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Occasional Report No. 2  
Groundwater Division  
Department of Mines

TRENDS IN GROUNDWATER CHEMISTRY IN THE  
BREMICK - WOLFVILLE AREA

1990

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1.0 ABSTRACT

Trends in groundwater chemistry are considered for the Berwick-Wolfville area. In a systematic way five different source areas, from which water is derived, have been recognized. There are: (1) the Halifax - New Cannan - Kentville Series of slates; (2) Pleistocene sands and gravels; (3) the Horton grit; (4) the Triassic sandstone and; (5) fractures in the North Mountain basalt.

Water from the Halifax - New Cannan - 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 102 ppm (total as  $\text{CaCO}_3$ ), and a comparatively high content (218 ppm) of total dissolved solids. The pH ranges from 6.3 to 9.1.

Water from the Horton source area contains as much as 90 p.p.m. chloride and 66 p.p.m. sodium. It is further characterized by a low (110 p.p.m.) 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 completion of chemical analyses.

Fifteen water supplies from the three different source areas show nitrate contamination. It is impossible, however, to predict contamination 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 vary 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. Hawley, H. Shand and G. Byers at the Truro Agricultural College. More than 250 samples remain to be processed. The amounts 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 29.

The term source 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. No 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 waters 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 these factors to Public Health standards.

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

### 4:0 GEOGRAPHY & GEOLOGY

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

The groundwaters within the area are believed to have five source areas. These are: (1) fractures in the Halifax-New Canaan-Kentville Series of slates; (2) Pleistocene sands and gravels; (3) the Horton grit; (4) the Triassic sandstone; and (5) fractures in the North Mountain basalt.

### 5:0 CHEMISTRY OF THE GROUNDWATERS

#### 5:1 GENERAL:-

The waterwell 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 two main well drillers in the Annapolis Valley, Trask 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 Gaspereau 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 practise 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 diagrams 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 areas for the waters of the wells and springs used in Table 5 are not known definitely. Ideally, that is if the source areas 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)

	U.S. Public Health Service	Alberta Government
Total dissolved solids	1000 p.p.m.	1600-2000 p.p.m.
Sulphates	250 p.p.m.	800 p.p.m.
Chloride	250 p.p.m.	435 p.p.m.
Nitrate	10 p.p.m.	10 p.p.m.
Iron	0.3 p.p.m.	0.3 p.p.m.

.....

MANDATORY LIMITS FOR

Constituent	Upper limit p.p.m.
Lead (Pb) .....	0.1 p.p.m.
Fluoride (F) .....	1.5 p.p.m.
Arsenic (As) .....	0.05 p.p.m.
Selenium (Se) .....	0.05 p.p.m.
Hexavalent Chromium .....	0.05 p.p.m.

.....after Todd (1959, pg 185)

.....

TABLE 2

HARDNESS CLASSIFICATION . . . . . after Johnson, L.E. (1951, pg 12)

Less than 15 p.p.m. ....	very soft water
15 to 50 p.p.m. ....	soft water
50 to 100 p.p.m. ....	medium hard water
100 to 200 p.p.m. ....	very hard water

.....



