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THE INDUSTRIAL UTILITY OF PUBLIC WATER SUPPLIES IN THE UNITED STATES, 1932

BY

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AND E. W. LOHR

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INTRODUCTION

Information relating to the chemical characteristics of water supplies is essential to the location of most industrial plants. It is also an aid in the distribution of many commodities. In certain areas there is no demand for water-softening equipment; in many places there is little need for materials and appliances to combat corrosion of pipes. Selection of steam-boiler-plant equipment or water-softening equipment will be influenced by the chemical character of the water to be used or treated. Some of the needs for information about the chemical character of water are best served by general or average data covering considerable areas or large groups of consumers. For other needs such general information is of little value, and it is necessary to learn the composition of particular supplies.

A large amount of information as to the chemical character of water from individual sources and indications of the character of the water likely to be obtained in certain areas may be found in water-supply papers of the United States Geological Survey and in other publications. These publications are listed in two reports [1] which indicate the kind and number of analyses that have been published for the different States.

A report [2] published in 1923 gave analyses showing the composition of the public water supplies of the larger cities in all the States. Data were given for 307 places with 37 percent of the total population of the United States. The present report follows the general plan of the previous report but gives data for 670 places with 46 percent of the total population of the United States. The report includes every water-supply system serving an area that had in 1930 a population

[1] Collins, W. D., and Howard, C. S., Index of analyses of natural waters in the United States: U.S. Geol. Survey Water-Supply Paper 560-C, 1925; Index of analyses of natural waters in the United States, 1926 to 1931: U.S.Geol. Survey Water-Supply Paper 659-C, 1932.

[2] Collins, W. D., The industrial utility of public water supplies in the United States: U.S. Geol. Survey Water-Supply Paper 496, 1923.

of 20,000 or more. Several cities with less than 20,000 inhabitants are also included in order that the different States may be more adequately and uniformly represented. At least five cities in every State are included.

The essential part of this report is the table of analyses on pages 38–135 (table 5). Next, perhaps, in value is the general discussion of hardness, including the very generalized map showing hardness (pl. 1). Even the detailed data in the main table must be generalized to a certain extent, because the water supply of a place may be derived from a source that varies in composition from time to time, or from several sources that differ in composition and furnish varying proportions of the total supply. An attempt is made to give in the descriptive matter relating to each supply statements and additional data that indicate how well the analyses represent the composition of the water at all times and that also give a better basis than the mineral analyses alone for an opinion as to the probable corrosiveness of the waters. The rest of the text of the report is devoted mainly to explanation of terms used in the table and brief discussions of features of water supply and utilization that will aid in the use of the information in the table.

Although the table of analyses relates to public water supplies as delivered to consumers, it can be made to yield much additional information. For many of the places the data indicate the probable chemical character of a private supply that might be developed for a manufacturing plant located in or near the city. For nearly all the supplies which are softened the table shows also the composition of the untreated water.

The table of analyses and descriptions was prepared chiefly by W. L. Lamar. Most of the analyses made for this report and most of the calculations for the minor tables were made by E. W. Lohr. The body of the text was prepared by W. D. Collins.

For most of the places mentioned in the table of analyses the descriptions were furnished by water-works officials, and the material given in the table was checked by them after it was prepared for publication. Most of the figures showing the range in composition of variable supplies and some of the complete analyses were furnished by individual water departments. Nearly all the samples analyzed by the United States Geological Survey were collected and sent to Washington by the water departments. Many State departments of health furnished descriptions, analyses, and other assistance, as indicated in the notes preceding the descriptions of the supplies of the States. Descriptions and analyses were furnished by officials of companies that control the operation of several plants in one or more States.

ANALYSES OF WATER FROM PUBLIC SUPPLIES

SOURCE OF ANALYSES

More than half the analyses in this report were made during its preparation either by the United States Geological Survey or by other laboratories, as listed in table 1. For the individual analyses the names of the analysts and the laboratories where the work was done are given with the analyses in table 5.

TABLE 1.—*Sources of analyses used in this report*

Source	Analyses	Places	Population in thousands
United States Geological Survey water-resources laboratory:			
Made for this report	357	269	19,306
Made for other reports	77	55	3,192
State laboratories	188	143	9,876
Water-works laboratories	192	137	21,875
Commercial laboratories	88	64	2,309
Analyses not obtainable	0	2	138
	902	670	56,696

APPLICABILITY OF ANALYSES

The analyses in this report were made by methods in general use.[3] The results have been examined carefully for possible inaccuracies. Any failure of the table of analyses to give reliable information as to the chemical character of the water supplies at all times is due to difficulties of sampling rather than to errors in analysis.

