BUREAU OF MINES
DEPARTMENT OF MINES AND RESOURCES, OTTAWA, CANADA

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INDUSTRIAL WATERS IN CANADA

Interim Report No. 2

by

Harald A. Leverin[1]

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to obtain better distribution of results over the less densely populated states. The 670 places contain 46.2 per cent of the total population of the United States.[1]

As Canada has only 31 places of 20,000 inhabitants or more, the adoption of this, as the minimum unit in a survey of the distribution of hardness in Canadian waters, would furnish inadequate data. For Eastern Canada, therefore, a population of 3,000 or more has been chosen and for the West 2,000 or more, giving a total of 235 communities, representing 45.5 per cent of the population of Canada. The distribution, expressed in percentages of the total of each province, would be: for Nova Scotia, 36.8 per cent; New Brunswick, 27.8 per cent; Prince Edward Island, 18.3 per cent; Quebec, 56.9 per cent; Ontario, 56.7 per cent, making a total of 53.2 per cent of the population of Eastern Canada as far west as Sault Ste. Marie. In the Maritime Provinces, the inclusion of towns of 2,000 inhabitants would not raise the ratio of the population served appreciably, but in Western Canada it is advisable, not because it would make much difference to the ratio, but because it would give a better geographical distribution of the varieties of industrial and civic waters for these large areas. The ratio of the population of the whole of the western provinces so included would be 38.2 per cent; of the province of Manitoba, 36.7 per cent; of Saskatchewan, 17.3 per cent; of Alberta, 28.5 per cent, and of British Columbia, 53.9 per cent.

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[1]United States Geological Survey Water Supply Paper 658, pp. 12-19.

These calculations are based on the 1931 census, with the exception of some larger cities, and of service adjacent to smaller towns and communities, for which calculation is based on the total number of persons served, in accordance with data obtained from the Engineering and Contract Record, April 4, 1934, pages 290-304.

Progress made during 1936.

The area over which operations were conducted in 1934 and 1935 was considerably extended during 1936. Check samples of civic waters were also collected and the regular sampling of surface waters at key stations in Quebec and Ontario was resumed. Water at these stations is sampled yearly, whenever possible at high, mean, and low gauge, so as to determine seasonal as well as yearly variation in the composition of the more important lakes and arterial waters of Canada.

In 1934 and 1935, the waters studied comprised those of Ontario south of the Ottawa river and Georgian bay, and those of all Quebec as far east as Riviere du Loup. Complete analyses were made of 48 samples of surface water, and of 189 samples of waters supplying cities and towns having populations of 3,000 or more; determinations were made of hardness, alkalinity, calcium, and magnesium.

During 1936, the investigation was extended to embrace the provinces of Nova Scotia, New Brunswick, Prince Edward Island, that part of Ontario lying between Georgian bay and Sault Ste. Marie, and the rest of Quebec, thus completing Eastern Canada as far west as Sault Ste. Marie, except for the mining areas north of lake Nipissing. Samples were collected of 77 municipal waters and 26 surface waters.

Thus, in Canada during the three years the investigation has been in progress, 340 samples of water have been collected and analysed; these in many cases being but single samples, whereas in the United States similar work has been done for over forty years, 800 water supply papers have been published and many thousands of analyses made. In compiling results relative to the distribution of hard waters in Canada, the method employed, follows as closely as possible that used by the United States Geological Survey, as it is obviously desirable that results in the two countries should be comparable.

Many of the waters have been analysed for mineral content for the first time. Some analyses have been checked and yielded fairly concordant results, but others have shown appreciable divergences in concentration and composition. Many analyses, especially from the Maritime Provinces, have not been checked.

As few official records of analyses of important Canadian water supplies are available, recourse has had to be made to independent sampling and analysis. In only a few waterworks in Canada are complete analyses of the water made, laboratory work being usually confined to determining quality, colour, turbidity, etc., so that proper control may be exercised and the product be a clear, sparkling water, safe for human consumption.

For an adequate report on the quality of water supplies, many samples have to be taken and analysed. The quality of a body of water, however large, differs from that of other mineral deposits because, besides being subject to seasonal changes in composition, due to concentration, dilution, and absorption, slow changes may take place from year to year.

Ground waters appear less liable to seasonal variation in composition, but exceptions to this are not rare as in the case of some well waters of the city of London, the composition of which is very unstable and subject to change at frequent intervals.

As the investigation progresses and more samples and analyses are available, changes may, therefore, be expected in the composition of the waters reported upon. The development of new water supplies as cities and towns grow larger or include new towns in their populations may also influence the composition considerably.

For reporting the hardness of waters in Eastern Canada, the following scale of hardness has been adopted:

Total hardness in parts per million, expressed as calcium carbonat	
1 to 60	Soft water
61 to 120	Medium hard water
121 to 180	Hard water
181 +	Very hard water

Subdivisions of these may be made in case the hardness approaches the limits set; for example, water of 63 hardness may be termed medium hard to soft; of 122, hard to medium hard, etc.

The Maritime Provinces.

Of two samples collected in Prince Edward Island one shows medium hard and the other hard water; of twenty samples from Nova Scotia, only one was hard, the others soft to very soft; and of twelve samples from New Brunswick, five were medium hard, although two of these were very close to soft, and seven were soft waters.

Only three surface waters were sampled in the Maritime Provinces, two from the St. John river at Edmundston and at Woodstock, and one from the Nipisiguit river at Bathurst. The reason for so few samples is that most rivers in Nova Scotia and New Brunswick are of little or no industrial value because towns, cities, and industries are usually situated on the estuaries of rivers and, owing to the tide, brackish waters extend twenty miles more or less upstream. The industries obtain their water supply from lakes and springs, many enterprises having their own water service.

In visiting manufacturing plants, it was learned that in general the waters in Nova Scotia and New Brunswick are soft, so that operating problems due to the quality of the water are usually caused by corrosion, in some cases by colour only, and in a few by algae. Algae are objectionable as they impart an unpleasant--usually fishy-taste to the water,making it unfit for drinking and for the manufacture of food products. This trouble usually occurs in smaller lakes, more or less stagnant, and can easily be corrected by addition of copper sulphate. The chemical is placed in cheesecloth bags and trailed behind a motor launch, traversing the lake in several directions, to obtain a uniform distribution. Two such treatments during the latter part of the summer months usually suffice.

