a second water-bearing zone of gravel was met at 70 feet. The well was finished at a depth of 150 feet. Water of good quality rose to a distance of 35 feet from the surface. In NW.$\frac{1}{4}$ section 30 and SW.$\frac{1}{4}$ section 32, wells drilled 90 and 103 feet, respectively, reached shale at 88 feet, and water of good quality, but containing much iron, rises within 5 feet of the surface. Wells 70 to 85 feet deep are drilled in SW.$\frac{1}{4}$ and SE.$\frac{1}{4}$ section 19 and SW.$\frac{1}{4}$ section 22. These wells penetrate blue clay to seams of sand and yield alkali water for stock use only. Dry holes 115 to 118 feet deep were drilled in NE.$\frac{1}{4}$ section 22.

Township 12, Range 24. The surface of this township is irregular with many knolls and hills in the area of end moraine that covers all but the eastern margin of the township. Undrained depressions of considerable size are occupied by permanent lakes, Bars Lake, in sections 20 and 29, being the largest.

Wells are dug 25 to 30 feet deep through overburden to bedrock, which is 10 to 40 feet below the surface. They yield an adequate supply of soft water, which even during years of drought is sufficient for 20 head of stock. A well 120 feet deep in NW.$\frac{1}{4}$ section 12 penetrated 90 feet of blue clay and reached a layer of gravel that yields alkali water suitable for stock only. In NW.$\frac{1}{4}$ section 25 and SW.$\frac{1}{4}$ section 36 wells reached bedrock at 40 feet, and were drilled into it to a water-bearing zone at a depth of 98 feet. The water in both wells is suitable for any use.

Township 12, Range 25. The surface of the township slopes to the valley of Assiniboine River, which crosses the western margin. The walls of the valley are, however, gullied by short streams. In sections 1, 2, and 11 a permanent lake occupies an elongate depression in the bedrock. Ground moraine underlies the entire township, covered in places by a thin layer of fine sand or patches of outwash sand and gravel.

Wells are dug 20 to 25 feet deep to bedrock where an adequate supply of water is obtained, either at its fractured surface or in the bedrock itself. Other wells less than 10 feet deep obtain water from the surface sands. These shallow wells are commonly dry in winter when the aquifers freeze. In NW.$\frac{1}{4}$ section 12, three wells are dug 20, 26, and 40 feet deep respectively, and all reach shale at 15 feet. During the years of drought these wells were dry until they again reached the water-table on being deepened 6 or 8 feet.

Township 13, Range 22. Ground moraine covers the entire township. Its surface is undulating with small depressions and clumps of scrub poplar trees except for the broad shallow valley of Oak River that runs from section 34 to section 1.

The overburden has nowhere yielded a sufficient supply of ground water. The upper 20 feet or more is a buff till, underlying which is a clay rich till. These tills are impervious, but local pockets and lenses of sand and gravel in them will yield a supply of hard, commonly alkali, water sufficient for 15 head of stock. The supply is variable and in years of less than normal rainfall these wells may be dry. The method followed is to dig a series of test holes 30 to 60 feet deep until a local aquifer is encountered and water enters the well. In places a zone of boulders at a depth of 45 feet is also a source of water.

Drilled wells are more successful and may obtain water either from fine sand below blue clay or in the upper fractured surface of the bedrock. These wells are drilled 90 to 160 feet and yield a supply of hard water with much iron. In SE.$\frac{1}{4}$ section 5, a well drilled 135 feet into blue clay taps an aquifer in which the water is under sufficient pressure to flow, and when first drilled rose 3 feet above the surface of the ground.

Township 13, Range 23. Ground moraine with the characteristic undulating surface covers the township, wooded except where cleared for farming and with many undrained depressions. Most of the wells in this township are drilled 60 to 180 feet to layers of fine sand or gravel below blue clay or to the upper fractured surface of the bedrock. The water is under sufficient pressure to rise to an average of 25 feet from the surface. It is commonly alkali and contains so much iron that it is necessary to filter it for domestic use. Some wells are, however, dug 35 to 50 feet to local aquifers in the blue clay, and, although they do not yield as much water as the drilled wells, there is generally sufficient for 25 to 30 head of stock. At Oakner two wells supply the residents. One, dug 32 feet into clay, pumped and refreshed frequently, yields hard, clear water of good quality. The other well, at the school, is drilled 65 feet and is believed to tap the upper surface of the bedrock. The water in this well rises to within 8 feet of the surface.

