Geoscience Canada

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Volume 9, Number 1, March 1982

URI: https://id.erudit.org/iderudit/geocan9_1aqg09

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Publisher(s)

The Geological Association of Canada

ISSN

0315-0941 (print)
1911-4850 (digital)

Explore this journal

Cite this article

Farvolden, R. N. (1982). Groundwater Supplies for Waterloo Region — The Role of Geology. *Geoscience Canada*, *9*(1), 68–70.

Article abstract

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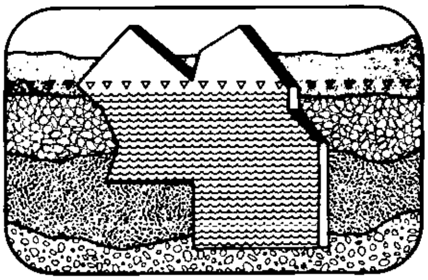

Groundwater Supplies for Waterloo Region — The Role of Geology

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Summary
The municipal water supply for the Kitchener-Waterloo-Cambridge region of Ontario is provided by wells in Quaternary gravels. There is justified concern that future needs cannot be provided for unless a new source is found. The favoured solution is a pipeline to Lake Erie at a very high cost ($150 million in the early '70s). Many informed geologists and engineers believe that additional groundwater supplies are available, and perhaps sufficient to meet the forecast demands. The key factor in a technical solution to the problem is better data on the Quaternary stratigraphy. Funds have not been made available for basic stratigraphic studies using modern techniques and as a consequence hydrogeology cannot be used effectively in dealing with the problem.

The inadequacy of geologic data is not limited to this region. Basic geologic mapping is lacking generally for assessment development and protection of our groundwater resources, and somehow we have to convince government officials and funding agencies that it will pay to correct this deficiency.

Groundwater Supplies
Since the turn of the century, Pleistocene aquifers have provided a very economical source of municipal water in the Kitchener-Waterloo-Cambridge region, with no failures or shortages worth mentioning. It is perhaps the major groundwater development in Canada.

In 1971, forecasts for future requirements were for an increase in average daily demand from about 23 million gallons per day to 60 million gallons per day by 1996. Analysis of well hydrographs suggested that withdrawals from the known aquifers were approximately balanced by natural recharge. Geologic evidence suggested that production of groundwater could be increased significantly by further exploitation of known aquifers, but rural residents were strongly opposed to additional municipal wells and higher pumping rates.

The Grand River flows through all three cities but the entire low flow in the summer is required to dilute the sewage effluent from the cities.

An alternative proposed by the Ontario Government was a pipeline to Lake Erie at a cost of 150 million dollars, of which the Kitchener-Waterloo-Cambridge share would have been about 100 million dollars. Local authorities objected to this expensive proposal because the need was not obvious to them.

Following a mild confrontation the Government funded an extensive field investigation which led to a design for an artificial recharge system to provide groundwater for the forecast demand. The recharge system was surely a reasonable proposal. However, as presented (Catch-22), it required a dam and a reservoir on the Nith River, which was opposed because farmland would be flooded. The opposition was strong enough that some of us believed the project would be rejected on political grounds.

The purpose of the dam and reservoir was to provide a guaranteed supply of river for recharge pits. This proposal ignored one of the major advantages of groundwater supplies, that is, the enormous volume of water in storage. In this case there is no need for continuous recharging of aquifers to maintain storage. It is quite acceptable to recharge only when water is available, during intervals of high flow, and to allow overpumping and a decline in storage at other times. Thus we remove the need for a dam and reservoir for this particular recharge scheme.

Public interest was high and the local newspaper reported on an interview with an experienced geologist who advised exploration for an underground river which he believed must be present in the region. The papers also reported that the Regional Government was pleased to accept this as another possible solution to the problem. A special meeting was called to consider the matter and all interested parties were invited. The idea of the underground river was quickly debunked.

Immediately there was renewed pressure on the Region to support the pipeline alternative on the basis that the costly studies on artificial recharge had not led to an acceptable solution to the problem. The "new" concept of intermittent artificial recharge called for a review of the project and it was argued that the lead time for proven additional supplies was becoming uncomfortably short. In order to gain time we then proposed an exploration program for river-connected aquifers along the Grand River to meet short-term growth in demand. The proposal was written as a simple search for additional water supplies with no component whatever for improving our basic understanding to enhance future work. This project was approved and funded by the Ontario Ministry of Environment ($75,000) and the Regional Municipality of Waterloo ($25,000), and work began in 1975.