Corrosion, however, is more serious and for some time past has been the subject of extensive investigation by the large manufacturing concerns. The corrosive action is due mainly to acidity caused by dissolved gases, oxygen and carbonic acid, which together form a very active agent. Experiments are still in progress for correcting such waters either by raising the pH value by addition of lime, soda, or tri-phosphate of soda, or by removal of the dissolved gases by pre-heating the water. The latter is considered to be applicable especially to boiler waters. No method of correction of industrial waters has so far been adopted which may be considered fully effective.

Quebec.

Check samples for Quebec taken in the early part of the summer, with few exceptions, show only smaller changes in composition.

Quebec waters are preponderantly soft except those supplies drawn from the St. Lawrence river, which is medium hard water, and even among the ground waters the hard types seem to be more the exception.

Ontario.

Samples in Ontario collected during the latter part of the summer tend toward somewhat higher hardness figures as compared with samples of 1935 and 1936. This is probably due to a series of drought years, which has lowered the levels of most supplies.

The northern and eastern parts of the province have soft to medium-hard waters. South of Georgian bay, lake Simcoe, and a strip following the St. Lawrence river, the water is very hard to hard.

The Basin of the Great Lakes.

Surface Waters. Surface waters collected in Quebec province represent mean gauge; for Ontario, low gauge, in fact, abnormally low, which is especially noticeable in the concentration of the mineral constituents of the waters, increasing thereby the hardness, chlorides and alkalies. This also is generally true but to a much less degree for the whole of the Great Lakes system.

Figure 1 shows the variations in hardness of the waters of the Great Lakes basin, computed from averages of two to eight samples, a number insufficient to afford as reliable an average as those published by the United States Geological Survey, that seldom represent less than twelve and usually twelve composites of daily samples. It is, therefore, likely that, as more samples and analyses are available, these figures may be subject to adjustment.

Variations in the mineral composition of these large bodies of water, judging from the comparative analyses, are not extreme and the diagram may, therefore, be regarded as showing the trend of the variation of the total hardness for the waters of the Great Lakes Basin through its course to the sea.

The Lake Superior water is represented by analyses of samples taken from St. Mary's river above the rapids at Sault Ste. Marie, and has a hardness of 56.0 p.p.m.

The United States Geological Survey reports for twelve composite samples taken for each month during the year 1924 a hardness of 46.0 p.p.m.[1] Both figures represent the same classification as regards hardness.

The Lake Superior water is diverted in three directions, to Lake Michigan, with which this report is not concerned, to Lake Huron, and through the North Channel to Georgian bay. The water running through Lake Huron receives tributaries of water from the State of Michigan of very high hardness, noticeable already at St. Ignace, Michigan, where there is an increase in hardness to 82 p.p.m.[2] Mention may be made of the tributaries, Shiwassie river, Cass river and Flint river, which drain into Saginaw bay and have hardnesses of 221, 178, and 298 p.p.m. respectively.[3]

The water following the Georgian bay receives from its northern tributaries waters softer than that of Lake Superior, as in the case of analyses tabled for lake Nipissing where a dilution would be expected. This dilution is counterbalanced at the southern end of Georgian bay by the tributaries, Severn, draining Simcoe and Couchiching lakes of hard water; and the Sydenham and a number of smaller tributaries of very hard water, increasing the hardness of the water considerably.

At Collingwood the Georgian bay water has a hardness of 117 p.p.m.; flowing north it mixes with the softer water and at Parry Sound it has a hardness of 70 p.p.m.

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[1]Professional Paper 135, 1924, p. 11, by F.G. Clarke.
[2]U.S. Geological Survey Professional Paper 135, p. 12, by F.G. Clark
[3]U.S. Geological Survey Water Supply Paper 658, by W.D. Collins, W.L. Lamar, E.V. Lohr, p. 77.

The mixture of the Lake Huron waters of various concentration appears to be fairly well accomplished at Goderich, where there is a hardness of 107 p.p.m., as from there on the decrease from 107 to 100 p.p.m. at Point Edward is not very appreciable.

Detroit river at Walkerville shows only a slight increase, in fact so slight that the difference might be due to analytical error. Nevertheless analyses of samples taken at Point Edward and at Walkerville at twelve hours' interval show consistently slightly lower total hardness for Point Edward water, which should be correct, as tributaries to the St. Clair river, notably the Thames river, although of comparatively small volume, have very hard water.

At Amherstburg there appears an increase of 10 p.p.m., which may be expected from the very large quantities of effluence and the heavy discharge of factory waste from the densely populated districts.

Lake Erie shows a further increase in hardness, samples taken at Port Colborne and Fort Erie having a hardness of 125 p.p.m Tributaries to Lake Erie have all very hard waters, the Huron river, Woolf creek, Raisin river, and Maumee river having 298, 295, 245, and 207 p.p.m. total hardness[1] respectively and even harder water being received from drainage and tributaries from Lake Ontario, for example, the Grand river, which varies from 275 to 400 p.p.m.

The peak in concentration for hardness appears to be reached at Niagara Falls and Hamilton, with 136 p.p.m. It is

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[1]U.S. Geological Survey Professional Paper 135, p. 17.

true this is supported by analyses of two samples only from each place, but eight samples taken along the Welland Canal, where the water flows more slowly through the same formation as the Niagara river, gave variations from 128 at Port Colborne to 143 at Merritton, with an average of 136 p.p.m. Analyses furnished by the Water Works of the city of Hamilton from which the total hardness has been calculated yield even higher values.

Lake Ontario shows a slight dilution at Oakville; this hardness appears uniform for the whole of the Canadian shore line of the lake as far as Prescott. The dip in concentration of hardness at Toronto would not appear justified in view of the very hard waters from the Don river, from industrial waste, etc., from such a large city, which should cause the opposite. The figure, however, is an average of five analyses giving hardness ranging from 98.5 to 128.5 p.p.m. and, had it not been for one analysis much lower than any of the others, it would have been appreciably higher. Another reason may be that samples collected at the Island Water Works at Toronto were taken at a depth of 90 feet from heavy low-level currents that may not be affected by waters from adjacent tributaries, industrial waste, etc. Depth samples from other key stations are usually taken at about 25 feet or less, depending on the depth of the lake or river.