Township 13, Range 24. The southwestern part of the township is composed of moraine, built into hills of till and gravel and depressions, the larger of which contain permanent lakes. The remainder of the township is covered with ground moraine whose surface is irregular and contains sloughs and numerous clumps of trees. The chief water-bearing zone of this township is the upper fractured surface of the bedrock, which yields abundant water containing much iron. Wells are drilled 60 to 150 feet to this zone. In sections 34, 35, and 36 a supply of good water is, however, obtained from a layer of sand 3 or more feet thick at a depth of approximately 70 feet below blue clay. Also, on those sections where wells have not been drilled, dug wells 20 to 50 feet deep yield a sufficient supply of good water from local lenses of porous material in the blue clay.

Township 13, Range 25. Much of this township is covered by end moraine the rolling surface of which is marked by knolls and hills of gravel or glacial till. The larger, undrained depressions contain permanent lakes. Most of the southwestern part is, however, covered by sands of the former glacial-lake Souris. The sand and gravel of the end moraine and the sandy lake beds everywhere yield a supply of hard, clear water to wells less than 20 feet deep. These wells have yielded a sufficient supply even in years of drought. In the northeast corner of the township is ground moraine, and there water is obtained from bedrock or porous lenses in blue clay in wells 40 to 70 feet deep. In SE.$\frac{1}{4}$ section 29 a well 50 feet deep reaches the upper fractured surface of the bedrock at 40 feet and obtains soft water. Two wells drilled on SW.$\frac{1}{4}$ section 34 about 40 feet deep, however, yield alkali water.

Township 14, Range 22. The surface of this township is much wooded, with numerous sloughs, and is crossed by Oak River from section 30 to section 3. Ground moraine covers the entire township and is made up of a weathered buff-coloured till about 20 feet thick underlain by a blue clay-rich till. This material is impervious and any water obtained from it comes from contained lenses or pockets of sand or gravel. The chief water-bearing zone, lying at a depth of 65 to 150 feet under the blue clay, is more or less continuous and consists of a layer of porous material, chiefly sand and gravel. Some drilled wells reach shale and obtain water from its upper fractured surface. In SE.$\frac{1}{4}$ section 20, a 150-foot well reaches shale, and water rises 6 feet from the surface of the ground. All the water in the township has a considerable amount of iron.

Township 14, Range 23. Conditions in this township are similar to those in the township to the east, just described. An abundant supply of water is obtained everywhere from aquifers below the blue clay or in the upper fractured surface of bedrock. The surface is uneven and is 60 feet lower in elevation in the south than in the north. Wells in the south are, consequently, dug, on the average, 60 feet to gravel or sand below the blue clay, and a supply of hard, clear water sufficient for 50 head of stock is obtained. In the north, however, wells are drilled to an average depth of 110 feet, but the water is under sufficient pressure to rise on the average 20 feet from the surface. Although the water is abundant it contains much iron. After filtering, however, through simple home made filters, most of the iron precipitate is removed. In the town of Hamiota a sufficient supply of water is obtained from wells 60 feet deep that reach a gravel aquifer at that depth.

Township 14, Range 24. An abundant supply of good water is obtained throughout this township from the overburden. Ground moraine covering the entire township, is made up of blue, clay-rich till overlain by about 20 feet of buff-coloured till. This till is impervious, but an aquifer of fine sand, grading in places to gravel or boulders, lies below the blue clay. Wells are drilled to depths of 80 to 208 feet, the deeper wells being in the north where the surface is at a higher elevation. The water is commonly alkali and contains an iron precipitate, but can be used for domestic purposes after it is filtered. The supply has proved sufficient, and even during the years of drought a well tapping this aquifer would water 50 head of stock.

Township 14, Range 25. The central and western part of this township is covered by end moraine built into hills and knolls and undrained depressions. Outwash gravel associated with the end moraine is a source of good water obtainable at shallow depths. Bedrock is, on the average, 20 feet below the surface in the low flat area covering sections 5 to 8 inclusive, where wells dug to its surface obtain a sufficient supply. In that part of the area not covered by end moraine the ground moraine is impervious, and wells are drilled to aquifers below the blue clay-rich till. These wells are drilled to a depth of 100 to 200 feet, and commonly yield a sufficient supply of hard, alkali water with much iron. This water is used for domestic purposes and the iron can be partly removed by filtering.

