No. _____

CANADA

DEPARTMENT OF MINES AND TECHNICAL SURVEYS

GEOLOGICAL SURVEY OF CANADA

TOPICAL REPORT NO. 46

PROSPECTS FOR A LARGE INDUSTRIAL GROUND-WATER SUPPLY IN TWO AREAS OF NOVA SCOTIA

(A PRELIMINARY SURVEY)

BY

P. MEYBOOM

OTTAWA

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Introduction

A textile industry that may be established somewhere in Nova Scotia, requires 6 or 7 million gallons of water per day for cooling purposes. This water has to be cool (50° - 55° F) and of good quality (non-corrosive, H_2S less than 5 ppm and hardness less than 100 ppm). As groundwater was believed to satisfy both the temperature and quality requirements, the Nova Scotia Department of Mines, initiated a small-scale ground-water investigation. The ground-water resources of two areas were considered, both of which will be discussed below in detail.

The following report is based on information obtained from discussions with Dr. J. P. Nowlan, Dr. J. D. Wright, Mr. F. Shea and Mr. F. C. Townsend; on field observations made during October 17 and 18, 1961 and upon stream-flow measurements contained in Water Resources Papers 104, 108, 112, 116 and 120.

Groundwater in the New Glasgow area

a. Groundwater in bedrock: The bedrock formation that was considered to be the most promising to yield large quantities of groundwater was the Triassic New Glasgow formation. The formation is exposed in the Green Hill area near New Glasgow (Fig. 1) and a short field trip in this area revealed that the formation consists of interbedded, conglomerate, sandstone and shale all having a conspicuous red colour. The strata dip 14° SE and form a steep escarpment of 400 feet high along the NW side of Green Hill. The sandstones and shales of the New Glasgow formation are probably of very low permeability and even the permeability of the tightly cemented

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Produced and printed by the Surveys and Mapping Branch, Department of Mines and Technical Surveys
Converted from the First Edition of the 1:63,360 map to 1:50,000 in 1956.

NEW GLASGOW
PICTOU COUNTY
NOVA SCOTIA

MAGNETIC DECLINATION 23°58′ WEST AT CENTRE OF MAP 1956
Annual magnetic change 1′30″ easterly

REFERENCE

Roads:
class 1, trunk road
class 2, secondary thoroughfare
class 3, local road well travelled
class 4, local road slightly travelled
pack trail or path
Railway: normal gauge, single track
Boundaries:
county
parish
Power transmission line
Telephone line

1 0 1 2 3 Miles
1000 500 0 1000 2000 3000 4000 Metres
1000 500 0 1000 2000 3000 4000 Yards

Figure 1

REFERENCE

Triangulation station
Buildings . School
Post office . Cemetery
Church, with spire . Church, without spire
Mines . Mill, saw, grist etc.
Lighthouse . Bench mark
Stream, non-perennial
Marsh
Contours
Contours, submarine in fathoms
Forest, heavy woods

conglomerate does not seem to be appreciable.

The beds are intersected by a well-defined system of NE striking joints, approximately perpendicular to the bedding planes. A supposed fault along the NW side of Green Hill (Fig. 2) separates the smooth topography of Carboniferous and Permian sandstone and shales from the more rugged topography of the Triassic sequence. Northwest of Green Hill (Fig. 1) are Dalhousie Mountain and Fitzpatrick Mountain, both consisting of New Glasgow conglomerate, separated from Green Hill by the West River which has its shallow valley in the softer Permian sediments. The Middle River, the valley of which is also in Carboniferous and Permian shales and sandstone, flows southeast of Green Hill.

There are numerous springs at both sides of Green Hill and all farms have a spring-water supply. There is no particular spring horizon however. In the lowland along the Middle River is a flowing well, approximately 60 feet deep that obtains water from shale (?). The flow is small and the head is only a few feet above surface.

