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INTRODUCTION  
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INDUSTRIAL WATERS IN CANADA

Interim Report No. 3

by

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## INTRODUCTION

The investigation of the quality of waters used in Canada for industrial purposes or available for industrial use was begun in 1934. An account of the work completed in 1934 and 1935 was published in the Interim Report No. 1 embracing the quality of the natural and treated waters of the province of Ontario south of the Ottawa River and Georgian Bay and of the province of Quebec as far east as Riviere du Loup. A second Interim Report covered the work done in 1936, when the whole of Eastern Canada east of Sault Ste. Marie was included, except the mining and industrial areas north of the Ottawa River and Lake Nipissing, and the results of the previous year's work were checked. A map showing the distribution of the hardness of the water for supplies from cities and towns of 3000 inhabitants and over, within the above territory was added.

For details regarding the work thus far completed, reference should be made to these two reports, which besides setting forth the procedure, discuss the general character of the waters, give a brief review of previous investigations, an outline of methods of analyses used for the investigation, and tabulations and diagrams compiled from data of the public water supplies.

The present report follows the general trend of the previous reports. It deals with the quality of the surface waters and civic supplies for Western Canada from Sault Ste. Marie as far west as the Columbia River, B.C., the Northern Ontario mining areas, the

Abitibi River and the Mattagami River, with tributaries, as far north as Smoky Falls and a check -- of the previous years' investigations of the Ontario arteries and lakes so as to ascertain the seasonal variations in composition of these waters, as well as changes in the quality of the civic supplies.

Complete analyses are included of 49 samples of surface water from key stations on the large lakes and rivers that are of industrial importance, and partial analysis of 84 public water supplies for alkalinity, total hardness, calcium and magnesium hardness. The information gained from these waters by complete or more detailed analysis would admittedly have been useful, but involved more work than the available laboratory staff is capable of completing from the time of sampling to the commencement of the following season's field work. Moreover, samples of water cannot be kept for an indefinite period as they change in composition on standing.

No hardness map has been compiled from analyses of civic water supplies for western Canada, because for this more analyses would be desirable, many of the waters having been analysed for mineral content for the first time. It is a matter of conjecture what effect the continuous eight years of drought has had on the mineral composition and the concentration of the surface waters and civic water supplies, especially from the southern areas where the drought has been severe; whether the analyses herein

reported represent normal or abnormal quality of these waters is therefore unknown. In the absence of official records of analyses for most rivers and supplies this investigation will have to depend largely on its own sampling and analyses.

#### Sampling of Natural and Treated Waters

In order to obtain a true average of the quality of a body of water it is essential to collect and analyse samples from each source of supply regularly and at as short intervals as possible. In the Quality of Waters Division of the United States Geological Survey, lakes, rivers, and other water supplies are usually sampled periodically throughout the year. A composite of daily samples for each month is made. This is not practicable in Canada at present and the rule adopted during the field season has been not to pass any supply or key station within reasonable reach without collecting a sample. This applies particularly to surface waters of industrial importance, so as to determine the seasonal variation in composition. As regards civic supplies from filtration plants of surface waters and from wells and springs, termed ground waters, treated and untreated, the latter are usually more permanent in composition. Every attempt is made to keep the information of the quality of civic water supplies up to date, through enquiries at the offices of the city engineers and water works officials concerning changes in water treatment, new water supplies developed, etc., and samples collected.



In previous years all civic waters were sampled from sources serving a population of 3,000 inhabitants and more. This would represent 53.2 per cent of the population of Eastern Canada as far west as Sault Ste. Marie. For Western Canada, with a comparatively sparse population and few large cities, the lower limit of population has been placed at 2,000 inhabitants, not because it would materially increase the ratio, but because it gives a better geographical distribution of the various types of industrial and civic water supply in these very large areas. Even then, the ratio of the population served for the whole of the Western Provinces so included is only 32.2 per cent; that of the Province of Manitoba from 6 places, 36.7 per cent; of Saskatchewan from 14 places, 17.3 per cent; of Alberta from 9 places, 28.0 per cent, and of British Columbia, 19 places, 53.9 per cent.

#### Character of the Waters

Of the surface waters of the West, those of Manitoba are very hard, except that of Lake Winnipeg, which is medium hard; those of Saskatchewan and Alberta, the North and South Saskatchewan River, Red Deer and Bow Rivers are hard to medium hard, Elbow River, hard, and Columbia River, medium hard to soft.

The waters of Western Ontario are mostly soft to medium hard with colour medium (20 p.p.m.), with the exception of Lake Kenogamish (70 p.p.m.). Apart from the high colour due to organic matter, the mineral composition of the water from the Lake of the Woods at Kenora is almost identical with that of Lake Superior

near Port Arthur.

The waters of the Northern Ontario river system, the Abitibi and Mattagami with tributaries, are medium hard to soft, with very high colour intensities, that at times are reported to be as high as 250 p.p.m. The same characteristics, as regards colour and hardness, appear to apply to the lakes that supply water to the mining industry. An exception, the only one noted so far, is Pearl Lake at Timmins, which has very hard water, and suggests that hard waters may be found as the investigation is extended into this area. Of the northern waters flowing south, those of the Ottawa River, Lake Timiskaming and Lake Nipissing are very soft with colour intensities 45, 70, and 35 p.p.m. respectively.

Regarding the arteries and lakes in Southern and Eastern Ontario, a comparison with previous years' records of analysis for the Ottawa River at Hawkesbury and the St. Lawrence River at Montreal has no significance because the composition of these waters is very unstable, as may be observed from tabulated results of analysis in this and previous reports. The Ottawa River water is one of the most unstable in composition of our surface waters; irrespective of season it has a wide range for the following constituents; of pH, 6.8 to 7.4; colour, 40 to 80 p.p.m.; turbidity, 7 to 11 and up to 100 p.p.m. at spring run-off; alkalinity, 15 to 38 p.p.m., and total hardness, 20 to 70 p.p.m.; that is, a change in concentration of 100 per cent and over may be expected for any

of these constituents. The composition and concentration of the St. Lawrence River at Montreal to a considerable extent depends on how heavy is the flow from the Ottawa River, its largest tributary, for as pointed out in previous reports, it requires a comparatively long time before the two waters mix. The Ottawa River at times of heavy flow, moreover, deflects the current of the St. Lawrence, whereby Ottawa River water, unmixed, enters the conduits of the Montreal filtration plant at Verdun. The increased values of iron in the Ottawa River water at the Hawkesbury key station seem important, samples collected in June and September having an iron content of 0.34 p.p.m., where it normally contains less than 0.10 p.p.m.; and much higher iron content even up to 5.00 p.p.m. has been reported for that part of the Ottawa River by local industrial concerns.

The more abundant rains during the past season and the very heavy run-offs in the spring are likely to have had an effect on the quality of the waters of the tributaries to the Great Lakes basin, the Grand River in June being of much less concentration, and both samples, collected in June and December, show appreciable decrease in sulphates and chlorides. The same characteristics are even more marked for the water of the Thames River; Lake Simcoe is almost unaffected, as are the Great Lakes themselves, a trend towards slightly lower values being noted in some of the samples collected during the summer. No conclusion can, however, be drawn from the smaller variations in composition of samples from such

large bodies of water, because variation does occur from time to time in most of the constituents of the water, as well as in the concentration, as may be seen from analyses of the United States Geological Survey Water Supply Papers of monthly composite samples<sup>1</sup> as, for example, those from Lake Erie and Lake Superior.

Of the municipal water supplies west of the Great Lakes, three out of four in Ontario are soft waters, and one medium hard to soft. From the Prairie Provinces, most are hard to very hard, whether supplied from springs, wells or surface waters, two exceptions being the wells at Vegreville, of medium hardness, and at Wetaskiwin, with very soft water; both these waters, however, have very high alkalinity, 525.5 p.p.m. and 491.5 p.p.m., respectively, indicating high sodium bicarbonate contents. The Winnipeg water supply is of medium hardness, but is obtained from the Shoal Lake at Lake of the Woods in Ontario. The hardnesses of the treated waters from the big arteries of the Prairie Provinces follow closely those of their raw waters, ranging from hard to very hard.

Of the three supplies examined in British Columbia, two show medium hard waters and one, at Kimberley, very soft, in fact it was the softest water supply, with the exception of two, so far sampled in this investigation.

In Ontario areas north of the Ottawa River and Georgian Bay, of thirteen supplies sampled and analyzed, eight were soft waters, two medium hard, and three very hard, the latter being supplied

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<sup>1</sup> The United States Geological Survey, Professional Paper B5, by F.W. Clarke, p.11 and p.16.



from deep wells.

In the southern and eastern parts of Ontario, check samples from twenty places show slightly lower values for hardness in eleven places, slightly higher in eight, and no change in one, the average hardness for the twenty places being 145.3 p.p.m. for 1937 as compared with 145.7 p.p.m. for 1934, 1935, and 1936.

The Effect of Certain Impurities in Waters  
on Some Industrial Processes

Industries are heavy consumers of water, every process of manufacture being dependent on this commodity at some stage, especially in the chemical industry, water being the most important of all our chemicals. Its uses are much diversified, such as: solvent, as a diluent, in ore dressing, for cleansing, as a conveyor and distributor of pulped material; in transmission of heat, for cooling, concrete mixing, fire extinguishing, and for power both thermo-dynamic and hydraulic.

The quantities of water used by many industries are enormous, many times, in some cases hundreds of times those of any other raw material used in the particular process. The water consumption for a fair-sized pulp or paper mill, a large concentrating plant, etc., would be adequate to supply a medium-large Canadian city.

