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CANADA

DEPARTMENT OF MINES

AND

TECHNICAL SURVEYS

GEOLOGICAL SURVEY OF CANADA

WATER SUPPLY PAPER No. 307

GROUND-WATER RESOURCES OF UXBRIDGE TOWNSHIP, ONTARIO COUNTY, ONTARIO

By

N. R. Gadd

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ILLUSTRATIONS

Map - Uxbridge township, Ontario county, Ontario:

Figure 1. Map showing bedrock formations and surface deposits;
2. Map showing topography, and location and types of wells;
3A. Town of Uxbridge, map showing approximate surface contours and average depth to water;
3B. Town of Uxbridge, map showing location and types of wells;
4A. Community of Goodwood, map showing average depth to water;
4B. Community of Goodwood, map showing location and types of wells.

INTRODUCTION

This report deals with the ground-water conditions of a township in the province of Ontario investigated by the Geological Survey of Canada. It is one of a series of ground-water reports on individual townships of Ontario.

All available information pertaining to the water wells in the area was recorded and water samples were taken for analysis. The elevation of the surface of the water in most of the wells was measured. As the ground-water conditions are directly related to the geology, the surface deposits were also studied and mapped.

Thanks are here extended to the farmers and to the residents of communities throughout the area for their co-operation and willingness to supply information regarding their wells. Valuable assistance was also given by well drillers and municipal waterworks authorities in the area.

Publication of Results

The essential information pertaining to ground-water conditions is being issued in reports covering each township investigated in the province of Ontario. These reports, as published, will be supplied directly to the proper municipal and township authorities. In addition, pertinent data on wells investigated in each township will be kept on file at Ottawa. The well record compilation sheets will not ordinarily accompany the reports, as, for most areas, they are too numerous. However, persons interested in individual wells may receive the information upon application to the Chief Geologist, Geological Survey of Canada, Ottawa. For this information the request should specify lot, concession, owner's name, and approximate location of the well -- at house, at barn, in pasture, etc.

With each report is a map consisting of two figures. Figure 1 shows the surface deposits that will be encountered in the

area, and Figure 2 shows the positions of all wells for which records are available, together with the class of the well at each location.

GLOSSARY OF TERMS USED

Alluvium. Recent deposits of clay, silt, sand, gravel, and other material deposited in lake beds and in flood-plains of modern streams.

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

Bedrock. Bedrock, as here used, refers to the consolidated deposits underlying the glacial drift. South of a line drawn between Midland, on Georgian Bay, and Kingston, the bedrock consists mainly of sedimentary rocks such as limestone, shale, slate, and sandstone; north of that line the bedrock consists chiefly of hard, crystalline, granitic rocks.

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

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

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

Effluent Stream. A stream that receives water from a zone of saturation.

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 that includes all the loose, unconsolidated materials that were deposited by the continental ice-sheet, or by waters associated with it. It includes till, deposits of stratified drift, and scattered boulders and rock fragments.

Several forms in which glacial drift occurs are as follows:

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

(2) Ground Moraine. A widely distributed moraine consisting of glacial drift deposited beneath an ice-sheet. The predominant material is till, which is clay containing stones. The topography may vary from flat to gently rolling.

(3) Kame Moraine. Assorted deposits of sandy and gravelly stratified drift laid down at or close to the ice margin. The topography is similar to that of an end moraine. Kame terraces are elongated deposits of this type laid down on the slopes of broad, flat-bottomed valleys.

(4) Drumlin. A smooth oval hill that has its long axis parallel with the direction of ice movement at that place. It is composed mainly of till.

(5) Esker. An irregular-crested ridge or series of discontinuous ridges of stratified drift deposited by a glacial stream that flowed beneath the continental ice-sheet or in deep crevasses within it. It is composed mainly of sand and gravel.

(6) Glacio-fluvial Deposits. Silt, sand, and gravel outwash deposited by streams resulting from the melting of the ice-sheet.

(7) Glacio-lacustrine Deposits. Clay, silt, and sand deposited in glacial lakes during the retreat of the ice-sheet. The clay deposits are commonly very distinctly stratified in layers a fraction of an inch to one or more feet in thickness; each layer is believed to represent deposition during one summer season and one winter season.

(8) Kame. An isolated mound or conical hill composed of stratified sand and gravel deposited in a crack or crevasse within the ice or in a depression along the ice front.

(9) Marine Deposits. Deposits laid down in the sea during the submergence that followed the withdrawal of the last ice-sheet. They consist chiefly of clay, silt, and sand, and have emerged beaches of sand and gravel associated with them.

(10) Shoreline. A discontinuous escarpment that indicates the former margin of a glacial lake or sea. It is accompanied by scattered deposits of sand and gravel located on former beaches and bars.

Ground Water. Sub-surface 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.

Influent Stream. A stream that feeds water into a zone of saturation.

Impervious or Impermeable. Beds such as fine clays or shale are considered to be impervious or 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, for example, porous sand, gravel, and sandstone.

Porosity. The porosity of a rock is its property of containing interstices or voids.

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.~~

Unconsolidated Deposits. The mantle or covering of loose, uncemented material overlying the bedrock. It consists of Glacial or Recent deposits of boulders, gravel, sand, silt, and clay.

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. Water may be retained above the main water-table by a zone of impervious material; such water is said to be perched and its upper limit to be a perched water-table.

Wells. Holes sunk into the ground so as to obtain a supply of water. When 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 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 generally dry for a part of each year.

Zone of Saturation. The part of the ground, below a water-table that is saturated with water.

