Occasional Report No. 2
Groundwater Division
Department of Mines

INVESTIGATION OF GROUNDWATER CHEMISTRY IN THE
Brisbane - Wollongong Area.

3 October 1959.

Messrs. D.J. & Background, To.

Property of:
Department of Mines
New South Wales Department of Mines
Hanna, N.S.
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Trends in groundwater chemistry are considered for the Dartmouth-
Wolfville area. In a systematic way five different source areas, from
which water is derived, have been recognized. These are: (1) the Halifax-
New Cummam - Kentville Series of slates; (2) Pleistocene sands and gravels;
(3) the Horten grit; (4) the Triassic sandstones and; (5) fractures in the
North Mountain basalt.

Water from the Halifax - New Cummam - Kentville slate source
area is characteristically soft, high in iron, contains less than 100 ppm
of dissolved solids and has a narrow (5.9 to 7) pH range.

Water from the Pleistocene source area is characterized by high
nitrate, a total hardness of as much as 138 ppm (total as CaCO₃), and a
comparatively high content (22 ppm) of total dissolved solids. The pH
ranges from 6.3 to 9.1.

Water from the Horten source area, contains as much as 90 ppm
chloride and 66 ppm sodium. It is further characterized by a low
(110 ppm) content of dissolved solids and by a narrow (7.6 to 8.2)
alkaline pH range.

Evaluation of the two remaining source areas will be made upon
acquisition of chemical analyses.

Fifteen water supplies from the three different source areas
show nitrate contamination. It is impossible, however, to predict con-
tamination in any particular water supply. It is recommended that where
contamination is shown to exist bacteriological counts be made.

The requirements of water quality in industry and agriculture
very widely. Reference should be made in the literature for recommended
tolerances, which may be compared with the data contained in this paper.

2:0 INTRODUCTION

The area under investigation falls within the following two map sheets; namely, Wolfville, 21 H/1 West and Berwick, 21 H/2 East. All maps and tables referred to by number in this report are listed in Appendix B.

The data employed in the compilation of this report consist mainly of chemical analyses of fifty-nine water samples. The analyses were performed by Messrs. J. Hailey, W. Shand and G. Byers at the Truro Agricultural College. More than 250 samples remain to be processed. The results of the individual and various combinations of the mineral constituents in these analyses have been expressed in parts per million (p.p.m.).

The water samples represent supplies of drinking water currently being utilized for human consumption. These supplies take the form of one of the following: - springs, dug wells, and drilled wells. Each station from which a sample has been taken is designated accordingly on the hydrochemical maps 8 to 23.

The term area area, as used in this report, refers to the particular rock (or to features of that rock) or to the material from which the water supply has been derived.

For the area under consideration hydrological data such as runoff, transmissibility of the various materials, groundwater flow, infiltration, etc., are sparse. To major hydrological investigations are known to have been carried out in the area prior to this present survey. Field investigations of the Groundwater Division in this respect have only just begun.

Chemical analyses of all the samples from the area under consideration are not yet available; therefore, this report must be regarded
as preliminary.

3:0 PURPOSE

Undoubtedly geological environment determines to large degree the quantity of groundwater available. That this environment also contributes to the quality of groundwater will be demonstrated for a particular case. Because the quality of groundwater is dependent on the quality of its source water, special consideration for possible contamination must be made. The purpose of this report will be to examine the chemical nature of the groundwater within the Berwick-Wolfville area, to consider such data in terms of the source areas of these waters, and to relate those factors to Public Health standards.

Note: Only those analysis sheets (on file) bearing a check mark \( \checkmark \) on the upper right hand corner have been used in preparation of this report.

4:0 OVERVIEW & GEOLOGY

Reference should be made to Occasional Report No. 2 (Koslowski, D., Aug., 1964) for a review of the geography and geology of the area.

The groundwater within the area are believed to have five source areas. These are: (1) fracture in the Halifax-Rus Canaan-Kentville Series of strata; (2) Pleistocene sands and gravels; (3) the Horton silt; (4) the Triassic sediments; and (5) fractures in the North Mountain basalts.

