CANADA

DEPARTMENT OF MINES AND RESOURCES

MINES, FORESTS AND SCIENTIFIC SERVICES BRANCH

GEOLOGICAL SURVEY

WATER SUPPLY PAPER NO. 293

GROUND-WATER RESOURCES OF KING TOWNSHIP, YORK COUNTY, ONTARIO

By

H. N. Hainstock, E. B. Owen, and J. F. Caley

OTTAWA

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PART I

INTRODUCTION

This report deals with the ground-water conditions of part of an area in southern Ontario investigated by the Geological Survey in 1936 and 1937. The entire area covers approximately 800 square miles. It consists of King, Markham, Scarborough, Vaughan, and Whitchurch townships, York county; Albion and Toronto Gore townships, Peel county; and Pickering township, Ontario county.[1]

A gradually diminishing annual rainfall over the 5-year period 1931 to 1936, culminating in the extremely dry season of 1936, brought about a lowering of the ground-water level that resulted in serious water shortages in many localities. Many farmers found themselves virtually without water, and the supplies of some villages dwindled to quite insufficient amounts. The water supplies throughout the entire area are derived for the most part from ground water. The principal object of this report is, consequently, to aid those who are in need of new or further supplies.

As the ground water is directly related to the geology, both bedrock and superficial deposits were studied and mapped. All available information pertaining to some 8,700 wells was recorded and 280 water samples were collected for analysis. T. H. Clark (1936) and H. N. Hainstock (1937) mapped the superficial geology, and also directed the collection of water data. Dr. Clark was ably assisted in the field by J. H. Douglas, J. W. Britton, D. K. Stadleman, G. W. Matheson, M. E. Woods, and E. C. S. Gould, and Mr. Hainstock by J. H. Douglas, P. D. Bugg, M. E. Woods, W. B. Gray, E. A. Gray, W. E. Tweed, and J. P. Clancy. J. F. Caley, assisted by M. C. Gardiner, studied the bedrock formations.

Thanks are here extended to the farmers throughout the area for their co-operation and willingness to supply information regarding their wells. Valuable assistance was given by the well drillers and by several municipal authorities who willingly supplied all available data.

To H. C. Rickaby, Deputy Minister of Mines for Ontario, and R. B. Harkness, Ontario Natural Gas Commissioner, thanks are here expressed for their hearty co-operation in the work.

Publication of Results

The essential information pertaining to ground-water conditions is being issued in reports covering each township in the area. Township authorities will be supplied with the information covering their respective townships. In addition, pertinent data on each well have been compiled, and may be obtained from either the Chief Geologist, Geological Survey, Ottawa, or the Provincial Geologist, Ontario Department of Mines, Toronto. When requesting such additional information, the applicant should clearly state the exact location, giving the lot and concession of the district about which data are required.

With each report is a map consisting of two figures: Figure 1 shows the surface formations that will be encountered, and Figure 2 shows the position of all wells for which records are available, together with the class of well at each location.

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1. The material contained in Part I of this report refers to the entire area comprising all the townships mentioned. The general discussion of ground water is universally applicable. Part II deals specifically with the ground-water conditions of one township.

GLOSSARY OF TERMS USED

Alluvium. Deposits of earth, clay, silt, sand, gravel, and other material in lake beds and in the flood plains of modern streams.

Aquifer. A geologic formation or structure that tranmits 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.

Contour. A line on a map passing through points that have the same elevation above sea-level.

Continental Ice-Sheet. The great ice-sheet that covered most of the surface of Canada many thousands of years ago.

Escarpment. A cliff or a relatively steep slope separating level or gently sloping areas.

Flood Plain. A flat part in a river valley ordinarily above water, but covered with water when the river is in flood.

Glacial Drift. A general term. It includes all the loose unconsolidated materials that were deposited by the continental ice-sheet, or by waters associated with it. Clay containing boulders forms part of the drift and is referred to as glacial till or boulder clay. Glacial drift occurs in 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) Drumlin. A smooth, oval hill composed mainly of glacial till, which has its long axis parallel to the direction of ice movement at thatplace.

(4) Ground Moraine. A boulder clay or till plain deposited at the base of the ice-sheet. The topography may vary from flat to gently rolling.

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

(6) Shore Line. A discontinuous escarpment, which indicates the former margin of a glacial lake.

(7) Bay-mouth Bar. A ridge of interbedded sands and gravels formed across the mouth of a glacial-lake bay.

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

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

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

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

Pervious or Permeable. Beds are pervious or permeable when they permit of the perceptible passage or movement of ground water, as for example porous sands, gravel, and sandstone.

Pre-glacial Land Surface. The surface of the land before it was covered by the continental ice-sheet.

Recent Deposits. Deposits that have been laid down by the agencies of water and wind since the disappearance of the continental ice-sheet.

Unconsolidated Deposits. The mantle or covering of alluvium or glacial drift consisting of loose sand, gravel, clay, silt, and boulders that overlie the bedrock.

Water-table. The upper limit of the part of the ground saturated with water. This may be very near the surface or many feet below it.

Perched Water. Water separated from an underlying body of ground water by unsaturated rock.

Wells. Holes sunk into the earth so as to reach a supply of water. Whennno water is obtained they are referred to as dry holes. Wells are divided into four classes:

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

(2) Non-flowing Artesian Wells. Wells in which the water is under hydrostatic pressure sufficient 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 intermittently dry.

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 below the ground will depend largely upon the type of soil or surface rock, and on the topography; more water will sink into sand and gravel for example, than into clay; if, on the other hand, the region is hilly and dissected by numerous streams, more water will be immediately drained from the surface than in a relatively flat area. Light, continued precipitation will furnish more water to the underground supply than brief torrential floods, during which the run-off may be nearly equal to the precipitation. Moisture falling on frozen ground will not usually find its way below the surface, and, therefore, will not materially replenish the ground-water supplies. Light rains falling during the growing season may be wholly absorbed by plants. The quantity of moisture lost through direct evaporation depends largely upon temperature, wind, and humidity.

Because of the large consumption of ground water in settled areas, it may seem surprising that precipitation can furnish an adequate supply. However, when it is borne in mind that a layer of water 1 inch deep over an area of 1 square mile amounts to approximately 14,520,000 imperial gallons, and that the annual precipitation in this area, for example, is about 30 inches, it will be seen that each year some 435,600,000 gallons fall on each square mile. If we estimate that only 10 per cent of this, namely 43,560,000 gallons, is contributed to the underground supplies, it will be seen that the annual recharge for the entire area of 800 square miles is 34,848,000,000 gallons. The annual consumption of water in this area is not known, but an estimate based upon per capita consumption shows it to be only about one-tenth of the annual recharge as estimated above. It seems reasonable then, to conclude that precipitation is adequate to furnish supplies of ground water for the area.