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; part evaporates either directly from the surface and from the upper

mantle of the soil or indirectly through transpiration of plants; the remainder infiltrates into the ground to be added to the ground-water supplies.

The proportion of the total precipitation that infiltrates from the surface into the zone of saturation will depend upon the surface topography and the type of soil or surface rock. More water will be absorbed in sandy or gravelly areas, for example, than in those covered with clay. Surface run-off will be greater in hilly areas than in those that are relatively flat. In sandy regions where relief is great, the first precipitation is absorbed and run-off only commences after continuous heavy rains. Light rains falling upon the surface of the earth during the growing season may be wholly absorbed by growing plants. The quantity of moisture lost through direct evaporation depends largely upon temperature, wind, and humidity. Ground water in areas overlain by pervious material may be recharged by influent streams carrying run-off from areas overlain by relatively impervious material.

Because of the large consumption of ground water in settled areas, it may seem surprising that precipitation can furnish and 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 region, for example, is about 30 inches, it will be seen that each year some 435,600,000 imperial gallons of water falls on each square mile. Although it would be impossible to determine the annual recharge of the ground-water supply of the area, if it were assumed that only 10 per cent of the total precipitation, namely 43,560,000 gallons, is contributed to the zone of saturation, it will be seen that the annual recharge for the entire area would be a very large volume. The annual consumption

of water in all areas investigated is not known, but an estimate for some restricted areas, based on per capita consumption, shows it to be only about one-tenth of the annual recharge as estimated above.

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 saturation. The water-table commonly is a subdued replica of the surface topography. The water that enters from the surface into the unconsolidated deposits and rocks of the earth is drawn down by gravity to where it reaches the zone of saturation or comes in contact with a relatively impervious layer. Such a layer may stop further downward percolation, resulting in perched water and creating a perched water-table. If a 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. The terms influent and effluent are used with reference to streams and their relation to the water-table. An influent stream flows above the water-table and feeds water into the zone of saturation; an effluent stream flows at or below the water-table and receives water from the zone of saturation. An effluent stream may become influent and eventually dry up if the water-table is lowered sufficiently. The ground water in the zone of saturation is almost constantly on the move percolating towards some point of discharge, which may be a spring or a pumping well.

All rocks and soils are to some degree porous, that is, the individual grains or particles of which they are composed are partly surrounded by minute interstices or open spaces that form the receptacles and conduits of ground water. In most rocks and soils the interstices are connected and large enough for the water to move from one opening to another. In some rocks or soils, however, they are largely isolated or too small to allow movement of water. The

porosity of a material varies directly with the size and number of its interstices, which in turn depend chiefly upon the size, shape, arrangement, and degree of assortment of the constituent particles. Horizons within the earth's crust of fine-grained rock such as shale, limestone or dolomite, or unconsolidated clay or silt, may have such small interstices that the contained water will not flow readily and wells penetrating them may derive little or no water from them. Such horizons are considered impervious. Beds of more coarse-grained materials such as sand, gravel, or sandstone have greater porosity and readily yield their waters to wells. They are called water-bearing beds or aquifers. A clean water-bearing gravel is one of the best sources of water. This is true whether the water is derived from the zone of saturation or from a bed of gravel confined above, between, or below beds of less pervious material.

Consolidated rocks usually considered to be impervious may sometimes produce water in relatively good supply from openings within them of primary or secondary origin. Those of primary origin, original interstices, were created when the rocks came into existence as a result of the processes by which they were formed; e.g. bedding planes, and intergranular spaces. Secondary interstices comprise joints and other fracture openings, solution openings, and openings produced by several processes of minor importance, such as the work of plants and animals, mechanical erosion, and recrystallization; all of these involve movement of a type that acted after the consolidation of the rock. The most important interstices with respect to water supplies are the original interstices, next to them are the fracture and solution openings.

The most common wells and those that in drift-covered areas yield the largest aggregate supply of ground water are water-table wells. These are wells that derive their water from the zone of

saturation. Many shallow wells become dry during the late summer and winter, or during periods of extreme drought. In most cases this is due to the lowering of the water-table below the bottom of the well. The grouping together of a number of water-table wells within a limited area will also lower the yield of any one of the wells. This is especially true of water-producing formations of low permeability. When a well penetrates an aquifer confined by impervious beds, water will be forced upward by hydrostatic pressure exerted at the point where the well enters the aquifer. If the hydrostatic pressure is great enough to force the water to or above the surface, a flowing well is formed.

Springs are formed where the water-table, or some water-bearing aquifer, outcrops at the surface of the ground. The water emerging from water-table springs is free-running water flowing down the gradient of the water-table. In many cases these springs occur as slow seeps along the steeper slopes of stream valleys. A large number in one area could maintain a swamp. A group of permanent springs occurring in one area could provide sufficient water to maintain a lake or form the source of a stream.

GENERAL DISCUSSION OF GROUND-WATER ANALYSIS

The mineral content of ground water is of interest to many besides those industries seeking water of specific quality. Both the kind and quantity of mineral matter dissolved in 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 Mines Branch, Department of Mines and Technical Surveys, Ottawa.

In any given area, an attempt is made to secure samples of water representative of all major aquifers. 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.

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

Silica (SiO_2) may be derived from the solution of almost any rock-forming silicate, although its chief source is the feldspars. It is commonly determined in the analysis of water for use in steam boilers, as silica is classed as an objectionable encrustant.

