CANADA
DEPARTMENT OF MINES
AND
TECHNICAL SURVEYS

GEOLOGICAL SURVEY OF CANADA

WATER SUPPLY PAPER No. 300

GROUND-WATER RESOURCES OF TOWNSHIPS 1 TO 6, RANGES 22 TO 25, WEST OF PRINCIPAL MERIDIAN MANITOBA

(DELORAINE AREA)

by

E. C. Halstead and J. A. Elson

OTTAWA
1949

C A N A D A

DEPARTMENT OF MINES AND RESOURCES

MINES, FORESTS AND SCIENTIFIC SERVICES BRANCH

GEOLOGICAL SURVEY OF CANADA

WATER SUPPLY PAPER NO. 300

GROUND-WATER RESOURCES

OF

TOWNSHIPS 1 to 6, RANGES 22 to 25, WEST PRINCIPAL MERIDIAN (Deloraine Area)

by

E.C. Halstead and J.A. Elson

OTTAWA
1949

CONTENTS

Part I — Page

Introduction.. 1
Publication of results............................. 1
How to use the report.............................. 1

Glossary of terms used................................ 2
General discussion of ground water.................... 4
Discussion of water analyses.......................... 5

Part II

Deloraine area, tps. 1 to 6, rges. 22 to 25, W. Princ. mer...... 8
Introduction... 8
Physical features.. 8
Geology.. 9
Table of formations...................................... 9
Water supply...11
Township 1, range 22, west Princ. meridian.................12
" 1, " 23, " " " 12
" 1, " 24, " " " 12
" 1, " 25, " " " 13
" 2, " 22, " " " 13
" 2, " 23, " " " 14
" 2, " 24, " " " 14
" 2, " 25, " " " 14
" 3, " 22, " " " 15
" 3, " 23, " " " 15
" 3, " 24, " " " 16
" 3, " 25, " " " 16
" 4, " 22, " " " 16
" 4, " 23, " " " 17
" 4, " 24, " " " 17
" 4, " 25, " " " 17
" 5, " 22, " " " 18
" 5, " 23, " " " 18
" 5, " 24, " " " 18
" 5, " 25, " " " 19
" 6, " 22, " " " 19
" 6, " 23, " " " 19
" 6, " 24, " " " 19
" 6, " 25, " " " 19

Discussion of water analyses.................................19
Table of analyses..20
Record of wells..22
Table of well records

Illustrations

Preliminary map - Townships 1 to 6, ranges 22 to 25, west Principal meridian, Manitoba:
Figure 1. Map showing surface and bedrock geology;
2. Map showing topography and the location and types of wells.

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 these 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:

<u>Silica</u> (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.

<u>Iron</u> (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.

<u>Calcium</u> (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.

<u>Magnesium</u>(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.

---

[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

[1]Thresh, 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

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 1 to 6, RANGES 22 to 25, WEST PRINCIPAL MERIDIAN, MANITOBA (Deloraine Area)

Introduction

An investigation of the glacial geology and the ground-water resources of tps. 1 to 6, rges. 22 to 25, W. Princ. mer., was conducted in the summer of 1946 by E. C. Halstead, and in the 1947 season by J. A. Elson.

Physical Features

Turtle Mountain extends for about 40 miles along the International Boundary and for 8 to 10 miles north of the boundary. When seen from a distance the surface appears fairly even and dome-shaped. On the summit a great many lakes occupy depressions between hills of various sizes and shapes. Nearly all the mountain is heavily forested. The western end occupies tps. 1 and 2, rges. 22 and 23 of the Deloraine area. The highest part of the mountain, 2,450 feet above sea-level, is in sec. 1, tp. 1, rge. 23. The slope to the plain below is 800 feet in 6 miles.

Near Dand, three small lakes, the Chain Lakes, occupy a post-glacial channel. Whitewater Lake occupies a shallow saucer-like depression near Deloraine, and is bordered by a mile or more of swamp land; it does not overflow, and is fed by intermittent streams from the summit of Turtle Mountain.

That part of the area north and west of the 1,600-foot contour is part of the basin formerly occupied by glacial Lake Souris. Souris River follows a narrow channel about 20 feet deep that crosses the northwest quarter of the area where the sands of the former lake are now duned and covered with shrubs and small poplar trees.