Such large quantities of water in contrast to other raw materials are used in processing, for example, ore concentrates, paper, sugar, textiles, or leathers, that it is evident impurities present even in small quantities may accumulate by precipitation

or concentration to cause very serious operating problems. Wherever large quantities of water are used, manufacturing problems may arise owing to salts precipitated from the water, or because the impurities in the water react on substances in the process; discolouration may be caused by the presence of iron, manganese, copper, and dissolved organic matter, offensive tastes and odours by impurities such as sulphur compounds, iron, algae, and magnesium chlorides or sulphates; lime and magnesium salts may cause scale formation in boilers and conduits endangering failures, and waste of cleansing material (soaps) may result in inferior textile products by precipitated insoluble soaps adhering to the fabric, etc. Many impurities in a water have an adverse effect on dyeing, on crystallization of salts from their solutions, on metal plating, on manufacture of mirrors, etc. There are also a number of impurities that cause corrosion.

Following is given a brief account of the effect of impurities and certain characteristics in waters on some manufacturing processes.

Mining Industry. Since the earliest time of mining, water has been the main agent for separating the precious metals and the more valuable ores from their gangues, and it still remains such, whenever an ore is associated with a large proportion of foreign matter. The quantity of water used in the concentration of an ore is very large. One large Western ore flotation plant uses 16,000 tons (3.2 million gallons) per day. Scarcity of water would severely hamper such an industry and the water from the Dorr

settlers would have to be used over again. Most of the water could be pumped back and run over again, were it not for the chemicals added to the water in the flotation process, which would accumulate to undesirable proportions. In consequence only 6,000 of the 16,000 tons of water required for the above plant can be reclaimed, and the rest is discharged.

For the concentration of ores it is necessary that the water used be alkaline. Alkaline waters facilitate the settling of the pulp and slime, after grinding with water, saving time. Alkaline water is essential for most of the flotation reagents and also for their chemical action on the minerals. Cyanides of the alkali metals are distinctly alkaline in their reaction, hence they would decompose in contact with acids in the water, with consequent loss of an expensive reagent.

Waters are rendered alkaline in ore dressing by the addition of alkali reagents in sufficient quantity to raise the pH value usually to 9. to 9.5. The reagent may be fed to the mill water as milk of lime (calcium hydrate), as free lime in the form of powder (calcium oxide) or as soda ash. Soda ash is preferable in flotation as the lime is likely to precipitate on the ore grains as calcium carbonate, which would interfere with their coating by the flotation chemicals. Lime is the usual reagent for raising the pH value of the mill water at gold mines using the cyaniding process, and it has the advantage of being one of our cheapest chemicals.

The alkalinity of a water may be determined either by direct

titration with 1/50 normal sulphuric acid using methyl orange as indicator on 100 cubic centimetres of the sample, the burette reading in cubic centimetres  $\times 10$  = parts per million of alkalinity expressed as calcium carbonate, or by determination of the hydrogen ion concentration (pH value). Neutral water has a pH value of 7.0; less than 7.0 indicates acidity and more than 7.0, alkalinity. Thus an adjustment of the pH value can be made by the addition of chemicals until the desired hydrogen ion concentration has been reached.

Distilled Water. All surface and ground water was originally evaporated from the ocean, and the vapour condensing in the higher strata of the air was precipitated inland to form the purest waters found in nature. All rain water, however, contains foreign matters absorbed during its descent that vary much in composition and concentration, according to locality. These impurities consist of oxygen, carbonic acid and atmospheric dust, nitrogen compounds especially after thunder storms, sulphur compounds and soot near large manufacturing centres, and volcanic ash, sodium chlorides from the ocean spray carried inland, etc. To obtain a pure water, therefore, distillation becomes essential.

Large quantities of distilled water are manufactured usually in auxiliary plants in connection with manufacturing processes, hence it is difficult to arrive at a figure of the production in the Dominion. Distilled water has most varied application in industry, being used, for example, in the manufacture of pure

chemicals and drugs, in photography, as a diluent of spirituous liquors, manufacture of ice, in chemical laboratories, storage batteries, manufacture of yeast, potable waters and soft drinks, plating of mirrors. It is used not only when the purity of the products is essential, but also when the process is very sensitive to certain constituents of the water, as in the following interesting cases:

Silver plating on glass for the manufacture of mirrors is so extremely sensitive to the presence of iron, that no upper limit can be set for iron in the water used for preparation of the silvering solution. At a mirror-plating works using 300 gallons of distilled water a day it has been found that the slightest trace of iron in the solution makes the silver deposit black and granular; and once when a two-inch iron pipe connection was made to the end of the worm of the still, several batches were ruined before the cause of the trouble could be located.

In the manufacture of yeast, sulphates of lime and magnesia retard the fermentation and the alkali sulphates somewhat less. Softening the water with soda, zeolite, etc. does not help as the sulphates of lime and magnesia will only be replaced by somewhat larger quantities of the alkali sulphates. A yeast manufacturer using the waters of the Lower Great Lakes, even when treated, will suffer a loss of time of as much as five to six hours per batch. Manufacturers of yeast have, therefore, found it economical to use distilled water.

The manufacturer of distilled water requires a pure water, low in calcium and magnesium carbonates, which are objectionable inasmuch as they cause scaling of the tubes in the still that is difficult to remove, and so previous softening of hard and medium hard waters is preferable. The raw water should be free from tastes and odours as the substances causing these may distill over, making the product unfit, especially for potable products.

Pulp and Paper Industry. Pulp and paper mills are among the heaviest consumers of water, which is used in the processes for the conveyance of pulped material for cleaning, heating, and as solvent, and its purity has an important bearing on the quality of the final product. Owing to the very large quantities of water used, their treatment becomes an important item in the cost of production, especially in the case of highly coloured waters that impart a yellowish tinge to the product, and if very white paper is required, the higher price obtained for the product pays well for the treatment. Other impurities in the water are sand, slime, and vegetable and animal matters, which have both a mechanical effect in clogging screens, save-alls, wires, etc., and in the case of sand in forming pin-holes in the paper. From the chemical point of view slime and grease spots, make the product inferior in appearance and create danger of breaks with consequent deterioration of the stock. These troubles may lead to the closing of the plant during heavy run-offs, causing loss of stock, higher labour cost, increased replacement of felt and loss of production.



Animal matters cause grease spots that will not take colour or printing ink, Sand, together with slime, makes the paper brittle and decreases its tensile strength. Iron in the water may precipitate and rust-stain the paper, and hard water in some paper mills owing to precipitation of lime and magnesia carbonates affects the quality of sized paper.

Textile Industry. The presence of alkaline earths and iron in waters used in the textile industry is objectionable, for in the cleansing process the detergent will precipitate insoluble soaps that adhere to the fibre of the fabric. Iron causes stains. For alkaline dyes these impurities are most objectionable and must be removed by the usual methods of water treatment. Calcium, magnesium, iron, and aluminium precipitate on the fibre rendering the fabric lustreless and of poor quality. Of these, iron and aluminium are the most objectionable because they will precipitate with the dye and form dark stains, particularly aluminium, which forms a scum on the fabric that leaves a spotty appearance when brushed off. Aluminium also acts as a mordant to the fibre and forms lake colours of different tints.

In the manufacture of artificial silk or cellophane, iron in the water has an objectionable effect as it hastens the maturing of the shredded cellulose after the treatment with caustic soda. Normally 90 hours is required for the maturing of the alkali cellulose, and the routine of the process is adjusted accordingly, but if the time factor be variable, whole batches of this material might not be processed in time, with consequent loss of production

and material. The water used must, therefore, be low in iron; if not, the iron must be removed by the usual treatments, aeration, filtration, etc., before use.

In the silk industry, the process of de-gumming, washing, and dyeing, differs only in detail from that of other textile processes. In the weighting of silk, however, the quality of the water plays an important part. Weighting of silk is possible because of the tubular structure of the silk thread, which contains two capillaries. The artificial silk threads, rayon or celanese, are solid and cannot be weighted. The amount of weighting of silk is usually calculated on a basis of ounces per pound of raw silk and expressed between limiting variations of 2 ounces, and it is further reckoned that one pound of raw silk is equivalent to 12 ounces of pure silk.

Many methods are used in the weighting of silk, but the most popular appears to be the tin-silico-phosphate method. It is evident that as these chemicals are readily precipitated by carbonates, the water used must not be hard nor contain free carbonic acid. Any calcium salt in neutral or alkaline solution precipitates the phosphate as insoluble metaphosphate that will not weight the silk but covers the fibre and causes a lustreless surface. Hard waters also form insoluble soaps during the boil-off process that settle on the fabric when it is washed in the soap solution, and adhering to the cloth will be broken up by the action of the tin shloride to leave oily spots on the silk, which cannot be weighted,

nor will these spots take the dye.

Manufacture of Felt Hats. Felt hats are made from the fur of rabbits that has first been cleaned and then had the coarse hair removed, after which it is mixed with water and pressed into a large cone. This is felted by a series of shrinkings, accomplished by wetting and drying between cloth until the desired density of the felt is obtained, when it is pressed into the shape of a hat. As the water added to the felt is evaporated, any impurities it may contain will concentrate and remain in the felt, affecting the softness and the lustre of the product. Very hard waters or waters containing organic matter must be avoided. Zeolite or soda softening will not improve the condition as the mineral matters in the water will be replaced with alkali salts, instead of those of the alkaline earths.

Soap Manufacturing. If hard water be used in the preparation of alkaline liquors in soap manufacture, wastage of alkali occurs through precipitation of calcium and magnesium salts forming insoluble soaps that become included in the soap, resulting in an inferior product. The same applies to the boiling of the soap if hard water be added at this stage. The boiling is essential in order to attain the proper degree of hydration and to neutralize<sup>1</sup> the free fatty acids such as oleic, stearic and coconut oil.