Calcium (Ca). The chief source of calcium dissolved in ground water is the solution of limestone, gypsum, and dolomite. The common compounds of calcium are calcium carbonate ($CaCO_3$) and calcium sulphate ($CaSO_4$), neither of which has injurious effects upon the consumer, but both of which cause hardness and, the former, boiler scale.

Magnesium (Mg). The chief source of magnesium in ground water is dolomite, a carbonate of calcium and magnesium. The sulphate of magnesium ($MgSO_4$) combines with water to form Epsom-salts ($MgSO_4.7H_2O$), and renders the water unwholesome if present in large amounts.

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 by that enclosed in sediments of marine origin. Moderate quantities of these salts have little effect upon the suitability of a water for ordinary uses, but water containing sodium in excess of about 100 parts per million must be used with care in 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.

Potassium (K), like sodium, is derived originally from the alkaline feldspars and micas. It is of minor significance and is sometimes included with sodium in a chemical analysis.

Iron (Fe) is almost invariably present in well waters, but rarely in large amounts. Salts, or compounds, of iron are dissolved from many rocks as well as from iron sulphide deposits with which the ground water comes in contact. It may also be dissolved from well casings, water pipes, and other fixtures in quantities large enough to be objectionable. Upon exposure of the water to the atmosphere, dissolved iron separates as the hydrated oxide that imparts a yellowish brown discoloration. Excessive iron in water causes staining on porcelain or enamelled ware and renders the water unsuitable for laundry purposes. Water is not considered drinkable if the iron content is more than 0.5 parts per million.

Sulphates (SO_4). Deposits of gypsum ($CaSO_4.2H_2O$) are the principal source of sulphates dissolved in ground water; soluble sulphates, chiefly of magnesium and sodium, are other sources. Sulphates cause permanent hardness in water and form injurious boiler scale. Sodium and magnesium sulphates are laxative when present in quantities of more than 900 parts per million.

Chloride (Cl) is derived chiefly from organic materials or from marine rocks and sediments. It occurs usually as sodium chloride and less commonly as calcium chloride and magnesium chloride. Sodium chloride is a characteristic constituent of sewage and a locally abnormal amount suggests pollution. However, because chlorides may be derived from many sources, such abnormal quantities should not, in themselves, be taken as positive proof of pollution. Chlorides impart a salty taste to water if they are present in excess of 300 parts per million.

Nitrates (NO_3) are of minor importance in the study of ground water. Relatively large quantities in a water may represent

pollution by sewage, or drainage from barnyards, or even from fertilized fields. It is recommended that a bacteriological test be made of water showing an appreciable nitrate content if it is to be used for domestic purposes.

Carbonate (CO_3) forms a large percentage of the solid compounds held in solution by the average ground water. The two chief sources are the decomposition of feldspars and the solution of limestone by water carrying carbonic acid in solution, which is the primary agent in rock decomposition. They are indicated in the table of analyses as alkalinity. Calcium and magnesium carbonates cause hardness in water, whereas sodium carbonate causes softness.

Bicarbonate (HCO_3). Carbon dioxide dissolved in water renders the insoluble calcium and magnesium carbonates soluble as bicarbonates. Boiling reverses the process by changing the bicarbonates into insoluble carbonates, which form a coating on the sides of cooking utensils.

Total Dissolved Solids (Residue on Evaporation). The term 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 per million, but may be accepted for domestic use up to that point if no better supply is available. Residents, accustomed to the waters, may use waters that carry well over 1,000 parts per million of total dissolved solids without inconvenience, although persons not used to such 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 power of the water

first to use a certain amount of soap to precipitate the above compoun s before a lather is produced. The hardness of water in its original state is its total hardness. Permanent hardness remains after the water has been boiled, and is caused by mineral salts that cannot be removed from solution by boiling. 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 larger quantities of sodium carbonate than of calcium and magnesium compounds are soft, but if the latter compounds are more abundant the water is hard. The following table[1] 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 and over	Very hard

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

UXBRIDGE TOWNSHIP, ONTARIO COUNTY, ONTARIO

Acknowledgments

The author here extends particular thanks to Mr. W. E. Remion, town clerk of Uxbridge, and to Mr. Wilson, town water supply engineer, for valuable information and plans supplied him during his study of water supply conditions in the town of Uxbridge. Mr. E. F. Roberts, of E. F. Roberts and Company, Brantford, very kindly supplied detailed logs and other information on the flowing wells sunk by his company in 1941 to supply water to the municipal water works at Uxbridge.

The author was ably assisted in the field investigations by Edwin G. Joe.

Physical Features

Uxbridge township is in the west half of Ontario county about midway between Lake Ontario and Lake Simcoe. Its largest community, the town of Uxbridge, is in the northeast part of the township on Highway No. 47, roughly 35 miles northeast of Toronto and 20 miles north of Whitby.

The entire surface of Uxbridge township is rolling or hilly. It is characterized by irregular sandy hills with steep slopes interspersed with deep kettle-like depressions and small areas with a gently rolling to nearly flat surface. A range of such hills extends across the township from the central part of the western boundary at Long Lake to the southeast part of the township north of Glen Major, passing south of the community of Goodwood. This range forms a part of the watershed between Lake Ontario on the south and Lake Simcoe on the north.

Natural springs arise from this height of land to feed the headwaters of many of the streams that drain the parts of the township north and south of it. Streams flowing northerly from the watershed are, from west to east, Pefferlaw Brook, Uxbridge Brook, and Beaverton River, all of which empty into Lake Simcoe. Duffin Creek, the principal creek south of the watershed, rises in the southeast part of the township near Glen Major and flows southerly to empty into Lake Ontario south of Pickering. At a point just northwest of Pickering, Duffin Creek is joined by a creek carrying the combined waters of several streams that rise in the southwestern part of Uxbridge township.