5:0 CHEMISTRY OF THE GROUNDWATER

5:0 GENERAL

The water-well survey carried out by the Groundwater Division provided general information on the depths of wells and on the nature of the material through which these wells were dug or drilled. In only a few
instances, however, was it possible to refer a particular drilled well to such records as the ten main well drillers in the Annapolis Valley, Frask and Kennedy, have maintained. In many cases the material in which a well is completed has been determined with a fair degree of assurance. A well may be described by the property owner as having been finished in "lodge" (slate Series) or in sandstone (Triassic), in gravel (Pleistocene), or in the case of deep wells located in the Opatowau Valley in sandstone (Horton grit). The source of water for a particular well is, however, not always known. Many people have attempted to by-pass the abundant, though relatively hard water in Pleistocene sands and gravels for the softer but less abundant water in the slate Series. (In fact, because the effectiveness of proper screening techniques is poorly appreciated such practice has been the rule rather than the exception.) In the instance where such a well is poorly finished, a mixing of waters from different source areas is almost certain to take place.

Table 4 shows the range of chemical composition of groundwater from supplies for which the source area of the water is known. Each analysis is represented on the diagram by a point. The central cross-hatched portion of each diagram represents variation in the amount of dissolved solids. It is apparent on inspection of these diagrams that the chemical composition does vary significantly among waters from the different source areas. For example, water from the source area of Pleistocene materials contains a higher content of total dissolved solids than water from either of other two source areas which are considered in this report. Table 6 further substantiates these differences in chemical composition very well.

Table 5 shows the range of chemical composition of groundwater from all supplies exclusive of those which have been used in the compilation of Table 4. The source area for the waters of the wells and springs used in Table 5 are not known definitely. Ideally, that is if the source area as used in Table 5 are correct, and if there were no pollution or influx of waters from another source, the diagrams of Tables 4 and 5 would match.
TABLE 1
DRINKING WATER STANDARDS ... after Le Breton (1963, pg 63)

<table>
<thead>
<tr>
<th>Constituent</th>
<th>U.S. Public Health Service</th>
<th>Alberta Government</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total dissolved solids</td>
<td>1000 p.p.m.</td>
<td>1600-2000 p.p.m.</td>
</tr>
<tr>
<td>Sulphates</td>
<td>250 p.p.m.</td>
<td>800 p.p.m.</td>
</tr>
<tr>
<td>Chloride</td>
<td>250 p.p.m.</td>
<td>435 p.p.m.</td>
</tr>
<tr>
<td>Nitrate</td>
<td>10 p.p.m.</td>
<td>10 p.p.m.</td>
</tr>
<tr>
<td>Iron</td>
<td>0.3 p.p.m.</td>
<td>0.3 p.p.m.</td>
</tr>
</tbody>
</table>

MANDATORY LIMITS FOR

<table>
<thead>
<tr>
<th>Constituent</th>
<th>Upperlimit p.p.m.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lead (Pb)</td>
<td>0.1 p.p.m.</td>
</tr>
<tr>
<td>Fluoride (F)</td>
<td>1.5 p.p.m.</td>
</tr>
<tr>
<td>Arsenic (As)</td>
<td>0.05 p.p.m.</td>
</tr>
<tr>
<td>Selenium (Se)</td>
<td>0.05 p.p.m.</td>
</tr>
<tr>
<td>Nonvalent Chromium</td>
<td>0.05 p.p.m.</td>
</tr>
</tbody>
</table>

...after Todd (1959, pg 185)
<table>
<thead>
<tr>
<th>Hardness Classification</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 15 p.p.m.</td>
<td>Very soft water</td>
</tr>
<tr>
<td>15 to 50 p.p.m.</td>
<td>Soft water</td>
</tr>
<tr>
<td>50 to 100 p.p.m.</td>
<td>Medium hard water</td>
</tr>
<tr>
<td>100 to 200 p.p.m.</td>
<td>Very hard water</td>
</tr>
<tr>
<td>11 Bottomed In</td>
<td>Type</td>
</tr>
<tr>
<td>----------------</td>
<td>------</td>
</tr>
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<td></td>
<td>SLATE</td>
</tr>
<tr>
<td>0</td>
<td>68</td>
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<tr>
<td>0</td>
<td>392</td>
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<tr>
<td>0</td>
<td>204</td>
</tr>
<tr>
<td>0</td>
<td>353</td>
</tr>
<tr>
<td>0</td>
<td>305</td>
</tr>
<tr>
<td>0</td>
<td>322</td>
</tr>
<tr>
<td>0</td>
<td>33₄</td>
</tr>
</tbody>
</table>

Quantities given as p.p.m.