Discussion of Water Analyses

The sample number shown in the first column of the Table of Analyses is for laboratory identification only.

Samples Nos. 4726 and 4728 are both representative of water from surface or outwash gravel. The water at Bradwardine school, No. 4726, has a total hardness of 640.0 ppm. of which 304.5 ppm. is non-carbonate or permanent hardness. The non-permanent hardness, 336.0 ppm., can be removed, and, although the water will still be hard, for southwestern Manitoba it is of good quality. The water sample No. 4728 has a greater concentration of the constituents analysed, partly because the aquifer is small and partly because the well is not pumped out and refreshed as is the case with the school well.

Samples Nos. 4727 and 4729 are representative of waters from aquifers in the blue clay. The deeper well has the greater concentration of constituents, as the water percolates through a greater depth of the clay permitting more sulphates and carbonates to be taken into solution. Both waters are, however, very hard. Sample No. 4731 again illustrates the concentration of the constituents as a greater depth of the blue clay is penetrated.

Samples Nos. 4732 and 4733 are taken from wells drilled to the bedrock and cased so that water from the blue clay does not enter the well. The analyses show soft water of good quality but the concentration of sulphates is sufficient to cause boiler and teakettle scale.

Sample No. 4730, also from the bedrock, is of poor quality and the nitrate concentration suggests contamination.

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 depth of the well, and its elevation is given as such. This commonly applies to wells drilled in bedrock or to wells obtaining water from sub-artesian or artesian aquifers in glacial or bedrock formations. In such wells digging or drilling continues only until a good supply of water is obtained and then is stopped. In shallow surface deposits (up to 30 feet), wells are usually dug a short distance below the water-table during a dry season, and thereafter water enters and leaves the well at any point below the water-table. The figures on the height to which the water will rise in the well fluctuate, depending on the amount of rainfall during the season. The rainfall for the season in which the well data were collected exceeded that of average years, and the height of the water in the wells was, consequently, 5 to 8 feet higher than in years of normal rainfall.

ANALYSES OF WELL WATERS FROM Townships 11 to 14, Ranges 22 to 25, WPM. Manitoba

										Constituents as Analysed (parts per million)								Hardness as($CaCO_3$) (pts. per million)		
Sample Number	¼	Section	Township	Range	Meridian	Owner	Depth of well (feet)	* Aquifer	Total dissolved solids (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
4733	NE	29	14	22	1st	J. McPhaden	69	Sh.	2152	128.0	47.0	500.0	1023.9	28.5	0	502.6	412.0	319.4	193.4	512.8
4726	SE	7	12	22	"	Bradwardine school	20	Sd.	872	180.0	46.5	33.7	318.9	10.5	0	409.9	336.0	449.1	191.4	640.5
4729	SW	35	11	23	"	S. Lowe	74	Gr.	3196	548.0	196.7	79.0	1646.1	43.5	0.7	710.0	582.0	1367.3	809.4	2176.7
4727	NE	2	12	23	"	H. Blackwell	40	Gr.	1268	265.0	61.6	35.0	417.3	50.0	10.6	597.8	490.0	661.2	253.5	914.7
4728	SE	22	12	23	"	E. Campbell	20	Gr.	3826	285.0	446.0	140.0	1991.8	78.0	78.0	690.5	566.0	711.1	1835.3	2546.4
4732	SW	35	14	23	"	Mrs. Cave	133	Sh.	2434	16.0	61.2	1080.0	1633.0	61.5	35.4	1066.3	874.0	39.9	251.8	291.7
4731	SE	17	14	24	"	M. Elliott	90	Gr.	4820	567.0	332.0	226.0	2021.4	137.5	510.0	534.4	438.0	1414.7	1366.2	2780.9
4730	SW	34	13	25	"	A. Rudd	40	Sh.	7154	500.0	597.0	640.0	3100.1	282.5	1239.6	819.8	672.0	1247.5	2456.7	3704.2

NO. 669

* Symbols used for aquifers   Sh. - Shale, Sd. - Sand, Gr. - Gravel.