TABLE 3

GROUNDWATER ANALYSES FROM SELECTED  
WELLS WITHIN KNOWN SOURCE AREAS

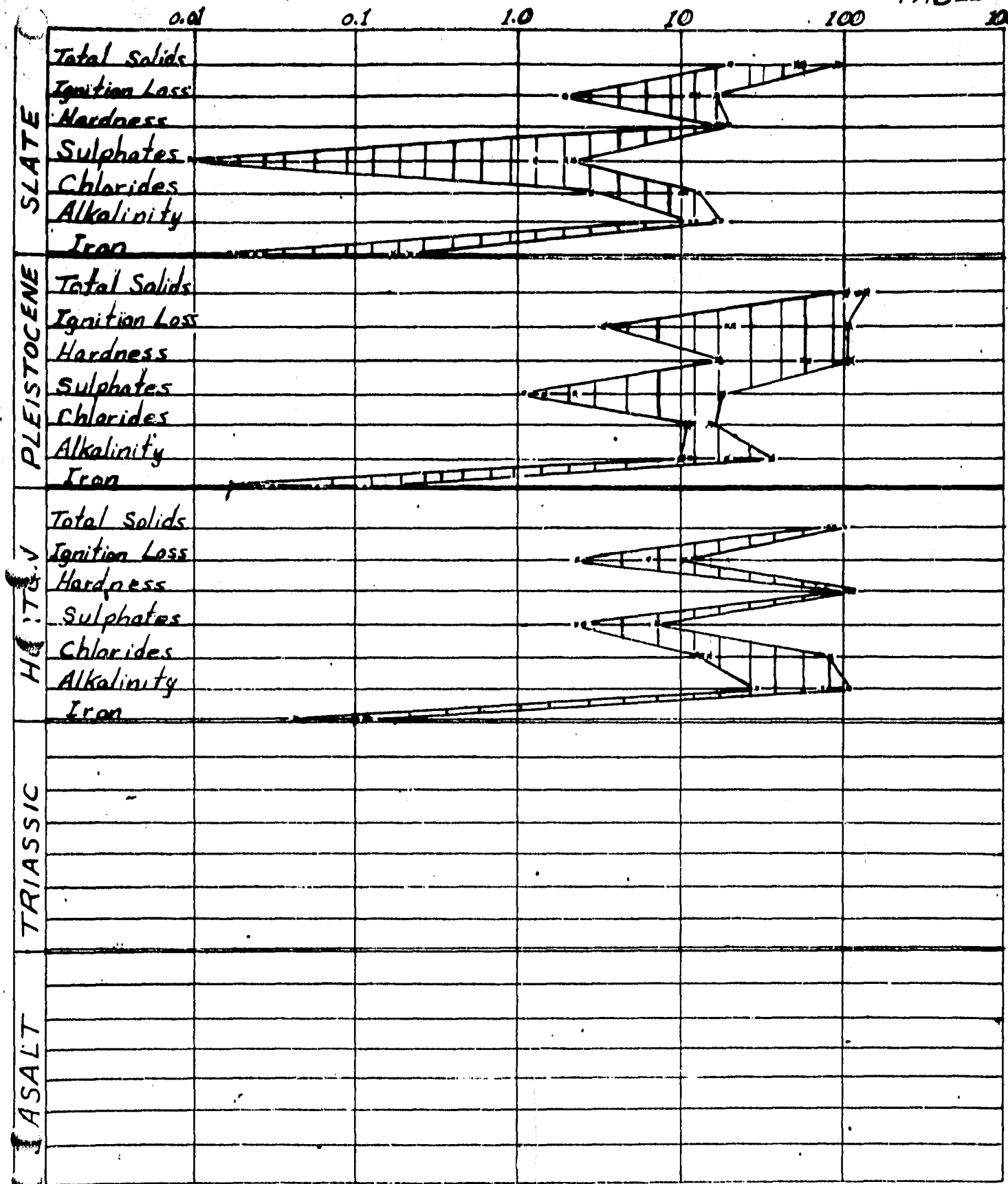
Bottomed In	Type	Number	Tract	Depth	Total Solids	Suspended Matter	Ignition Loss	Total Hardness	SO <sub>4</sub>	Cl	Alkalinity	NO <sub>3</sub>	Fa	pH
SLATE	0	51	34	14.2'	42	5	4	38.1	4.1	5.9	32	T=1.0	0.12	6.7
	0	11	36	120'	72	5	18	40.1	4.0	10.0	16	15.0	0.05	5.9
	0	49	38	75'	76	12	30	34.1	T=2.0	12	34	8	0.45	7.0
	0	136	56	83'	96	0	22	32	7.9	26	16	6	0.03	6.6
LEISTOCENE	0	68	57	13.0'	120	10	46	34	2.9	14	10	15	0.14	6.3
	0	392	71	10.5'	218	10	110	132	1.4	34	48	27	0.05	9.1
	0	244	44	5.0'	126	6	44	72.1	4.6	15.1	60	T=2.0	0.05	7.2
	0	359	46	11.0'	128	8	6	70.3	39.8	31	16	T=2.0	0.07	6.7
HORTON	0	305	53	75'	93	8	5	137	4.8	29	55.2	T=1.0	0.07	7.6
	0	322	68		89	1	12	140.3	8.2	90	128	T=2.0	0.12	8.2
	0	334	69	60'	110	3	7	107	4.8	23	88	T=2.0	0.15	8.0
	0													
CLASSIC														
BASALT														

Quantities given as p.p.m.