M.B.: Symbols Used: 0 --- dug well
O --- drilled well
O --- spring
<table>
<thead>
<tr>
<th></th>
<th>Table 4</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total Solids</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Ignition Loss</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Hardness</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Sulphates</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Chlorides</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Alkalinity</strong></td>
<td></td>
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<tr>
<td><strong>Iron</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Total Solids</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Ignition Loss</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Hardness</strong></td>
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<td><strong>Sulphates</strong></td>
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<td><strong>Chlorides</strong></td>
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<td><strong>Alkalinity</strong></td>
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<tr>
<td><strong>Iron</strong></td>
<td></td>
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<tr>
<td><strong>Total Solids</strong></td>
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<td><strong>Ignition Loss</strong></td>
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<td><strong>Hardness</strong></td>
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<td><strong>Sulphates</strong></td>
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<td><strong>Chlorides</strong></td>
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<tr>
<td><strong>Alkalinity</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Iron</strong></td>
<td></td>
</tr>
</tbody>
</table>

Shaded portions represent variation in amounts of dissolved solids.

N.B.: Plotted on a Log Scale.
RANGE OF CHEMICAL COMPOSITION OF GROUNDWATER FROM WELLS WITHIN SUGGESTED SOURCE AREAS (Excluding those in Table 4) TABLE 5

<table>
<thead>
<tr>
<th></th>
<th>SLATE</th>
<th>PLEISTOCENE</th>
<th>H.G. T.S.</th>
<th>TRIASSIC</th>
<th>ASALT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Solids</td>
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<td></td>
<td></td>
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<td></td>
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<tr>
<td>Ignition Loss</td>
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<td>T. Hardness</td>
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<td>Sulphates</td>
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<td>Chlorides</td>
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<td>Alkalinity</td>
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<td>Total Solids</td>
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<td>Ignition Loss</td>
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<td>T. Hardness</td>
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<td>Sulphates</td>
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<td></td>
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<tr>
<td>Chlorides</td>
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<td>Alkalinity</td>
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<td>Total Solids</td>
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<td>Ignition Loss</td>
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<tr>
<td>Sulphates</td>
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<tr>
<td>Chlorides</td>
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<tr>
<td>Iron</td>
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<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

N.B. - Data plotted to a log scale. Shaded portions represent variation in amounts of dissolved solids. Well 1 spring.
CHEMICAL ANALYSES OF GROUNDWATERS FROM THE KNOWN SOURCE AREAS

TABLE 6

SLATE

PLEISTOCENE

HORTON
TABLE 7

HUSES OF COINCIDENT CONSTRUCTION OF DRAINAGE

<table>
<thead>
<tr>
<th>No.</th>
<th>H.</th>
<th>Soil</th>
<th>Oil</th>
<th>Ps</th>
<th>Rainfall</th>
<th>Barometric</th>
<th>Low</th>
<th>Material</th>
<th>No.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Min</td>
<td>Max</td>
<td>Min</td>
<td>Max</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>13.5</td>
<td>5.0</td>
<td>4.0</td>
<td>1.9</td>
<td>30</td>
<td>5.0</td>
<td>2.5</td>
<td>0.09</td>
<td>128.5</td>
</tr>
<tr>
<td>2</td>
<td>14.6</td>
<td>5.0</td>
<td>6.2</td>
<td>4.0</td>
<td>42</td>
<td>5.0</td>
<td>2.8</td>
<td>0.09</td>
<td>120</td>
</tr>
<tr>
<td>3</td>
<td>65</td>
<td>5.0</td>
<td>3.2</td>
<td>1.6</td>
<td>50</td>
<td>20</td>
<td>2.0</td>
<td>0.03</td>
<td>0.07</td>
</tr>
</tbody>
</table>
Finally, of course, concentration changes, 'absorption phenomena, 
are exchange, etc., will have played important roles in modifying the 
chemistry of the waters from any one source area. Furthermore, in Table 5, 
data on spring water is considered together with data from dug and drilled 
wells. This fact has apparently caused some anomalies in the diagrams of 
Table 5. In general, the diagrams of Table 4 match those of Table 5, which 
both strengthen the case for classification by source area as a useful in-
dication of water quality.