The nature of the springs and the flowing well indicate an unconfined flow system in a non-homogeneous aquifer (Fig.2). The entire Triassic sequence can therefore be considered as one hydrologic unit, the yield of which is demonstrated by the magnitude of the springs. The fault zone separating the Triassic from the Permo-Carboniferous strata does not seem to disturb this hydrologic unity and the yield from this zone is therefore probably not more than the yield from the undisturbed formations.

b. Groundwater in recent alluvial deposits: Most alluvial deposits in Nova Scotia are fine-grained and they are therefore unsuitable for induced infiltration as a means of obtaining large quantities of groundwater. However, some gravel was reported along the West River near

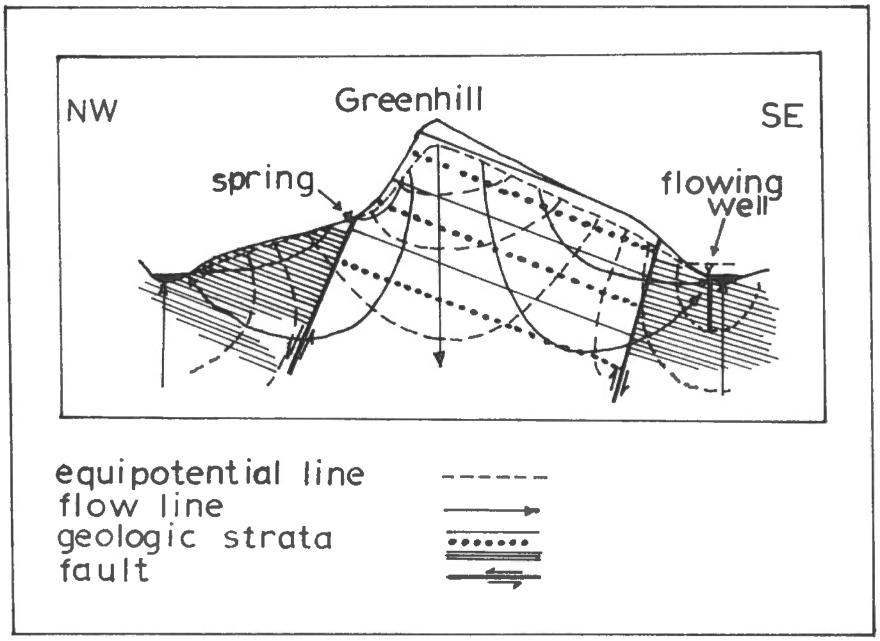

Figure 2. Schematic cross-section of Green Hill showing pattern of ground-water flow between West River and Middle River

Durham (Fig.1). A short examination of this site showed bedrock outcrops at both sides of the river and the gravel deposits that are mined here for road construction are thin and irregular in occurrence. Mr. Shea informed me that this was the common situation in this part of Nova Scotia and the occasional gravel pockets in the river valleys can therefore not be considered as potential aquifers for industrial purposes.

c. Groundwater in abandoned coal mines: A number of old coal mines in the New Glasgow area are filled with water, and judging from the amount that has to be pumped from one of the active mines (0.4 million gallons per day), these abandoned mines could be a considerable source of water. However, for the present purposes the water appears to be unsuitable, for its quality is poor (high hardness and very corrosive) and the temperature is probably close to 70°F because of the depth of the mines. Nevertheless, this water may be a usuable supply for some future purpose.

Groundwater in the Milford area

It is obvious that one type of aquifer that may fulfill the primary physical requirements is one consisting of coarse unconsolidated material, having a free water-table and a firm catchment area (or being in the vicinity of a body of surface water).

One of the few places in Nova Scotia where these conditions seem to exist is near Milford (Fig.3), situated 30 miles NE of Halifax. Here an esker and outwash plain, occupies an area of nearly 1,800 acres. The esker is a narrow ridge, about 4 miles long and 0.25 - 1 mile wide, trending E - W. During a short field trip an attempt was made to determine the approximate boundaries of the esker and to collect some hydrologic information of the area. The area is gently undulating and the vegetation