The River St. Lawrence.

At Prescott there is a drop of about 7 p.p.m. in hardness, which is maintained until the Ottawa river joins the St. Lawrence. No tributaries of importance come from the Canadian side, but from the State of New York there is an appreciable drainage and the waters are medium to very soft. The Oswegatche river at Ogdensburg has a hardness of only 50 p.p.m.[1]

A true average of the Montreal water is difficult to obtain unless numerous samples are collected throughout the year. The hardness of the nine samples so far collected and analysed ranged from 74 to 124 p.p.m. This great range in hardness is due to the soft and coloured water of the Ottawa river, the largest tributary of the St. Lawrence, joining it at lake St. Louis. The two waters do not mix as readily as might be supposed and may run for many miles before complete mixture has been accomplished.

A parallel case, often quoted, is that of the blue Mississippi and the white Missouri, which, after joining, run for miles with a sharp dividing line between the two waters and much farther before a complete mixture has been attained.

The bulk of the water used by close to 1¼ million consumers of the city of Montreal and adjoining districts is drawn from above the Lachine Rapids. When the Ottawa river flows rapidly it deflects the current of the St. Lawrence, the Ottawa river water, soft and coloured, enters the conduit of the Montreal Water Works, affecting the quality of the supply accordingly.

Although soft water is generally advantageous and economical, the Ottawa river water as seen by the tabulated analyses is rather highly coloured and, as it is more expensive to remove colour than the usual method of purification at the Montreal Water Works, the intermixture of Ottawa river water is objectionable.

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[1]U.S. Geol. Survey Professional Paper 135, 1924, p. 20.

Thorough mixing of the two waters would take time and need some distance of flow; it is doubtful whether it has been accomplished below the Lachine rapids, as the two samples collected within one hour at St. Lambert and at Longueuil showed on analysis a marked difference in hardness.

Fifty miles below Montreal, at Sorel, the hardness is 93.0 p.p.m. which no doubt represents a uniform mixture, as the difference in the composition of the three samples collected is not appreciable. This is, however, no check on the average composition of the Montreal water supply, because a large part of the Ottawa river water is diverted through the channel north of Montreal.

Distribution of Hard Waters in Eastern Canada.

The computation of results of analyses showing the hardness of the larger public water supplies in Eastern Canada has been summarized in Tables I, II and III, in the hardness map, Figure 2, Figure 1, and in the diagram, Figure 3. Interpreting these data, it must be borne in mind that they relate only to the 53.2 per cent of the total population served by the larger water supplies that have been sampled and analysed in this investigation.

From Table II it is clear that the proportion of persons served by ground water is small, or 5.2 per cent of the total population. This is due to the densely populated districts around the Great Lakes water basin and the more important rivers and lakes

Were data available for the total population, the proportion of well water would doubtless be much higher as the rural and smaller community population is usually served by ground water.

As regards hardness, the ground waters, especially in the province of Ontario, are preponderantly hard, the average for the whole of Eastern Canada being classified as very hard, whereas surface waters are medium hard.

Table I.

Number of persons, in thousands, using water of different degrees of hardness from large public supplies in Canada.

Hardness in p.p.m.	Surface Water	Ground Water	Total
1 - 10	10.0	-	10.0
11 - 20	265.0	8.8	273.8
21 - 30	218.6	-	218.6
31 - 40	93.6	23.6	117.2
41 - 50	214.0	3.0	217.0
51 - 60	65.7	5.6	71.3
61 - 80	31.0	13.2	44.2
81 - 100	59.2	16.0	75.2
101 - 120	1335.3	4.0	1339.3
121 - 180	1050.2	7.0	1057.2
181 - 250	8.1	60.3	68.4
251 - 400	65.9	177.6	243.5
401 - 600	--	49.4	49.4
	3416.6	368.5	3785.1

3,785,100 users of water in a territory of 7,115,038 population comprise 53.2 per cent of its population and an average hardness of 115.8 p.p.m.

In Table II the hardness data have been summarized from the analyses for each province, by calculating the weighted average for the hardness of the surface water supplies, of the ground water supplies, and of both under heading "all supplies".

TABLE II

WEIGHTED AVERAGE HARDNESS OF WATER FROM LARGE PUBLIC SUPPLIES

	Surface Supplies			Ground Supplies			All Supplies		
	Average hardness as $CaCO_3$ (parts per million)	Population Served		Average hardness as $CaCO_3$ (parts per million)	Population Served		Average hardness as $CaCO_3$ (parts per million)	Population Served	
		Thousands	Percentage of total population of province		Thousands	Percentage of total population of province		Thousands	Percentage of total population of province
Nova Scotia	24.5	105.8	36.2	124.6	3.1	0.6	26.2	188.9	36.8
New Brunswick	43.7	98.0	24.0	76.8	14.1	3.5	47.9	112.1	27.5
Prince Edward Island	----	----	----	118.3	16.1	18.3	118.3	16.1	18.3
Quebec	90.7	1587.4	55.3	55.0	46.8	1.6	89.7	1634.2	56.9
Ontario *	124.5	1545.4	47.8	302.3	288.4	8.9	152.5	1833.8	56.7
Eastern Canada	102.6	3416.6	48.0	243.0	368.5	5.2	115.8	3785.1	53.2

* Exclusive of territory west of Sault Ste.Marie and northern mining territory.