In most regions of the world where precipitation is effective, there is an underground horizon known as the ground-water level or "water-table", which is the upper surface of the zone of water-saturation. Water that sinks into the ground finds its way downward to where it either reaches this water-table or comes in contact with an impervious layer of rock. Such a layer may stop further downward percolation, resulting in perched water. If the water-table is at or near the surface, there will be a lake or swamp; if it is cut by a valley, there will be a stream in the valley.

All rocks are to some degree porous, that is, the individual grains or particles of which they are composed are partly surrounded by minute open spaces or pores. Water stored within the rocks fills these spaces. A fine-grained rock such as shale, limestone, or clay may have such small pores that the contained water will not flow readily, and wells sunk in such rocks may obtain little or no supply of water. Such rocks are considered impervious. Those rocks on the other hand that readily yield their water to wells are called water-bearing beds or aquifers. Sand and gravel, porous sandstone, and sand form good aquifers. A clean gravel constitutes one of the best types of aquifer, as it is sufficiently porous to yield its water freely.

Many shallow wells that derive their water from below the water-table have become dry. In many cases this is due to the lowering of the water-table below the bottom of the well. So long as the annual recharge is equal to or greater than the loss through consumption and underground drainage, there will be no lowering of the water-table, and hence wells sunk below this level will have a permanent supply. If, however, the annual precipitation were to decline over a period of years, the quantity of water available for recharging the underground supply would necessarily decrease, and if it were to decrease to a point where loss through consumption and underground drainage was greater than the annual recharge, the level of the water-table would be lowered and some wells would go dry. Such a decline in precipitation occurred in the general area under consideration during the 5-year period 1929 to 1935.

Although springs are utilized in some parts of this area, the chief method of recovering ground water is by means of wells. The quantity of water obtained from springs is usually small, but the town of Markham, with a population of about 1,[illegible]00, obtains its public water supply from such a source. Two types of wells are in common use, namely dug wells and drilled wells, the former outnumbering the latter by about ten to one. In places where the aquifer yields its water slowly, dug wells, because of their greater storage capacity, are more satisfactory than drilled wells. However, if proper precautions are not taken, dug wells are more likely to become contaminated by polluted surface waters, especially in barnyards. Ground water for industrial and commercial uses, where large quantities are required, is commonly obtained from the deeper drilled wells. When drilling such wells, the more shallow and perhaps smaller supplies can be cased off and drilling continued to where adequate supplies are encountered.

The wells have been classified as artesian and non-artesian, and artesian wells are subdivided into flowing artesian and non-flowing artesian. A fourth class, called intermittent non-artesian, comprises those wells that dry up periodically.

DESCRIPTIONS OF FORMATIONS AND THEIR WATER-BEARING PROPERTIES

Bedrock Formations

The bedrock formations that underlie the area are listed in the following table:[1]

[1]Caley, J. F.: Palaeozoic Geology of the Toronto-Hamilton area, Ontario, Geol. Surv., Canada, Mem. 244, p. 12 (1940).

Table of Formations

System	Formation	Thickness (Feet)	Lithology
Silurian	Lockport	151 ±	Light grey dolomite; some brownish, bituminous, dolomite at top.
	Medina	74 ±	Red, green, and grey shale; grey, sandy, and shaly dolomite (Cabot Head); grey, magnesian and argillaceous limestone (Manitoulin); grey sandstone (Whirlpool).
Ordovician	Queenston	340 - 400	Red, in part sandy, shale.
	Meaford	120 ±	Grey, bluish, and brownish shale, with thin layers of limestone; calcareous sandstone and arenaceous shale.
	Dundas	550 ±	Grey and blue shale; thin, sandy beds; thin, lenticular, limestone beds.

	Billings	100 - 250	Dark grey to nearly black, slightly bituminous shale.
	Trenton and Black River	550	Chiefly grey limestone, in places dolomitic and shaly; sandstone and arkose at the base.
Precambrian			Granitic and altered volcanic and sedimentary rocks.

Precambrian

These rocks consist of granitic and altered volcanic and sedimentary formations that underlie the Palaeozoic sediments unconformably. They are not an important source of water in the area. Water contained in these rocks probably occurs in joints and fissures. From the few wells that have reached the Precambrian, the water is reported to be highly mineralized.

Trenton and Black River Formations

The Trenton and Black River formations consist predominantly of grey and blue-grey limestone, and are at least 550 feet thick. Thin layers of shale occur in some parts of the succession, and dolomitic limestone may be present in the lower part of the Black River beds. Coarse sandstone or arkose, resting unconformably on the Precambrian, is known to occur in some localities.

Water found in these rocks occurs in cracks, fissures, or solution channels, and along bedding planes. The limestone itself is too fine grained and compact to be water yielding, but the coarse sandstone or arkose may contain a considerable quantity of water. Water derived from these formations is commonly highly mineralized and unfit for domestic use.

Collingwood Formation

The Collingwood formation consists of dark grey to black, fine-grained, thin-bedded, bituminous shale. It is about 30 feet thick. Water recoverable from these rocks occurs largely in fractures and along bedding planes; the shale itself is too fine grained to yield its water freely. The water obtained is usually too saline for either domestic or stock purposes.

Billings Formation

The Billings formation is a thin, and evenly bedded, soft, bituminous shale that weathers dark grey, bluish, or even yellowish. On fresh surfaces it is dark grey to nearly black, with distinct brown and green shades in many places. Much pyrite occurs in the darker parts.

The shales are exposed on both Rouge and Little Rouge Rivers a short distance above highway No. 2. They also outcrop on Duffin Creek, where they may be seen on lot 15, cons. II and III, and on lot 13, con. IV, Pickering tp. No other exposures of this formation occur in the area, but the shales underlie all that part east of a line joining the mouth of Rouge River and Lemonville.

Some water occurs along the bedding planes of this formation, but the quantity recoverable is small and the water saline.

Dundas Formation

The Dundas formation is prevailingly a bluish grey, thin-bedded shale that weathers somewhat lighter. There is, however, some variation from compact, blue, argillaceous shale to buff or yellowish, silty, and frequently arenaceous rock. Hard bands, both calcareous and arenaceous, occur interbedded with the shale; they rarely exceed a foot in thickness, the average being only a few inches. The formation is about 550 feet thick. It outcrops on Humber and West Humber Rivers in Vaughan and Toronto Gore townships respectively, and underlies the drift throughout most of Vaughan and King townships together with the western part of Whitchurch,, Markham, and Scarborough townships and a small part of each of Albion and Toronto Gore townships.