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Technology of Water, by Alan A. Pollitt, p.58-59.

Hard waters are therefore most undesirable at all stages of soap manufacture, in fact, hardness of water is often termed soap consuming power, the proportion <sup>1</sup> per part per million being 0.1 pound per 1,000 gallons of water.

In industries using soap such as that of textiles dealt with above, and in the laundry industry and the home, hard water causes waste of soap, because the soap will have no detergent quality until it has softened the water to zero hardness. As other water softeners are much cheaper than soap, it pays a community to soften its civic water although but a very small part of the water is used for cleansing with soap. It has been estimated that for a water of 250 p.p.m. hardness, the waste of soap would amount to 5 to 10 dollars per annum for a household <sup>2</sup> of five persons.

Domestic Waters. In the home a good clear and soft water contributes to comfort and lightens the burden of housekeeping. Water containing iron and manganese causes staining on laundered materials, white porcelain and enamelled receptacles that is difficult or impossible to remove. Hard water is unpleasant for washing and gives poor results in laundry work, owing not only to waste of soap but to the fact that the precipitated insoluble soap adheres to the fabric and imparts an unattractive

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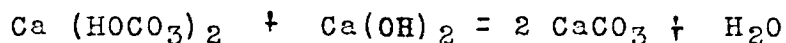
Examination of Water, by Wm. P. Mason, p.30.

Examination of Water, by Mason and Bushwell, p.37.

greyish colour as well as renders it rough to the touch. Hard water, moreover, causes scaling in hot water tanks and pipes that adds to the householder's plumbing bill. Many householders, therefore in districts where the waters are hard install softening devices in their homes because soda, phosphate or zeolite, whichever is used, is far cheaper than soap, and the owner has the comfort derived from a soft water. Small water-softening plants are simple to operate, comparatively low in first cost and in operation, and the saving in soap more than pays for the cost of softening the water.

Manufacture of Ice. Water used for the manufacture of ice must be pure. Lime and magnesia cause opacity of the ice; organic matter, iron, and manganese, discoloration; and other mineral matter such as alkalis, uneven freezing. In the ordinary methods of manufacture the water is frozen as a whole, the cake of ice formed thickening upwards from the bottom and from the sides. As the ice crystals build up and grow towards the top and to the centre, they exclude the impurities, which become concentrated in the water, thus purifying the ice, so that foreign matter, soluble and insoluble, collects in the centre of the ice cake, and will eventually freeze provided the temperature is sufficiently low. From this condition, especially when organic matters, soluble or insoluble, iron or manganese are present, results a coloured core and an unattractive ice cake. As sodium salts are about as troublesome as those of calcium and magnesium - the concentrated salt solution requiring much

lower temperature to solidify - it has been customary in treating hard waters high in calcium and magnesium bicarbonates, to remove these only by milk of lime.



If a high grade ice is required distilled water is used.

The above difficulty, however, does not arise in such freezing methods as are similar to nature, in which the ice forms on vertical freezing plates suspended in cold, slowly flowing water.

The Brewing Industry. From the earliest days of the brewing industry, breweries were built near suitable sources of water, and the water in certain districts therefore determined the characteristics of the beers made. For example, the wells at Burton-on-Trent are known for giving the best ales, Dublin and London for stout and porter, and Munich, Pilsen, and Dortmund for lager beer. This idea still holds, and the kind of water is an important factor in choosing the site of a brewery.

Water used in brewing must, therefore, be carefully analysed and adjusted to the desired mineral content; the proper balance between the various mineral salts is important to ensure the desired action of the enzymes in the mashing process, a good fermentation and satisfactory maturing beer.

For light ales a water is required of medium hardness, largely calcium sulphate, and for dark beers and porters, soft waters. In general waters should be free from organic matter,



should be colourless and odourless. Deficient aeration retards and may even prevent fermentation, resulting in rotting of the grain.

The advantages of calcium sulphate in waters for brewing pale ales are several; it does not precipitate the carbonates and it neutralizes the acidity of the wort and the beer; it facilitates the production of peptones and amides during the brewing proper. It further causes albuminoids to coagulate in readily separable form during the boiling of the wort, resulting in a clear and good-keeping product.

Calcium carbonate is objectionable as it precipitates phosphoric acid, an essential food for yeast, and thus retards the fermentation. Magnesium sulphate is not desirable as it retards the extraction of the malt and imparts an unpleasant taste to the product, owing to formation of amylo<sup>1</sup>in. Common salt and potassium chloride are generally beneficial, lending a flavour to the beer, noticeably lacking when they are absent. Too much salt or over 350 p.p.m. deters the production and the activity of the yeast.

A water with an iron content in excess of 0.1 p.p.m. is undesirable as the presence of iron may impart an unpleasant taste and odour and a greenish tint to the beer.

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Technology of Water, by Alan A. Pollitt, p. 45.

Distillery Industry. The criteria of suitability applied to water for producing a superior product in brewing are equally adopted by some distillers, especially in the United Kingdom, where the waters from certain springs are credited with yielding superior grades of liquor. The springs used at some distilleries are closely guarded against contamination and the water is led to the plants in wooden pipes.

The effect of the various impurities in the preparation of the mash for brewing applies to the malt preparation for the distilling process; owing to the greater concentration of distillery products, the effect would be much greater. For beers the fermentation mashes are adjusted to produce an alcohol content of about 5 per cent, whereas for distillery products the fermentation is carried to the highest possible alcohol concentration. The most concentrated alcoholic mashes usually contain from 12 to 15 per cent alcohol by volume although as high as somewhat above 17 per cent alcohol is obtainable from grape juice and sugar solutions. Impurities that retard germination and reduce the activity of the fermentation, such as iron, carbonates of lime and magnesia, calcium chloride and sodium chloride should, therefore, be avoided. Organic matter is likely to cause putrefaction during the fermentation of the grain. This, in combination with calcium sulphate, may cause the formation of hydrogen sulphide, which would impart an

offensive taste and odour to the distilled spirit.

In diluting the spirituous distillates to the desired proof spirit content, the water used must be free from calcium and magnesium salts, which would be precipitated by the alcohol, causing cloudiness, and so in the absence of any soft waters, distilled water is regularly used as a diluent in the distilleries.

Tanning Industry. Compared with the amount of tannin extracted in the tanning liquors, the water used in the leather industry is very considerable, and impurities that precipitate the tannin have an important bearing on the success and the economy of the tanning process. With the exception of the sodium salts tannin will precipitate all metals that normally occur in natural waters.<sup>1</sup> Limey magnesia and iron in the leaching vats result in loss of tannin and, by forming a coating on the leached material, interfere with the extraction. Iron forms dark coloured precipitates with tannin, ranging from black to dark blue and green according to the origin of the tannin. Any such precipitate reaching the tanning pits causes reduced tanning efficiency and discoloured leather.

If water used in liming the hides contain appreciable quantity of calcium bicarbonate it precipitates on the hide and if not removed, makes the deliming difficult and interferes with the tanning proper, causing brown stains on the leather owing to the oxidation of tannate of lime. Calcium carbonate

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Technology of Water, by Allan A. Pollitt.

introduced in this way is very difficult to remove in the acid bath. Bicarbonate of magnesia has a similar effect in the tanning pits, forming readily oxidizable tannates. Sulphates of calcium and magnesium are not harmful and are sometimes added by the tanners to the water. Waters rich in alkali carbonates or free carbonic acid bring about the same complications by precipitating the lime in the liming process. Free carbonic acid up to 5.0 p.p.m. is not unusual especially in the northern soft waters, but natural waters rich in alkali carbonates are comparatively rare in Canada. Waters contaminated with organic matter and bacteria are especially harmful in the soaking of the leather as putrefication is likely to set in and destroy the tissues of the hide.

Sugar Industry. Raw sugar refineries, cane- and beet- sugar factories, are heavy consumers of water, especially the last mentioned, for besides being used as a solvent in extracting the sugar, it is used for cleansing the beets, and for conveyance of the beets from the storage sheds to the factory, and of the spent pulp away.

As milk of lime is added in the process for precipitating soluble organic matter extracted from the cosettes (sliced beets) in the diffusion battery, bicarbonates of lime and magnesia do not greatly interfere in a moderately hard water, but waters very high in bicarbonates of the alkaline earths may adversely effect the extraction of the sugar from the cosettes, as when heat is

applied it precipitates calcium carbonate and coats the surfaces. Sulphates and chlorides of lime and magnesia and the alkalis, however, are detrimental, holding up an appreciable quantity of sugar in the syrups and molasses. One part of salt will hold up five parts of sugar in the massecuite (first crystallization from the sugar boiler) and subsequent crystallizations from the molasses that has been separated from the sugar crystals by centrifuging, and treatment of the water by removing the lime and magnesia by soda or zeolite only aggravates the condition, because it requires a greater quantity of alkali bases to replace those of the alkaline earths, and as they act in a similar way they decrease still further the yield of crystallizable sugar obtainable from the concentrated juices and molasses.

In the final treatment of molasses by the osmose process part of the alkali salts and some soluble organic salts are removed by diffusion through parchment diaphragm from the hot diluted non-crystallizable molasses on one side of the diaphragm to hot water on the other side, making two more crystallizations possible after the syrup has been boiled down to the desired concentration. The water used in this process must be clear and not too hard, as calcium carbonate is likely to precipitate in the hot solution and clog and reduce the porosity of the parchment membrane, which is the prime principle on which this process is based.

Bakery. In bread-making, about equal parts of flour and water are used. That so little attention has been given to the quality of the water is astonishing. It may be because of its cheapness and the fact that a clear sparkling water is popularly regarded as free from foreign matter. The literature on water, in relation to the fermentation of dough, is more popular than scientific, with the result that much confusion exists in the trade about this subject.