Detailed discussion of all data anomalies to those listed in Table 3 
is beyond the scope of this report. When all the chemical analyses become 
available, scatter diagrams prepared for pH, etc., can be employed to portray 
the number of values falling outside of the standard range as decided from 
these source areas. These diagrams would do much to clarify any apparent 
differences and are recommended. Table 28 is an example of such a diagram.

The following sections 5.2 to 5.6 deal with the chemistry of the 
waters from each of the five source areas. In these sections only data from 
the selected wells used in the compilation of Tables 3, 4 and 6 will be 
discussed. The general patterns of hydrochemistry will be considered in 
section 5.6 in which the hydrochemical data for the new area evaluated.

5.2 COUNTRY AREA INDEX - NEW MEXICO - SOUTH SANTA FE VALLEY.

The important and fundamental nature of the Santa Fe area is well 
known today. In the vicinity local it also makes present in numbers.
According to Rankama and Salama (1949, pp 663-664) oxidation of pyrite results in the following reactions.

\[ 2 \text{FeS}_2 + 3 \text{H}_2\text{O} + 7 \text{O}_2 \rightarrow \frac{9}{2} \text{Fe}_2\text{O}_4 + 2 \text{H}_2\text{SO}_4 \]

\[ 2 \text{Fe}_2\text{O}_4 \rightarrow \text{Fe}_2\text{O}_3 + \text{O}_2 \]

FeSO₄ is unstable in the presence of atmospheric and dissolved oxygen and becomes converted to ferric compounds. In effect the ferric iron tends to enter into hydrolysis reactions, thus lowering pH by removal of OH⁻.

Thus

\[ 4 \text{FeSO}_4 + 2 \text{H}_2\text{O} + \text{O}_2 \rightarrow 2 \text{Fe}_2\text{O}_3\text{SO}_4 + 2 \text{H}_2\text{O} \] and

\[ \text{Fe}_2\text{O}_3\text{SO}_4 + \text{H}_2\text{O} \rightarrow 2 \text{Fe} \cdot (\text{OH})_3 + 2 \text{H}_2\text{SO}_4 \]

These equations may explain the relatively high iron content (see Table 6) and the acid pH range of the water which has been derived from this particular formation.

Crosby (1962, p. 19) has determined that the feldspars of the natick formation in the plate series are dominantly albite or sodium oligoclase and that this constituent may compose as much as 10% of the rock. Thus weathering of this feldspar could make available a supply of sodium cations to take part in base exchange reactions. This fact might explain the generally soft water found in this formation.

The comparatively low quantity of dissolved solids present in the source area under consideration suggests that movement of groundwater is fairly rapid and that this provides for a constant replenishment of supply. This seems reasonable because of the irregular topography characteristic of areas of alpine.
In one drilled well (Table 3) nitrate content reaches 15 p.p.m. This indicates pollution and, according to Le Breton (1963, pg 45) should be considered dangerous for children less than one year old.

5:3 SOURCE AREA PLIOGENECE:

The nature of the Pleistocene materials of the Norwick - Wolfville area was considered in some detail in Occasional Report No. 2 (Nossman, Aug. 1964).

Inspection of Table 6 reveals that the hydrochemistry of this source area is markedly different from that considered in section 5:2.

Iron content is low.

The range of hardness is comparatively great suggesting that both calcium and magnesium are present in the glacial materials. This fact provides too an explanation of the typically alkaline pH, which ranges from 6.3 to 9.1.

Generally speaking, the Pleistocene source areas have been formed extensively. Thus sprays of copper sulphate, lead acetate, cyanide together with fertilizer in the form of nitrates, lime, etc., have no doubt contributed to the high content of total dissolved solids. However, much of the Pleistocene detritus consists of material derived from igneous rocks such as granite and basalt. These rocks are relatively soluble and probably provide much of the total dissolved solids.

Analyses from two dug wells (Table 3) give values for nitrate of 15 p.p.m. and 27 p.p.m., thus proving that contamination has taken place.