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, dune sands, assorted sands and gravel in beaches and deltas	0-50
	Glacial drift	Till, clay, sand, gravel, boulders, assorted sand and gravel in outwash plains	0-400
Upper Cretaceous and Paleocene	Turtle Mountain Ravenscrag Boissevain	Soft shale; lignite beds, fine-grained white to yellowish sand and sandstone Greenish grey sandstone and sand	300-400 100
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 ±

e	Formation	Character	Thickness (Feet)
	Vermilion River	Dark grey and black shales; 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
-wer and - per Cret- eous	Ashville	Dark grey to black shales with silt and sands	40
wer etaceous	Swan River	White to green sandstone, black shale and silt	50
:assic		Light grey to red shale, calcareous sandstone, grey to buff to brown shales, light grey limestone and sandstone	380
'assic or 'lier	Amaranth	Red beds and gypsum	220

Upper Cretaceous shales of the Riding Mountain formation outcrop in the vicinity of Dand and Chain Lakes, and underlie the unconsolidated glacial deposits except on Turtle Mountain. An abundant supply of salty water is recovered by wells that reach aquifers at an approximate elevation of 1,450 feet above sea-level, in the Riding Mountain formation. Overlying the Upper Cretaceous shales at the base of Turtle Mountain is the Boissevain formation of greenish grey sandstone, which weathers a yellowish, somewhat rusty colour. Only a few exposures of the formation have been observed and its boundaries are little known. A series of shale and sandstone and some lignite beds of the Tertiary Turtle Mountain formation rests on the Boissevain formation on Turtle Mountain.

Glacial drift overlies all the bedrock formations. It varies in thickness from little or nothing to about 100 feet, and consists mainly of till. The upper 20 feet or more is a greyish buff till, with many boulders and lenses of stratified sands and gravels. A compact, impervious, blue clay underlies the greyish buff till and rests on bedrock. The upper till is a source of a moderate supply of hard, clear water reached by dug wells that in some areas are intermittent.

The area occupied by former glacial Lake Souris is covered, south of Souris River by a thin mantle of sand, and in places water-worked till forms the surface deposits. North of the river, the glacial-lake sands are duned, and the sands average 20 feet in thickness. Sandpoints can be used satisfactorily in the sand for an abundant supply of water.

Water Supply

Aquifers in the Riding Mountain formation are reached by drilled wells averaging 150 feet in depth. An abundant supply of salty or alkali water is recovered, and is commonly under sufficient pressure to rise 100 to 150 feet in the casing. This water is useful mainly for stock, but a few drilled wells are reported to yield soft, clear water useful for domestic purposes as well. Good potable water is reached by dug wells that receive water from stratified lenses of sand and gravel within the upper 20 feet of till. Where this supply is lacking, deeper dug wells may reach an aquifer at the contact of the blue clay and shale or in the upper fractured surface of the shale. Dugouts are essential on most of the farms in the district near Waskada, Goodlands, and Medora. Driven wells yield an abundant supply of hard, clear water and are used in the northeast quarter of the area where glacial-lake sands 20 feet or more thick comprise the surface deposits.

Good water, though possibly coloured by organic matter, is obtained from wells drilled into the sandstone and lignite that underlie the surface deposits around the base of Turtle Mountain. Surface water is abundant on Turtle Mountain, where many small lakes fill pot holes and depressions in the surface deposits. Streams coming from this upland carry good, fresh water, but the supply is small and the streams may fail entirely in exceptionally dry seasons. Whitewater Lake, near Deloraine, is fed by six intermittent streams coming from Turtle Mountain. Its water is saline, and on evaporation in dry seasons leaves a white encrustation of salts around the shores. Chain Lakes, near Dand, are three small lakes fed by intermittent streams. They drain north to Souris River, which is also a source of surface water for stock.

Township 1, Range 22. The township is on the summit of Turtle Mountain where the surface is irregular and dotted with many lakes. Wells averaging 7 feet in depth are dug beside these lakes in the Recent alluvium. These wells supply sufficient water, which has a characteristic hydrogen sulphide odour because of the presence of decaying organic matter in the alluvium. The surface deposits of glacial till are penetrated by dug and bored wells that reach aquifers of sand and gravel. The dug wells average 15 feet in depth and supply hard, clear water sufficient for thirty head of stock. Bored wells are 18 to 68 feet in depth. A well 42 feet deep, in NE.$\frac{1}{4}$ section 30, is bored into a pocket of gravel and averages 27 feet of hard, clear water. Other holes, 90 and 100 feet deep, were bored on the same section and penetrated blue clay. Most farms require only a domestic supply as the many lakes are sources of water for the stock.