The problem in practice is the adjustment of the conditions of fermentation for the best use of the local water, not the reverse. Treatment of water is rarely necessary except in localities where the composition is very unsuitable. Reagents are often added at the time of mixing without any expensive treatment of the water.

Chemists who have conducted experiments on waters from bakeries in connection with the manufacture of yeast, aver that it is exceptional to find one wholly unsatisfactory. A potable water is usually suitable. It is surprising how a vigorous yeast fermentation changes the reaction of a dough made from alkaline water. A water of medium hardness, largely calcium sulphate, seems to be preferable. Dr. H.A. Kohman of the University of Pittsburgh has made a study of the effects of mineral salts on the fermentation of dough and of how those contained in natural waters influence the process of the manufacture of bread. Of a large number of substances he studied, surprisingly

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<sup>1</sup> Baker Weekly, Oct. 2, 1915.



few have a really significant effect upon fermentation. The salts of mineral acids such as chlorides, nitrates, nitrites and sulphates, which are of common occurrence, in water are almost without effect unless combined with a metal that influences fermentation. This is equally true of phosphates, which is surprising, for they are essential to fermentation. This quasi-paradox may be explained by the fact that flour is relatively rich in these substances, and therefore adequately supplies the phosphate requirements of the yeast. Sulphides are particularly objectionable in breadmaking. Very small quantities of potassium sulphide render the dough so sticky that it is impossible to make bread from it. -

The carbonates are especially common in natural waters and, as a class, they neutralize the acids in the dough, and thus interfere with the fermentation. The carbonates of alkali metals are especially harmful, but waters containing them are comparatively rare in Canada. Sodium chloride is added to bread in much larger quantities than it generally occurs in waters, but in some localities it is present in such concentration as to warrant its being taken into consideration in the manufacture of bread. Next in importance in this group are the salts of potash. The significance of these salts in the life and growth of yeast is indicated by its ash of which, according to analysis by Netscherlich, shows that potash constitutes about 35 per cent.

Calcium chloride has a marked effect in raising the dough; the addition of 3.5 grammes of  $\text{CaCl}_2$  per 1000 grammes of flour, increases the volume of the loaf 15.5 per cent. Bakers' bread is usually light enough - if not, indeed, too light - hence the volume per se is not important. The increased activity of the yeast, due to added salt, can be taken advantage of either by shortening the time of fermentation or by effecting economy in the amount of yeast required. From the small quantities of calcium chloride present in civic water supplies, there is little likelihood of much effect on the fermentation of the dough, but it should be beneficial.

Canning Industry. In canning meat, a clear water free from organic matter is needed, but hard water does not appear to be injurious to the curing and preparation of meats for consumption.

In canning fruit and vegetables the only vegetable affected by hard water is the pea, which tends to harden and acquire a mealy taste. The turbid juice often found in canned peas is not due to calcium salts precipitated from the water, but to starchy matter. Hard water is, however, beneficial to vegetables and fruits that tend to soften in canning - string beans, peaches, pears, etc. - as it hardens the product, making it crisp and retentive of its shape. Calcium sulphate toughens the vegetable.

Starch Industry. In the process of manufacturing, starch is sensitive to colour, for the product must be perfectly white so that waters containing iron, manganese, or organic matter,

especially those of the humic series, need flocculation and filtration.

Glue Manufacture. Glue is made from odd ends of hide and, in some cases, from bone. Hard water retards the breaking up of the tissue. The water used in boiling glue should be softened.

Boiler Waters. For steam raising water should be free from sedimentary matter, contain only a small quantity of free carbonic acid, and the smaller the amounts of salt in solution, the better, especially such salts as precipitate on heating and on concentration. Waters containing free carbonic acid or other acids cause corrosion by acid steam and should be neutralized.

Bicarbonates of lime, magnesia, iron, etc., are readily precipitated on heating and if in large amount form scale on plates and tubes, but in smaller amount, usually set at a maximum of 90 p.p.m. and less, the insoluble deposit is precipitated as a sludge that can be blown down.

Other soluble salts like calcium sulphate deposit and crystallize out when the boiler water becomes concentrated and form a hard scale that is difficult to remove. Failure of the metal caused by scale may occur either by overheating of the plates and tubes, causing bulging from the boiler pressure, or by weakening the plate from the fire side by oxidation of the overheated metal, the cover of oxide of iron scales formed being flaked off.

Silica in appreciable quantity deposits with the alkaline earths and forms a very hard and tough scale difficult to remove, and calcium and magnesium chlorides in concentrated solutions hydrolyze, setting free hydrochloric acid that may pit and even perforate the boiler plates above the water level.

All these salts can be removed by the usual water softening processes, but the soluble alkali salts that replace them concentrate in the boiler water and crystallize out, unless the boiler is regularly blown down. They may also cause bumping, the denser solution becoming superheated and then going into a violent ebullition, so that not merely foam but water in bulk is thrown into the steam pipes.

Nitrates are undesirable in boiler feed waters, because they are reduced by the iron of the boiler plates and are given off as ammonia with the steam.

Corrosion. Corrosion does not take place in pure water, but is due to dissolved foreign matter. Some corrosive agents are more active than others, some are inactive or less active singly, but active with other agents; others active singly become very active in combination with another agent. As corrosive agents are usually classed all acids, sulphates of iron and aluminium, calcium chloride and nitrate, magnesium sulphate. Free and half-bound carbonic acid and dissolved oxygen are very active especially when both are present in appreciable amount.

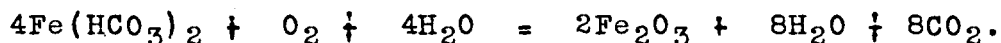
Soft waters are generally more corrosive than hard, which form a scale that protects the surface of the metal. The

corrosive action of soft waters is principally due to their higher acidity and consequent lower pH value. Free carbonic acid decreases the pH value and so increases the corrosive power of a water, and in combination with dissolved oxygen becomes a very destructive corrosive agent. The rate at which the action progresses increases with the temperature and with the hydrogen ion concentration (pH), hence hot waters with low pH value are most corrosive.

The chemical action of corrosion by free carbonic acid and dissolved oxygen takes place in the following order:



Dissolved oxygen in the water near the iron surface oxidizes some of the hydrogen back to water. After the oxygen near the iron is used up the hydrogen remains a gas, in the cold reaction usually about 20 per cent. The dissolved oxygen at the same time oxidizes the soluble iron bicarbonate to insoluble red oxide, setting free again the carbonic acid.



The carbonic acid, set free, dissolves more iron and is again set free until all the dissolved oxygen is exhausted.

The red oxide of iron then acts as an oxidozer until it is completely reduced to black magnetic oxide of iron, setting free carbonic acid again.



Final product is  $\text{Fe}_3\text{O}_4$  and reduction does not take place after this stage.

After all dissolved oxygen has been used up, nitrates are completely reduced to ammonia serving to supply oxygen.



After all possible sources of oxygen have been exhausted the carbonic acid dissolves more iron, which is probably precipitated as basic carbonate of iron because the iron in solution is only from 0.2 to 0.7 p.p.m. and the water impoverished in free carbonic acid, dissolved oxygen and nitrate<sup>1</sup>.

These reactions go to show how effectively the corrosion can be accomplished by free carbonic acid and dissolved oxygen in combination. Under normal conditions, 10 p.p.m. of oxygen could oxydize only 31 p.p.m. of iron, but in combination with the catalytic action of free carbonic acid it will oxidize 126 p.p.m. of  $\text{Fe}_3\text{O}_4$  expressed in iron.

Methods used to prevent corrosion are several, depending on conditions. For boiler feed, dissolved oxygen and free carbonic acid can be almost all driven off by preheating. In large industrial or civic supplies it is more economical to remove most of the free carbonic acid by aeration, or it can be neutralized with lime or soda. By this treatment as well as by

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<sup>1</sup> Journal of the American Water Works Association, by Frank E. Hale, Vol. 26, No. 10, October 1934.



the use of a number of boiler water compounds on the market the acidity of the water can be neutralized, raising its alkalinity to the desired pH value.

# ANALYSIS OF SURFACE WATERS

Sample No.	346	347	345	348	349
Date of sampling	June 5	Sept. 27	Apr. 13	June 5	Sept. 29
Source	Ottawa river		St. Lawrence river		St. Lawrence river
Locality	Hawkesbury		Montreal		Montreal
Sample collected	Depth sample at 20 feet midstream		Intake pipe Montreal water works Verdun		Intake pipe Montreal Water Works Verdun
Gauge	high	mean	high	high	mean
Temperature	16°C.	18°C.	4°C.	15°C.	18°C.
pH	6.8	7.0	7.4	7.1	7.5
Dissolved oxygen cc. per litre	6.5	6.6	9.5	7.0	6.0
Free carbonic acid (CO <sub>2</sub> ) p.p.m.	3.0	2.0	2.0	1.0	none
Turbidity	15.0	8.0	20.0	7.0	6.8
Colour	45.0	40.0	30.0	5.0	5.0
Alkalinity	22.5	43.0	57.0	73.0	87.6
Suspended matter	11.8	9.4	13.0	4.5	11.3
Total dissolved solids	67.1	84.3	114.6	144.7	160.5
Silica (SiO <sub>2</sub> )	5.6	6.8	1.8	5.4	1.3
Iron (Fe)	.35	.35	.06	.16	.16
Calcium (Ca)	9.8	15.5	24.8	31.5	33.3
Magnesium (Mg)	3.7	3.5	6.5	7.0	8.5
Alkalies as Sodium (Na)	2.7	2.7	5.0	5.8	10.4
Bicarbonate (HCO <sub>3</sub> )	27.5	52.5	67.2	89.1	106.8
Sulphate (SO <sub>4</sub> )	12.6	6.8	16.2	22.0	21.4
Chloride (Cl)	2.0	2.0	9.0	10.0	14.5
Nitrate (NO <sub>3</sub> )	1.1	1.0	.8	1.0	.2
Hardness as CaCO <sub>3</sub> calculated					
Total hardness	39.7	66.7	88.7	107.5	118.2
Carbonate hardness	22.5	43.0	57.0	73.0	87.6
Noncarbonate hardness	17.2	23.7	31.7	34.5	30.6
Calcium hardness	24.5	38.8	62.0	78.8	83.3
Magnesium hardness	15.2	27.9	26.7	28.7	34.9