Other toxins yet to be identified, may possibly accompany the nitrate which is present in such states as these. (See also sections 7:1 and 7:2)
5:4 SOURCE AREA HORTON GRIT:

Crosby (1962, pp 31 - 33) has provided a very concise description of the Horton Group of grey and red shales, sandstone, grits and minor conglomerate. Thin calcareous beds occur interbedded with the shales and an arkosic grit containing fragments of K-feldspar is well represented throughout the entire sequence.

Inspection of Table 6 reveals that the pH of water derived from this source area lies wholly within an alkaline range. Alkalinity is correspondingly high.

Sodium and chloride are comparatively strongly represented in the water from one drilled well. Due to the tidal nature of the Gaspéean River intrusion of salt water may be considered a likelihood in the lower reaches of the Gaspéean Valley, which is underlain by Horton rocks.

Johnson (1951, pg 5) has suggested that "if total chlorides occur in a water in greater quantity than 100 p.p.m., they are of sufficient importance to warrant further examination to determine which chlorides they are and what their effect may be." The chloride content of the groundwater of the Horton source area (and for that matter all three of the source areas considered in this report) is less than this limit.

5:5 SOURCE AREA TRIASSIC SANDSTONE

5:6 SOURCE AREA NORTH MOUNTAIN BASALT

Data not available to date.

6:9 HYDROCHEMICAL DATA

5:1 IRON:

The analyses performed at the Trent Agricultural College
represent iron in "total" form. This "total" iron includes all the iron
in solution plus iron which has been precipitated in the sample bottle.
The water samples were not filtered at the time of collection in the field;
therefore, the "total" iron value includes iron that may have been in sus-
pension as well as what was in solution.

Consideration of the sources, chemistry and range of concentra-
tion of the different cations and anions has been presented by Hem (1959)
and the reader is referred to this excellent work.

Because all the chemical analyses are not available, the detailed
hydrochemical pattern for iron is not known. Tables 3, 4, 5 and 6 reveal
a definite trend, however, and there is no reason to suspect that this
trend will not continue. Thus, hydrochemical contours will probably be
closely controlled by the nature of bedrock and the presence of Pleisto-
cene deposits.

6:2 SULPHATE

Hem (1959, pg 103) reports that sulphate values can be con-
sidered "as precise as any determination in routine water analysis."

In the state Scriber source area, high sulphate values and high
iron values invariably occur together. This association is probably due
to the presence of ferrous sulphide and other iron minerals in the state.
The high sulphate values common to the Pleistocene source area may have
resulted from the use of fertilizers. In this way sulphate is formed on
oxidation of the hydrogen sulphide provided by decaying organic matter.
It is difficult to predict accurately the content of sulphate in the water
of the Pleistocene source area. In the North Mountain source area,
comparatively high values of sulphate and iron are expected.
6:3 CHLORIDE:

Differences of about 2 to 5% between identical samples having 30 p.p.m. to 100 p.p.m. chloride are stated by Hom (1959, pg 111) as within the range of normal error in laboratory work. It is presumed that a volumetric technique was employed in reporting the analyses.

Analyses show that the highest values of chloride occur in the Horton source area and that these values are complemented by high sodium values. These values will probably increase in water supplies adjacent to the coast. Locally, however, base exchange may be expected to have affected the relative cation concentration.

6:4 TOTAL HARDNESS:

Hardness has been reported in terms of an equivalent quantity of CaCl₂.

The hydrochemical trend for hardness is clearly shown for three source areas in Table 6. Assuming that these data represent amounts of calcium and magnesium, a prediction of hard water within the Triassic source area is made. The basis of this prediction is the presence of cementing calcite in the Triassic sandstone. This cementing calcite has been encountered in deep test holes drilled in Triassic sandstone in Bridgetown, Berwick and Kentville. Hard water may be found in the North Mountain basalt source area because of the reported tectonic nature of the basalt. It is difficult, however, to interpret hardness in terms of geology.

6:5 TOTAL DISSOLVED SOLIDS:

It is not known what technique was employed in the determination of total dissolved solids. Hom (1959, pg 102-105) lists four satisfactory methods of analysis. He states that "results in duplicate samples could
differ by as much as 50°. Errors of this magnitude can, therefore, be expected.