N.B.: Symbols Used: 0 --- Dug Well  
 0 --- Drilled Well  
 0 --- Spring

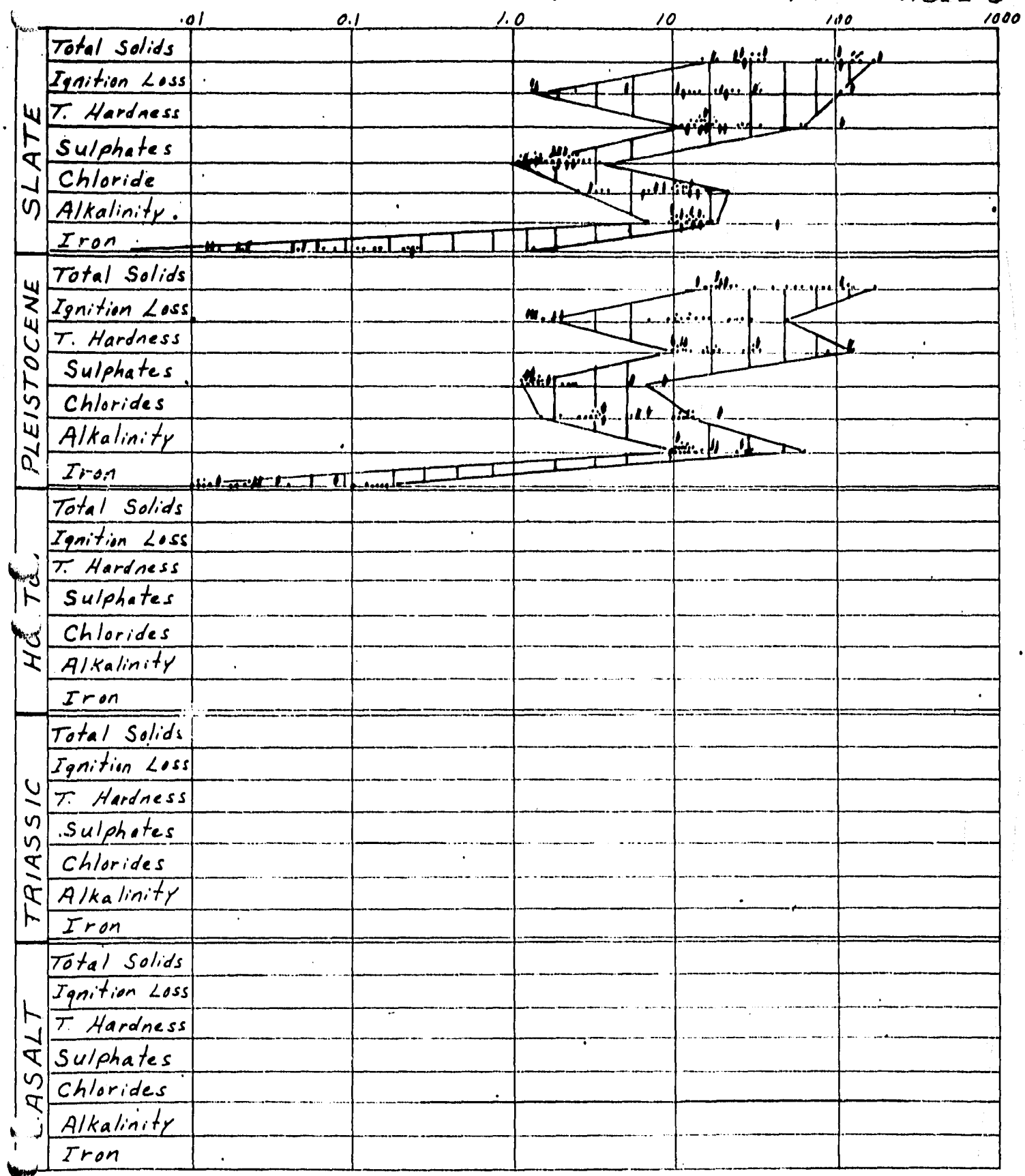
RANGE OF CHEMICAL COMPOSITION OF GROUNDWATER FROM  
SELECTED WELLS WITHIN KNOWN SOURCE AREAS