# ANALYSIS OF SURFACE WATERS

Sample No.	374	463	464	351	465
Date of sampling	Sept. 26	Dec. 20	Dec. 21	June 12	Dec. 24
Source	St. Lawrence river		St. Lawrence river	Lake Ontario	
Locality	Cornwall		Kingston	Toronto	
Sample collected	Intake pipe Price Bros. Pulpmill		Depth sample 20' 1 mile from shore	Intake pipe Toronto Water Works at 90' depth	
	low	normal+	mean	high	low
Gauge	18°C.	4°C.	2°C.	4.5°C.	3°C.
Temperature	7.8	7.9	7.9	7.7	7.7
pH	6.5	8.5	8.9	9.3	8.8
Dissolved oxygen c.c. per litre					
Free carbonic acid (CO <sub>2</sub> )	p.p.m. none	none	none	none	none
Turbidity	" " " none	none	2.0	none	none
Colour	" " " none	none	none	none	none
Alkalinity	" " " 91.5	92.5	94.0	90.6	92.5
Suspended matter	" " " 1.7	2.6	3.8	1.6	4.2
Total dissolved solids dried at 180°C.	" " " 150.6	160.3	161.8	169.8	160.0
Silica (SiO <sub>2</sub> )	" " " 1.8	1.0	2.2	2.1	2.0
Iron (Fe)	" " " .06	.03	.03	.05	.06
Calcium (Ca)	" " " 35.5	36.4	37.0	38.3	37.5
Magnesium (Mg)	" " " 8.5	9.0	11.0	9.1	8.5
Alkalies as sodium (Na)	" " " 9.0	10.2	10.2	9.1	9.1
Hydrocarbonate (HCO <sub>3</sub> )	" " " 111.6	112.9	114.7	110.5	112.9
Sulphate (SO <sub>4</sub> )	" " " 21.2	22.0	22.0	28.0	23.0
Chloride (Cl)	" " " 16.0	16.0	16.0	15.5	16.5
Nitrate (NO <sub>3</sub> )	" " " .6	.4	.4	.9	.4
Hardness as CaCO calculated:	" " "				
Total hardness	" " " 123.5	127.9	125.3	133.9	128.7
Carbonate hardness	" " " 91.5	92.5	94.0	90.6	92.5
Noncarbonate hardness	" " " 31.5	34.4	31.3	42.1	36.2
Calcium hardness	" " " 88.6	91.0	92.5	95.8	93.8
Magnesium hardness	" " " 34.9	36.9	32.8	38.1	34.9

# ANALYSIS OF SURFACE WATERS

Sample No.	350	466	354	353	356	357
Date of sampling	June 11	Dec. 24	June 15	June 16	June 18	Aug. 5
Source	Lake Erie		Detroit river	St. Clair river	St. Mary's river	
Locality	Fort Erie		Windsor	Point Edward	Sault Ste. Marie	
Sample collected	Midstream Niagara river 20' depth		Intake pipe Windsor Water Works	Intake pipe Water Works	Intake pipe at 12' depth above rapids	
Gauge	Mean	mean	mean	mean	mean	low
Temperature	18°C.	4°C.	18°C.	17°C.	16°C.	18°C.
pH	7.6	7.9	8.1	8.0	7.5	7.5
Dissolved oxygen cc. per litre	5.4	9.0	7.2	6.2	6.5	6.0
Free carbonic acid (CO <sub>2</sub> )	p.p.m. none	none	none	none	1.0	1.0
Turbidity	" " " 3.0	30.0	7.0	none	none	none
Colour	" " " 5.0	15.0	none	none	none	none
Alkalinity	" " " 96.0	92.5	83.5	82.0	45.5	41.0
Suspended matter	" " " 6.0	33.5	9.3	1.5	2.5	1.8
Total dissolved solids dried at 180°C.	" " " 170.4	160.2	126.4	125.0	66.9	57.5
Silica (SiO <sub>2</sub> )	" " " .6	2.8	6.7	9.1	2.8	3.1
Iron (Fe)	" " " .06	.08	.06	.06	.06	.07
Calcium (Ca)	" " " 39.5	37.0	30.5	29.0	17.0	15.0
Magnesium (Mg)	" " " 10.3	8.9	9.4	8.5	4.0	3.7
Alkalies as sodium (Na)	" " " 9.8	9.3	5.5	3.3	2.2	3.1
Hydrocarbonate (HCO <sub>3</sub> )	" " " 117.1	112.4	101.9	100.0	55.5	45.9
Sulphate (SO <sub>4</sub> )	" " " 26.6	24.7	16.6	18.5	6.2	5.1
Chloride (Cl)	" " " 15.5	13.0	4.6	3.5	2.0	1.5
Nitrate (NO <sub>3</sub> )	" " " .9	.5	.4	.9	1.1	.9
Hardness as CaCO calculated:						
Total hardness	" " " 141.0	129.0	114.7	107.4	58.9	51.2
Carbonate hardness	" " " 96.0	92.5	83.5	82.0	45.5	41.0
Noncarbonate hardness	" " " 45.0	36.5	31.2	25.4	13.4	10.2
Calcium hardness	" " " 98.8	92.5	76.3	72.5	42.5	37.5
Magnesium hardness	" " " 42.2	36.5	38.4	34.9	16.4	13.7

# ANALYSIS OF SURFACE WATERS

Sample No.	359	375	352	467	355	377
Date of sampling	Aug. 4	Sept. 23	June 14	Dec. 23	June 15	Sept. 22
Source	Lake Superior	Trent river	Grand river		Thames river	Lake Simcoe
Locality	4 miles south of Port Arthur	1 mile above Trenton	Brantford		Chatham	Beaverton
Sample collected	18' depth	Intake pipe Hine and Dauch Paper Mill	Depth sample 6' one mile above Brantford		At Water Works mid-stream depth sample 10'	2 miles from shore depth sample 20'
Gauge	low	mean	mean	low	mean	mean
Temperature	10°C.	18°C.	27°C.	5°C.	23°C.	13°C.
pH	7.3	7.2	7.6	7.8	8.0	8.4
Dissolved oxygen cc. per litre	8.1	6.7	6.8	8.5	6.2	8.0
Free carbonic acid (CO <sub>2</sub> )	p.p.m. 1.0	none	none	none	none	none
Turbidity	" " " none	8.0	1.5	10.0	15.0	4.0
Colour	" " " none	15.0	25.0	25.0	10.0	none
Alkalinity	" " " 46.0	84.5	191.6	253.5	201.0	109.0
Suspended matter	" " " .4	10.3	3.5	14.4	18.7	8.4
Total dissolved solids dried at 180°C.	" " " 66.2	128.7	391.6	539.0	342.1	157.2
Silica (SiO <sub>2</sub> )	" " " 5.3	5.7	3.4	6.5	5.1	3.6
Iron (Fe)	" " " .04	.07	.04	.16	.06	.04
Calcium (Ca)	" " " 15.7	35.0	86.5	122.0	76.8	42.0
Magnesium (Mg)	" " " 4.0	4.5	23.3	28.2	18.4	4.1
Alkalies as sodium (Na)	" " " 3.8	4.1	11.4	16.7	16.1	8.0
Hydrocarbonate (HCO <sub>3</sub> )	" " " 57.3	103.1	233.6	309.3	245.2	133.0
Sulphate (SO <sub>4</sub> )	" " " 6.4	13.0	111.0	148.2	54.0	18.0
Chloride (Cl)	" " " 1.5	1.2	10.0	15.0	23.0	4.5
Nitrate (NO <sub>3</sub> )	" " " .4	2.2	2.7	.9	.5	1.1
Hardness as CaCO calculated:	" " "	" " "	" " "	" " "	" " "	" " "
Total hardness	" " " 58.3	106.0	311.8	420.6	267.4	121.8
Carbonate hardness	" " " 46.0	84.5	191.5	253.5	201.0	109.0
Noncarbonate hardness	" " " 12.3	21.5	120.3	167.1	66.4	12.8
Calcium hardness	" " " 39.3	87.5	216.3	305.0	192.0	105.0
Magnesium hardness	" " " 18.5	18.5	95.5	115.6	75.4	16.8