The water of the Pleistocene source area has been shown to contain the highest (218 p.p.m.) amount of total dissolved solids. In the Beaverlodge District of Alberta, Jones (1960) found that the groundwater derived from the Pleistocene sands and gravels contained well over 1600 p.p.m. of total dissolved solids. It appears, therefore, that in the Burwick-Wolviile Pleistocene source area groundwater is comparatively low in dissolved solids.

The chemistry of water from the two source areas, Triassic sandstone and North Mountain basalt, remains to be determined.

6:6 pH...

Hem (1957, pp 43-48) at al, have considered the basic principles behind the pH concept.

Ideally any interpretation of pH data must consider the following factors: (1) conditions under which samples are taken; (2) possible disturbance of the carbon dioxide-bicarbonate-carbonate equilibrium and buffer system; (3) temperature conditions during storage and transport of samples; and (4) oxidation changes, etc. For surface and shallow unconfined groundwater, however, it is probable that the laboratory conditions approximate field conditions.

Distinct differences in the range of pH are indicated (Table 6) for the water of the three source areas investigated.

6:7 NITRATES...

The analyses for nitrate are given for the union NO₃. The nitrate form of nitrogen, the phthalylphosphonic acid technique was employed in the determinations and is ideal for concentrations here then
30 p.p.m. At the upper end of this range it is accurate to within a few p.p.m.; at the lower end, to the nearest tenth of a p.p.m.

High values of nitrate appear in all the three source areas considered, and in all forms of water supplies. Dug wells seem to be most consistently liable to contamination. It is impossible, however, to predict the nitrate content of an individual water supply in any particular source area.

7:0 STANDARD OF DRINKING WATER

7:1 GENERAL-

The U.S. Public Health Service's drinking water standards are listed in Table 1. Analyses for the cations listed under "mandatory limits" are not available for the purpose of this report. Data are, however, available for the union N\(_3\). Nitrate nitrogen in excess of 10 p.p.m. has been related to incidents of cyanosis, the so-called "blue baby" disease in young children.

Nitrate concentrations in water bear a close relationship to life processes and, therefore, are influenced by the activities of plants and animals. In this respect bacteria play a particularly important role.

In many instances high content of nitrate in groundwaters can be traced to drainage of water through soil that has been repeatedly fertilized. In rural areas shallow groundwaters may be subject to pollution from seepage. In this latter case shallow dug wells prove to be most unreliable receptacles of drinking water. Table 2 also reveals that relatively high nitrate concentrations occur in deep drilled wells in those cases it is difficult to determine an contamination. It is possible that leaching of nitrate from fertilized land leachates into the groundwaters.
SCATTER DIAGRAM SHOWING RANGE OF pH & HARDNESS IN SLATE

TABLE 24

O = Standard range in known source area (Taken from Table 3)