Water occurs along the bedding and joint planes of the shales, but the rock itself is too dense to yield its water readily to wells. Where the formation occurs at or near the surface, small quantities of water suitable for domestic needs may be obtained from the upper 50 feet. Water obtained deeper in the formation is commonly too saline for either domestic or stock uses.

Meaford Formation

The Meaford formation as a whole consists of grey to bluish and even brownish, fissile shale with interstratified hard layers that vary in composition from impure calcareous sandstone to rather pure crystalline limestone. It is exposed on a smalll tributary of West Humber River in Toronto Gore and underlies the glacial drift near the extreme western part of the area. It is known to be about 115 feet thick on Credit River a short distance southwest of the area.

The shale of this formation is too compact to be a good source of water. Wells penetrating the formation have yielded moderate quantities of water presumably from bedding planes and joint cracks, but in most instances the water is saline and not suitable for domestic needs.

Queenston Formation

The Queenston formation consists of brick-red, thin-bedded, compact shale. It does not outcrop in the present area, but underlies the glacial drift in the northwest part of Albion and Toronto Gore townships. The rock is a very poor source of water. It has been penetrated by a few wells, but the quantity of water obtained is small and commonly too saline for domestic use.

Medina Formation

The Medina formation overlies the Queenston, and forms the basal part of the Silurian system in Ontario. It has been divided into three members, which, in ascending order, are: Whirlpool sandstone, Manitoulin dolomite, and Cabot Head shale.

Whirlpool Member. This member is typically a resistant, light grey, fine to medium-grained sandstone. It usually occurs in beds of considerable thickness, but, where seen in its entirety, the upper few feet are commonly more thinly bedded than the lower part. Wave marks are common, but are best developed in the upper, thinner beds. The sandstone outcrops in the northwestern corner of Albion township, where it lies at the base of the Niagara escarpment. Its thickness within the area is not known, but wells drilled for natural gas a few miles to the west of the area show 20 feet of sandstone present. No wells have penetrated this rock, so that its water-bearing properties are not definitely known. However, where it lies below the water-table this type of rock should form a good aquifer, due to its relatively high porosity.

Manitoulin Member. This member does not outcrop within the area, but, as seen a few miles to the west, it consists essentially of buff weathering, grey, magnesian limestone, in part argillaceous, and disposed in even beds from 2 to 8 inches thick. The lower few feet show thin interbeds of soft grey or bluish grey shale from 2 to 4 inches thick. This rock underlies the glacial drift in the northwestern part of Albion township, and is about 25 feet thick.

Small quantities of water can be expected to occur along bedding planes and in solution cavities in this rock, but, as none of the wells examined penetrates this member, little definite information is available regarding its water-bearing properties.

Cabot Head Member. This member consists typically of red, green, and grey shales, sandy dolomite, shaly dolomite and ferruginous limy beds. It does not outcrop within the area, but can be seen in the railway cut at Limehouse a few miles to the west. It underlies the glacial drift only in the extreme northwest part of Albion township and is at least 40 feet thick. The shales do not form good aquifers due to their fine-grained texture, and the calcareous beds are few and too thin to hold much water. None of the wells examined penetrates the Cabot Head beds, but they are not thought to be an important source of water in the area.

Lockport Formation

The Lockport formation consists of magnesian limestone and dolomite, commonly light grey to bluish, fine to coarsely crystalline, in places quite porous, and disposed in beds from 2 to 4 feet thick, with both thicker and thinner beds locally developed. Jointing is general throughout the formation; it is commonly vertical but very irregular. Weathered surfaces may show joint cracks as much as a foot wide. These rocks may be seen in the extreme northwest part of Albion township, where they constitute the upper, cliff-forming member of the Niagara escarpment. The formation is perhaps 150 feet thick, with only the lower 50 feet occurring in the area of this report.

Appreciable quantities of water may occur in joint cracks, in solution cavities, and along bedding planes in this formation. Wells encountering these openings yield sufficient water for farm requirements. Numerous springs issue at the base of the Lockport formation where the contact with the underlying impervious Cabot Head is exposed by the topography. Some of these springs are reported to flow as much as 3,000 gallons an hour.

Unconsolidated Deposits

During the Pleistocene or glacial epoch, great accumulations of ice formed at various centres in northern Canada. This ice moved out in all directions from these centres and covered large regions with what has been called the continental ice-sheet. As the ice advanced, it picked up great quantities of loose rock debris, which was deposited when the ice finally melted. This material is unconsolidated, and is commonly called glacial drift. The ice-sheet advanced and retreated several times and on each retreat left an accumulation of drift on the surface over which it passed.

The area was entirely covered by one or more continental ice-sheets during Pleistocene time, and the final retreat of the ice left the bedrock surface covered to a variable depth with a mantle of glacial drift. This drift, together with flood plain deposits of alluvium, constitutes the unconsolidated deposits in the area. Most of the glacial drift consists of boulders and pebbles of various compositions and sizes embedded in a matrix of clay to form a more or less impervious mass known as boulder clay. Irregularly intermingled with this impervious mass, and also lying above, below, and between successive boulder-clay sheets, are beds, pockets, and lenses of sands and gravels that form the water-bearing members or aquifers of the drift. The following types of unconsolidated deposits occur in the area: (1) ground moraine; (2) terminal moraine; (3) kame moraine; (4) outwash sand and gravel; (5) glacial-lake deposits; (6) interglacial deposits; and (7) alluvium.

Ground Moraine. This type of glacial drift is chiefly boulder clay laid down at the base of the ice-sheet, and consists of a heterogeneous mixture of clay, boulders, and pebbles enclosing irregularly distributed lenses and pockets of water-laid sand and gravel.

Pore spaces in the boulder clay are very small, and much of the contained water is not recoverable through wells. However, where the clay is sandy, small domestic supplies may be obtained from it, and larger supplies, for industrial or municipal purposes, can be expected from the included lenses and pockets of sand and gravel.

At most places in the ground-moraine areas, water is obtained at depths of about 40 feet or less, but owing to the heterogeneous character of the deposits, it is not possible to predict the depth at which water may be encountered in any particular locality.

Terminal Moraine. Part of the load carried by the continental ice-sheet was dropped at its front or margin during pauses in the general retreat of the melting glacier. This load consisted of material gathered during the advance of the ice-sheet, and was deposited as a mixture of boulder clay, silt, sand, and gravel. Streams flowing from the melting ice carried away a large part of the silt, sand, and finer gravel, leaving chiefly compacted boulder clay and heaps of loose boulders as terminal moraine. In general, such material carries very little recoverable water, except where small lenses of sand or gravel are present.

Kame Moraine. The hilly region in the extreme north part of Markham and Vaughan townships is composed of boulder clay, sand, and gravel. Exposures show in road cuts at or near the tops of the hills; some of these are of sand, others of boulder clay. At one place a 6-foot layer of boulder clay overlies well-bedded sand, and wedges out southward; it is overlain by still more sand. This hilly area probably represents a terminal moraine, the sand and gravel being a mixture of outwash and kame deposits resulting from local readvances of the ice-front during its general retreat.