Township 1, Range 23. The principal water-bearing zone is tapped by bored wells 28 to 100 feet in depth, dug into glacial till that overlies the Turtle Mountain shale, sandstone, and lignite-bearing beds that rest on the Boissevain formation. The upper 20 feet or more of the till is a yellow clay, underlain by blue clay of variable thickness below which lies a gravel aquifer that supplies hard, clear water to most of the bored wells. These wells are usually sufficient for forty head of stock.

In NE.$\frac{1}{4}$ section 36, a bored well 100 feet deep reached gravel below 20 feet of yellow clay and 80 feet of blue clay. The well is usually three-quarters full of hard, alkali water. In SE.$\frac{1}{4}$ section 34, a bored well 45 feet deep, carries about 15 feet of iron-bearing water, sufficient for domestic use only. In the same section, a hole drilled to a depth of 225 feet reached sand below blue clay, and for a few months was an artesian flow.

Wells 10 to 25 feet deep are dug into the till and tap local pockets and seams of gravel from which a supply of hard, clear water sufficient for thirty head of stock is usually obtained. Springs issuing from the outcrops of lignite are found along the west side of the township. The water may be coloured by organic matter, but will supply seventy head or more of stock. Streams coming from the uplands of Turtle Mountain carry good, fresh water, but the supply is small and the streams fail entirely in exceptionally dry seasons.

Township 1, Range 24. The township is located on the west end of Turtle Mountain. Boissevain sandstone underlies the surface deposits along the base of the mountain at an elevation of about 1,725 feet. No wells are recorded that have been drilled to the sandstone, and its water-bearing possibilities are unknown in this township. The township is covered with a recessional moraine composed of boulder clay, silt, sand, and gravel. Deposits of gravel 50 to 60 feet in thickness have accumulated along the south part of the township, and these are excellent aquifers, yielding moderately hard to soft water. In the northwest corner of the township, ground moraine and lake clays form the surface deposits. Dug wells 10 to 25 feet deep tap local pockets of sand and gravel in these deposits and yield a small supply of hard, clear, commonly alkali water. Of the sixty wells recorded twenty-eight, ranging from 30 to 80 feet in depth, are bored to sand aquifers below blue clay. Throughout the township, a sufficient supply of water is available and dugouts are not common.

Township 1, Range 25. The surface deposits are ground moraine except in the southeast quarter where shallow water-laid deposits of silt, sand, and gravel are present. Two water-bearing zones are present. The upper one is reached by wells 10 to 25 feet deep dug to local pockets of sand and gravel in the ground moraine. Hard, clear, commonly alkali water is pumped from this zone, but dugouts are needed to supply stock water.

The second water-bearing zone, in the underlying shale, is reached by bored and drilled wells 50 to 120 feet deep. The upper fractured surface of the shale supplies alkali water usually sufficient for thirty head of stock. In SW.$\frac{1}{4}$ section 15, a bored well 68 feet deep reaches a zone of boulders overlying the shale, and carries on the average 20 feet of water, which is concentrated with chlorides and sulphates of sodium. In the same section, two other wells were bored to a depth of 68 feet, a fourth well was drilled 145 feet and reached shale at 75 feet where a small pocket of gas was encountered, but no water. In NE.$\frac{1}{4}$ section 17, a drilled well 73 feet deep was first bored through 65 feet of blue clay then drilled through a foot of shale, a foot of sand, 2 feet of shale, and then a zone of fine sand that yields soft water under sufficient artesian pressure to rise 48 feet in the casing. Sections 3, 4, 6, 8, 29, 33, and 34 have no wells, and depend entirely on surface run-off collected in dugouts.

Township 2, Range 22. The surface deposits of the township are ground moraine and recessional moraine. Boissevain sandstone outcrops along the base of Turtle Mountain and is present below the 1,750-foot contour. The till overlying the Boissevain sandstone is about 60 feet thick; the upper 20 feet is a yellow clay with lenses and pockets of gravel, and is underlain by a relatively impervious clay. The principal water-bearing zone lies at the base of the blue clay, where bored and dug wells averaging 60 feet in depth reach an aquifer of fine sand or gravel that yields hard, alkali water commonly sufficient for fifty head of stock. In NW.$\frac{1}{4}$ section 22, a bored well 70 feet deep penetrated 30 feet of yellow clay, and reached gravel at 70 feet. This gravel yields hard, clear water with some iron salts and an average temperature of 44°F. It is sufficient for seventy head of stock.