The relief of the township as a whole is approximately 550 feet. The greatest elevation is on the height of land near Sky Loft Ski Lodge, north and east of Glen Major, where the altitude is about 1,375 feet above sea-level. The lowest elevation, a few feet less than 825 feet above sea-level, is on Uxbridge brook in the northeast corner of the township.

Geology and Water Supply

Bedrock Formations and their Water-bearing Properties

A very thick mantle of glacial drift obscures the bedrock in Uxbridge township, as in Scott township directly north of it. One well, in lot 3, con. 4, Scott tp. penetrates 300 feet of overburden (glacial

drift) and all the sedimentary bedrock formations beneath it to a total depth of 976.6 feet. The well was drilled by Sunderland Oils Limited in search for oil and gas. Samples of the rock taken at regular intervals during drilling were examined and logged by geologists of the Borings and Ground-water Division of the Geological Survey of Canada. A log of the well condensed from their records is given here. Borings in other townships immediately west of Scott and Uxbridge townships show that the log is representative of the sequence of rocks to be encountered everywhere below the overburden in this area. The upper shale member may be absent locally.

Table of Formations

Era or period	Formation	Thickness (feet)	Lithology
Ordovician	Collingwood	78	Thin-bedded, dark grey to black, somewhat bituminous shale.
	Trenton	463	Thin-bedded grey limestone with darker shale partings; low porosity.
	Black River	103.75	Dense, thick-bedded limestone; dove-grey to cream in colour; highly porous, shell fragment limestone in upper 6 feet of the formation.
	Potsdam	5	Dark green basal arkose with some few pebbles; a porous rock.
Precambrian		Penetrated 26.75	Lit-par-lit injected granitic gneiss; pink in colour; very low porosity.

Precambrian. Precambrian rocks in general are of granitic and other intrusive types and associated volcanic and sedimentary rocks. Such rocks have low porosity and water contained in them probably occurs in joints and fissures. Some few wells in other areas, of which there are records available, have obtained highly mineralized water from them, but no water is derived from Precambrian rocks in Uxbridge township.

Potsdam Formation. Distinctly sandy, fairly porous arkose, a type of sandstone, comprises the Potsdam formation in the Scott township bore-hole. It lies unconformably upon the Precambrian gneiss. Some natural gas and a small flow of saline water issued from this formation at the time of drilling.

Black River Formation. The porous limestone made up of shell fragments in the upper 6 feet of this formation produced a relatively small flow of gas at the time of drilling, but no potable water is reported. Water might be obtained from this porous zone in other localities, but probably would be contaminated by natural gas trapped with it.

The lower part of the formation is too fine grained and compact to yield water unless, by chance, there should be sufficient cracks, fissures, or solution channels in which the water might occur.

Trenton Formation. The Trenton formation is not an important aquifer in Uxbridge township. Its water, though plentiful in adjacent areas, is commonly highly mineralized and unfit for domestic use. No well in this area derives water from the Trenton limestone.

Collingwood Formation. The Collingwood formation, in this hole 78 feet thick, consists of very fine-grained, distinctly banded, black and dark grey shale. It produces no well water in this area, but in others water is derived from it that is too saline for domestic or stock uses.

It has not been found necessary to rely on consolidated rocks in the township as a source of water as the unconsolidated deposits that overlie the bedrock supply abundant water of good quality, much better, in fact, than is to be expected from bedrock sources.

Unconsolidated Deposits and their Water-bearing Properties

The log of the Scott township well described above records the unconsolidated deposits overlying the bedrock as follows:

0 (surface)	to 8 feet	- Glacial till
8	to 110 feet	- Sand and light gravel
110	to 170 feet	- Mostly coarse gravel, small amounts of sand
170	to 300 feet	- Fine sand containing clay, very compact; hole stood wide open. No boulders or gravel on bedrock.

It also reported that in the zone of coarse gravel, at depth 110 to 170 feet, much water was encountered with best flows at 110 and 160 feet. No well in Uxbridge township is reported to have reached bedrock, but one of the wells drilled in the town of Uxbridge for municipal water supply has a total depth of 75 feet and a sequence of deposits that is somewhat similar to the above. The log of the well, as provided by E. F. Roberts and Company, Brantford, is as follows:

0 (surface)	to 16 feet	- Sand
16	to 55 feet	- Clay and stones (glacial till)
55	to 60 feet	- Coarse sand
60	to 75 feet	- Sand

As in the Scott township well, the best flow of water in this well, an artesian flow of 110 imperial gallons per minute, is from the coarse material directly under the glacial till.

The conditions in these two wells may be considered as fairly representative of those in the ground moraine areas of the north and southwest parts of the township. Ground moraine deposits consist mainly of a heterogeneous mixture of clay, boulders, pebbles, and sand, of low porosity that may enclose lenses and pockets of water-laid sand and gravel of relatively high porosity. The thickness of the till varies considerably from place to place, but is underlain, at least in part, by porous sand and gravel.