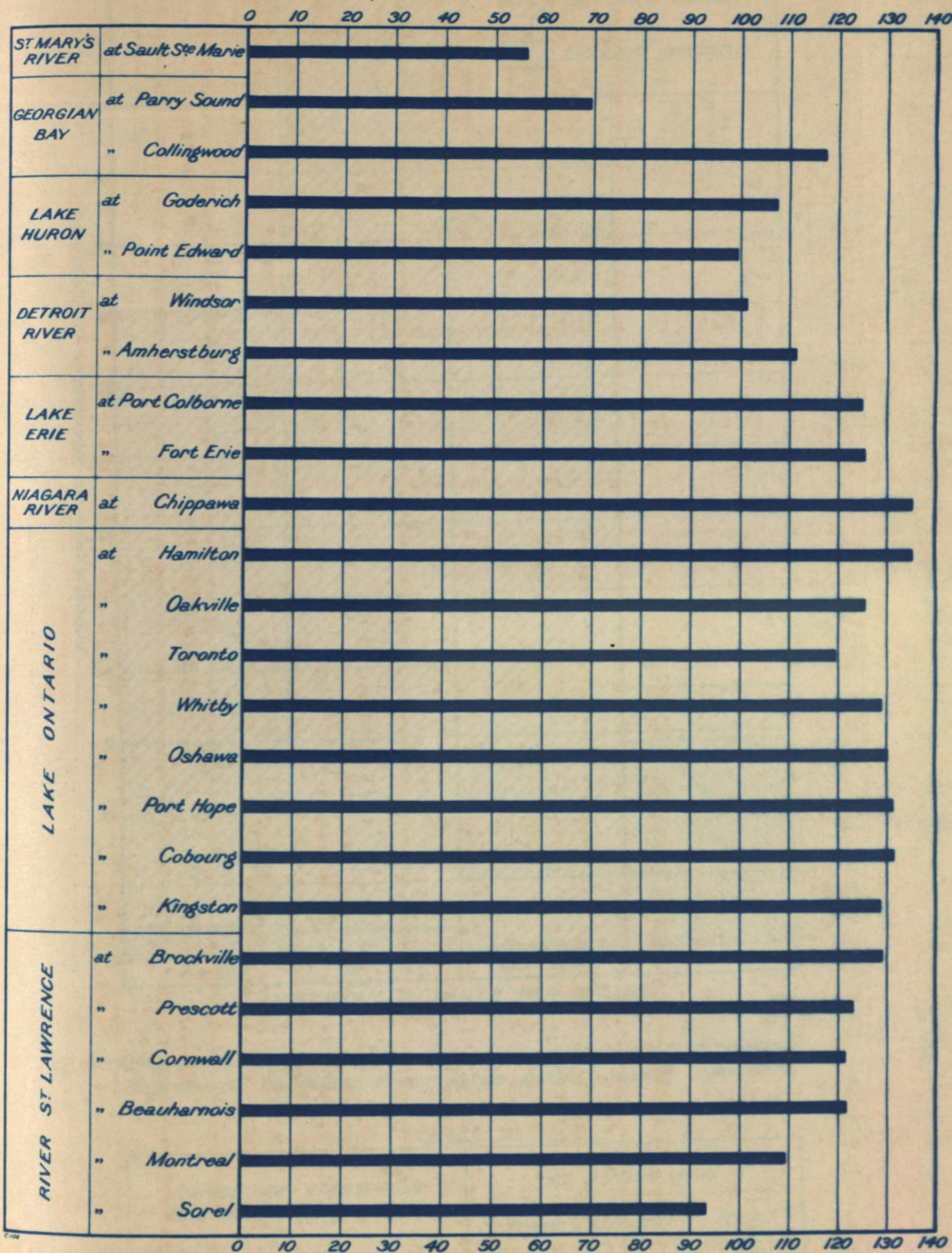

Fig. 1 Diagram showing variations of total hardness in parts per million of the waters of the Great Lakes basin.

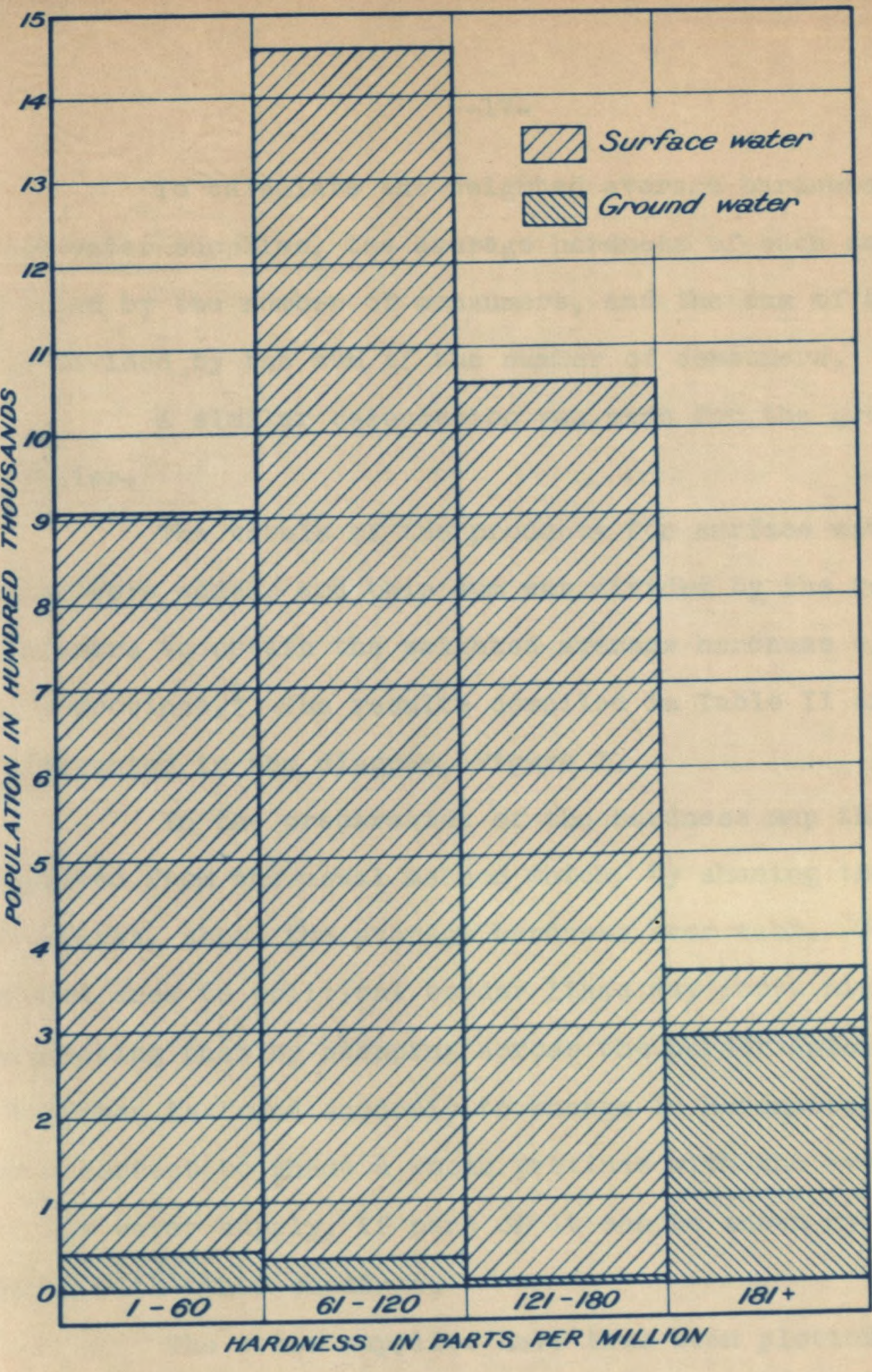

Fig. 3 Diagram showing number of persons using water of certain degrees of hardness from large public supply systems.