The typical terminal moraine part of the hilly region contains favourable aquifers at depth, but shallow wells do not, in general, yield adequate supplies. Water is obtained at depths of from 38 to 150 feet, with the deeper wells producing the more permanent and larger supplies. In the sand and gravel areas, however, where the deposits represent outwash and kame conditions, domestic supplies are obtained within about 17 feet of the surface.

Outwash Sand and Gravel. Sand and gravel carried out from the front of the melting ice-sheet and deposited on plains at or near such a front may form important aquifers. These deposits are porous, and readily absorb rain falling upon them. If they rest on impervious clay, which would prevent downward percolation of the water, they may become saturated to within a few feet of the surface. Shallow wells in such deposits can be expected to yield adequate domestic supplies. If the deposits are thick and contain extensive gravel lenses, they may yield supplies sufficient for industrial or municipal uses.

Glacial-lake Deposits. These deposits include the silt, sand, and gravel deposited in glacial Lake Iroquois. Most of the deposits consist of fine sand and silt, with the gravel occurring in the form of bay-mouth bars. The sandy deposits vary from a thin veneer to at least 10 feet in thickness; the gravel deposits reach a thickness of 40 feet. Such deposits are very porous, and will yield their water freely to shallow dug wells.

Interglacial Deposits. These deposits are exposed in Scarborough and Pickering townships, along the shore of Lake Ontario, where they consist typically of stratified sand overlying a grey, peaty clay. The clay is almost impervious and very little water can be expected from it. The stratified sand, however, does contain water, and springs issue from the contact of the sand and underlying clay in the cliffs along Lake Ontario. Unless the sand is so fine as to partly clog wells that are dug or drilled in it, a fair supply of water should be obtained.

Alluvium. Alluvial deposits consist of clay, silt, sand, and gravel laid down as flood-plain deposits along the valley bottoms of many streams. 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.

WATER ANALYSES

Both the kind and quantity of mineral matter dissolved in a natural water depend largely upon the structure and chemical composition of the rocks with which the water has been in contact. Water may be polluted by organic matter or its decomposition products.

Two hundred and eighty samples of well water from the area were analysed for their mineral content in the laboratory of the Water Supply and Borings Section, Geological Survey, Department of Mines and Resources, Ottawa. The analyses are given in parts per million, that is, in parts by weight of the constituents in 1,000,000 parts by volume of water. No examination was made for bacteria, and hence a water that may be termed suitable for use on a basis of its mineral content might be condemned by reason of its bacterial content. Bacteriological analyses are made by the Provincial Department of Health, Toronto. As a rule, waters high in bacteria have been contaminated by polluted surface water.

The following mineral constituents include all that are normally 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 staining on porcelain or enamelled ware, and renders the water unsuitable for laundry purposes. In the table of analyses accompanying this report, alumina is included with the iron and both are reported as the oxides.

Calcium (Ca) is dissolved from almost all rocks, though in greater quantities from limestone, dolomite, and gypsum. Magnesium (Mg) is similarly dissolved from many rocks, but particularly from dolomite. These constituents impart hardness to water and are active in contributing to the formation of boiler scale. The sulphate of magnesia ($MgSO_4$) combines with water to form "Epsom salts", and renders the water unwholesome if present in large amounts. Calcium salts in minor quantities have no injurious effects.

Sodium (Na) is found in all natural waters in various combinations, though its salts constitute only a small part of the total dissolved mineral matter in most waters in humid regions. Sodium salts may be present as a result of pollution by sewage, or of contamination by sea water either directly or with that enclosed in marine sediments. No estimate of potassium (K) has been made, and any that may be present has been included as sodium. Moderate quantities of these constituents have little effect upon the suitability of a water for ordinary uses, but waters containing sodium in excess of about 100 parts a million may require careful operation of steam boilers to prevent foaming. Waters containing large quantities of sodium salts are injurious to crops and are, therefore, unfit for irrigation. The quantity of sodium salts may be so large as to render a water unfit for nearly all uses.

Sulphate (SO_4) is dissolved from deposits such as gypsum and sodium sulphate. It is also formed by oxidation of iron sulphides and is, therefore, found in mine waters. Sulphate, in combination with calcium and magnesium, causes formation of boiler scale; it also increases the cost of softening the water.

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, and if present much in excess of 300 parts a million, render it unfit for domestic use.

The term "total dissolved solids" is applied to the residue obtained when a sample of water is evaporated to dryness. Waters are considered high in dissolved mineral solids when they contain more than 500 parts a million. Waters containing up to 500 parts a million may be accepted for domestic use.provided they are otherwise satisfactory, but a content of 1,000 parts a million does not prohibit domestic use if no better supply is available. Residents accustomed to the waters may use those that carry much more than 1,000 parts a million of total dissolved solids without inconvenience, although persons not used to highly mineralized waters would find them objectionable.

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, 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] t- l'

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

may 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 water samples analysed were taken from depths of from 7 to 462 feet, and with 51 exceptions all are from glacial drift. They show little variation in either the total dissolved solids or the quantities of the individual constituents. As far as mineral content is concerned, the waters are quite suitable for domestic and stock purposes as well as for most industrial uses. Softening would be desirable for laundry purposes. None of the drift waters analysed contains sufficient salts to render it injurious to crops and so unsuitable for irrigation.

PART II

KING TOWNSHIP, YORK COUNTY, ONTARIO

Physical Features

King township is in the north-central part of York county and has an area of approximately 150 square miles. The village of Schomberg, the largest of several small municipalities within the township, lies about 26 miles northwest of the city of Toronto.

Except for a small area in the southeast corner and for the reclaimed marsh lands along Schomberg River, the surface of King township is rolling or hilly. A well marked divide extending from east to west across the centre of the township forms the height of land between Lake Simcoe and Lake Ontario. The area to the south of this divide is drained by Humber and East Branch Humber Rivers, which together with their numerous, small tributaries, cross the south part of the township in a general southeasterly direction. Streams rising on the abrupt northern slopes of the divide drain rapidly down to the flat land of Holland Marsh, where a canal diverts the water around a part of the marsh now reclaimed and on into the west branch of Holland River and thence to Lake Simcoe. Twelve small lakes, all of which lie south of the height of land, are included in the township.

A prominent topographic feature in the north part of the township is a discontinuous ridge or bluff, which represents the former shoreline of glacial Lake Algonquin. The Algonquin shoreline trends in a southwesterly direction across the north part of the township, and forms the south border of the flat marsh lands of Holland River. In general, it follows the 750 - and 800-foot contour lines.