TABLE 4



N.B : Plotted on a Log Scale  
shaded portions represent variation in amounts of dissolved solids

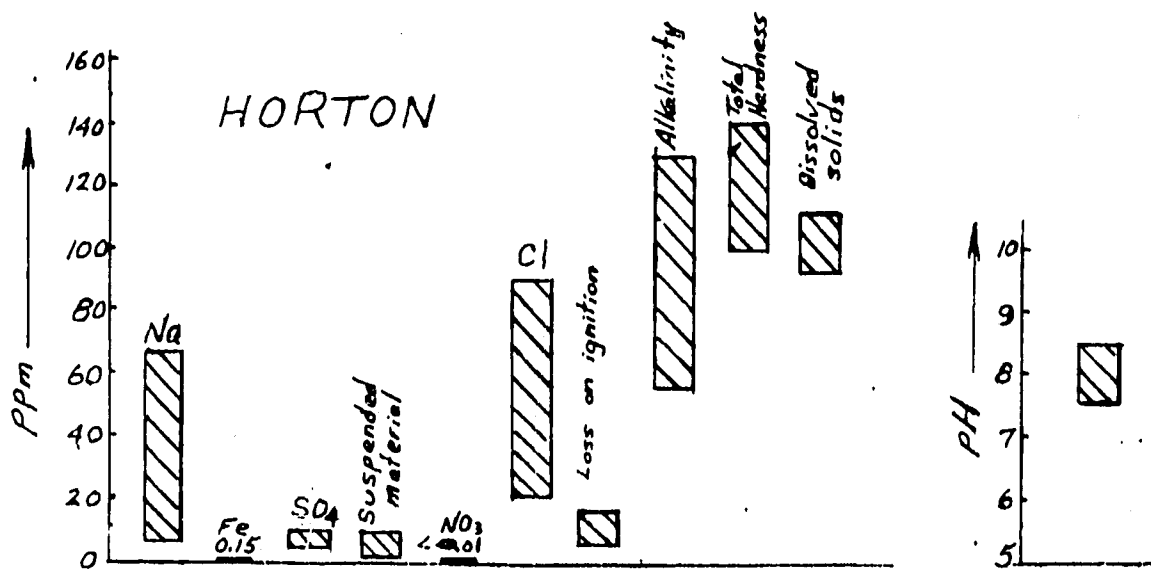
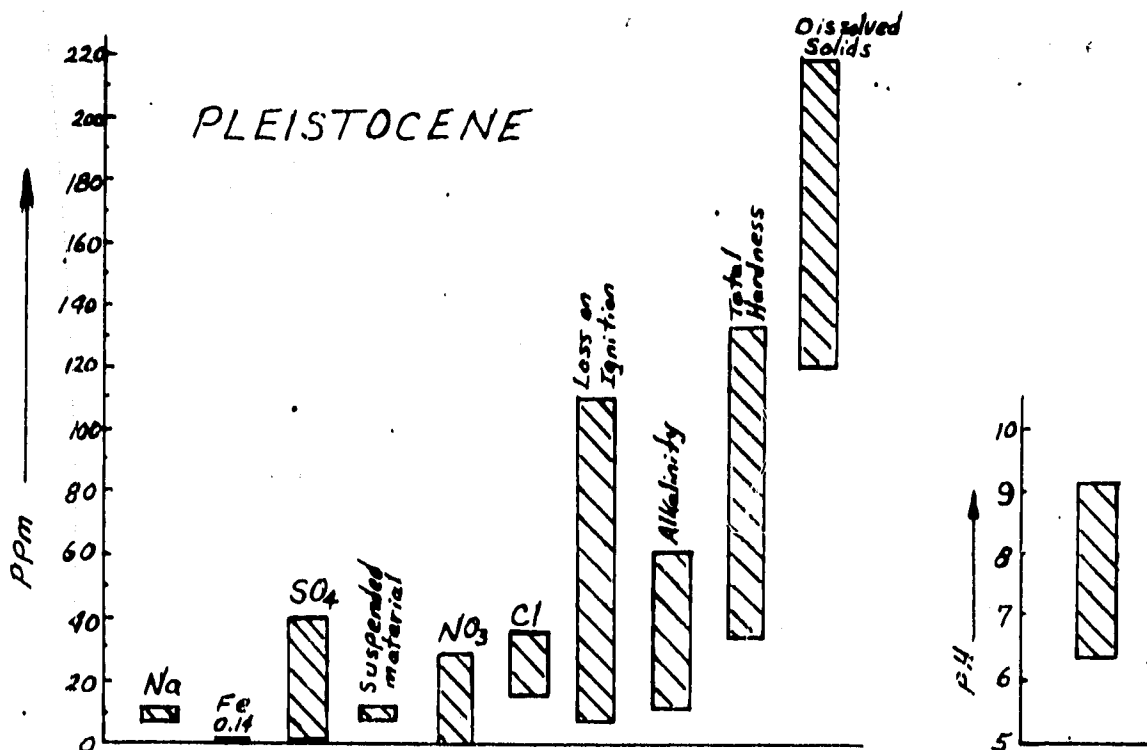
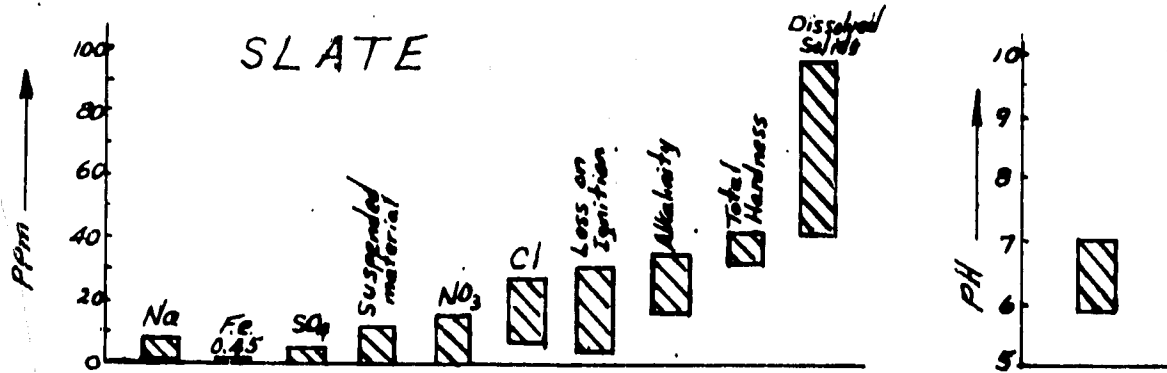
RANGE OF CHEMICAL COMPOSITION OF GROUNDWATER FROM WELLS WITHIN SUGGESTED SOURCE AREAS (Excluding those in Table 4) TABLE 5