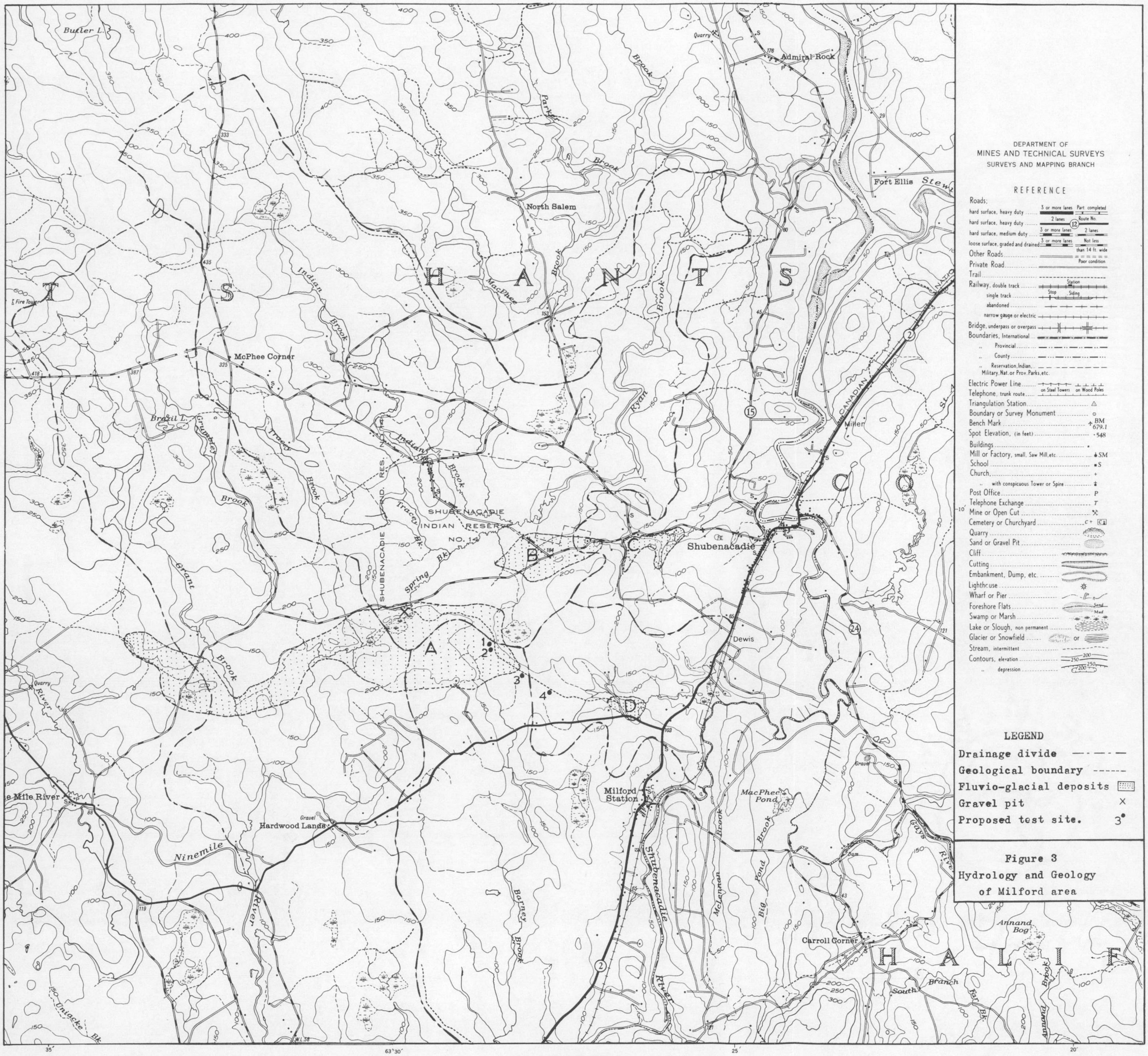

Figure 3
Hydrology and Geology
of Milford area

consists of spruce, fir, pine, poplar and birch. The infiltration capacity of the soil is probably very high.

The Nova Scotia Sand and Gravel Ltd. has a large gravel pit (marked X on figure 3) in the northern flank of the esker. The exposed section showed about 40 feet of cross-bedded sand and gravel layers, varying in thickness from a few inches to several feet. The materials range in grain size from medium-fine sand to boulders, but the predominant sediment is coarse sand. The mining operations do not got below the water-table, which is marked by the presence of a slough in the lower portion of the pit. A borehole at the bottom of the pit penetrated 40 feet of saturated sand and gravel, that becomes coarser with increasing depth. The hole did not reach the bottom of the esker deposits.