TABLE III

RANGE OF HARDNESS IN PARTS PER MILLION	POPULATION IN THOUSANDS		
	Surface	Ground	Total
1 - 60	866·9	41·0	907·9
61 - 120	1425·5	33·2	1458·7
121 - 180	1050·2	7·0	1057·2
181+	74·0	287·3	361·3
	3416·6	368·5	3785·1

To calculate the weighted average hardness of the surface water supplies, the average hardness of each supply was multiplied by the number of consumers, and the sum of these products was divided by the sum of the number of consumers.

A similar calculation was made for the ground water supplies.

The totals of the products for surface water and ground water were added, and this sum was divided by the total number of consumers to obtain the weighted average hardness of all supplies of a province.[1] The results compiled in Table II are graphically represented in the diagram, Figure 3.

In the preparation of the hardness map the writer has departed from the usual method which, by shading the States or Provinces, shows the average hardness over each. To limit a shaded area to political border lines may prove misleading , suggesting that by stepping across the border into another province the water is found suddenly to change in hardness. Nor would it seem correct to shade a whole province with the average hardness of its water supply, if part of it can be shown by one and other parts with other shadings.

The water supplies have thus been plotted on the map, on which symbols indicate the hardness of the water. The reader, at a glance, can perceive the geographical distribution of the hardness of the various water supplies of Eastern Canada.

In weighted averages the Maritime Provinces are the most uniform, Nova Scotia (with the exception of Pictou, which is

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[1]U.S. Geol. Survey Water Supply Paper No. 658, p. 15.

hard water) having almost entirely soft water, well within the limit set for that classification, Yarmouth and Windsor with 6.2 and 7.6 total hardness being the softest waters so far sampled in this investigation.

Prince Edward Island water from its two samples has a hardness range of medium hard, being very near to hard.

The weighted average for New Brunswick is decidedly soft water, only a few supplies like the St. John river supply being medium hard near to soft, and Edmundston and Newcastle medium hard water.

The water of Quebec averages medium hard, but is much dominated by the Montreal-St. Lawrence district, within which comparatively small area is located about 50 per cent of the population. Elsewhere in the province the waters are prevailingly soft.

For the province of Ontario the weighted average is hard water, but water supplies of all hardnesses exist, from the soft waters of the Northern supplies to medium hard beginning from Lake Huron to Lake Erie. Western surface supplies from Lake Erie to Lake Ontario and the St. Lawrence are also hard, and very hard waters are found in the southwestern part of the Province.

Practically all ground waters investigated are very hard, and with few exceptions these are to be found in the southwestern districts.

Surface waters range in hardness from very soft to very hard, with the general tendency for lakes and rivers to increase in hardness towards the south. The Sydenham, the Thames, and the Grand rivers have the hardest water of all surface supplies so far investigated. To the north, lakes and rivers, such as Simcoe, Couchiching, Severn, Scugog, have hard water, and farther north and east the Otanabee, Rideau, Madawaska and Trent waters are medium hard. Still farther north the St. Mary, lake Nipissing, Ottawa, Bonnechere, and Sturgeon range from soft to very soft water.

Table IV shows the sources of the public water supplies and the method of treatment of the waters at the various distributing stations. These data are compiled from Table V and from Tables I and II.

Table IV.

Source and treatment of public water supplies in cities and towns of 3,000 inhabitants and over in Eastern Canada.

Source and Treatment	Number of Places	Population served	
		Thousands	Percentage[1]
Surface waters:			
No treatment	20	202.0	2.8
Chlorination only	31	412.1	5.8
Filtration and Chlorination	36	2802.5	39.4
	87	3416.6	48.0
Ground waters:			
No treatment	30	186.1	2.6
Chlorination	9	163.1	2.3
Softening and iron removal	2	19.3	.3
	41	368.5	5.2

[1]Percentage of total population for territory covered in this report.

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TABLE V. ANALYSIS OF SURFACE WATERS

Sample No.		317	318	319	320	321	322
Date of sampling		13/7/36	2/6/36	2/6/36	15/7/36	11/7/36	10/7/36
Source		St. Maurice river	Richelieu river	St. Francis river	St. Francis river	St. Maurice river	St. Charles river
Locality		Grand Mere	St. John	East Angus	Drummondville	Three Rivers	Chateau d'Eau 7 miles from Quebec
Sample collected		Depth sample	Depth sample	Depth sample	Depth sample	Intake pipe Water Works	Depth sample from dam at intake
Gauge		low	high	mean	mean	low	low
Temperature		22.8 °C.	24° C.	21 °C.	25° C.	23 °C.	20 °C.
pH		6.3	7.7	7.7	7.2	6.1	7.3
Dissolved oxygen cc. per litre	p.p.m.	5.5	6.2	5.4	6.6	6.1	6.7
Free carbonic acid (CO_2)	"	5.0	none	3.0	3.5	4.0	1.5
Turbidity	"	10.0	4.0	14.0	2.0	none	4.0
Colour	"	65.0	5.0	60.0	40.0	65.0	35.0
Alkalinity	"	6.5	35.5	36.5	42.5	5.5	24.5
Suspended matter	"	18.8	6.8	6.9	6.5	2.5	7.2
Total dissolved solids dried at 180°C.	"	33.8	72.6	91.9	76.0	35.6	75.4
Silica (SiO_2)	"	6.7	7.8	17.6	2.6	2.5	21.4
Iron (Fe)	"	.18	.10	.20	.22	.18	.26
Calcium (Ca)	"	5.3	15.0	8.2	9.3	5.8	8.6
Magnesium (Mg)	"	1.7	4.3	3.2	3.5	1.9	1.7
Alkalies as sodium (Na)	"	--	--	7.12	7.7	--	2.7
Hydrocarbonate (HCO_3)	"	7.9	43.3	44.5	51.9	8.1	29.9
Sulphate (SO_4)	"	5.8	12.9	7.8	6.6	6.7	10.9
Chloride (Cl)	"	2.0	3.1	2.5	3.5	2.1	2.5
Nitrate (NO_3)	"	.24	.16	1.32	.44	1.77	1.32
Hardness as $CaCO_3$ calculated							
Total hardness	"	20.8	55.1	33.7	37.7	22.3	27.5
Carbonate hardness	"	6.5	35.5	--	--	5.5	24.5
Noncarbonate hardness	"	14.3	19.6	--	--	16.8	3.0
Calcium hardness	"	13.8	37.5	20.5	23.3	14.5	21.5
Magnesium hardness	"	7.0	17.6	13.1	14.4	7.8	7.0