N.B. - Data plotted to a log scale. Shaded portions represent variation in amounts of dissolved solids.  
 • well      | spring

# CHEMICAL ANALYSES OF GROUNDWATERS FROM THE KNOWN SOURCE AREAS

TABLE 6





Locally, of course, concentration changes, sorption phenomena, base 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 fact strengthens the case for classification by source area as a useful indication of water quality.

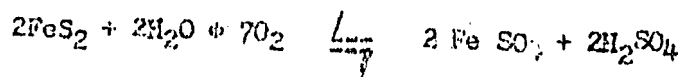
Detailed discussion of all data anomalous to those listed in Table 3 is beyond the scope of this report. When all the chemical analyses become available, scatter diagrams proposed for pH, etc., can be employed to portray the number of values falling outside of the standard range as deduced from known source areas. These diagrams would do much to clarify many apparent differences and are recommended. Table 24 is an example of such a diagram.

The following sections 5:2 to 5:6 deal with the chemistry of the water 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 5:8 in which the hydrochemical maps for the areas are evaluated.

#### 5:2 SOURCE AREA HUNTER - NEW CANON - HEMPVILLE SERIES OF SLATES:-

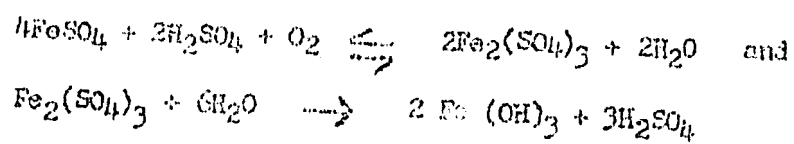
The gypsiferous and carbonaceous nature of the slate series is a well known fact. In the rocks there is also commonly present in with iron.