The township as a whole has a relief of more than 530 feet. The highest elevation is on the height of land in the northeast part of the township where an altitude of more than 1,200 feet above sea-level is attained. The lowest part is on Humber River in the southwest corner of the township where the altitude is only 670 feet.

The mean annual temperature is 43 degrees Fahrenheit.[1] The average daily maximum temperature varies from 80 degrees in July to 25 degrees

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[1] Mayall, K.M.: The Natural Resources of King Township, Ontario; Trans. Royal Can. Inst.; vol. XXII, pt. 2, p. 217, (Oct. 1939).

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in February, and the average minimum from 56 degrees in July to 7 degrees in February. Normal annual precipitation is 28.94 inches. The average total snow fall is close to 4 feet. These figures refer to Oak Ridges at the east end of the township.

Geology

Bedrock Formations. Except for a small area in the extreme southwest corner, King township is entirely underlain by the Dundas formation of Ordovician age. These rocks consist of grey and blue shale; thin, sandy beds; and thin, lenticular beds of limestone. Rocks of the succeeding Meaford formation, consisting of grey, bluish, and brownish shale, with thin layers of limestone, calcareous sandstone, and arenaceous shale, underlie the southwest corner of the township. No outcrops of bedrock have been observed.

Unconsolidated Deposits. Ground moraine deposits occur in both the south and north parts of the township. They consist chiefly of a heterogenous mixture of clay, boulders, and pebbles enclosing irregularly distributed lenses and pockets of water-laid sand and gravel. A considerable part of the material covering the surface immediately south of the Algonquin shoreline is ground moraine; a second large area occurs in the vicinity of the village of Nobleton. The relief of the areas of ground moraine is moderate, and in general the topography could be classed as rolling.

The greater part of the glacial drift covering King township is terminal moraine. To a large extent, the height of land that crosses the township from east to west is composed of these deposits. The material consists predominately of boulder clay, with scattered pockets and lenses of sand and gravel. The relief of the terminal moraine area is more rugged than that of the ground moraine.

Glacial outwash and kame deposits are numerous in King township. A large area that extends from east to west across the centre of the township, and smaller areas in the northeast and northwest corners, consist of kame and outwash material that was, apparently, laid down on top of the terminal moraine during the first stages in the retreat of the ice-sheet. The large deposit in the centre of the township is thought to be laid down by torrential melt waters flowing between two parallel ice lobes of the retreating ice-sheet. These deposits consist mainly of deep sands and gravels overlying boulder clay. In places where they have been sorted by running water, the fine and coarse materials have been separated; this sorting action has produced deposits of high porosity and, in the coarser material, high permeability. Such material constitutes the most elevated, hilly, and agriculturally worthless land in the township.[1] Rain falling upon it would readily pass through the permeable

[1]Putman, D.F. and Chapman L.J.; The Physiography of South-Central Ontario; Scientific Agriculture, 16:9, May 1936.

materials until it encountered the relatively impermeable underlying boulder clay. This is the probable source of much of the ground water that forms seepages and springs along the edges of the kame and outwash areas.

Two glacial-lake deposits of different origin have been identified in the township. The first of these, which is known as Schomberg Lake Plain, is located along the north boundary of King township in the vicinity of the village of Schomberg. Varved clays and silts overlying boulder clay comprise the bulk of the material. However, in some places, principally near the margin of the clay, sandy deltas are found. The thickness of the clay is unknown, in most places although exposures up to 15 feet thich have been observed. Topographically, the area has somewhat greater relief than is usually associated with a lake plain. The surface is moderately rolling, and is cut by several well developed stream valleys that provide excellent drainage.

The second glacial-lake deposit is north of the shoreline of glacial Lake Algonquin. It constitutes what is known as Holland Marsh, which has been reclaimed and brought under cultivation for market gardens. The material forming these deposits in King township consists mainly of sands and silts overlying boulder clay. The topography is very flat, and drainage so poor as to form large marshy tracts of land.

Alluvial deposits of clay, silt, sand, and gravel occur along the flood plains of Humber and East Branch Humber Rivers. An extensive deposit of alluvium in the southeast corner of the township was probably due to the damming of East Branch Humber River in the vicinity of Kinghorn. The deposits of alluvium in King township are thin, and are unimportant as sources of ground water. The material is derived mainly from the reworking of glacial drift.

A summary of the areal extent of the various types of glacial drift in King township is as follows:[1]

Type of deposit	Extent (Acres)
Ground moraine	20,000
Terminal moraine	34,000
Kame and outwash plain	13,000
Schomberg lake plain	3,000
Algonquin lake plain.......................	12,000
Alluvium deposits	6,000
Total ...	88,000

[1]Mayall, K.M.: The Natural Resources of King Township, Ontario; Trans. Royal Can. Inst., vol. XXII, pt. 2, p. 224, (Oct. 1939).

Variations in the thickness of drift were not determined as only one of the recorded wells appears to have reached bedrock. This well is in lot. 1, con. XI, and is reported to have encountered bedrock at 178 feet.

The following table indicates the minimum thickness of drift at several localities:

Well No.[1]	Concession	Lot	Depth (Feet)	Aquifer
1	I	1	165	drift
3	I	11	462	clay
10	I	20	330	sand
7	I	24	340	sandy gravel
12	I	34	330	drift
5	II	6	260	drift
5	II	18	160	drift
2	II	31	150	sand
26	III	5	211	sand
20	III	8	213	sand
19	III	25	175	gravel
15	III	35	150	sand
10	IV	3	220	
2	IV	16	295	drift

Well No.[1]	Concession	Lot	Depth (Feet)	Aquifer
18	IV	34	200	sand
20	V	9	133	gravel
4	V	22	165	sand
2	VI	1	200	sand
3	VI	26	110	sand
29	VI	30	280	sand
12	VII	3	290	
25	VII	15	213	sand
19	VII	29	160	sand
17	VIII	7	265	gravel
12	VIII	14	204	sand
3	VIII	26	178	sand
16	VIII	34	292	sand
16	IX	4	135	gravel
15	IX	7	335	sand
10	IX	19	272	sand
70	IX	35	245	sand
1	X	1	250	gravel
7	X	29	220	gravel
1	XI	1	180[2]	shale
5	XI	17	240	sand
12	XI	34	108	gravel
13	XII	22	135	sand
15	II	4[3]	198	sandy gravel
11	II	10[3]	248	drift
10	II	19[3]	310	sand
2	III	11[3]	242	sand

[1]Well numbers used in this report refer to those wells on which data have been compiled, as indicated on page 2 of this report.