In general the samples were as representative as could be obtained. For supplies obtained from very large reservoirs or lakes a single sample is representative of the character of the water throughout the year. For other sources and for many treated waters a single sample is not sufficient. A river water may have at different times 25 to 50 percent more or less than its average hardness and content of dissolved solids. In order to know the composition of the water throughout the year it is necessary to take samples frequently for analysis. For questions like the determination of the total use of soap throughout the year an average analysis is entirely satisfactory. In making plans for softening, information as to the maximum hardness is needed. For some other purposes it is desirable to know the minimum concentration and hardness.

Comparatively few water-works laboratories are in a position to furnish complete analyses of the water at many different periods throughout the year. Perhaps the most common of the more thorough methods is the analysis of monthly composites of daily samples. This gives some indication of the limits in composition but

[3] Collins, W. D., Notes on practical water analysis: U.S. Geol. Survey Water-Supply Paper 596-H, 1928. Am. Public Health Assoc., Standard methods for the examination of water and sewage, 7th ed., 1932. Assoc. Official Agr. Chemists, Official and tentative methods of analysis, 3d ed., ch. 77, pp. 403–430, 1931.

obviously does not give the extremes. Many water-works laboratories, especially where water is treated, make daily determinations of alkalinity, hardness, and pH. Some laboratories make other determinations daily. Where these are available they serve to indicate the extremes. For many of the supplies for which such data are available single analyses have been made of samples collected when the hardness was about the average for the year. It has been assumed that these analyses of single samples generally represent the average composition of the water and the relative concentration of the different constituents at times of greater or less hardness.

For a number of supplies from sources that vary considerably in composition it seemed best to use analyses of composites of daily samples of the river waters made by the United States Geological Survey in a series of studies conducted from 1905 to 1912. At most places these river waters are filtered for use as public supplies. It is known that the filtration generally affects the mineral content of the water, and notes are given in the table of analyses to indicate the probable differences between the composition of the water delivered to consumers and that shown by the analyses of the untreated waters.

Several cities taking water from rivers had no complete analyses of the mineral content. For these places it seemed better to use the results of comprehensive analyses of water obtained from the same river for some other city rather than attempt to show the character of the water by 1 or 2 single analyses.

It is believed that for the cities supplied from surface sources for which analyses are given the composition of the dissolved mineral matter in the water is well represented by the analyses if consideration is given not only to the complete mineral analyses but also to the figures that show the range of some of the constituents and to the statements that are made as to the relation between the analyses and the probable character of the water.

A supply from a single source of ground water is likely to be uniform in composition throughout the year and can be represented by a single analysis. Many public supplies of ground water, however, are obtained from several wells or groups of wells which furnish waters that differ considerably in composition. The wells may be so located that different parts of the city receive different kinds of water. Some points may receive one kind of water or another, according to the pumpage from different sources and the draft on the mains between the sources and the points considered. For some supplies of this type the analysis given in table 5 is that of a single tap sample, which is bound to be within the range of composition of the various waters but does not necessarily represent closely the water used by any large number of consumers. For other supplies analyses are given for several sources, with estimates of the percentage of the total supply represented by each analysis. It is obvious that these conditions make it necessary to consider the descriptions of the sources in connection with the use of the analyses of ground-water supplies.

EXPRESSION OF RESULTS

In accordance with the long established practice of the United States Geological Survey the analyses in this report are given in parts per million of the different constituents. The Geological Survey has never favored the expression of analyses in hypothetical combinations. In recent publications the general chemical character of waters for which analyses are given has been shown by diagrams.[4] In some reports calculations of certain properties of the waters have been made by formulas developed by Stabler[5] and by Palmer.[6]

CONSTITUENTS GIVEN IN TABLE OF ANALYSES

The complete analyses in the table include results for total dissolved solids, silica, iron, calcium, magnesium, sodium, potassium, bicarbonate, sulphate, chloride, nitrate, and total hardness (calculated). Each of these determinations is discussed in succeeding paragraphs with reference to its reliability and its significance.

Total dissolved solids.[7]—The results given under "Total dissolved solids" show approximately the total quantity of dissolved mineral matter in each water analyzed. The quantity of total solids is determined by evaporating a given quantity of water and weighing the residue after it has been dried at some definite temperature. Results for total solids were not reported in some analyses that were obtained from outside laboratories, but if enough other determinations were reported the quantity of total solids was calculated as the sum of the constituents, the bicarbonate being calculated as carbonate. If silica was not determined it was assumed to be from 5 to 20 parts per million, according to the quantity of total solids.