Other wells are dug to depths of 15 or 30 feet, and yield an average supply of hard, alkali water from lenses and pockets of sand and gravel included in the yellow clay or at the contact of yellow and blue clay. In NE.$\frac{1}{4}$ section 9, a well 28 feet deep reaches a gravel seam between yellow and blue clay at a depth of 15 feet. The level of the water in the well is usually 13 feet from the surface of the ground or 2 feet above the aquifer. The temperature of the water is 42 F and is sufficient for twenty-five head of stock even in periods of drought. In SW.$\frac{1}{4}$ section 36, a well 38 feet deep reaches fine sand below yellow clay. The well averages 4 feet of hard, clear water with a temperature of 44°F, and pumping tests gave 180 gallons an hour.

Township 2, Range 23. The ground moraine of the south part of the township is underlain by Boissevain sandstone, and is composed of yellow and blue clay with local pockets and lenses of stratified sands and gravels. The north part of the township is covered with glacial-lake clays. The till yields hard, clear, alkali water that is reached by dug and bored wells 15 to 77 feet in depth. The aquifers are sand and gravel lenses below blue clay or within the upper yellow clay. In NE.$\frac{1}{4}$ section 12, a bored well 77 feet deep carries 10 feet of water sufficient for twenty-five head of stock.

In that part of the township underlain by Boissevain sandstone, sections 7, 16, 17, 18, 21, 22, 24, 25, and 26, dug and bored wells 15 to 50 feet deep tap aquifers of white sand underlying blue clay. This area has an abundant supply of soft, clear, iron-bearing water sufficient for one hundred head of stock. Farther north, in the area covered by glacial-lake clays, dug wells averaging 18 feet in depth yield a small supply of slightly alkali water sufficient for ten head of stock.

Wells were drilled in sections 22 and 32 to depths of 263 and 200 feet respectively. Both wells were drilled into shale of the Riding Mountain formation. The 263-foot well yields soft, calcium sulphate water sufficient for twenty head of stock and the 200-foot well (bedrock at 90 feet) yields salty water sufficient for only four head.

Township 2, Range 24. The township has gently undulating topography accented by broad valleys and low hills. The surface deposits are ground moraine, except for that part included in sections 13, 14, 23, 24, 25, and 36, where glacial-lake clay is present.

The town of Goodlands, in section 3, has no water supply; water for the town is drawn from a well $1\frac{1}{2}$ miles west of the town. Several wells have been dug, averaging 40 feet for bored wells and 8 to 15 feet for dug wells, but any water obtained was too alkali for domestic use.

The dug wells in this township average 14 feet in depth, and commonly yield water from the greyish buff or blue clay. In section 6, a lens of gravel, at least 14 feet thick, crosses the section, and three wells dug in this aquifer yield an abundant supply of hard, clear water. The supply of potable water is limited to aquifers of local sand and gravel that are exposed at the surface. In sections 23, 24, 25, and 26, dugouts only are used. Dugouts are needed on all sections, although numerous sloughs are seen throughout the township. A drilled well in section 21, 125 feet deep, reached bedrock at 90 feet and yields hard water with a sulphur odour. The well is not used.

Township 2, Range 25. The problem of water supply was greatly helped when dugouts were excavated in this township. Twelve sections are entirely dependent on the surface run-off, collected in dugouts, to supply water for stock and domestic uses other than drinking. Drinking water is hauled from centres of supply and stored in cisterns on the farms.

The surface deposits are ground moraine, which averages 60 feet in total thickness. The upper 10 to 15 feet of the moraine is a yellow clay with very little sand and gravel, below which lies the impervious blue clay. The dug wells average 15 feet in depth, and yield a small supply of alkali water.

In sections 1, 12, 18, and 22, and along the border of the recessional moraine in the north part of the township, the deposits of outwash gravels are about 12 feet thick and commonly cover a large enough area to allow sufficient intake of rainfall to supply enough potable water for local needs.