TABLE V, (cont.) ANALYSIS OF SURFACE WATERS

Sample No.		323	324	325	326	327	328
Date of sampling		4/6/36	5/6/36	3/6/36	11/8/36	15/8/36	17/8/36
Source		St. John river, N. B.		Nipisiguit river	St. Mary's river	St. Clair river	Detroit river
Locality		Edmundston	Woodstock	Bathurst N. B.	Sault SteMarie	Point Edward	Windsor
Sample collected		Depth sample	Intake pipe Woodstock Works	Intake pipe Paper Co.	12' Depth above rapids	Intake pipe Sarnia Water Works	Intake pipe Windsor Water Works
Gauge		mean	mean	mean	mean	low	low
Temperature		15 °C.	12 °C.	16 °C.	19 °C.	25 °C.	25 °C.
pH		6.8	7.5	6.8	7.5	8.1	8.1
Dissolved oxygen cc. per litre		6.6	6.5	7.0	7.0	6.6	6.5
Free carbonic acid (CO_2)	p.p.m.	2.5	none	none	.5	none	none
Turbidity	"	none	none	none	none	none	30.0
Colour	"	60.0	50.0	30.0	5.0	none	none
Alkalinity	"	25.5	34.0	12.1	43.0	81.0	82.5
Suspended matter	"	2.6	0.6	none	.3	3.6	38.0
Total dissolved solids dried at 180 °C.	"	68.2	67.6	30.0	58.0	111.0	115.2
Silica (SiO_2)	"	5.8	3.4	3.8	5.5	5.6	6.9
Iron (Fe)	"	.11	.09	.10	.04	.06	.09
Calcium (Ca)	"	16.1	12.9	4.2	12.1	26.4	27.4
Magnesium (Mg)	"	2.3	2.0	1.5	5.6	7.5	8.0
Alkalies as sodium (Na)	"	7.7	2.6	--	1.5	2.6	2.7
Hydrocarbonate (HCO_3)	"	31.1	41.1	14.7	52.2	98.8	100.7
Sulphate (SO_4)	"	8.2	10.3	5.2	7.9	12.0	13.9
Chloride (Cl)	"	15.5	3.5	2.5	3.0	5.5	6.5
Nitrate (NO_3)	"	.88	.24	.24	.88	1.32	1.32
Hardness as CaCO calculated:							
Total hardness	"	49.7	40.7	16.7	56.1	96.8	101.3
Carbonate hardness	"	25.5	34.0	12.1	43.0	81.0	82.5
Noncarbonate hardness	"	24.2	6.7	4.6	13.1	17.8	18.8
Calcium hardness	"	40.3	32.3	10.5	30.3	66.0	68.5
Magnesium hardness	"	9.4	8.2	6.2	25.8	30.8	32.8

TABLE V, (cont.) ANALYSIS OF SURFACE WATERS

Sample No.		335	336	337	338	339	340	341
Date of sampling		8/9/36	6/8/36	22/8/36	18/8/36	4/10/36	8/8/36	16/8/36
Source		Ottawa river	Otonabee river	Grand river	Thames river	Trent river	Nipissing lake	Simcoe lake
Locality		Hawkesbury	Peterborough	Brantford	Chatham	Trenton	Sturgeon Falls	Beaverton
Sample collected		Depth sample	Intake pipe Peterborough Water Works	Depth sample	Depth sample	Intake pipe Hinde Dauch Paper Mill	25' depth 2 miles from shore	25' depth 2 miles from shore
Gauge		low	low	low	low	low	mean	mean
Temperature		15 °C.	22 °C.	20 °C.	25 °C.	22°C.	23 °C.	24 °C.
pH		7.0	7.7	7.6	7.9	8.2	7.3	7.9
Dissolved oxygen cc. per litre	p.p.m.	6.5	6.5	3.8	6.2	7.0	6.8	6.5
Free carbonic acid (CO_2)	"	5.0	none	none	none	none	1.0	none
Turbidity	"	2.5	none	2.0	25.0	3.0	none	none
Colour	"	45.0	20.0	5.0	10.0	10.0	25.0	10.0
Alkalinity	"	16.5	69.5	157.5	154.5	85.0	20.0	112.0
Suspended matter	"	4.6	.7	5.0	29.8	5.2	1.2	3.2
Total dissolved solids dried at 180°C.		71.5	107.1	531.4	475.4	126.7	56.0	166.8
Silica (SiO_2)	"	2.3	4.4	23.1	12.2	5.8	6.1	10.9
Iron (Fe)	"	.12	.07	.12	.10	.04	.08	.05
Calcium (Ca)	"	8.2	28.0	100.7	64.3	31.8	8.9	40.7
Magnesium (Mg)	"	3.0	3.8	31.8	29.5	4.1	2.9	4.1
Alkalies as sodium (Na)	"	--	.8	16.1	54.8	3.3	.3	11.8
Hydrocarbonate (HCO_3)	"	20.1	84.8	192.2	188.5	104.3	24.4	135.7
Sulphate (SO_4)	"	8.3	11.3	214.8	89.4	11.6	10.3	17.1
Chloride (Cl)	"	3.0	3.0	25.0	107.0	3.5	2.0	5.5
Nitrate (NO_3)	"	.70	.88	.62	1.88	.88	1.32	.62
Hardness as $CaCO_3$ calculated:								
Total hardness	"	32.8	85.5	397.9	280.9	96.3	34.2	113.6
Carbonate hardness	"	16.5	69.5	157.5	154.5	85.0	20.0	112.0
Noncarbonate hardness	"	16.3	16.0	240.4	136.4	11.3	14.2	6.6
Calcium hardness	"	20.5	70.0	267.5	160.8	79.5	22.3	101.8
Magnesium hardness	"	12.3	15.5	130.4	120.1	16.8	11.9	16.8