According to Rankama and Sahama (1949, pp 663-664) oxidation of pyrite results in the following reactions.



$\text{FeSO}_4$  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  $\text{OH}^-$ .

Thus



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 source area.

Crosby (1962, pg 19) has determined that the feldspars of the siltstone members in the slate series are dominantly albite or sodic oligoclase and that this constituent may compose as much as 10% of the rock. Thus weathering of this feldspar would make available a supply of sodium cations to take part in base exchange processes. This fact might explain the generally soft water found in this source area.

The comparatively low quantity of dissolved solids common to 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 slate.

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 PLEISTOCENE:

The nature of the Pleistocene materials of the Berwick - Wolfville area was considered in some detail in Occasional Report No. 2 (Mossman, 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 farmed 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 cases 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 Gaspareau River intrusion of salt water may be considered a likelihood in the lower reaches of the Gaspareau 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.

6:0 HYDROCHEMICAL MAPS

6:1 IRON:-

The analyses performed at the Terre 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 suspension as well as what was in solution.

Consideration of the sources, chemistry and range of concentration 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 Pleistocene deposits.

#### 6:2 SULPHATE:-

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

In the slate Series 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 slate. The high sulphate values common to the Flakatscone 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 waters of the Triassic source area. In the North Mountain Basalt source area, comparatively high values of sulphate and iron are expected.

### 6:3 CHLORIDE: -

Differences of about 2 to 5% between identical samples having 10 p.p.m. to 100 p.p.m. chlorides are stated by Hem (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  $\text{Ca CO}_3$ .

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 tholeiitic 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. Hem (1959, pp 142-143) lists four satisfactory methods of analysis. He states that "results in duplicate samples could

differ by as much as 5%. 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 1000 p.p.m. of total dissolved solids. It appears, therefore, that in the Berwick - Wolfville 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 (1959, pp 43 - 48) et 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 groundwaters, however, it is probable that the laboratory conditions approximate field conditions.

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

#### 6.7 NITRATE:..

The analyses for nitrate are given for the anion  $\text{NO}_3^-$ , the nitrate form of nitrogen. The phenoldisulphonic acid technique was employed in the determinations and is ideal for concentrations less than

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 anion  $\text{NO}_3^-$ .

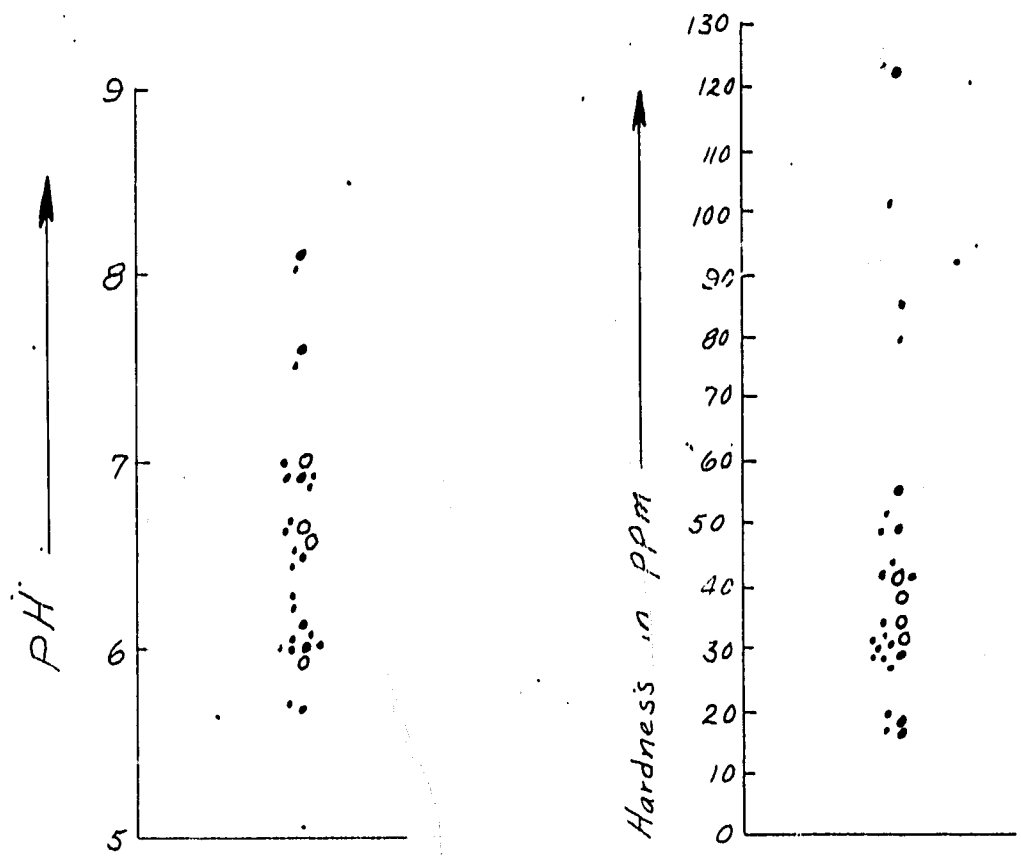
Nitrate nitrogen in excess of 10 p.p.m. has been related to incidents of cyanosis, the so-called "blue baby" disease in young children.