Bedrock is reached at 60 feet on the average, and no water is available at the contact of the blue clay and shale. Drilling into the shale has located a few small pockets of gas, but no water. Holes drilled 200 to 215 feet in depth, in section 5, were dry, and in section 8 a drilled hole 200 feet deep encountered gas. Other holes ranging in depth from 100 to 308 feet were drilled in sections 26, 33, 34, and 35. A well drilled in SW.$\frac{1}{4}$ section 33 is 211 feet deep and supplies about 2 barrels of salty water a day, used only for stock.

Township 3, Range 22. Whitewater Lake occupies the northeast quarter of the township. The lake is shallow, and is surrounded by a swampy border about a mile wide. The surface deposits of the remainder of the township are lake clays and silts overlying yellow and blue clay. The south part of the township is underlain by Boissevain sandstone, and the surface deposits are ground moraine and outwash gravels. Dug wells averaging 15 feet in depth are supplying sufficient water for thirty-five head of stock. In SE.$\frac{1}{4}$ section 6, a dug well 14 feet deep in a deposit of outwash gravel yields an abundance of hard, clear water, which is hauled into the town of Deloraine and distributed for domestic use. Wells 35 to 50 feet deep are bored to sand and gravel beds below blue clay and supply slightly alkali water sufficient for thirty head of stock.

Along the west side of the township, in sections 19, 20, 30, 31, 32, and 33, drilled wells 90 to 180 feet deep reach bedrock about 90 feet below the surface. The wells in sections 31, 20, and 19 are 180 and 160 feet deep, and yield salty water, with a concentration of sulphate salts, but supply fifty head of stock. The other drilled wells yield a softer water and of equal abundance. In SW.$\frac{1}{4}$ section 2, a drilled well 180 feet deep reached bedrock at 80 feet, and yields a limited supply of hard, clear water sufficient for twenty head of stock.

Township 3, Range 23. Two water-bearing zones are present in this township. The upper zone is reached by dug wells that average 16 feet in depth and yield sufficient water for thirty head of stock. These wells are dug to pockets of sand and gravel within the yellow clay of the ground moraine. The wells are used mostly for domestic purposes and are not pumped excessively.

The second water-bearing zone is at an elevation of about 1,600 feet, and is within the shale of the bedrock. This aquifer yields abundant water for seventy head or more of stock. It is salty and unfit for human consumption, but useful for stock. Forty-two wells have been drilled to this aquifer. The artesian pressure varies greatly throughout the area. The water in some wells is under sufficient pressure to rise 200 feet in the casing, and in others only 100 feet. A flowing well drilled in Deloraine, in 1890, was 1,943 feet deep, and yielded salty water from the Lower Cretaceous, Swan River formation. Of the forty-two wells drilled, four are 50 to 150 feet deep; twenty-two are 150 to 200 feet deep; twelve are drilled 200 to 250 feet; and three are drilled to a depth of 250 to 300 feet. These wells assure an ample supply for stock, and the problem is to find a satisfactory supply for domestic needs.

Township 3, Range 24. An intermittent creek, tributary of Souris River, flows north across this township over surface deposits of recessional and ground moraine. The chief water-bearing zone lies within the bedrock at an elevation of 1,440 feet. The zone is reached by drilled wells 100 to 200 feet deep, drilled 50 to 150 feet into the bedrock. The thirty-four drilled wells recorded in this township yield an abundant supply of salty water useful only for stock. The water is under sufficient artesian pressure to rise as much as 150 feet in some wells, but none overflows.

A supply of water for domestic use is found on some sections by digging wells 12 to 20 feet deep into the yellow clay of the surface deposits, where a small supply is recovered from lenses and pockets of sand and gravel. Dugouts are found on nearly every section, and a domestic well is dug about 6 feet from the dugout. This procedure is unsatisfactory, but is widely used. A water-bearing zone may be found at the contact of the bedrock and blue clay, but the water will probably be salty. In SW.$\frac{1}{4}$ section 24, a bored well reached bedrock at 60 feet and obtained 2 feet of very salty water useful only for stock.

Township 3, Range 25. In the south part of the township, in sections 1 to 13 inclusive, the only water-bearing zone is reached by drilled wells 100 to 150 feet deep that yield salty water useful for stock only. The aquifer lies at an elevation of about 1,420 feet, and is in shale. The water is under sufficient artesian pressure to rise within 30 feet of the surface of the ground. For a domestic supply, dug wells in the drift have proved unsatisfactory, and dugouts are excavated, with a dug well beside each dugout.