Water-laid deposits of gravel, sand, silt, and clay overlie the till in small areas at the north and southwest of the township. In most places these deposits form a thin veneer, a few feet thick, over the glacial till, but in some the thickness is in tens of feet. Such deposits are shown on the map as outwash, glacial lake deposits, and alluvium. They are, with the exception of the alluvium and muck, formed of materials considered to have been transported into the area beneath, within, and upon the ice-sheet that covered the area, and subsequently carried away, sorted, and redeposited by streams that flowed from the melting ice during its retreat. Small, temporary, ice-dammed lakes were formed at this time also and flat-lying deposits of sand, silt, and clay were laid down in them.

Deposits of alluvium consist of sand, silt, and some muck laid down in the flood-plains of modern streams. The material mapped as alluvium in the vicinity of Goodwood does not lie in the flood-plain of a permanent stream, but is in an area subject to seasonal floods that carry and deposit much fine material.

The deposits classified as mainly muck are of vegetable material accumulated in poorly drained plains and stream valleys since glacial time. The deposits do not commonly exceed a few feet in thickness.

The greater part of the glacial drift covering Uxbridge township consists of sand and gravel deposited as kame moraine at the front of the ice when it reached its maximum extension and in the first stages of its retreat by melting. This was deposited by torrential streams of melt-water whose volumes and courses over the ice changed rapidly and frequently. The resultant topography of the kame moraine area, with its typically rounded, knob-like hills and deep kettle-like depressions, and the irregular distribution and sorting of its materials record many and varied conditions of deposition. It is believed that the kame moraine was laid down upon ground moraine and also upon part of the terminal moraine.

The terminal moraine, where exposed, has a topography very similar to, if not more rugged than, that of the kame moraine. The essential difference is that in the terminal moraine there are deposits of till, boulder clay, and boulders, dumped from the ice front, in addition to sand and gravel.

Together the kame and terminal moraine areas constitute the most elevated, hilly land of the township. That its value as agricultural land is quite low is proved by the fact that large areas have been reduced to barren, desert-like expanses of free-blowing, duning sand. Deforestation and intensive cultivation have reduced the culture of these areas from fairly luxurious mixed forest to practical desolation.

Most of the material in these areas has a relatively high porosity. In places where sorting action has separated coarse and fine materials the porosity, and hence the permeability, increases with the coarseness of the material. Rain falling on such an area of sorted material would readily pass through the permeable strata until it encountered less permeable material at depth. This is the probable source of much of the water that forms seepages and springs along and near the edges of the kame and terminal moraine areas.

The presence of ground moraine till both north and south of the kame moraine belt and the great quantity of material deposited in that belt speak for the existence, in glacial time, of two major ice-sheets that moved in opposed directions to meet or approach one another somewhere near a line drawn east-west through the centre of Uxbridge township.

The thickness of the unconsolidated deposits in Uxbridge township is not known. However, the following reasoning may be used to give a rough estimate of the thickness of glacial deposits at the highest point in the terminal moraine, 1,375 feet above sea-level. Let it be assumed that the elevation 1,100 feet, that of a drumlin 1 mile west and ½ mile north of Uxbridge known as Quaker Hill, is the maximum elevation attained by the upper surface of the ground moraine till. This figure is chosen because it is the highest known exposure of till in the area. Then the depth of terminal moraine deposits at the highest point mentioned above would be from 200 to 300 feet; the difference in elevation between the top of the ground moraine till and the highest point in the terminal moraine. The thickness of the ground moraine and other deposits underlying the terminal moraine measured 300 feet in the Sunderland Oils well in Scott township. If it be assumed that this thickness is maintained throughout Uxbridge township and that the gradient of the bedrock surface is relatively uniform, the total assumed thickness of overburden in the highest part of the morainic belt is 500 to 700 feet.

The above is pure hypothesis and may be far from the true figure for the thickness of drift in the area. Only actual measurements can give that figure, but as no well or other boring in the township penetrates all the materials overlying the bedrock only minimum thicknesses can be recorded. The deepest well in each group of five lots from 1 to 30, and the seven lots from 31 to 37, is recorded in the following table, and indicates the minimum thickness of drift in those places:

Well No.	Concession	Lot	Depth (feet)	Aquifer
3	I	5	100(E)	Unconsolidated deposit
1	I	8	92(E)	Sand and gravel
3	I	15	110(E)	Quicksand
2	I	17	212(E)	Quicksand
1	I	25	90(E)	Unconsolidated deposit
1	I	27	150(E)	Unconsolidated deposit
1	I	32	180(E)	Gravel
3	II	5	75(E)	Clay till
2	II	7	86	Gravel
1	II	13	128(E)	Unconsolidated deposit

Well No.	Concession	Lot	Depth (feet)	Aquifer
1	II	18	100(E)	Quicksand
3	II	24	84(E)	Clay till
1	II	27	65	Sand and gravel
2	II	35	70	Quicksand
6	III	1	66	Gravel
2	III	7	118(E)	Sand
4	III	15	123(E)	Sand
1	III	20	110	Sand
1	III	22	95(E)	Unconsolidated deposit
5	III	30	55(E)	Sandy clay
2	III	35	56(E)	Unconsolidated deposit
1	IV	3	160(E)	Sand
3	IV	9	140(E)	Unconsolidated deposit
3	IV	11	140(E)	Unconsolidated deposit
2	IV	18	96(E)	Sand
1	IV	22	90(E)	Unconsolidated deposit
1	IV	26	127(E)	Sand
1	IV	35	29	Sand
3	V	4	146(E)	Unconsolidated deposit
1	V	8	39(E)	Sand
1	V	15	35	Gravel
2	V	20	65	Clay
7	V	25	43	Sand
1	V	28	50	Sandy till
4	V	31	204	Gravel
3	VI	2	35	Gravel
1	VI	7	160(E)	Sand
2	VI	13	147(E)	Sand
1	VI	20	45	Sand
1	VI	21	125(E)	Sand and gravel
2	VI	30	31	Clay till
5	VI	32	60(E)	Gravel
1	VII	5	140	Sand
2	VII	7	95(E)	Sand
1	VII	12	58	Gravel
1	VII	18	120(E)	Unconsolidated deposit
1	VII	21	150(E)	Unconsolidated deposit
2	VII	30	34	Sand
1	VII	35	69(E)	Sand and gravel

(E) - Owner's estimate of total depth of well. Other depths by actual measurement.