• = Other values from suggested source area (25 chosen at random)
### TABLE 25

**LIST OF CONTAMINATED WELLS**

<table>
<thead>
<tr>
<th>NUMBER</th>
<th>PPM NITRATE</th>
<th>SUPPLY</th>
<th>SOURCE</th>
<th>TYPE</th>
<th>NAME OF OWNER</th>
</tr>
</thead>
<tbody>
<tr>
<td>W-S-36-11</td>
<td>15</td>
<td>Family</td>
<td>Slate</td>
<td>Drilled</td>
<td>E. Walker</td>
</tr>
<tr>
<td>W-S-57-68</td>
<td>15</td>
<td>Family</td>
<td>Slate</td>
<td>Dug</td>
<td>---</td>
</tr>
<tr>
<td>W-S-71-392</td>
<td>27</td>
<td>Family</td>
<td>Slate</td>
<td>Dug</td>
<td>A. Hancock</td>
</tr>
<tr>
<td>W-S-72-409</td>
<td>12</td>
<td>Family</td>
<td>Slate</td>
<td>Dug</td>
<td>C. Carver</td>
</tr>
<tr>
<td>W-S-33-330</td>
<td>15</td>
<td>Family</td>
<td>Slate</td>
<td>Dug</td>
<td>J. Brian</td>
</tr>
<tr>
<td>B-A-34-504</td>
<td>15</td>
<td>Family</td>
<td>Pleistocene</td>
<td>Drilled</td>
<td>C. Pempington</td>
</tr>
<tr>
<td>B-A-41-521</td>
<td>12</td>
<td>Family</td>
<td>Pleistocene</td>
<td>Drilled</td>
<td>---</td>
</tr>
<tr>
<td>W-B-40-59</td>
<td>15</td>
<td>Family</td>
<td>Slate</td>
<td>Drilled</td>
<td>E. Mosher</td>
</tr>
<tr>
<td>W-B-41-123</td>
<td>18</td>
<td>-----</td>
<td>-----</td>
<td>Spring</td>
<td>---</td>
</tr>
<tr>
<td>W-B-64-71</td>
<td>15</td>
<td>3 Families</td>
<td>Slate</td>
<td>Drilled</td>
<td>A. Vaughn</td>
</tr>
<tr>
<td>B-A-24-632</td>
<td>10</td>
<td>Family</td>
<td>Slate</td>
<td>Dug</td>
<td>J. Wamboldt</td>
</tr>
<tr>
<td>B-A-47-493</td>
<td>24</td>
<td>Family</td>
<td>Pleistocene</td>
<td>Dug</td>
<td>M. Brown</td>
</tr>
<tr>
<td>B-A-28-497</td>
<td>15</td>
<td>Family</td>
<td>Slate</td>
<td>Drilled</td>
<td>E. Beach</td>
</tr>
<tr>
<td>B-A-17-519</td>
<td>12</td>
<td>Family</td>
<td>Slate</td>
<td>Dug</td>
<td>---</td>
</tr>
<tr>
<td>B-A-5-462</td>
<td>12</td>
<td>Family</td>
<td>Slate</td>
<td>Dug</td>
<td>L. Street</td>
</tr>
</tbody>
</table>

**Scheme of numbering:**

```
W    B  21   11
Wolfville Sheet - Quarter - Mining Tract - Well Number
```

```
B   A  30   165
Berwick Sheet - Quarter - Mining Tract - Well Number
```
TABLE 26
The Laboratory - Nova Scotia Sanatorium

DEPARTMENT OF PUBLIC HEALTH
PROVINCE OF NOVA SCOTIA

Report on Examination of Water
Kentville, N. S. June 2, 1964

Sent by D. Mossman, PO Box 16, Wolfville

Source of specimen: Spring 20 feet from manure heap

Received: May 27, 1964

Lab. No.: W. #1

Result of Examination

The most probable number of coliform organisms is per 100 cc. of sample.

Bacterial count at 37°C.: colonies per cc.

Remarks:

Waters that show a most probable number of more than 5 coliform organisms per 100 cc. must be considered unsuitable as a source for drinking water. When the most probable number shows between 2 and 5 per 100 cc., the water should be regarded with suspicion and, after a sanitary inspection, may be declared unfit for drinking. Specimens that show most probable number of coliform organisms less than 2 per 100 cc. of sample are satisfactory from a bacteriological standpoint.

The quality of surface waters such as springs, shallow wells, streams and lakes, varies with changing weather conditions. Thus, while the result of the examination of a single sample may show the water to be unsafe, no definite conclusion regarding the safety of the water supply can be drawn from a single bacteriological examination that shows a satisfactory result. It is necessary to have samples collected under varying conditions for examination and to consider the results of these together with a sanitary inspection of the source of supply.

Bacteriological examinations of water are a time consuming laboratory procedure, requiring from two to five days depending largely on the degree of contamination of the sample.

[Signature]

Technician-in-charge
the Pleistocene source area, is the cause of the high nitrate content in certain drilled wells.

Although it appears impossible to predict the content of nitrate in any particular water supply it is essential that control be exercised where contamination is shown to exist.

7:2 PARTICULAR:

During the course of summer field work three samples were taken for "sanitary" (bacteriological) analysis from different private supplies of drinking water. Two of these three selected cases proved to be badly contaminated supplies. Table 26 is one of these two reports, the analysis for which was undertaken by the Nova Scotia Sanatorium. Unfortunately, nitrate content is not available for this particular sample because a "sanitary" analysis only, and not a "mineral" analysis, was performed. Nitrate, however, provides the food required by coliform organisms, and therefore, its presence in this sample is suspected. The property owner, Mr. Vormuhlen, was informed in due course by the Groundwater Division of the dangerous condition of this water supply. It is not known, however, whether steps have been taken to remedy the situation.