In sections 25 to 36 inclusive, bedrock lies on the average 18 feet below the surface. Dug wells to the top of the shale yield a sufficient supply of potable water. Drilled wells averaging 80 feet in depth are drilled for a supply of stock water that is salty.

Township 4, Range 22. The water-bearing zone is in bedrock, and is reached by drilled wells. The quantity of the water is sufficient for fifty to seventy-five head of stock, and the quality is variable, some well water being fit for domestic use, some very salty, and some soft. A total of forty-six drilled wells is recorded, and these are drilled to depths of 150 to 200 feet. Eleven of the wells yield soft water from an aquifer at an elevation of about 1,480 feet, and the others yield hard, alkali or salty water from an aquifer at an elevation about 1,450 feet above sea-level.

Only five dug wells are recorded, and these are in gravel pockets that yield a dependable supply of hard, clear water. Wells have been bored 18 to 59 feet, but are not satisfactory as the supply is limited. Bedrock averages 90 feet below the surface, and is overlain by an impervious blue clay.

Township 4, Range 23. The principal water-bearing zone of this township lies within the bedrock and is reached by drilled wells 80 to 200 feet deep. The water is hard, alkali or soda, and under sufficient artesian pressure to rise within an average of 25 feet from the surface. Five wells report soft water that can be used for domestic as well as stock purposes, but the remainder are used for stock only, and many are sufficient for eighty head. The domestic wells are dug into the recessional moraine that forms the surface deposits. The moraine ranges from 0 to 25 feet in thickness, and water is recovered from the contact of the till and shale as well as from the local lenses and pockets of sand and gravel. Some of the dug wells supply alkali water, but most of them yield a sufficient supply of potable water. Twenty-eight drilled wells are recorded, and all are in bedrock except a well in NE.$\frac{1}{4}$ section 24, which was drilled to a depth of 100 feet in gravel, and yields an abundant supply of hard, clear water.

Township 4, Range 24. The surface deposits in the southeast quarter are recessional moraine overlying shale that lies within 25 feet of the surface. In sections 2, 3, 4, 6, 9, and 10, drilled wells 40 to 150 feet deep reach an aquifer of salty water in the bedrock. One drilled well, in section 10, 74 feet deep, yields soft water under sufficient pressure to rise 60 feet in the casing. Dug wells are also used in this part of the township, and are dug to depths of 32 feet, where aquifers of broken shale, gravel, and till yield a sufficient supply of potable water. In section 7, a hole drilled 160 feet was dry. In sections 18, 19, 20, and 27, and in SW.$\frac{1}{4}$ section 35, many holes have been dug and all were dry and penetrated impervious blue clay. In sections 27 to 36 inclusive, the surface deposits are glacial-lake clays and sand. Dug wells 13 to 18 feet deep dug into the sand and clay yield an abundant supply of hard, clear water. In section 34, a sandpoint is used. A dug well 30 feet deep, in SE.$\frac{1}{4}$ section 27, yields an abundant supply of hard, clear water.

Township 4, Range 25. Souris River crosses the northwest corner of the township in sections 30, 31, and 32. Its valley is bordered by deltaic gravel deposits about 2 miles wide, on the south side. One tributary flows west across the township and empties into Souris River in section 30. The remainder of the township is relatively flat, and glacial-lake sands comprise the surface deposits. Along the south side, on sections 1, 2, 4, and 5, drilled wells, 70 to 104 feet deep, reach shale at an average of 20 feet below the surface, and are drilled 50 feet or more into the shale to an aquifer that yields an abundant supply of salty water suitable for stock only. The water rises within 25 feet of the surface.

The chief water-bearing zone is reached by dug wells averaging 15 feet deep, dug into the sands and gravels of the deltaic gravel and lake-bed sands. An abundant supply of hard, clear water is obtained. In SW.$\frac{1}{4}$ section 16 and in section 12, several attempts to secure water have failed and dugouts are used.

In the village of Napinka, wells 12 to 30 feet deep yield an abundant supply of hard, clear water from the surface sands and gravels. Sandpoints are also used. One well was drilled to a depth of 125 feet, and reached shale at 60 feet. The water was salty and under sufficient pressure to rise within 15 feet of the surface.