[2]To bedrock

[3]New survey of lots north of old lot 35

Water Supply

Except for a few localities, King township is fairly well supplied with ground water for both domestic and stock purposes. About 66 per cent of the wells are of the dug type, and about 71 per cent are supplying water from depths of 40 feet or less. A survey of the well records shows that about 72 per cent of the wells have a permanent water supply sufficient for the present demands made upon them; the remainder constitute dry holes, wells that go dry periodically, and wells that went dry apparently as a result of the last period of extremely dry weather (1931-1936).

All wells in King township derive their water supply from glacial deposits. In describing the principal water-bearing beds, no account is taken of their age with respect to the successive advances and retreats of the ice-sheet, as the water-bearing properties of the aquifers seem to be independent of their position within the drift. In most wells, the statements of owners and drillers as to the character of the aquifer were accepted.

The chief sources of satisfactory ground water in the ground and terminal moraine areas are irregular deposits of water-laid sand and gravel that occur within the boulder clay. In some wells the principal aquifer is listed as glacial clay, material that yields little water. Commonly, boulder clay is a poor reservoir for ground-water storage, as it takes up water slowly and holds relatively little. Furthermore, due to the sluggish circulation, the quality of ground water obtained from boulder clay is commonly poor. In wells where the yield is considerably greater than might be expected, it is possible that the boulder clay is mixed with sand or might even consist of fine sand or silt, with a pore space large enough to permit more ready circulation. There is no way of ascertaining where a water-bearing deposit of sand or gravel may occur in the boulder clay, unless it outcrops at the surface or has been located by a well or test boring.

The glacial outwash and kame deposits, which cover a large area in the central part of the township, constitute a fair source of water, although the average depth of wells is greater than in other parts of the township. These deposits generally consist of irregular lenses of sand, quicksand, and gravel. A few, small, scattered beds of clay were observed. The clay and quicksand may contain water, but clay does not yield it freely to wells, and the water-bearing quicksand flows bodily into wells and is, therefore, undesirable as a source of ground water. The coarser sand and gravel yield their water freely, and large quantities are obtainable from them. Drilled wells employing well screens are best for obtaining a satisfactory supply of ground water from these deposits.

The supply of ground water obtained from Schomberg Lake Plain is poor, due to the slow-yielding property of the clays that comprise the bulk of the deposit. The best supply of ground water obtained in this area is derived from small, sandy, deltaic deposits that occur along the margins of the clay deposit.

Due to the extreme flatness of the land and the resultant poor drainage, the water-table lies close to the surface in the area covered by the clay, silt, and sand deposits of glacial Lake Algonquin. This has resulted in the formation of large, marshy tracts of land of which Holland Marsh is a good example. The supply of ground water in this area is ample.

The alluvial deposits in King township are not an important source of ground water, although in a few localities the deposits are of sufficient thickness and porosity to yield a fair supply of water to shallow wells.

Only one well in King township was reported to have reached bedrock. Well No. 1, in lot 1, con. XI, is 180 feet deep and is reported to have penetrated 2 feet of shale at the bottom of the hole. It is probable that the ground water supplied by this well is derived entirely from glacial drift, as a chemical analysis of the water showed that the amounts of dissolved constituents are comparable to those in waters whose source is known definitely to be drift. Drilling into the bedrock underlying King township is not recommended. In adjacent townships, the water from wells, that have penetrated into these rocks contains a large amount of sodium chloride (common salt), which renders it unfit for domestic or industrial use.

Buried stream channels could not be recognized from the evidence of the wells. Such channels should contain quantities of sand and gravel, and hence form favourable source beds for large supplies of ground water. The occurrence in a locality of a few drift wells that are appreciably deeper than the average might indicate the presence of an underground channel, but the deep drift wells are scattered throughout the township and, hence, no reliable conclusions as to the location of buried channels can be drawn.

The intake area for the ground-water supplies of King township includes almost the entire surface of the township as well as limited areas to the east and west. Rain falling upon sand and gravel will penetrate rapidly, and such material is widespread in the central part of the township. Contours drawn through the water levels of non-artesian wells show a gradual slope north and south away from the height of land across the centre of the township.

The distribution of the unconsolidated formations with relation to the topography is such as to provide excellent conditions for flowing-artesian wells in King township. The porous deposits of kame and outwash sands and gravels, which cover a large part of the height of land extending across the centre of the township, provide an excellent intake area for ground water that would eventually return to the surface at lower elevations in flowing-artesian wells. These same conditions would provide water for the numerous springs that, appear along both sides of the height of land.

The township includes three distinct areas within which flowing-artesian wells are known to occur. The most important of these is in lots 32 to 35, cons. VIII and IX, near the village of Schomberg. These wells, which vary in depth from 140 to 292 feet, all derive their water from sand and gravel beds in the boulder clay that underlies the glacial-lake deposits in the area. The flow of water is reported to be from 8 to 625 gallons an hour.

A second area containing flowing-artesian wells occurs in lots 25 to 30, cons. VI, VII, and VIII. The wells in it are located both above and below the Algonquin shoreline. They derive their water from extensive beds of sand and gravel that occur within the boulder clay and believed to extend south into the terminal moraine area.

Several flowing-artesian wells occur in lots 24 to 29, con. I, near the town of Aurora. The wells, whose depths vary from 91 to 140 feet, obtain their water from large beds of sand and gravel, which are thought to be continuous with extensive deposits of kame and outwash sand and gravel south of the town.

Springs are numerous throughout King township. At least 146 are known to be used as a source of water supply for domestic and stock purposes. They occur principally along the sides of the height of land, where the porous beds of kame and outwash sand and gravel overlie the relatively impervious boulder clay, and along the base of the glacial Lake Algonquin shoreline. Several of the springs, form the source of small creeks in the township.

Village Supplies

Aurora. The town of Aurora obtains its water supply almost entirely from a municipal water-works. The water is supplied by flowing-artesian wells in King and Whitchurch townships, and is derived from extensive sand and gravel beds at depths of from 91 to 140 feet. The production from these wells during 1936 was approximately 77,000,000 gallons. The villages of Schomberg, King, Nobleton, Lloydtown, and Kettleby all derive their water from privately owned wells.

Analyses of Water Samples

Sixty samples of well waters from King township were analysed for their mineral content in the laboratory of the Geological Survey of Canada. The samples were taken from depths of from 4 to 462 feet and are all from glacial drift. Most of them were found to be suitable for domestic and farm use.

Amounts[x] of Dissolved Mineral Matter in Waters Collected in King Township.

Constituent	Water from glacial drift (60 analyses)		
	Maximum	Average	Minimum
Total dissolved solids....................	1,140	369.7	160
Silica..................................	44	14.9	6
Iron (Fe_2O_3) and alumina (Al_2O_3)..........	20	4.0	2
Calcium................................	186	80.8	14
Magnesium..............................	86	22.1	3
Sodium.................................	61	16.8	1
Sulphate...............................	174	50.8	10
Chloride...............................	151	22.4	2
Total hardness.........................	1,000	191.7	90

[x] In parts per million

CONCLUSIONS

This investigation warrants the following conclusions.