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 lawns. In this latter case shallow dug wells prove to be most unsatisfactory receptacles of drinking water. Table 2 also reveals that relatively high nitrate concentrations occur in deep drilled wells in these cases it is difficult to determine an explanation. It is possible that leaching of nitrate from aerial soil horizons in the case of

# 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

NUMBER	PPM NITRATE	SUPPLY	SOURCE	TYPE	NAME OF OWNER
W-B-36-11	15	Family	Slate	Drilled	E. Walker
W-B-57-68	15	Family	Slate	Dug	-----
W-B-71-392	27	Family	Slate	Dug	A. Hancock
W-B-72-409	12	Family	Slate	Dug	C. Carver
W-B-53-330	15	Family	Slate	Dug	J. Brian
B-A-44-504	15	Family	Pleistocene	Drilled	C. Pempington
B-A-41-521	12	Family	Pleistocene	Drilled	-----
W-B-40-59	15	Family	Slate	Drilled	E. Mosher
W-B-41-123	18	-----	-----	Spring	-----
W-B-64-71	15	3 Families	Slate	Drilled	A. Vaughn
B-A-24-432	10	Family	Slate	Dug	J. Wamboldt
B-A-47-493	24	Family	Pleistocene	Dug	M. Brown
B-A-28-497	15	Family	Slate	Drilled	B. Beach
B-A-17-519	12	Family	Slate	Dug	-----
B-A-5-462	12	Family	Slate	Dug	L. Sweet

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

Station 16

DEPARTMENT OF PUBLIC HEALTH  
PROVINCE OF NOVA SCOTIA

Report on Examination of Water

Kentville, N. S. June 2, 1964 196

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

H. Vermuhlen  
Property

The most probable number of coliform organisms is 7.6  
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.

*K. M. ...*

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. Vermuhlen, 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 Vermuhlen'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 experiment; 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 tolerances, 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 can not be stated because of the wide variation in salinity tolerance among different plants. Field plot studies have been made by the Kentville Research Station, and it is to this institution 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 bacteriological 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-Holville 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 Gaspercau 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 Gaspercau 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 enticement to industry, the Gaspercau Valley seems to offer a classic opportunity for basic research.

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APPENDIX A

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LIST OF MAPS AND TABLES ACCOMPANYING THIS REPORT

APPENDIX B

- 1) Drinking water standards .....after Le Breton & Todd.
- 2) Hardness classification .....after Johnson, Edward E.
- 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.
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- 12) West-Half Wolfville Map Hydrochemistry .....total hardness.
- 13) West-Half Wolfville Map Hydrochemistry .....chloride.
- 14) West-Half Wolfville Map Hydrochemistry .....sulphate.
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- 16) East-Half Berwick Map showing sample locations & geological boundaries.
- 17) East-Half Berwick Map Hydrochemistry .....nitrate.
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- 21) East-Half Berwick Map Hydrochemistry .....chloride.
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- 24) Scatter diagram showing range of pH and hardness in slate.

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- 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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