Township 5, Range 22. The township is crossed by a post-glacial valley, the bottom of which is covered with water-worked till. The south part is gently rolling ground moraine. Wells 9 to 28 feet deep are dug to the top of the bedrock, and yield hard, clear water from the upper fractured surface. Wells are drilled 100 to 165 feet deep, in bedrock, and yield hard, soda, or slightly alkali water. The water is useful for domestic as well as stock purposes, and affords an abundant supply.

Township 5, Range 23. Bedrock outcrops in the south along the abandoned channel now occupied by Chain Lakes. Overlying the bedrock, the ground moraine varies in thickness from a thin mantle of drift to more than 20 feet. In sections 1 to 15, drilled wells 66 to 165 feet deep yield abundant hard, clear, slightly salty water. The principal water-bearing zone of the shale in this township is reached at an average depth of 80 feet below the surface. Wells dug to the upper fractured surface of the bedrock supplement the household supply.

In the north part, the surface deposits are of sand and water-worked till. Dug wells averaging 18 feet in depth commonly carry 4 or 5 feet of hard, clear water. In NE.$\frac{1}{4}$ section 34, a sandpoint well, 25 feet deep, yields 15 gallons a minute. In SE$\frac{1}{4}$ section 34, seventeen wells were dug in 1942 in search of a water supply for the Hartney Airport. The wells were dug to depths of from 12 to 40 feet and only two yielded any water. One well, 40 feet deep, reached shale at 37 feet, and the other was a dug well, 22 feet deep, in sand and gravel.

Dugouts are the only source of supply in sections 17, 18, 19, 25, 30, and 33. In section 32, a drilled hole 194 feet deep was dry. In NE.$\frac{1}{4}$ section 29, a well was drilled 72 feet and reached an aquifer at a depth of 60 feet that supplied salty water under sufficient pressure to rise 56 feet in the casing. This supply was depleted in 6 months time, and the well is now dry.

Township 5, Range 24. Two small creeks flow north across the township and empty into Souris River where it crosses the northwest corner. The surface deposits of glacial-lake sands and associated silt are relatively thin and overlie an impervious blue clay. Dug wells 12 to 35 feet deep, which yield a good supply of hard, clear water from sand, are found in sections 2, 5, 12, and 27. Throughout the remainder of the township the only wells are those beside dugouts. Several test holes have been dug, but all are into blue clay, and any water recovered was too alkali for use. No record was reported of drilling operations, but wells drilled to bedrock might lead to a supply of water for stock.

Township 5, Range 25. Souris River follows a channel across this township, entering in section 5 and leaving in section 25. Recent alluvium is found along the river valley, and deltaic gravels and glacial-lake sands form the surface deposits elsewhere. Low sand dunes, covered with small poplar trees, trend southeast across the township. Dug wells and sandpoints 12 to 18 feet deep yield an abundant supply of hard, clear water.

Township 6, Range 22. The principal water-bearing zone is within the greyish buff till underlying the shallow surface sands. Dug wells averaging 18 feet in depth reach aquifers of sand and gravel within the greyish buff till. The supply is not plentiful, and many of the wells are nearly dry by the end of the summer months. The water is hard, clear, and at an approximate temperature of 44°F. Dugouts are necessary for a stock supply.

A well drilled to a depth of 215 feet in NE.$\frac{1}{4}$ section 25, yields salty water, and the well is not used. In NE.$\frac{1}{4}$ section 36, a drilled well 150 feet deep reaches an aquifer in shale at 120 feet below the surface. The water rises 135 feet in the casing, and is salty and used only for stock.

Township 6, Range 23. The surface deposits are glacial-lake sands; in the northwest quarter of the township they are duned and covered by a dense growth of small poplar trees. In that part of the township north of Souris River, an abundant supply of hard, clear water is recovered by means of sandpoint wells averaging 20 feet in depth. South of the river, water is not plentiful, and dug wells 20 feet or more in depth, dug into till, yield an insufficient supply of very hard, clear, alkali water, and dugouts are needed for a stock supply. In section 6, several test holes were dug, averaging 27 feet in depth, and all were dry and in blue clay.

Township 6, Range 24. The surface deposits are glacial-lake sands that are duned and now covered with a dense growth of small poplar trees. Dug wells and sandpoints, 12 to 20 feet in depth, yield an abundant supply of hard, clear, iron-bearing water. Souris River crosses the southeast quarter of the township and is a source of water for the stock.