Except for a few localties, Uxbridge township is well supplied with water for present municipal, domestic, and stock purposes. About 84 per cent of the wells are of the dug type. About 77 per cent are supplying water from depths of 40 feet or less and 46 per cent from depths of 20 feet or less. A survey of well records shows that about 87 per cent of the wells have a permanent water supply sufficient for present demands; the remainder constitute dry holes and intermittent non-artesian wells.

All wells in Uxbridge 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 aquifers are irregularly distributed through the drift and their water-bearing properties seem to be independent of their position within it. In most wells the character of the aquifer was learned from the owners or drillers.

In the areas covered by ground moraine satisfactory supplies of ground water are derived chiefly from irregular deposits of water-laid sand and gravel that occur within the till or that are overlain by the till. The principal aquifer of some wells is listed as glacial till, or clay. Commonly clay till, or boulder clay, has relatively low porosity, which prevents infiltration and storage of large volumes of ground water, and such material normally yields little water to a well. Furthermore, slow circulation of water within such a till commonly results in water of poor quality. In wells reported to be in till, whose yield is considerably greater than might be expected, it is possible that the till is mixed with sand or might even consist of fine sand or silt, with porosity great enough to permit more rapid circulation.

There is no way of ascertaining where a water-bearing deposit of sand or gravel may occur in the till unless it outcrops at the surface or has been located by a well or test boring.

Only a few wells in the township obtain water as slow seepage from the till. Many penetrate the till mantle to underlying sand and gravel deposits and produce good water in abundant supply. There is insufficient direct evidence at hand to allow prediction of the thickness of till to be expected in different parts of the ground moraine area. However, wherever the till mantle has been penetrated by deeper wells, a good aquifer of sand and/or gravel has been encountered. In fact, every deep well in the township has encountered sand and/or gravel at its bottom whether or not it penetrated a layer of glacial till.

Quaker Hill, a drumlin north and west of the town of Uxbridge, is apparently composed of successive strata of clay till and sand and gravel. Numerous springs along the east side of the hill flow almost continuously from the contact of a layer of sand with an underlying till layer. Many of the wells that penetrate the upper till of the drumlin have encountered water under artesian pressure and some of the wells have been known to flow for short periods, usually in the spring of the year. The frequency with which these wells flow has diminished in the past 25 years, probably because of a general lowering of the ground-water table over that period.

Relatively shallow deposits of alluvium, outwash, and glacial lake sands overlying relatively impervious till provide water from shallow wells. Their water is probably perched. These deposits cannot be expected to provide large permanent supplies of water as their area and volume are relatively small. In years of normal precipitation they usually supply sufficient water for domestic purposes. One or two wells derive very murky water from shallow wells or dugouts in muck deposits. These serve only as supplementary supplies of water for pastured stock.

The kame moraine and end moraine deposits, which cover the largest area of any of the glacial deposits, are a fair source of water,

although the average depth of wells is greater in them than in other parts of the township. Water-bearing quicksand, encountered in a number of wells in this area, flows bodily into the wells and is, therefore, an undesirable source of ground water. Quicksand has been successfully screened out of wells by filling the bottom of the well with gravel or, preferably, crushed stone. Coarser sand and gravel yields its water freely and in large quantity. Drilled or driven wells employing screens are best for obtaining a satisfactory supply of ground water from these deposits. Lenses or discontinuous strata of till occur in the end moraine areas and act as relatively impervious layers retaining perched water above them. Some shallow wells in the end moraine areas derive water from perched water-tables of this type, but they are mainly of the intermittent non-artesian type. Buried stream channels could not be outlined from the evidence of the wells, but it is suspected that such a channel, or network of channels, exists approximately in the valley of the present Uxbridge Brook and some of its tributary streams. Flowing artesian wells exist at the town of Uxbridge pumping station, at Uxbridge Creamery, at the Main street mill pond in Uxbridge, north of the town of Uxbridge, and at Leaskdale in Scott township. All of these wells, ten in all, are in the main valley, or in a tributary valley, of Uxbridge Brook. The log of each of these wells is similar to that described at the beginning of this chapter. Till at or near the surface overlies sand and gravel like that laid down in the glacio-fluvial deposits in this and adjoining areas. It seems reasonable to assume, then, that before the last advance of the ice-sheet there was an active stream or river following the course of the present Uxbridge Brook but at a somewhat lower elevation.

A number of permanent springs are active throughout Uxbridge township. At least twenty-six are known to be used as a source of water supply for domestic and stock purposes. Most of them occur along the sides of the height of land formed where the porous beds of kame and outwash sand overlie the relatively impervious glacial till. Others occur within the terminal moraine area under similar conditions. Smaller, intermittent springs are fairly numerous in seasons of normal precipitation, but during the very dry summer of 1949 many of them were not flowing.