1. Ground-water supplies in King township are not abundant, but are adequate for stock, domestic, and municipal purposes.

2. Precipitation appears sufficient to furnish adequate supplies of ground water. In times of drought, or during extended periods of decreased rainfall, annual consumption may be greater than annual recharge, resulting in a lowering of the water-table. Some wells may go dry at times, and it may be necessary to deepen such wells.

3. The water-bearing beds in the ground and terminal moraine areas consist of irregular lenses and pockets of sand and gravel.

4. The chief source of ground water in Schomberg Lake Plain consists of sand and gravel beds underlying the relatively impervious clay.

5. The water-bearing beds in the glacial-lake deposits north of the Algonquin shoreline consist of silt, sand, and gravel deposits overlying relatively impervious boulder clay.

6. The quality of ground water derived from the glacial drift is quite suitable for domestic and farm use.

7. The quantity of ground water recoverable from a well depends upon the porosity, thickness, and extent of the aquifer penetrated.

8. It is possible to obtain ground water nearly everywhere in the township, but it is not always possible to predict the depth at which favourable aquifers may be reached.

9. Conditions that produce flowing-artesian wells appear to be good in King township.

10. Drilling into the bedrock underlying the glacial drift is not advised. Water recovered from this source will, in all probability, be too salty for domestic use.

ANALYSES[1] OF WELL WATERS FROM KING TOWNSHIP, YORK COUNTY, ONTARIO

							Constituents as analysed (parts per million)									Constituents as calculated in assumed combinations (parts per million)									
Sample No.	Well No.	Lot	Concession	Owner	Aquifer*	Depth of well (feet)	Total dissolved solids	Silica (SiO_2)	Iron & alumina (Fe) (Al)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Sulphate (SO_4)	Chloride (Cl_2)	Alkalis (as Na)	Total hardness	$CaCO_3$	$CaSO_4$	$MgCO_3$	$MgSO_4$	Na_2CO_3	Na_2SO_4	NaCl	$CaCl_2$	$MgCl_2$
1	1	1	I	Carswell	D.	165	180	8	2	31	18	13	31	9	135	220	78		48	20		22	15		
2	1'	6	I	Bond		156	200	20	6	23	34	16	15	2	215	200	58		118		18	22	3		
3	2	6	I	Switzer	S.	28	260	40	6	49	16	9	51	8	145	240	123		18	54		12	13		
4	14	7	I	School	S.	20	240	18	6	57	12	17	43	9	170	200	143		23	25		34	15		
5	1	11	I	A. Harmond	D.	150	240	12	6	74	15		23	4	220	240	185		29	29					5
6	3	11	I	De Lasalle College	SG.	462	240	10	4	20	12	44	10	6	175	120	50		42		80	15	10		
7	16	14	I	E. Wright	S.	50	300	14	4	83	17	14	33	6	265	260	208		48	15		31	10		
8	12,13,14	18	I	Town of Aurora	SG.	91-98	280	18	4	86	14	5	82	6	190	260	190	34		69		4	10		
9	15	19	I	Town of Aurora	G.	119-140	280	12	4	80	23	2	28	6	245	300	200		38	35					
10	9	20	I	R. Hayes	C.	12	360	12	4	69	10	50	43	83	160	260	160	17		39			127		8
11	6	23	I	R. Fierheller	D.	4	280	8	4	94	13		44	4	225	280	225	14		43					5
12	11	25	I	F. Copson	S.	52	540	44	4	103	26		74	24	160	460	160	105							
13	2	26	I	R. Rank	S.	22	680	18	6	174	24		67	35	325	400	325	95						44	9
14	12	28	I	J. Buckle	SG.	67	260	14	8	34	36	16	44	15	200	320	85		97	40		18	25		
15	13	28	I	J. Buckle	C.	32	520	6	8	72	53	29	103	51	285	520	180		88	120			74		8
16	18	29	I	W. Armstrong	S.	49	440	30	4	120	23		67	18	245	380	245	75							
17	16	35	I	G. Anning	C.	242	640	6	6	72	73	28	100	84	320	750	180		118	125			71		55
18	2	1	II	Kurswell	S.	180	280	18	8	66	20	18	30	5	250	280	165		69		3	44	8		
19	6	1	II	Bainon	D.	180	300	16	4	69	17	14	20	4	245	280	173		59		2	30	7		
20	7	6	II	Paxton	D.	18	420	14	4	114	11	8	93	12	235	280	235	68		56			20		
21	6	12	II	S. Borain	S.	160	280	14	4	89	15		21	3	260	280	223		31	29					5
22	2	16	II	Timmins	S.	2	280	12	4	74	17	2	41	6	210	280	185		21	51			5		4
23	13	23	II	E. Johnson	S.	97	240	8	6	54	17	7	33	8	175	260	135		34	35		7	13		
24	17	24	II	H. Morning	S.	120	300	8	6	69	21	9	41	4	230	280	173		48	35		17	7		
25	19	25	II	H. White	G.	83	400	12	6	89	25		49	21	245	360	223		18	61					28
26	9	28	II	H. Haines	SG.	75	640	20	4	180	36		79	50	340	550	340	112						31	40
27	1	31	II	J. Newton	S.	121	220	12	2	54	16	3	25	4	175	260	135		34	30		1	7		
28	2	31	II	R. Mills	S.	150	300	12	4	72	19	4	34	4	225	260	180		38	40		3	7		
29	5	3	III	Stuart	S.	190	160	18	4	40	14	15	30	6	150	190	100		42	10		33	10		
30	21	8	III	Carson	G.	6	280	14	4	60	12	3	52	19	125	220	125	34		35			7		20
31	9	15	III	Beauclere	D.	86	120	16	4	31	11	13	25	7	115	180	78		31	10		25	12		
32	7	18	III	G. Bechett	S.	85	260	14	4	83	16	16	67	6	230	240	208		18	54		36	10		
33	13	29	III	R. Hall	G.	60	280	10	6	29	27	19	77	21	115	320	73		35	84		15	35		
34	17	29	III	L. Smith	S.	165	280	10	4	72	14	19	30	6	240	280	180		49		2	44	10		
35	28	5	IV	Stone	S.	9	620	12	4	137	30	15	92	38	350	280	343		6	45			38		20
36	3	6	IV	School	D.	90	780	18	4	174	31	4	174	99	250	500	250	247					10	3	122
37	4	17	IV	P. Ball	S.	140	380	12	2	86	16		33	23	195	280									
38	26	29	IV	E. Morris	D.	22	500	10	2	134	19	16	44	28	365	280	335		25	55			41		4