River-connected aquifers are permeable sands and gravels that underlie a river and are hydraulically connected to it. Pumping water from the aquifer causes a cone-of-depression that expands in the ideal case only as far as the river which acts as a recharge boundary (Fig. 1). The water level in the aquifer is maintained by "induced infiltration" from the river. If the hydraulic connection is not good then induced infiltration may be insufficient for stabilization and the cone-of-depression then expands underneath the river.

Geologic factors are the primary concern in exploration for river-connected aquifers. It was immediately apparent that thickness, extent and permeability of the river-connected aquifiers were of primary importance to opportunities for induced infiltration. An abritrary decision was reached that 6 to 7 metres of saturated gravel was the minimum thickness for a successful operation. This would allow for a 3-metre screen at the bottom of a well, and 3 to 4 metres of drawdown. The minimum extent of suitable aquifers was not set as pump testing would be better than subsurface geologic data in checking adequacy in this respect. The water quality of the bedrock was known to be poor so localities with an impermeable stratum between the aquifer and bedrock would be favoured over those where the aquifer lay directly on bedrock. Finally, fine grained bottom sediments are common in the Grand River and they reduce the hydraulic connection between the river and the aquifer.

At this stage we knew very little of the history and associated alluvium in the Grand River valley. The work began by examination of maps and airphotos of the river and tributaries within a few miles of Kitchener and Waterloo. Data on subsur-

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face geology were assembled and examined Some 21 sites were selected as worthy of field examination and preliminary test drilling (Fig. 2). In the end, test wells and observation wells were installed at the four sites named on the map and pump tests were conducted. In addition, a river-connected aquifer previously discovered by International Water Supply while working on a Region project was pump tested for several weeks to test for migration of pollutants from the river to the well.

All aquifers tested showed a hydraulic connection with the river that was far from ideal. As expected, river-bottom sediments seriously impeded infiltration to aquifers. Drawdown cones expanded far under the river and were detected on the opposite side. This handicap was reduced significantly by dredging in the vicinity of the pumped wells. Drawdown cones stabilized to the degree we believed a steady state solution was possible. Figure 3 shows response in observation wells for a test at the Doon site.

The main conclusion of the study was that 9 million gallons of water per day could be developed from the four new sites and the previously known site. This was about one-quarter of the additional supplies then sought by the Region to meet future demands. The Forewell site (Fig. 2) has now been partially developed and supplies about 1.5 million gallons per day to the municipal system. The quality of the water is good. Other sites will be developed as required.

One of the obstacles to exploiting the river-connected aquifers discovered in this study was a government ruling that pumping would not be allowed during low flow because it would reduce the flow of the river needed for sewage dilution - this in spite of the fact that the affect would be too slight to detect. Nevertheless, water from induced infiltration will not be available when needed most - during a summer drought. The answer is to make up the difference by heavier pumping withdrawals from the existing well fields. But further development of the best of the known aquifers is blocked by an Ontario Government policy that limits interference in domestic wells by heavy pumping of municipal wells. Thus shallow private wells which are seriously affected by even minor interference can preclude development of a major aquifer. Heavier pumping of the municipal wells would indeed cause increased drawdown within the cone-of-influence but this merely takes advantage of the enormous volume of water in storage in the subsurface. Following a drought, when river flow increases, production from the river-connected aquifers could resume and the other well fields could be allowed to recover.

But herein we encounter another "Catch-22". Analysis to predict the response of well fields to intermittent and varying production would require very good data on hydrogeology. However, geology has never been the prime con-