Table VI

NEW BRUNSWICK

No.	Date sampled	City or Town	Source of Supply	Method of Purification	Total hardness	Calcium hardness	Magnesium hardness	Alka-linity	Cal-cium	Magnes-ium
					Parts per Million					
248	July 3/36	Bathurst	Springs	No treatment	94.6	73.3	21.3	69.5	29.3	5.2
250	" 4/36	Campbellton	Smith's Lake	" "	57.8	39.3	18.5	14.5	15.7	4.5
299	" 4/36	Chatham	Wells, brook pumped to stand-pipe	" "	20.0	14.3	5.7	15.5	5.7	1.4
249	" 3/36	Dalhousie	Well and creek	" "	49.5	35.6	13.9	35.0	14.3	3.4
240	June 5/36	Edmundston	Madawaska river	Chlorination	95.7	67.0	28.7	66.5	26.8	7.2
252	" 6/36	Fredericton	St.John river	Filt. chlorination	57.0	41.0	16.0	19.0	16.4	3.9
247	July 2/36	Moncton	Reservoir fed by springs and creek	Chlorination	32.8	16.0	16.8	10.0	6.4	4.1
245	" 1/36	Newcastle	2 Wells	No treatment	101.5	78.5	23.0	113.5	31.4	5.6
241	June 6/36	St. John	Loch Lomond	Chlorination	66.6	46.5	20.1	47.5	18.6	5.1
243	" 6/36	" "	Spruce lake	"	27.3	15.0	12.3	3.5	6.0	3.0
251	" 6/36	St.Stephens	Deep wells	No treatment	38.3	21.5	16.8	15.0	8.6	4.1
242	" 6/36	Woodstock	St.John river	Filt. chlorination	67.6	43.8	23.8	34.5	17.5	5.8

Table VI continued

NOVA SCOTIA

No.	Date sampled	City or Town	Source of Supply	Method of Purification	Total hardness	Calcium hardness	Parts per Million Magnesium hardness	Alkalinity	Calcium	Magnesium
246	June 29/36	Amherst	Upper Nappan	Chlorination	37.7	25.0	12.7	17.0	10.0	3.1
258	" 16/36	Bridgewater	Hebbs lake	No treatment	21.5	10.8	10.7	None	4.3	2.6
256	" 18/36	Dartmouth	Dartmouth water supply lakes	$CaSO_4$ intermittent	24.8	12.5	12.3	None	5.0	3.0
266	" 23/36	Dominion	Sand lake	No treatment	28.7	14.3	14.4	None	5.7	3.5
267	" 23/36	Glace Bay	" "	" "	30.4	16.0	14.4	None	6.4	3.5
254	" 18/36	Halifax	Long lake low service	Chlorination	14.7	5.3	9.4	None	2.0	2.3
255	" 18/36	"	Spruce Hill lake high service	"	21.9	10.8	11.9	None	4.3	2.7
264	" 20/36	Inverness	Mabot reservoir fed by springs	No treatment	32.0	16.0	16.0	3.5	6.4	3.9
260	" 17/36	Kentville	Magee lake	" "	21.3	5.3	16.0	15.0	2.1	3.9
259	" 16/36	Liverpool	Town lakes	" "	23.1	10.8	12.3	None	4.3	3.0
268	" 22/36	New Glasgow	Forbes lake	" "	43.3	30.2	13.1	7.5	12.1	3.2
265	" 23/36	New Waterford	Waterford lake	" "	24.2	9.0	15.2	19.5	3.6	3.7
315	" 25/36	Pictou	Deep wells	" "	124.6	89.3	35.3	73.0	35.7	8.6
263	" 20/36	Stellarton	East river	Chlorination	28.7	14.3	14.4	15.5	5.7	3.5
342	" 23/36	Sydney	Lakes and brooks	No treatment	20.4	9.8	10.6	None	3.9	2.6
269	" 22/36	Sydney Mines	Lake	" "	28.7	14.3	14.4	3.5	5.7	3.5
244	" 19/36	Truro	Lepper brook	" "	38.3	21.5	16.8	9.0	8.6	4.1
262	" 20/36	Westville	Springs and part of middle river	" "	28.4	10.8	17.6	18.0	4.3	4.3
301	" 17/36	Windsor	Mill lake, 8 miles from town	" "	7.6	3.5	4.1	None	1.4	1.0
261	" 6/36	Yarmouth	Lake George	Chlorination	6.2	None	6.2	None	None	1.5

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Table VI (continued)

PRINCE EDWARD ISLAND

No.	Date sampled	City or Town	Source of Supply	Method of purification	Total Hardness	Calcium hardness	Magnesium hardness	Alka-linity	Cal-cium	Magnes-ium
253	June 30/36	Charlottetown	Wells at Brackley 1 well 2 miles from town	No treatment	112.7	60.8	51.9	86.5	24.3	12.5
257	" 29/36	Summerside	Wells	No treatment	137.3	125.0	12.3	111.5	50.0	3.0

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Table VI (continued)