* C. -Clay SG. -Sandy gravel
G. -Gravel D. -Drift
S. -Sand B. -Bedrock

[1] Analyses by F.J. Fraser and A.H. Bray, Geological Survey of Canada

ANALYSES[1] OF WELL WATERS FROM KING TOWNSHIP, YORK COUNTY, ONTARIO

Sample No.	Well No.	Lot	Concession	Owner	Aquifer*	Depth of well (feet)	Constituents as analysed (parts per million): Total dissolved solids	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Sulphate (SO_4)	Chloride (Cl_2)	Alkalis (as Na)	Constituents as calculated in assumed combinations (parts per million): Total hardness	$CaCO_3$	$CaSO_4$	$MgCO_3$	$MgSO_4$	Na_2CO_3	Na_2SO_4	NaCl	$CaCl_2$	$MgCl_2$
39	4	31	IV	G. Prosser	S.	28	300	12	2	63	14	12	46	27	155	280	155	3		55			30		2
40	6	1	V	G. Rountree	D.	35	640	12	2	80	31	43	97	151	105	380	105	129		8			109		114
41	11	28	V	W. Folliott	S.	27	420	14	4	117	17		71	19	220	280	220	99		1					25
42	9	32	V	S. Bavadell	S.	39	360	18	2	49	33	7	31	19	215	320	123		77	39			17		12
43	24	35	V	W. Clarkson	S.	3	320	14	2	100	19		39	9	235	240	235	20		31					12
44	5	22	VI	E. Reed	S.	10	380	18	4	83	24	10	18	10	295	375	208		73	15		9	17		
45	11	32	VIII	A. Mitchell	S.	14	300	26	2	74	25	3	49	7	235	340	185		42	61				7	4
46	7	31	IX	E. Ashton	G.	14	480	20	2	114	24		48	21	285	400	285			60					28
47	4	32	X	L. Proctor	G.	80	580	22	4	120	35		34	32	260	360	260	48						6	38
48	15	35	X	A. Jewitt	G.	3	280	14	2	77	17	29	100	6	215	260	193		18	59		78	10		
49	7		I	J. Cutting	S.	0	400	12	4	94	17	3	36	22	245	300	235		8	45			7		
50	3		II	G. Webster	SG.	2	280	4	2	72	17	1	36	5	210	220	180		25	45					4
51	12		II	L. Pottage	SG.	43	380	14	2	103	25		59	7	230	280	230	37		41					9
52	1		II	G. Doney	S.	149	280	14	4	66	19	5	31	6	215	240	165		42	35		4	10		
53	5		II	J. Woolden	S.	100	1140	14	2	186	86		174	118	450	1000	450	20		200					158
54	12		II	S. Morning	SG.	2	180	10	2	57	4	9	38	6	130	220	130	17		20		15	10		
55	10		II	K. Morris	S.	310	180	14	2	14	3	61	13	54	90	50	35		10		46	19	89		
56	13		II	C. Charles	S.	13	500	10	2	114	20	32	77	21	325	280	285		34	50		55	35		
57	11		III	A. Doan	D.	85	240	12	2	43	18	19	26	6	190	260	108		62		8	38	10		
58	14		III	W. Deavitt	S.	38	240	18	2	40	19	24	21	6	200	210	100		66		22	31	10		
59	2		III	Holland Marsh Settlement	S.	242	240	14	2	26	9	43	18	29	135	110	65		31		35	27	48		
60	4		III	J. Didichter	S.	23	580	18	20	140	28	25	38	21	445	400	350		80	20		33	35		

King Township
Summary of Wells and Springs Used as a Sourced of Water Supply

Wells and Springs	CONCESSIONS 1	2	3	4	5	6	7	8	9	10	11	12	1 O.S	2 O.S	3 O.S	Total No in Township	Per cent of total
Total number	174	134	149	159	138	120	113	125	186	92	74	28	7	52	21	1572	
Dug	106	86	114	119	84	86	70	68	123	65	47	24	6	35	9	1042	66.2
Bored	2	0	0	0	3	3	1	6	2	1	1	1	0	1	1	22	1.4
Driven	0	0	0	0	0	1	0	0	0	0	0	2	0	6	5	16	1.1
Drilled	54	45	22	21	32	21	23	35	47	22	17	1	0	1	5	346	22.0
Springs	12	3	12	19	19	9	19	16	14	4	9	0	1	7	1	146	9.3
Wells 0-40 feet deep	110	77	109	126	100	90	89	82	134	63	55	22	6	38	14	1115	71.0
41-80	23	14	17	14	9	10	3	14	7	12	3	3	1	6	4	140	8.9
81-120	12	11	9	6	15	9	10	9	8	2	4	2	0	2	2	101	6.4
121-160	12	17	1	4	8	5	5	10	9	6	3	1	0	2	0	83	5.3
161-200	1	5	3	2	1	4	3	3	15	3	6	0	0	1	0	47	3.0
over 200	6	1	3	2	0	1	2	7	12	6	3	0	0	2	1	46	2.9
depth unknown	10	9	7	5	5	1	1	0	1	0	0	0	0	1	0	40	2.5
Wells that yield hard water	174	133	144	137	118	110	89	103	158	84	61	27	6	43	19	1406	98.4
soft water	0	0	1	1	1	1	0	0	11	0	2	0	0	1	1	19	1.3
salty water	0	0	1	0	0	0	0	0	1	3	0	0	0	0	0	5	0.3
Wells with aquifer in sand	65	53	62	79	53	66	65	66	69	34	33	13	3	30	13	704	45.6
in gravel	14	6	22	24	16	12	16	17	47	22	7	3	0	2	0	208	13.5
in clay	42	23	30	20	29	22	8	14	5	10	11	4	2	10	1	231	15.0
in drift	52	51	32	34	39	20	19	22	62	22	19	7	2	9	7	397	25.7
in bedrock	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	2	0.1
unknown	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	2	0.1
Flowing wells	8	2	0	2	0	5	7	6	13	1	0	0	0	1	1	46	2.9
Non-flowing wells	154	128	133	136	119	106	82	97	156	83	63	27	6	43	19	1352	86.0
Wells with permanent supply	139	105	116	116	98	86	75	80	128	67	43	21	5	36	19	1134	72.3
Wells with non-permanent supply	23	25	17	22	21	25	14	23	41	17	20	6	1	8	1	264	16.8
Dry holes	0	1	3	2	0	0	5	6	3	4	2	1	0	1	0	28	1.7
Wells not used	25	12	9	12	9	12	8	18	12	8	4	3	0	6	5	143	9.0

1 Sand, silt, sandy clay, or sand and gravel.
2 O.S.- old survey