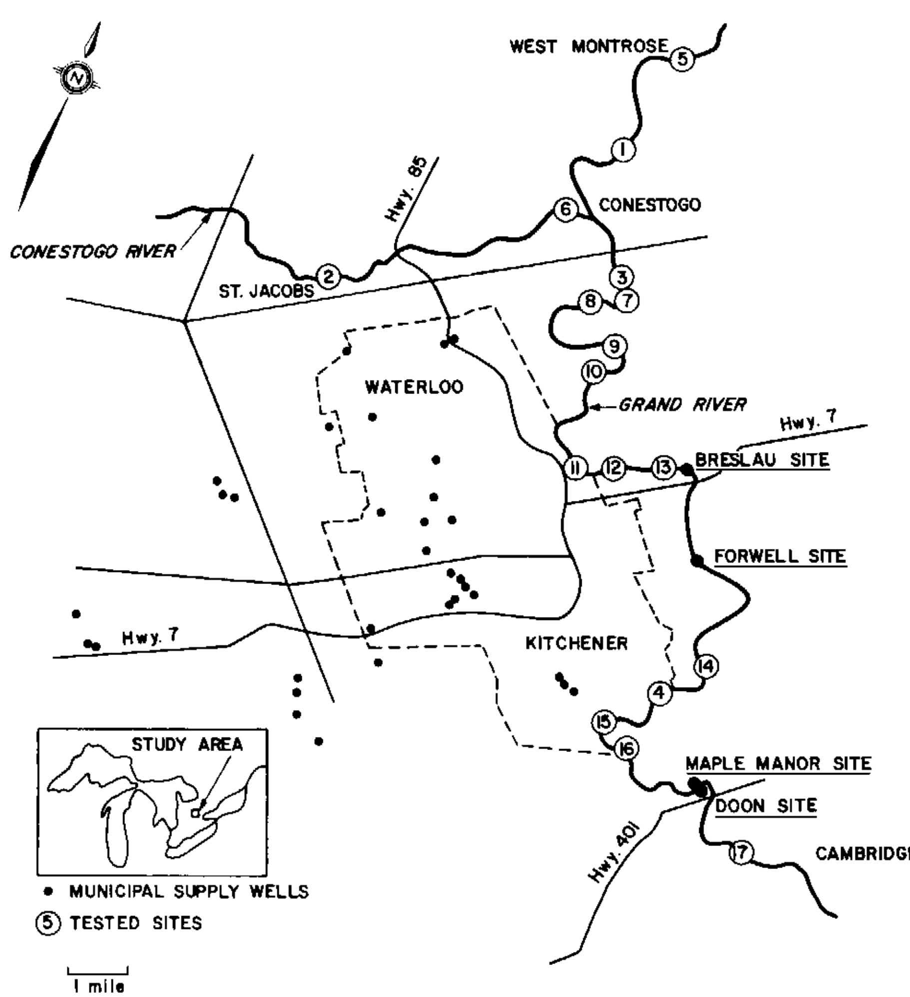

Figure 2 *The Grand River Induced Infiltration Study. Pump tests were conducted at Breslau site, Forewell site, Doon site and Maple Manor site. Test drilling was done at sites 1-17.*

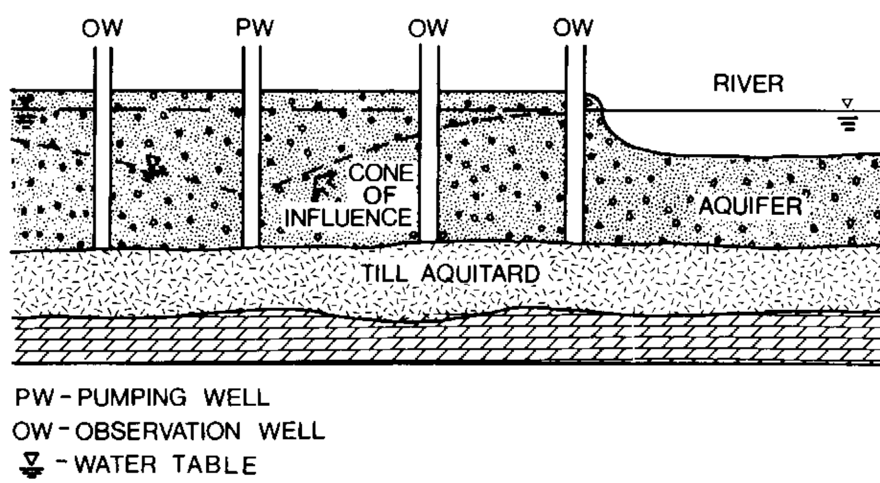

Figure 1 *Induced Infiltration. The spread of the cone-of-influence is restricted by the river, a recharge boundary.*

cern of any of the numerous major studies on the water supply of the Region, including our induced infiltration study. Thus the hydrogeology of the aquifers and the groundwater regime remain obscure.