QUEBEC

No.	Date sampled	City or town	Source of supply	Method of purification	Parts per million: Total hardness	Calcium hardness	Magnesium hardness	Alkalinity	Calcium	Magnesium
284	July 9/36	Baie St.Paul	Reservoir fed by springs and creek	No treatment	49.1	32.3	16.8	59.5	12.9	4.1
289	" 20/36	Beauharnois	St.Lawrence river	Filt.Chlorination	129.2	94.8	34.4	97.0	37.9	8.4
281	" 11/36	Beauport	Springs	No treatment	118.7	103.5	15.2	86.5	41.4	3.7
280	" 11/36	Cap de la Madeleine	Springs	No treatment	19.8	10.8	9.0	11.5	4.3	2.2
279	" 15/36	Drummondsville	St.Francis river	Filt.Chlorination	54.5	39.3	15.2	17.5	15.7	3.7
288	June 3/36	East Angus	Willard and Big Hollow brook	Chlorination	18.4	14.3	4.1	10.0	5.7	1.0
271	July 15/36	Granby	Shefford Mountain lake	Coag. Chlorination, soda filtr.	27.5	16.0	11.5	11.5	6.4	2.8
276	" 12/36	Grande Mere	Lac de Pile lake	Chlorination	16.8	9.0	7.8	None	3.6	1.9
277	" 17/36	Joliette	L'Assomption river	Alum, coag. filtr. chlor.	38.3	26.8	11.5	16.5	10.7	2.8
314	Sept.29/36	Lachute	St.John's lake (from stream)	No treatment	46.9	31.3	15.6	65.0	12.5	3.8
273	June 3/36	Magog	Lake Memphremagog	No treatment	91.2	71.5	19.7	72.0	28.6	4.8
270	" 1/36	Montreal	St.Lawrence river	Sand filtr.chlor.	115.9	82.3	33.6	74.0	32.9	8.2
287	" 3/36	Montmagny	Springs	No treatment	34.7	28.5	6.2	26.5	11.4	1.5
282	July 9/36	Murray Bay	Malbai river	Filtration	78.1	53.5	24.6	33.5	21.4	6.0
278	July 11/36	Quebec City	St.Charles river	Chlorination	23.3	14.3	9.0	None	5.7	2.2
284	July 5/36	Rimouski	Lake	No treatment	54.4	39.3	15.1	46.5	15.7	3.7

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Table VI (continued)

QUEBEC (Continued)

No.	Date sampled	City or town	Source of supply	Method of purification	Parts per million: Total hardness	Calcium hardness	Magnesium hardness	Alkalinity	Calcium	Magnesium
286	July 6/36	Riviere du Loup	Lac Municipal	No treatment	29.6	21.6	9.0	17.5	8.6	2.3
275	" 14/36	Three Rivers	St.Maurice R.	Alum.coag. chlor.filtr.	22.2	10.7	11.5	10.5	4.3	2.8
272	June 3/36	Thetford Mines	Wells	No treatment	41.6	28.5	13.1	15.0	11.4	3.2
274	" 3/36	Sherbrooke	Magog river	Chlorination	61.3	42.8	18.5	35.0	17.1	4.5
290	July 21/35	Valleyfield	St.Lawrence R.	Chlorination	133.8	94.8	39.0	88.0	37.9	9.5
285	" 16/36	Victoriaville	Bulstrode river	Chlor.filtr.	62.3	59.2	13.1	50.0	23.6	3.2

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Table VI (continued)

ONTARIO

No.	Date sampled	City or town	Source of supply	Method of purification	Total hardness	Calcium hardness	Magnesium hardness	Alkalinity	Calcium	Magnesium
					Parts per million					
309	Aug.1/36	Burlington	Lake Ontario	Filtr.Alum. Charcoal Chlor.	152.6	110.8	41.8	94.5	44.3	10.2
294	" 9/36	Copper Cliff	Meat Bird lake	Chlorination	41.2	21.5	19.7	43.0	8.6	4.8
305	July 29/36	Dunnville	Grand river	Slow sand filtr. alum. ammonia	438.8	312.5	126.3	112.0	125.0	30.8
303	Aug.26/36	Fort Erie	Niagara river	Chlorination	132.6	92.8	39.8	97.0	37.1	9.7
302	Aug.20/36	Leamington	Wells	No treatment	242.4	119.8	122.6	292.5	47.9	29.6
306	Aug.27/36	Merrilton	Welland Canal Ammon. Sulph.	Filtr.Chlor.	142.4	94.8	47.6	94.0	37.9	11.6
312	Sept.30/36	New Toronto	Lake Ontario	Act. carbon Filtr.chlor.	137.9	94.8	43.1	88.5	37.9	10.5
343	Dec.23/36	North York Tp.	Don river	Filtr. Alum, Chlorination	308.5	223.2	85.3	262.0	89.3	20.8
293	Aug. 9/36	North Bay	Trout lake	Chlorination	33.0	21.5	11.5	6.5	8.6	4.8
291	" 8/36	Parry Sound	Georgian bay	Chlorination	69.7	50.0	19.7	40.0	20.0	4.8
292	" 6/36	Peterborough	Otonabee	Filt.Chlor.	92.0	75.2	16.8	69.5	30.0	4.1
311	Sept.4/36	Picton	Bay of Quinte	Filtr.Chlor.	129.3	92.8	36.5	75.0	37.4	8.9
300	Aug.28/36	St.Catherines	Welland Canal	Filtr.Chlor.	136.0	98.3	37.7	96.0	39.3	9.2
296	Aug.10/36	Sault Ste.Marie	St.Mary's river	Chlorination	55.9	38.5	20.1	30.0	14.3	4.9
297	Aug.10/36	" " "	Wells at Steelton 1/5 to 1/8 of supply	No treatment	78.6	56.5	22.1	82.0	28.6	5.4
313	Dec.23/36	Scarboro Tp.	Lake Ontario	Coag.Rapid sand filtr. chlor.	146.9	101.8	45.1	91.5	40.7	11.0
298	Aug.9/36	Sturgeon Falls	Sturgeon river	Sand Filtr. Chlor.	35.8	19.8	16.0	12.1	7.9	3.9

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Table VI (continued)

ONTARIO (continued)

No.	Date sampled	City or town	Source of supply	Method of purification	Parts per Million: Total hardness	Calcium hardness	Magnesium hardness	Alkalinity	Calcium	Magnesium
295	Aug.9/36	Sudbury	Ramsay Lake	Airation Chlorination	39.5	19.8	19.7	9.0	7.9	4.3
308	Aug.28/36	Thorold	Welland Canal	Rapid sand Filt.Chlor.	135.6	89.3	46.3	94.5	35.7	11.3
304	Aug.20/36	Tillsonburg	New wells and springs	No treatment	204.5	139.3	65.2	164.5	55.7	15.9
310	Sept.5/36	Trenton	Wells*	No treatment	253.3	195.5	57.8	206.5	78.2	14.1
344	Dec.23/36	Weston	2 wells	No treatment	316.6	250.0	65.6	326.0	100.0	16.0

* New Wells, spring supply chlorinated

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