Nova Scotia Sand and Gravel Ltd. processes its raw products for various purposes and large quantities of water are required for the washing and crushing plant. To this end a shallow pond has been dug, containing about six feet of water. By means of a simple intake mechanism water is pumped from this pond at a rate of 1,700 gallons per minute (gpm) which amounts to 2.44 million gallons per day (mgpd). Last summer this practice was maintained for 24 hours during 30 days. This caused a 4-foot drawdown in the pond, but after pumping stopped, recovery was nearly instantaneous, except for the last foot which recovered more slowly. The operator of the pit had noticed neither any seasonal fluctuations nor a regional decline of the water-table, probably because the water is returned to the aquifer after it has been used. This recharge mechanism is simply a wooden flume, discharging into the slough. The consumptive use of this entire process is probably very low, which enabled continuous operation without overdraft of the aquifer.

The gravel pit is located slightly north of the watershed between the Ryan Brook drainage (northward) and the Grant Book drainage (southward) and the aforementioned slough marks the divide, indicating that the drainage from the slough takes place in northeastern as well as southwestern direction. This seems to be quite characteristic for this area, for a number of sloughs appear at or near the watersheds (Fig.3). This feature has also been noticed by Scott (1961) who reports that peat bogs occur in the headwaters of the Shubenacadie drainage system also.

The areal extent of the esker and the associated kames is well shown on the soil map of Hants County (Cann, Hilchey and Smith, 1954) and it would not be surprising to find that this complex of fluvioglacial deposits continued east of Milford, across the Shubenacadie River. (Information given by Professor R.H. McNeill of Acadia University substantiated this opinion. His maps of glacial landforms indeed show various sand ridges - eskers or kames - east of Milford). The sand deposits are surrounded by a reddish, clayey till, locally containing abundant pebbles. It is not known whether the sand and gravel islands near Milford and Shubenacadie (marked B, C and D on figure 3) are connected with the main esker underneath the till. Professor McNeill did not rule out this possibility, for the esker may rest on an older till than the one that surrounds it at the surface.

General considerations

In applying the principle that the mean minimum stream discharge (MN_q) is indicative for the amount of ground-water discharge from any particular drainage basin, one may obtain reliable estimates of the amount of groundwater that is discharged annually by analyzing stream-flow