The case described above indicates that sanitation surveys as conducted under supervision of the county inspector are either incomplete or ineffective, or both. It is reported that during the ten years that Vormuhlen's water supply had served a family of five, it had not been tested.

Table 25 describes 15 water supplies for which nitrate is in excess of 10 p.p.m., the recommended upper limit. It is not improbable that colonies of coliform organisms should thrive on such quantities of nitrate. Bacteriological counts carried out on several, or preferably all
of these contaminated supplies would at least be an interesting expe-
iment; they are, therefore, recommended.

8:0 WATER FOR INDUSTRY AND AGRICULTURE.

The requirements of water quality in industries vary widely. 
Reference should be made to Todd (1959, pp 186-187) for recommended tol-
terences, which may be easily compared to the data presented in Tables 4,
5, 6 and 7.

Exact limits of permissible salt concentrations in water to be 
used for irrigation purposes cannot be stated because of the wide varia-
tion in salinity tolerance among different plants. Field plot studies 
have been made by the Kortville Research Station, and it is to this in-
stitution that the reader is referred for further information.

9:0 CONCLUSIONS AND RECOMMENDATIONS

With a fair degree of accuracy Tables 4 and 6 can be used as 
guides to groundwater quality in the three source areas considered in this 
report.

Sprays and fertilizers, especially in Pleistocene source areas, 
could modify hydrochemical trends.

Contamination by nitrate is common in several cases of waters 
derived from each of the three source areas. When all chemical analyses 
are made available it will be possible to better compare contamination in 
the different source areas. Tentatively it is recommended that samples of 
each of the water supplies listed in Table 25 be submitted for a bacterio-
logical count.

The main standard by which domestic water supplies may be
evaluated is on the basis of total dissolved mineral matter. In this respect the quality of the groundwaters in the Berwick-Jolifville area is encouraging.

Data on well-water levels are available for the Slate Series source area because of the number of dug wells. This source area, however, is one of very irregular topography. In the lowlands of the Annapolis Valley proper drilled wells predominate, and the water levels in these wells are not known. For these reasons, therefore, it is not feasible at this time of writing to prepare an accurate piezometric surface.

**NOTE:**

The four test holes in the Gaspeau Valley indicate the presence of two tills and not an extensive deposit of outwash sands and gravels (as believed at first), though such deposits are present as local features. The Gaspeau River has downcut through these tills leaving at least three pairs of terraces, which may be best seen on the northern slopes near the head of the valley.

The fact that impermeable clay tills and not outwash sands and gravels are dominant should, however, focus rather than discourage attention on the area so far as groundwater potential is concerned. The underlying bedrock of Horton grit is a proven aquifer by virtue of the many cases of flowing artesian wells in the area. Thus, apart from providing an obvious enrichment to industry, the Gaspeau Valley seems to offer a classic opportunity for basic research.
APENDIX A


LIST OF MAPS AND TABLES ACCOMPANYING THIS REPORT

APPENDIX B

1) Drinking water standards .....after Le Breton & Todd.
2) Hardness classification .....after Johnson, Edward F.
3) Typical groundwater analyses from selected wells within known source areas.
4) Range of chemical composition of groundwater from wells within known source areas.
5) Range of chemical composition of groundwater from wells within suggested source areas.
6) Histograms showing chemical analyses from water supplies within known source areas (using 3 as basic data).
7) Tabulated range of chemical composition of groundwater from supplies within suggested source areas.
8) West-Half Wolfville Map Sheet showing sample locations & geological boundaries.
9) West-Half Wolfville Map Sheet Hydrochemistry ......nitrate.
10) West-Half Wolfville Map Hydrochemistry ............pH.
13) West-Half Wolfville Map Hydrochemistry ............chloride.
14) West-Half Wolfville Map Hydrochemistry ............sulphate.
16) East-Half Berwick Map showing sample locations & geological boundaries.
18) East-Half Berwick Map Hydrochemistry ............pH.
21) East-Half Berwick Map Hydrochemistry ............chloride.
22) East-Half Berwick Map Hydrochemistry ............sulphate.
24) Scatter diagram showing range of pH and hardness in slate.
APPENDIX B Con't.

25) List of contaminated water supplies.

26) Example of bacteriological test conducted by Kentville Sanatorium on Vermuhlen property. (See Section 7:2).

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