Township 6, Range 25. Sandpoint wells, 14 to 30 feet deep, are in use everywhere in the duned sands of the surface deposits, and yield an abundant supply of hard, clear water, which commonly carries abundant iron salts. The sands are coarse to fine; the finer sands require a sandpoint with a screen of 80 mesh, and the coarser sands a screen of 60 mesh.

Discussion of Water Analyses

The results of analyses of twelve samples are tabulated on the following page. Samples No. 11 and No. 12, from the Hartney Airport, at Hartney, were analysed by the National Testing Laboratories, Limited, Winnipeg; other samples were analysed by the Bureau of Mines, Ottawa.

Each sample is actually representative of only a small area. In general, the water from drilled wells that reach aquifers in the shale has a high proportion of total dissolved solids, the chloride or sulphate predominating to make the water salty as with ordinary salt water, or alkali, as with magnesium sulphate, Epsom Salts.

The total hardness of water is determined by the soap-destroying power of the salts present, and affects the utility of the water for most domestic purposes. Calcium (Ca.) hardness is temporary hardness,, and can be removed by boiling, but magnesium (Mg.) hardness is permanent. Samples, Nos 3, 5, 6, and 8, will, upon boiling, become softer and more suitable for laundary purposes. For further interpretation of analyses of water, See Part I, pages 5, 6, and 7.

ANALYSES OF WELL WATERS FROM Deloraine Area, Townships 1 to 6, Ranges 22 to 25, W.Princ. mer.

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 (HMO_3)	Alkalinity (as $CaCO_3$)	Ca hardness (Temporary)	Mg hardness (Permanent)	Total hardness
										Constituents as Analysed (parts per million)								Hardness as($CaCO_3$) (pts. per million)		
1	SE	12	2	22	1st	E.Clarke	20	Gr.	1382	137.	127.6	15	101.2	93.5		580.7	476.0	343.3	523.2	866.5
2	NW	22	2	22	1st	S.Vanmackell-berg	70	Gr.	3494.	366.0	143.8	360	1423.	127.4		594.6	457.4	913.2	592.0	1505.2
3	SW	36	2	22	1st	I.Dougall	38	Ss.	2235	149.0	16.8	472	1159	36.5		295.2	242.0	371.8	69.1	440.9
4	NW	8	2	23	1st	M.James	9	Ss.	1944	141.5	69.1	352	911.1	22.1		631.5	517.6	353.0	284.3	637.3
5	SW	8	2	25	1st	T.Wright	200	Sh.	4029	46.0	16.2	1280	1346	849.6		773.2	633.8	114.8	66.7	181.5
6	SE	4	3	22	1st	W.Beedie	32	L.	733	60.0	23.6	160	201.5	18.5	5.3	455.8	373.6	150.0	96.8	246.8
7	NW	16	3	23	1st	E.Kitchen	16	Gr.	531.5	75.0	44.8	40	67.8	3.7	2.7	456.5	374.2	187.5	183.7	371.2
8	NW	16	3	23	1st	E.Kitchen	177	Sh.	4638.	59.0	12.7	1750.	5.4	2329.3	3.1	863.8	708.0	147.5	52.1	199.6
9	SW	10	4	22	1st	T.H.Wilson	160	S.R.	2343.	18.0	10.3	840	357.2	686.8	6.6	751.5	616.0	45.0	42.2	87.2
10	SE	15	4	22	1st	W.Potter	200	Sh.	13,535	1120.	510.4	2000.	7299.	616.0	5.5	889.6	729.2	2794.0	2100.	4894.0
11	SE	34	5	23	1st	Hartney Air-	40	T.s	674	95	61	54	238	58		168	280			487
12	"	"	"	"	"	" port. "	22	Gr.	619	88	56	41	228	47		159	265			450

* Symbols used for aquifers Sh.-Riding Mountain shale. S.R.- sand in Riding Mountain shale. L.- Lignite
Gr.-gravel T.s.- contact of till and shale Ss. - Boissevain sandstone.

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 general 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 the bedrock. Digging or drilling is commonly continued until a good supply of water is obtained and then operations are stopped. In shallow surface deposits, especially those that are sand, the wells are dug a short distance below the water-table in dry seasons. The level of the water-table changes about 2 feet each year in near-surface deposits of wide extent, but may rise or fall as much as 8 feet during a wet to dry 10-year cycle.

Not every well in the area is recorded because of lack of available information on many wells, especially those on farms that have recently changed ownership. Wells that are dug beside dugouts are not included in the well records.

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.