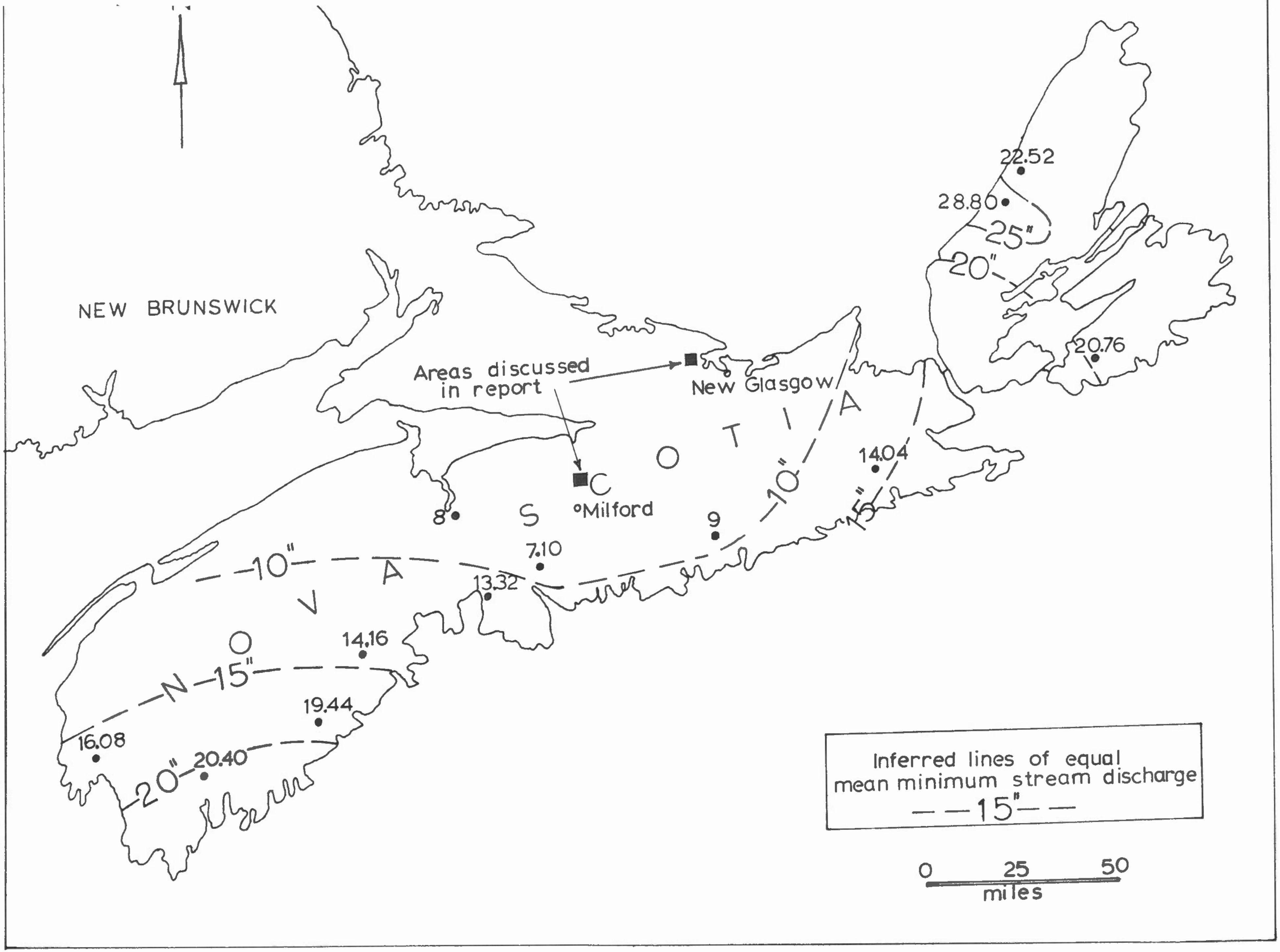
NEW BRUNSWICK
NOVA SCOTIA
Areas discussed in report
New Glasgow
Milford
22.52
28.80
25"
20"
20.76
14.04
15"
10"
9
8
7.10
13.32
10"
14.16
15"
19.44
16.08
20.40
20"
Inferred lines of equal mean minimum stream discharge
15"
0 25 50
miles

Figure 4

records. By assuming that the ground-water system is in equilibrium, it can be stated safely that the amount of ground-water recharge equals the amount of ground-water discharge. This method of MN_q analysis is particularly valid in humid areas, where the evapotranspiration losses by vegetation are negligible on account of the fact that plants have ready access to other water than that in the zone of saturation.

In order to obtain an estimate of the annual ground-water recharge in Nova Scotia, stream-flow records of 11 Nova Scotia rivers were analyzed for the period 1947-1957. The mean minimum discharge of each river during this period is presented in table 1 as well as in figure 4. Figure 4 shows a very tentative pattern of ground-water discharge in southern Nova Scotia.

According to Cann et al. (1954) the annual water surplus in Windsor amounts to 18.24 inches. From the stream records it appears that 44% of this surplus is used for ground-water recharge, which would result in a value of 8 inches of recharge for Windsor. This value agrees very well with the ones obtained from the stream-flow analysis. It can thus be estimated that approximately 7 inches of water are annually available for ground-water recharge in the Milford area. Converted to Imperial gallons per day per acre (gpd/a), this means a "daily" natural recharge of 425 gpd/acre.

TABLE I

Mean minimum stream discharge of 11 Nova Scotia rivers for the period 1947-1957

(Annual data obtained from Water Supply Papers) 104, 108, 112, 116, 120.