Municipal Water Supplies

Uxbridge. Three flowing artesian wells located near the pumping station on Brock street, Uxbridge, Ontario, supply about 200 imperial gallons of water per minute, or approximately 300,000 imperial gallons per 24-hour flow. This water flows by gravity to an underground reservoir of 175,000 gallons capacity from where it is supplied to 23,700 feet of 6-inch main and 2,500 feet of 4-inch main at a pressure of 60 pounds by two 10-H.P. motor pumps. There are forty-four hydrants installed for fire protection, and when there is a fire water is pumped to them at a pressure of 125 pounds by a 50-H.P. motor. A gasoline engine pump stands by for emergency use.

The average daily consumption of water from the municipal supply is between 20,000 and 25,000 gallons[1]. Part of the daily surplus

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[1] "Directory of Canadian Water Works Systems"; Reference Data, Water and Sewage, December 1948, p. 105.

of 275,000 gallons will be used when construction is completed on sewerage and sewage disposal projects, work on which was being carried out during the summer of 1949.

Of the 118 wells investigated in the town, 38 are no longer in use and many others are used only for irrigation of lawns and garden plots. Most of the wells derive their water from sand or gravel at relatively shallow depths. A map of the town of Uxbridge accompanies this report: Figure 3B gives the location and type of wells investigated; Figure 3A shows approximate surface contours and average depths to water within the town limits.

Goodwood. The community of Goodwood derives water for domestic use from individually owned wells. These wells are relatively shallow and produce water from fairly fine-grained sand. One well owned by S. Slack, supplies sufficient water of good quality for the domestic needs of fourteen families.

A map of the village of Goodwood accompanies this report: Figure 4B shows the location and type of wells investigated; Figure 4A shows average depths to water in different parts of the community.

Analysis of Water Samples

Twenty-two samples of water from Uxbridge township were analysed for their mineral content in the analytical laboratories of the Mines Branch, Department of Mines and Technical Surveys, Ottawa. The well-water samples were drawn from depths of from 5 to 127 feet, and the reservoir and spring samples at or near the surface. Most of them were found suitable for present uses. All the well waters sampled were derived from aquifers in glacial drift.

Amounts[1] of Dissolved Mineral Matter in Waters Collected in Uxbridge Township

Constituent	Water from glacial drift (22 samples)		
	Maximum	Average	Minimum
Total dissolved solids	852	338.4	178
Silica (SiO_2)	18.6	12.6	6.0
Calcium (Ca)	147.2	74.1	21.7
Magnesium (Mg)	38.0	12.3	4.0
Alkali (As Na)	147.4	20.0	2.7
Sulphate (SO_4)	120.6	28.0	6.0
Chloride (Cl)	102.6	15.2	nil
Nitrate (NO_3)	150.6	26.8	0.4
Bicarbonate (HCO_3)	396.5	263.8	112.2
Alkalinity (As $CaCO_3$)	325.0	201.0	92.0
Total hardness	464.0	236.6	111.5

[1]In parts per million.

Conclusions

The results of this investigation warrant the following conclusions:

1. Ground-water supplies in Uxbridge township are fairly abundant, and are sufficient for present uses.

2. Precipitation appears to be sufficient to furnish adequate supplies of ground water. In times of drought, or during extended periods of decreased rainfall, consumption may be greater than recharge, resulting in a lowering of the water-table. Some wells go dry at these times, but could be deepened to ensure a permanent supply.

3. The aquifers in the terminal moraine areas consist of irregular lenses and pockets of sand and gravel. The ground moraine areas have such aquifers within the till and are underlain, at least in part, by sand and gravel deposits that are excellent aquifers.

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

5. It is possible to obtain ground water in all parts of the township, but it is not always possible to predict the depth at which it may be encountered, particularly in the terminal and kame moraine areas.

6. Conditions that produce flowing artesian wells appear to be fairly common in Uxbridge township, particularly in or near the valley of Uxbridge Brook.

7. Unconsolidated deposits are thick enough to supply sufficient water for all purposes. Drilling to bedrock sources would be prohibitively expensive, and probably would not produce water of as good quality as is available much nearer the surface.

Wells and Springs	CONCESSIONS 1	2	3	4	5	6	7	COMMUNITIES Goodwood	Uxbridge	Total No. in Township	Per cent of Total No.
Total Number	79	85	86	77	86	72	81	28	118	712	100.00
Dug	50	66	69	63	83	67	70	27	106	601	84.41
Bored	0	0	0	0	0	0	0	0	0	0	0.00
Driven	22	18	14	12	1	4	11	1	3	86	12.08
Drilled	7	1	3	2	2	2	0	0	9	25	3.51
Wells 0-20 feet deep	22	36	29	30	33	32	54	15	76	327	45.93
21-40	23	29	30	22	38	31	12	8	27	220	30.90
41-80	10	13	12	14	10	5	8	2	5	79	11.09
81-120	15	5	11	5	0	1	2	1	2	42	5.90
121-160	2	1	1	5	1	3	3	0	4	20	2.81
161-200	1	0	0	0	0	0	0	0	0	1	0.14
over 200	1	0	0	0	1	0	0	0	0	2	0.28
depth unknown	5	1	3	1	3	0	2	2	4	21	2.95
Flowing wells (F.A.)	0	0	0	1	0	0	3	0	8	12	1.69
Non-flowing wells (N.F.A.)	1	2	6	0	7	10	1	0	2	29	4.07
Wells with permanent supply (N.A.)	63	63	65	64	52	42	59	23	63	494	69.38
Wells with non-permanent supply (I.W.)	6	15	4	9	21	13	5	3	5	81	11.38
Dry Holes (D.H.)	4	0	2	2	1	0	1	0	2	12	1.69
Springs (S)	2	2	5	1	2	4	10	0	0	26	3.65
Wells not used	3	3	4	0	3	3	2	2	38	58	8.14
Wells with aquifer in sand	41	38	43	40	26	33	39	24	39	323	45.36
in gravel	14	10	11	14	16	21	17	0	11	114	16.02
in clay	0	5	7	4	12	5	6	0	9	48	6.75
in till	12	13	7	5	19	8	3	0	2	69	9.69
in bedrock	0	0	0	0	0	0	0	0	0	0	0.00
unknown	12	19	18	14	13	5	16	4	57	158	22.18