# ANALYSIS OF SURFACE WATERS

Sample No.	364	363	361	362	358
Date of sampling	Aug. 9	Aug. 27	Aug. 1	Aug. 2	June 23
Source	Lake Nippising	Lake Temiskaming	Lake Kenogamisis	Nipigon river	Rainy river
Locality	Sturgeon Falls	Haileybury	Geraldton	Nipigon	Fort Francis
Sample collected	2 miles from shore, depth sample 20 ft.	1 mile from shore, depth sample 15 ft.	Intake pipe at Hard Rock Gold Mines 7 ft. depth	C.P.R. bridge depth sample 10 ft.	Intake pipe Fort Francis Pulp Mill
Gauge	mean	mean	mean	mean	mean
Temperature	26°C.	27°C.	20°C.	20°C.	18°C.
pH	7.1	6.7	7.6	8.0	6.8
Dissolved oxygen cc. per litre	6.7	6.8	6.7	6.5	6.5
Free carbonic acid (CO <sub>2</sub> )	p.p.m. 1.0	2.5	none	none	2.0
Turbidity	" " " none	none	none	2.0	none
Colour	" " " 35.0	75.0	70.0	20.0	40.0
Alkalinity	" " " 19.5	12.5	64.5	82.5	23.5
Suspended matter	" " " 1.9	3.8	2.6	4.0	2.7
Total dissolved solids dried at 180°C.	" " " 53.2	50.7	106.1	108.9	64.8
Silica (SiO <sub>2</sub> )	" " " 5.5	1.4	6.1	9.4	4.8
Iron (Fe)	" " " .14	.08	.04	.05	.10
Calcium (Ca)	" " " 7.0	7.5	23.0	28.2	9.2
Magnesium (Mg)	" " " 2.9	2.8	5.2	4.8	3.2
Alkalies as sodium (Na)	" " " 4.5	1.1	5.0	6.8	7.2
Hydrocarbonate (HCO <sub>3</sub> )	" " " 23.8	15.2	78.6	100.6	28.7
Sulphate (SO <sub>4</sub> )	" " " 11.7	8.9	5.8	5.3	8.2
Chloride (Cl)	" " " 2.0	1.5	1.0	1.5	1.2
Nitrate (NO <sub>3</sub> )	" " " .4	1.1	1.1	.4	.5
Hardness as CaCO <sub>3</sub> calculated:	" " "	" " "	" " "	" " "	" " "
Total hardness	" " " 29.4	30.3	78.7	89.6	36.1
Carbonate hardness	" " " 19.5	12.5	64.5	82.5	23.5
Noncarbonate hardness	" " " 9.9	18.0	14.3	7.1	12.6
Calcium hardness	" " " 17.5	18.8	57.5	70.5	23.0
Magnesium hardness	" " " 11.9	11.5	21.3	19.1	13.1

# ANALYSIS OF SURFACE WATERS

Sample No.	360	376	365	368	367
Date of sampling	July 29	July 29	Aug. 29	Sept. 3	Sept. 1
Source	Lake of the Woods	Wabigoon river	Abitibi river	Mattagami river	Ground Hog river
Locality	Kenora	Dryden	Iroquois Falls	Smooth Rock	Smoky Falls
Sample collected	Intake pipe Kenora Paper Mills	Intake pipe at Pulp Mill	Intake pipe at Pulp Mill	Intake pipe at Pulp Mill	Depth sample at dam of power plant

Gauge		high	mean	mean	low	low
Temperature		23°C.	22°C.	17°C.	20°C.	20°C.
pH		7.4	7.3	7.1	7.1	6.7
Dissolved oxygen cc. per litre		6.0	6.1	6.3	5.8	6.5
Free carbonic acid (CO <sub>2</sub> )	p.p.m.	trace	none	3.0	3.5	5.5
Turbidity	" " "	none	2.0	20.0	none	none
Colour	" " "	20.0	20.0	200.0	100.0	130.0
Alkalinity	" " "	47.0	64.5	41.5	41.0	47.5
Suspended matter	" " "	2.2	4.9	24.0	3.0	3.1
Total dissolved solids dried at 180°C.	" " "	83.8	103.3	113.4	83.7	126.7
Silica (SiO <sub>2</sub> )	" " "	1.2	3.9	16.0	5.5	5.4
Iron (Fe)	" " "	.20	.05	7.50	.22	.18
Calcium (Ca)	" " "	14.5	28.0	17.5	16.0	19.5
Magnesium (Mg)	" " "	4.5	3.7	7.4	3.7	5.4
Alkalies as sodium (Na)	" " "	3.0	4.6	5.8	4.5	4.7
Hydrocarbonate (HCO <sub>3</sub> )	" " "	57.3	78.1	50.6	50.0	58.0
Sulphate (SO <sub>4</sub> )	" " "	5.4	10.7	10.3	4.9	7.2
Chloride (Cl)	" " "	1.0	1.2	1.2	1.0	1.5
Nitrate (NO <sub>3</sub> )	" " "	.7	1.8	.6	.5	.5
Hardness as CaCO <sub>3</sub> calculated:						
Total hardness	" " "	54.8	77.7	74.0	55.2	70.9
Carbonate hardness	" " "	47.0	64.5	41.5	41.0	47.5
Noncarbonate hardness	" " "	7.8	13.2	32.5	14.2	33.4
Calcium hardness	" " "	36.3	62.5	43.7	40.0	48.8
Magnesium hardness	" " "	18.5	15.2	20.3	15.2	22.1

# ANALYSIS OF SURFACE WATERS

Sample No.	369	366	370	371	372
Date of sampling	Sept. 2	Aug. 29	Sept 4	Sept. 9	Sept. 15
Source	Ground Hog river	Kapuskasing river	Pearl lake	Dufault lake	McTavish, Gull and Victoria Lake
Locality	Fauquier	Kapuskasing	Timmins	7 miles north of Noranda	Kirkland Lake
Sample collected	Depth sample 6' midstream	Depth sample at dam 6'	Intake pipe McIntyre Mine	Depth sample 18' 2 miles from shore on road 46	Composite depth sample
Gauge	low	low	mean	mean	mean
Temperature	20°C.	19°C.	20°C.	18°C.	14°C.
pH	7.3	7.2	8.1	6.8	7.2
Dissolved oxygen cc. per litre	6.0	5.3	6.6	7.0	7.6
Free carbonic acid (CO <sub>2</sub> )	p.p.m. 37.0	4.0	1.0	3.0	2.0
Turbidity	" " " 10.0	none	10.0	none	none
Colour	" " " 70.0	140.0	60.0	40.0	25.0
Alkalinity	" " " 53.0	62.0	68.5	11.5	35.0
Suspended matter	" " " 14.0	2.0	15.0	1.2	.8
Total dissolved solids dried at 180°C.	" " " 100.0	124.1	419.0	69.6	72.9
Silica (SiO <sub>2</sub> )	" " " 5.4	7.7	6.3	3.3	1.8
Iron (Fe)	" " " .20	.12	.11	.12	.11
Calcium (Ca)	" " " 18.0	24.3	66.0	10.0	15.4
Magnesium (Mg)	" " " 4.5	8.1	19.5	3.9	5.0
Alkalies as sodium (Na)	" " " 3.1	3.4	31.3	4.0	3.1
Hydrocarbonate (HCO <sub>3</sub> )	" " " 64.5	75.6	83.6	14.0	43.9
Sulphate (SO <sub>4</sub> )	" " " 5.7	5.2	186.1	38.6	11.1
Chloride (Cl)	" " " 1.5	1.2	25.5	1.5	1.1
Nitrate (NO <sub>3</sub> )	" " " .2	.9	.4	3.5	1.1
Hardness as CaCO calculated:	" " "	" " "	" " "	" " "	" " "
Total hardness	" " " 67.3	92.2	245.0	41.0	59.0
Carbonate hardness	" " " 53.0	62.0	68.5	11.5	35.0
Noncarbonate hardness	" " " 24.3	30.2	176.5	30.5	24.0
Calcium hardness	" " " 48.8	59.0	165.0	25.0	38.5
Magnesium hardness	" " " 18.5	33.2	80.0	16.0	20.5



# ANALYSIS OF SURFACE WATERS

Sample No.	378	379	380	381	382
Date of sampling	June 25	June 28	July 27	July 5	July 21
Source	Red river	Assiniboine	Lake Winnipeg	South Saskatchewan river	
Locality	Winnipeg	Brandon	Gimli	Medicine Hat	Saskatoon
Sample collected	Depth sample 6' 1 mile above city limits	Depth sample midstream 6' at Water Works	Depth sample 5' 2 miles from shore	Depth sample midstream at Water Works	Intake pipe at Water Works

Gauge	mean	mean	mean	mean	low
Temperature	25°C.	23°C.	20°C.	23°C.	24°C.
pH	8.0	8.3	7.7	8.4	8.4
Dissolved oxygen cc. per litre	6.5	6.3	6.2	6.8	6.5
Free carbonic acid (CO <sub>2</sub> )	p.p.m. none	none	none	none	none
Turbidity	" " " 40.0	18.0	43.0	70.5	50.0
Colour	" " " 70.0	40.0	40.0	10.0	10.0
Alkalinity	" " " 182.5	225.0	76.5	107.0	114.5
Suspended matter	" " " 47.3	19.8	61.8	77.2	66.0
Total dissolved solids dried at 180°C.	" " " 864.4	585.0	150.3	150.8	175.1
Silica (SiO <sub>2</sub> )	" " " 14.8	18.3	19.2	6.9	3.2
Iron (Fe)	" " " .34	.04	.40	.05	.08
Calcium (Ca)	" " " 98.0	83.0	25.0	34.0	37.5
Magnesium (Mg)	" " " 40.0	38.0	9.2	10.0	13.0
Alkalies as sodium (Na)	" " " 134.3	43.9	9.8	7.5	10.0
Hydrocarbonate (HCO <sub>3</sub> )	" " " 222.7	274.5	93.3	130.5	139.7
Sulphate (SO <sub>4</sub> )	" " " 202.0	192.1	21.2	25.5	36.0
Chloride (Cl)	" " " 211.5	10.0	6.0	1.5	1.2
Nitrate (NO <sub>3</sub> )	" " " .9	1.2	1.0	.5	.2
Hardness as CaCO calculated					
Total hardness	" " " 409.0	363.3	100.2	126.0	147.1
Carbonate hardness	" " " 182.5	225.0	76.5	107.0	114.5
Noncarbonate hardness	" " " 327.5	138.3	23.7	19.0	33.6
Calcium hardness	" " " 245.0	207.5	62.5	85.0	93.8
Magnesium hardness	" " " 164.0	155.8	37.7	41.0	53.3