River	MN_q sec. feet	MN_q inches
East River at St. Margaret Bay	9.7	13.32
Grand River at Loch Lomond	66.2	20.76
Lahave River at W. Norfield	523	14.16
NE branch Margaree River at Frizzleton	261.2	22.52
SW branch Margaree River at U.Margaree	304	28.80
Medway River at Charleston	815	19.44
Musquodobit River at Crawford's Falls	173	9.00
Rawdon River at Kinsac	29.1	7.20
Roseway River at L. Ohio	287.6	20.40
St. Mary River at Stillwater	460	14.04
E. branch of Tusket River at Wilson's bridge	588	16.08

It is obvious that any area in the vicinity of Milford that may be physically able to yield 6 mgpd, will only receive an equal amount of natural recharge if the cone of depression around the well (-field) comprises of an area of $\frac{6 \text{ mgpd}}{425 \text{ gpd/a}}$ = over 14,000 acres. It is highly unlikely however that the physical boundaries of the aquifer will allow the existence of such a large area of withdrawal. If the esker aquifer is able to transmit the required 6 mgpd, the production will exceed natural replenishment approximately 14 times and it is clear that in case such an amount were to be withdrawn, the aquifer has to be recharged artificially in order to prevent overdraft and to maintain the natural balance between intake and output. Apparently, this principle is applied successfully in the gravel pit, for even 2 mgpd without artificial recharge would be a serious overdraft of the aquifer.

It is interesting to report similar conditions from Sweden. Jansa (1954) states: "The only sand and gravel layers of any interest with respect to the value for municipal water supplies are the glacial eskers. The natural ground-water resources of the eskers are, however, limited, and therefore the method of artificial replenishment has been applied at a growing number of municipal waterworks".

It is fortunate indeed, that the textile industry does not contaminate its cooling water, for this means elimination of treatment prior to artificial recharge. The system could operate as a closed circuit in which the aquifer serves as a natural cooler of large quantities of water. The temperature rise within the aquifer due to the injection of heated water is difficult to determine analytically, but experience elsewhere has shown that this method can be used successfully, provided that the recharge wells or recharge gallery are properly located in relation to the entire flow system.

Summary and Recommendations:

1. The ground-water resources of the New Glasgow area appear to be insufficient for large-scale industrial development.

2. The ground-water resources of the Milford area appear to be quite promising for industrial development for the following reasons:

   a. The esker-outwash complex NE of Milford is capable of yielding 2.5 mgpd by very simple and crude means.

   b. The saturated thickness of the aquifer is proven to be at least 40 feet at one location.

   c. Continuous pumping at 1700 gpm (2.44 mgpd) caused a drawdown of 4 feet, indicating a very high transmissibility value of the aquifer.

3. Based on the facts mentioned under 2, it is necessary and justified to carry out further testing in order to determine the following points:

a. Are the isolated sand and gravel islands B, C and D connected underneath the till with the main esker A?

b. What is the thickness, extent and lithology of the esker deposits?

4. In carrying out this testing program, the following points should be kept in mind:

a. All test holes should be logged properly and should be provided with temporary casing.

b. Two of the test holes should be spaced sufficiently close together (200 feet) to enable a pump test with one observation well.

c. The test holes that are to be used for pump test purposes, should be provided with slotted casing across the saturated portion of the aquifer, and these wells should be developed to such an extent that they can yield at least 250 gpm. The pumping well should be fitted with a so-called airline, in order to carry out water-level measurements inside the pumping well.

The four test holes shown on figure 3 are considered to be most favourable for initial testing purposes. If the initial tests are successful further tests have to determine what the configuration of the water-table would be if 6 mgpd were withdrawn from the aquifer. This knowledge will enable the most efficient location of recharge wells.

REFERENCES

Cann, D.B., Hilchey J.D., and Smith, G.R., 1954, Soil Survey of Hants County Nova Scotia. Nova Scotia Soil Survey Rept. 5 65 pages and 1 map.

Jansa, O.V.E., 1954, Artificial ground-water supplies of Sweden. Intern. Assoc. Sci. Hydrol. Publ. 37, Tome II, p. 269.

Scott, J.S., 1961, Toxicity of surface waters in a part of Shubenacadie drainage system, N.S. Geological Survey of Canada, Topical Report No. 34, 5 pages and 1 map.