Sample Number	Owner	Lot	Concession	Depth of well (Feet)	Aquifer	Total dissolved solids parts per million)	Constituents as Analysed (parts per million) Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Alkalis (as Na)	Sulphate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Bicarbonate (HCO_3)	Alkalinity (as $CaCO_3$)	Hardness as $CaCO_3$ (pts.per million) Ca hardness (as $CaCO_3$)	Mg hardness (as $CaCO_3$)	Total hardness (as $CaCO_3$)
1	Mill Pond - Toronto St.Uxbridge					234	13.2		59.5	8,0	4.8	13.6	nil	2.4	214.7	176.0	148.5	32.9	181.4
2	Mill Pond - Bascom St.Uxbridge					222	12.3		57.8	9.8	4.3	14.8	nil	2.4	219.4	179.8	144.2	40.3	184.5
3	D. McTavish	28	V	50	till	560	17.8		52.0	38.0	52.8	120.6	102.6	24.8	134.0	109.8	129.7	156.4	286.1
4	A. McDermott	26	IV	127	sand	208	10.9		57.5	6.5	2.9	17.3	nil	12.4	181.0	148.4	143.5	26.7	170.2
5	F.J. Jones	30	III	12	sand	202	13.5		41.4	8.0	9.8	21.0	nil	19.5	146.0	120.4	103.3	32.9	136.2
6	H. Chapman	31	II	20	sand	390	10.0		99.9	7.5	6.5	23.0	40.2	28.4	229.4	188.0	249.3	30.9	280.2
7	H. Shillinglaw	35	I	98	gravel	178	18.6		21.7	18.2	8.5	14.8	nil	0.6	168.4	138.0	54.1	74.9	129.0
8	G. Wagg	24	I	30	sand	162	13.7		27.2	10.6	5.0	25.5	2.2	4.9	112.2	92.0	67.9	43.6	111.5
9	T.H. Paisley	14	I	95	gravel	266	14.1		71.[illegible]	11.8	4.2	13.2	nil	13.3	256.4	218.4	178.9	48.6	227.5
10	S. Slack	16	II	18	sand	576	11.1		135.1	11.8	41.9	48.4	95.9	8.0	362.1	296.8	337.1	48.6	385.7
11	Town of Uxbridge	Pumping station			gravel	246	17.8		53.0	12.8	8.5	6.2	nil	0.4	247.2	202.6	132.2	52.7	184.9
12																			
13	W. Beach	26	I	52	sand	512	10.3		68.5	12.0	147.4	35.4	4.7	67.6	368.4	302.0	170.9	49.4	220.3
14	W. Davis	6	I	55	sand	284	11.9		72.7	11.5	3.8	12.3	nil	21.3	263.5	216.0	181.8	47.3	229.1
15	O.M. Madill	1	II	25	till	306	10.2		95.1	6.5	3.8	14.0	nil	14.2	300.1	246.0	237.3	26.7	264.0
16	J. Morgan	1	IV	40	sand	852	17.8		147.2	23.5	90.8	86.8	66.1	150.6	396.5	325.0	367.3	96.7	464.0
17	J. Faulkner	6	IV	24	gravel	430	11.6		113.2	11.3	8.3	26.3	8.4	52.1	309.4	253.6	282.4	46.5	328.9
18	R. Norton	10	IV	14	till	289	6.0		83.3	4,0	11.3	12.8	nil	17.7	256.7	210.4	207.8	16.5	224.3
19	J. Albright	13	VI	147	sand	394	12.6		72.9	22.3	4.9	15.2	20.7	97.5	192.8	158.0	181.9	91.8	273.7

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							Constituents as Analysed (parts per million)										Hardness as $CaCO_3$ (pts.per million)		
Sample Number	Owner	Lot	Concession	Depth of well (Feet)	Aquifer	Total dissolved solids parts per million)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Alkalis (as Na)	Sulphate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Bicarbonate (HCO_3)	Alkalinity (as $CaCO_3$)	Ca hardness (as $CaCO_3$)	Mg hardness (as $CaCO_3$)	Total hardness (as $CaCO_3$)
20	W. Ross	2	VI	25	Clay	420	13.4		116.2	12.3	10.4	31.7	13.2	24.8	361.1	296.0	289.9	50.6	340.5
21	Spring near Chalk Lake	6	VII	0	sand	244	10.2		63.4	10.0	3.2	12.8	nil	7.1	224.5	184.0	158.2	41.2	199.4
22	E. Carlin	16	VII	5	sand	190	8.8		53.2	4.5	2.7	8.6	nil	3.1	178.1	146.0	132.7	18.5	151.2
23	G. Campbell	23	VII	16	sand	290	10.8		79.0	8.8	3.7	12.8	nil	17.7	262.3	215.0	197.1	36.2	233.3

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