ANALYSIS OF SURFACE WATERS

Sample No.	383	384	385	386	387	388
Date of sampling	July 17	July 22	July 14	July 13	July 13	July 10
Source	North Saskatchewan river		Red Deer river	Bow river	Elbow river	Columbia river
Locality	Edmonton	Prince Albert	Red Deer	Calgary		Golden B. C.
Sample collected	Intake pipe at Water Works	Intake pipe at Water Works	Intake pipe at Water Works	Intake pipe No. 2 Pumping Station	Midstream depth sample 6'	Midstream depth sample 8'
Gauge	high	high	mean	mean	mean	mean *
Temperature	13°C.	21°C.	18°C.	18°C.	17°C.	19°C.
pH	7.8	8.4	8.4	8.2	8.2	7.3
Dissolved oxygen cc. per litre	6.0	6.5	7.2	7.0	7.1	6.7
Free carbonic acid (CO <sub>2</sub> )	p.p.m. none	none	none	none	none	none
Turbidity	" " " 3000.0*	200.0	5.8	10.0	5.8	90.0
Colour	" " " 15.0	10.0	none	5.0	5.0	5.0
Alkalinity	" " " 109.0	94.0	123.0	97.0	127.0	55.5
Suspended matter	" " " 3000.0	199.5	9.3	12.9	7.2	92.0
Total dissolved solids dried at 180°C.	" " " 172.8	132.8	180.3	145.6	207.7	88.3
Silica (SiO <sub>2</sub> )	" " " 11.8	10.9	6.1	9.4	11.8	3.8
Iron (Fe)	" " " .03	.06	.06	.01	.04	.07
Calcium (Ca)	" " " 35.5	33.0	35.0	35.0	48.5	18.5
Magnesium (Mg)	" " " 10.5	11.5	12.3	10.9	13.3	8.0
Alkalies as sodium (Na)	" " " 9.2	6.5	4.9	3.1	3.7	2.2
Hydrocarbonate (HCO <sub>3</sub> )	" " " 133.0	114.7	150.0	118.3	154.9	67.1
Sulphate (SO <sub>4</sub> )	" " " 30.5	31.3	35.6	26.0	23.1	18.0
Chloride (Cl)	" " " 1.2	1.2	1.5	1.2	1.2	1.5
Nitrate (NO <sub>3</sub> )	" " " .2	1.2	none	.2	.2	.1
Hardness as CaCO calculated:						
Total hardness	" " " 131.9	129.7	137.9	132.2	176.8	79.1
Carbonate hardness	" " " 109.0	94.0	123.0	97.0	127.0	67.1
Noncarbonate hardness	" " " 22.9	40.7	14.9	35.2	49.8	12.0
Calcium hardness	" " " 88.8	82.5	87.5	87.5	121.3	46.3
Magnesium hardness	" " " 43.1	47.2	50.4	44.7	54.5	32.8

\* After two days heavy rainfall.

# ANALYSIS OF CIVIC WATER SUPPLIES

## QUEBEC

No.	Date sampled 1937	Locality and Source of Supply	Method of Purification	Parts per Million						
				Total hardness	Calcium hardness	Magnesium hardness	Alka- linity	Cal- cium	Magne- sium	Iron
389	Sept. 12	Amos, Harricana river	Filt. Chlor.	24.0	12.5	11.5	14.5	5.0	2.8	0.8
377	April 13	Montreal*	Sand filtr.	88.7	62.0	26.7	57.0	24.8	6.5	0.06
		St. Lawrence river	Chlorination							
468	June 5	" " " "	" " "	107.8	78.8	28.7	73.0	31.5	7.0	0.16
469	Sept. 29	" " " "	" " "	118.2	83.3	34.9	87.6	33.3	8.5	0.16
483	Dec. 29	Noranda and Rouyn, Dufault lake	Chlorination	50.4	39.3	11.1	9.8	15.7	2.7	0.01
409	Sept. 12	Valdor, spring	Chlorination	32.1	22.3	9.8	12.6	8.9	2.4	--

Chlor. Chlorination; Filtr. Filtration; Coag. Coagulation; Act. Carb. Activated Carbon

\* Supplies also adjacent communities of a combined population of 146,000 inhabitants.

# ANALYSIS OF CIVIC WATER SUPPLIES

## ONTARIO

No.	Date sampled 1937	Locality and Source of Supply	Method of Purification	Parts per Million						Iron
				Total hardness	Calcium hardness	Magnesium hardness	Alka- linity	Cal- cium	Magne- sium	
389	Aug. 19	Arnprior, Madawaska river	Alum. Chlor. Filtr.	54.9	38.5	16.4	33.8	15.4	4.0	0.08
411	Sept. 23	Belleville, Bay of Quinte	Filtr. Chlor.	103.7	84.8	18.9	75.4	33.9	4.6	---
412	Aug. 10	Blind river, wells	No treatment	217.4	151.0	66.4	194.5	60.4	16.2	---
391	Sept. 22	Bowmanville, wells	" "	191.6	131.3	60.3	171.8	52.5	14.7	---
413	June 14	Brantford, Grand river	Setting basin, Filtr.	297.6	209.0	88.6	221.0	83.6	21.6	0.04
-44- 470	Dec. 23	" " "	" " "	420.6	305.0	115.6	253.5	122.0	28.2	0.16
392	Sept. 22	Brockville, St. Lawrence river	Chlorination	127.0	89.3	37.7	85.5	35.7	9.2	---
479	June 15	Chatham and Chatham Tp., Thames river	Double Coag. " Chlor. Filtr. Alum	267.4	192.0	75.4	201.0	76.8	18.4	0.06
393	Aug. 28	Cobalt, Lake Sasaganiga	Chlorination	70.7	47.3	23.4	48.7	18.9	5.7	---
394	Sept. 23	Cobourg, Lake Ontario	Pressure Filtr. Chlorination	127.9	91.0	36.9	93.8	36.4	9.0	---
395	Sept. 3	Cochrane, well	Chlorination	314.1	235.0	79.1	300.0	94.0	19.3	---
396	Sept. 25	Cornwall *St. Lawrence river	Chlorination	128.7	93.8	34.9	90.2	37.5	8.5	0.06
472	Dec. 21	" " " "	Chlorination	127.9	91.0	36.9	92.5	36.4	9.0	0.03
414	July 11	Fort Erie, Lake Erie	Chlorination	121.5	85.8	35.7	87.0	34.3	8.7	0.06
473	Dec. 24	" " " "	Chlorination	129.0	92.5	36.5	92.5	37.0	8.9	0.08

\* Supplies Cornwall Tp.

## ANALYSIS OF CIVIC WATER SUPPLIES

ONTARIO (cont.)

No.	Date sampled 1937	Locality, and Source of Supply	Method of Purification	Total hardness	Parts per Million					
					Calcium hardness	Magnesium hardness	Alka- linity	Cal- cium	Magne- sium	Iron
415	July 11	Fort Francis, Rainy Lake	Gravel Filtr. Chlorination	25.8	14.3	11.5	7.0	5.7	2.8	---
416	Aug. 3	Fort William, Loch Lomond Lake	No treatment	18.7	12.5	6.2	none	5.0	1.5	none
397	Sept. 17	Haileybury, Lake Temiskaming	Chlorination Filtration	32.2	21.5	10.7	11.3	8.6	2.6	0.08
417	June 11	Hamilton,*Lake Ontario	Rapid sand Filters, Ammonia, Chlorination	129.1	93.8	35.3	117.3	37.5	8.6	- --
482	Aug. 29	Iroquois Falls, Abitibi river	Chlorination Filtration	74.0	43.7	30.3	41.5	17.5	7.4	7.50
398	Aug. 31	Kapuskasing, Kapuskasing river	Coag. Alum, Lime, Chlor. Filtr.	112.3	93.0	19.3	52.3	37.2	4.7	---
399	July 29	Kenora, Lake of the Woods	Chlorination	68.5	41.0	27.5	19.9	16.4	6.7	0.20
400	Sept. 24	Kingston, Lake Ontario	Chlorination	125.9	91.0	34.9	92.3	36.4	8.5	---
474	Dec. 21	" " "	Chlorination	125.1	92.5	32.6	94.0	37.0	8.0	0.03
401	Aug. 8	Kirkland Lake, Chain of lakes, Victoria, Gull and McTavish	Chlorination	50.2	35.8	14.4	33.8	14.3	3.5	---

\* Supplies Burlington Beach and Dundas

## ANALYSIS OF CIVIC WATER SUPPLIES

ONTARIO (cont.)