All geologists who have worked and reported on the water resources of the Region believe that considerably more groundwater can be safely developed from existing or undiscovered aquifers. However, it is impossible to defend this view against skeptics because of lack of good data. None of the major studies on groundwater resources since 1962 have included the acquisition of new geologic data. One of these studies was undertaken without any direct geologic input. Another study of the water resources of the Grand River Basin is just being completed and again, no new geologic information was acquired. These so-called studies are really mere reviews. They have not led to the discovery of new sources of water. Small wonder that water supply officials and local politicians have little faith in "further studies".

In the case of the induced infiltration study we knew the geologic target of the search. Using only geologic common sense we were able to prove new sources for one-quarter of the additional water supplies needed for the region for the next two decades. The cost was about $150,000 which would be approximately the carrying charges on the pipeline to Lake Erie for a long weekend. Surely this speaks well for the role of geology in this enterprise.

This project could have been much more effective if detailed geologic reports and maps of the Grand River alluvial had been available. We are still not sure of the origin of the aquifers that were discovered. We are even more ignorant of the properties, distribution and origin of the aquifers exploited by the existing well fields. It seems incredible that we know so little of the geology in one of Canada's most productive and perhaps most important aquifer systems that we cannot apply standard hydrogeologic principles to groundwater exploration and development. If this were the case in a city in the third world, CIDA would rush to sponsor a project to bring the benefits of modern science to our less fortunate friends.

Further, if we were to bring in consultants from any European country, or the USA, their first reaction would be one of incredulity that we do not have reliable data on subsurface geology. Their first recommendation would be to get it.

Lack of information on groundwater occurrence favours the local driller who is generally regarded as the expert. Under the circumstances, this may well be so. Few people in politics think water supply problems may be solved through geology. Thus there is no pressure on the government to discover and map our aquifers. The subject is not highly regarded by academic peers as a research theme. So less than 19 years before 2000 A.D. we still depend in Ontario on logs submitted by drillers for most of our geologic information on groundwater resources. It's simply not good enough for decisions on 100 million dollar projects.

MS received November 2, 1981

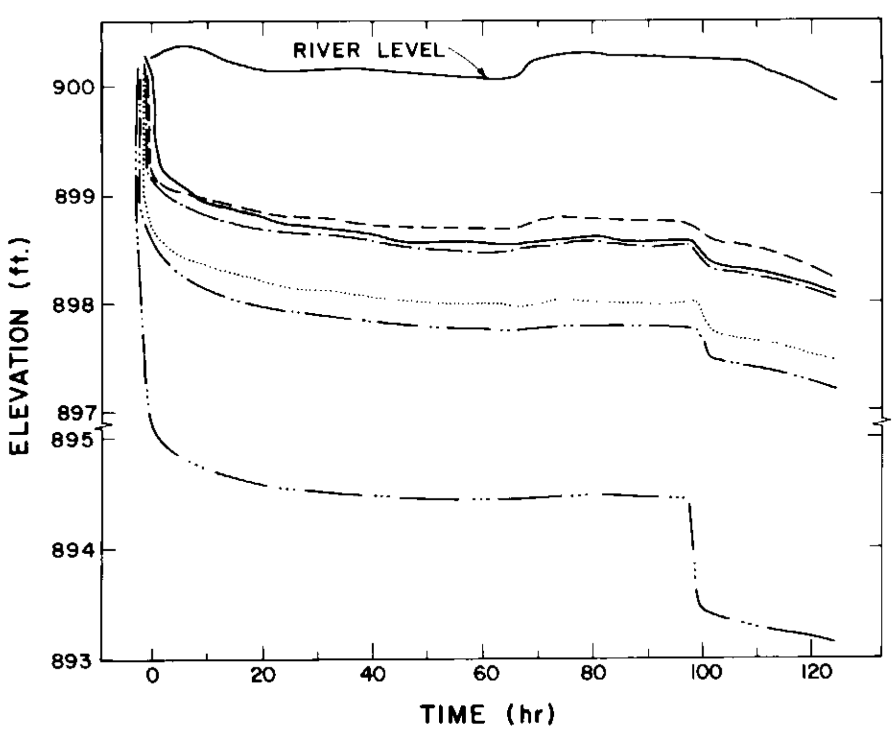

Figure 3 *Doon Pump Test. Hydrographs show response to pumping in observation wells. The hydraulic connection between the aquifer and the river is apparent.*