No.	Date sampled 1937	Locality, and Source of Supply	Method of Purification	Parts per Million						
				Total hardness	Calcium hardness	Magnesium hardness	Alka- linity	Cal- cium	Magne- sium	Iron
418	June 14	Leamington, wells	No treatment, Chlorination of emergency supply from Lake Erie	366.1	218.0	118.1	327.3	87.2	28.8	---
419	Aug. 10	Lindsay, Scugog river	Chlorination Filtration	149.2	116.1	33.2	111.5	46.4	8.1	---
402	Sept. 23	Napanee, Napanee river	Act. Carb. Filtr. Chlor.	131.4	96.5	34.9	100.8	38.6	8.5	---
403	" 16	New Liskeard, wells	No treatment	326.5	176.8	149.7	240.9	70.7	36.5	---
420	Aug. 10	North Bay, Trout Lake	Chlorination	18.6	10.8	7.8	4.7	4.3	1.9	---
404	Sept. 22	Oshawa, Lake Ontario	Rapid sand Filtr. Chlor.	127.4	93.8	33.6	93.0	37.5	8.2	---
421	Aug. 10	Orillia, Lake Couchiching	Pressure Filtr. Chlorination	117 .8	90.3	27.5	95.2	36.1	6.7	---
405	" 22	Pembroke, Ottawa river	Chlorination	26.8	15.3	11.5	30.0	6.1	2.8	---
406	" 3	Port Arthur, Lake Superior	Chlorination	60.8	44.8	16.0	51.0	17.9	3.9	0.04
477	June 11	Port Colborne, Lake Erie	Chlorination	141.0	98.8	42.2	96.0	39.5	10.3	0.05
407	Aug. 19	Renfrew, Bonne- chere river	Chlorination	58.4	37.5	20.9	43.3	15.0	3.9	---

# ANALYSIS OF CIVIC WATER SUPPLIES

## ONTARIO (cont.)

No.	Date sampled 1937	Locality, and Source of Supply	Method of Purification	Parts per Million						
				Total hardness	Calcium hardness	Magnesium hardness	Alka- linity	Cal- cium	Magne- sium	Iron
422	June 15	Sarnia <sup>1</sup> , Lake Huron	Chlorination	89.5	60.8	28.7	77.8	24.3	7.0	0.05
423	" 18	Sault Ste. Marie,	Chlorination	53.4	35.8	17.6	34.0	14.3	4.3	trace
424	" "	Wells at Steelton								
424	" "	Sault Ste. Marie,	Chlorination	45.3	30.5	14.8	34.5	12.2	3.6	trace
		St. Mary's river								
425	Aug. 8	Sturgeon Falls,	Filtr. Chlor.	27.0	14.3	12.7	13.6	5.7	3.1	trace
		Sturgeon river								
426	Aug. 9	Sudbury, Ramsay	Chlorination	38.3	22.3	16.0	11.1	8.9	3.9	----
		lake								
-47- 480	June 12	Toronto <sup>2</sup> , Lake	Filtr. Chlor.	133.9	95.8	38.1	90.6	38.3	9.3	0.05
		Ontario								
481	Dec. 25	" " "	" "	128.7	93.8	34.9	92.5	37.5	8.5	0.06
408.	Sept. 4	Timmins, <sup>3</sup>	Chlorination	52.5	34.0	18.5	30.5	13.6	4.5	0.22
		Mattagami river								
427	" 23	Trenton, wells	No treatment	247.2	200.0	47.2	203.6	80.0	11.5	----
410	" 22	Whitby, Lake	Chlorination	136.2	99.3	36.9	98.1	39.7	9.0	----
		Ontario								
428	June 15	Windsor <sup>4</sup> Detroit	Rapid sand	99.8	67.0	32.8	85.9	26.8	8.0	----
		river	Filtr. Chlor.							

1. Also supplies Point Edward
2. " " Forest Hill, Leaside, Long Branch, Swansea, York Tp. with combined population of 88,000 inhabitants
3. " " Schumacher and Tisdale
4. " " Riverside and Tecumseh

# ANALYSIS OF CIVIC WATER SUPPLIES

## MANITOBA

No.	Date sampled 1937	Locality and Source of Supply	Method of Purification	Total hardness	Parts per Million					
					Calcium hardness	Magnesium hardness	Alka- linity	Cal- cium	Magne- sium	Iron
429	June 28	Brandon, Assiniboine river	Pressure Filtr. Chlor.	368.9	209.0	159.9	230.0	83.6	39.0	0.03
430	July 26	Dauphin, Dauphin Dam supplied from Edwards lake	No treatment	220.5	145.5	75.0	247.9	58.2	18.3	0.07
431	" 25	Neepawa, White Mud river	Alum. Filtr. Chlorination	298.8	198.3	100.5	322.4	79.3	24.5	---
432	June 27	Portage La Prairie, Assiniboine river	Sand Filtr. Chlorination	331.7	194.8	136.9	262.3	77.9	33.4	---
433	July 28	Selkirk, wells	No treatment	662.4	245.8	416.6	585.0	98.3	101.6	20.24
434	June 26	Winnipeg*, Shoal lake	Chlorination	86.1	59.0	27.1	79.5	23.6	6.6	0.04

\* Also supplies: East Kildonan, St. Boniface, St. James, St. Vital, Transcona and Tuxedo of a combined population of 57,000 inhabitants.



# ANALYSIS OF CIVIC WATER SUPPLIES

## SASKATCHEWAN

Parts per Million

No.	Date sampled 1937	Locality and Source of Supply	Method of Purification	Total hardness	Calcium hardness	Magnesium hardness	Alka- linity	Cal- cium	Magne- sium	Iron
435	July 20	Biggar, wells	Alum, Filtr. Aeration	420.0	300.3	119.7	411.5	120.1	29.2	0.20
436	June 29	Estevan, Long Creek	Sand Filtr. Alum, Aeration, Chlor. Soda	232.4	116.0	116.4	275.8	46.4	28.4	0.12
437	July 24	Kamsack, Assiniboine river	Sand Filtr. Alum, Chlor.	427.7	246.5	181.2	316.8	98.6	44.2	trace
438	" 5	Maple Creek, springs	No treatment	297.1	166.3	112.8	270.5	66.5	27.5	trace
439	" 22	Melfort, Melfort Creek	Alum, Filtr. Chlor. inter- mittent copper sulphate	276.2	123.3	152.9	288.0	49.3	37.3	0.07
440	" 23	Melville, C.N.R. Dam	Alum, Filtr. Act. Carbon Chlorination	277.5	120.5	157.0	289.4	48.2	38.3	0.07
441	" 3	Moose Jaw, springs	Chlorination	467.2	311.8	155.4	321.5	124.7	37.9	0.45

# ANALYSIS OF CIVIC WATER SUPPLIES

## SASKATCHEWAN (cont.)

Parts per Million

No.	Date sampled 1937	Locality, and Source of Supply	Method of Purification	Total hardness	Calcium hardness	Magnesium hardness	Alka- linity	Cal- cium	Magne- sium	Iron
444	July 20	North Battleford, wells on bank of North Saskatchewan river	No treatment	235.2	152.8	82.4	216.1	61.1	20.1	0.60
445	" 21	Prince Albert, North Saskatchewan river	Sedimentation, Alum, Filtr. Chlorination	125.0	84.0	41.0	122.5	33.6	10.0	0.05
446	" 3	Regina, wells and springs	No treatment Chlor. necessary	673.4	375.3	298.1	412.5	150.1	72.7	0.04
447	" 21	Saskatoon, South Saskatchewan river	Alum, Filtr. Chlor. ferrous Sulphate, Lime	137.1	87.5	49.6	152.3	35.0	12.1	trace
448	" 4	Swift Current, Swift Current Creek	Alum, Filtr. Chlorination	230.6	56.3	174.3	171.3	22.5	42.5	trace
449	June 29	Weyburn, wells	No treatment	473.6	290.3	183.3	335.3	116.1	44.7	12.30
443	July 24	Yorkton, wells	No treatment	569.3	300.0	269.0	498.3	120.1	65.6	0.26

## ANALYSIS OF CIVIC WATER SUPPLIES

ALBERTA

No.	Date sampled 1937	Locality, and Source of Supply	Method of Purification	Parts per Million						
				Total hardness	Calcium hardness	Magnesium hardness	Alka- linity	Cal- cium	Magne- sium	Iron
450	July 10	Banff, Mountain stream	No treatment	156.6	104.5	52.1	135.4	41.8	12.7	trace
451	" 7	Coleman, wells	No treatment	145.7	103.5	42.7	133.5	41.4	10.3	trace
452	" 13	Calgary, Glenmore reservoir	Alum, Filtr. Chlor. Activated Carbon	175.0	119.8	56.2	124.0	47.9	13.7	trace
453	" 13	Drumheller, Red Deer river	Filtr. Chlor.	250.2	167.0	83.2	240.8	66.8	20.3	0.39
454	" 17	Edmonton, North Saskatchewan river	Alum, Coag. Filtr. Chlor.	140.8	96.5	44.3	64.8	38.6	10.8	slight trace
-51- 455	" 16	Lethbridge, Old Man river	Alum, Coag. Filtr. Chlor.	117.6	75.0	42.6	106.5	30.0	10.4	slight trace
456	" 6	McLeod, Old Man river	Alum, Coag. Filtr. Intermittent Chlor. all year	136.9	93.0	43.9	125.3	37.2	10.7	0.04
457	" 5	Medicine Hat, South Saskatchewan river	Alum, Coag. Filtr. Chlor.	129.9	84.8	45.1	102.4	33.9	11.0	0.27
458	" 14	Red Deer, Red Deer river	Filtr. through cinder bed. Chlor.	162.3	104.5	57.8	139.1	41.8	14.1	0.06
442	" 18	Vegreville, wells	No treatment	88.5	59.0	29.5	525.5	23.6	7.2	0.08
459	" 15	Wetaskiwin, wells	No treatment	6.9	5.3	1.6	491.5	2.1	0.4	0.05

ANALYSIS OF CIVIC WATER SUPPLIES

BRITISH COLUMBIA

Parts per Million

No.	Date sampled 1937	Locality, and Source of Supply	Method of Purification	Total hardness	Calcium hardness	Magnesium hardness	Alka- linity	Cal- cium	Magne- sium	Iron
460	July 8	Cranbrook, St. Joseph's Creek and Gold Creek	No treatment	93.4	64.3	29.1	90.0	25.7	7.1	0.05
461	" 7	Fermie, Fairy Creek Dam	No treatment	96.5	71.5	25.0	84.0	28.6	6.1	0.04
462	" 9	Kimberly, Mark Creek C.M.S. Reservoir	No treatment	11.9	9.8	2.1	8.9	3.9	0.5	0.04