Silica.—Silica is dissolved from practically all rocks. Its state in natural water is not definitely known, but in reports of analyses it is assumed to be in the colloidal state, taking no part in the equilibrium between the acids and the bases.

A survey of the analyses in this report shows that most of the waters examined contained less than 30 parts per million of silica. In several analyses of untreated river water made by the United States Geological Survey the quantity of silica is greater than it should be,

[4] Collins, W. D., Graphic representation of water analyses: Ind. and Eng. Chemistry, vol. 15, p. 394, 1923.

[5] Stabler, Herman, The mineral analysis of water for industrial purposes and its interpretation by the engineer: Eng. News, vol. 60, p. 335, 1908; Some stream waters of the western United States, with chapters on sediment carried by the Rio Grande and the industrial application of water analyses: U.S. Geol. Survey Water-Supply Paper 274, pp. 165–181, 1911.

[6] Palmer, Chase, The geochemical interpretation of water analyses: U.S. Geol. Survey Bull. 479, 31 pp., 1911.

[7] Howard, C. S., Determination of total dissolved solids in water analysis: Ind. and Eng. Chemistry, Anal. ed., vol. 5, pp. 4–6, 1933.

because the result reported includes silica from finely divided suspended matter that was not removed by laboratory filtration of the sample before analysis. When waters carrying this finely divided material are coagulated and filtered for public supplies all the insoluble matter is removed. Some silica that is not visible is also removed by the treatment, so that the silica in a filtered public supply is generally appreciably less than the quantity found in the water before filtration. The silica in most filtered waters is below 10 parts per million, and in some it is less than 5.

The silica in water contributes to the formation of boiler scale and sometimes helps to cement the other materials into a hard scale. Silica is especially troublesome in some waters that carry considerable quantities of sodium bicarbonate and are low in calcium and magnesium, which together are the chief causes of most boiler scales. Very hard and tightly adherent scale consisting largely of silica is sometimes found in boilers using such waters. Waters of this type are, however, not common among the public supplies of the larger cities. On the whole, silica is of comparatively little importance in the public supplies included in this report.

Iron (iron and aluminum oxides).—Iron is dissolved from practically all rocks and is frequently dissolved from iron pipes in sufficient quantity to be objectionable.

Iron is reported in all the analyses made by the United States Geological Survey and in most of the others. The figures given under the heading "Iron" in some analyses represent the quantity of iron and aluminum oxides, as is indicated by a footnote. These results do not show the minimum limit of the iron, but they do show its maximum limit, for the iron cannot be more than 0.7 times the quantity of oxides.

Few surface waters contain in solution as much as 1 part per million of iron. In most of them the quantity is less than 0.1 part. Many ground waters contain several parts per million of iron, which must be removed in order to make the waters satisfactory for domestic and industrial use. Only a few of the cities considered in this report are supplied from sources that furnish water carrying excessive quantities of iron, but the use of such sources is not uncommon in smaller cities. Water that contains much iron is objectionable on account of its appearance after exposure to the air and on account of stains it makes on white porcelain or enameled ware and fixtures and on clothing or other fabrics washed in it. Excessive iron may interfere with the efficient operation of exchange-silicate water softeners.

Iron is almost completely removed by filtration as practiced at water-purification plants, but the treatment sometimes leaves the water in such condition that it can and does dissolve iron from pipes, particularly hot-water pipes. (See p. 36.) Some natural waters also have this property.

Aluminum is found in only negligible quantities in natural waters used for large public supplies.

Calcium and magnesium.—Though calcium and magnesium have somewhat different properties their effects upon the industrial uses of water are so much alike that they cannot well be discussed separately. They cause hardness in water (see p. 11) and together with the acid radicles in equilibrium with them make up from 60 to 90 percent of the dissolved mineral matter of hard waters. Calcium and magnesium are also the predominating basic radicles in many soft waters.

The general industrial value of waters used for public supplies is more affected by calcium and magnesium than by any other constituents. Their main effects are discussed under "Hardness" (p. 11) and under "Industrial treatment of water" (p. 31).

Sodium and potassium.—The sodium and potassium in the water of most public supplies have little effect on the industrial use of the water. Natural waters that contain only 3 or 4 parts per million of the two together are likely to contain about equal quantities of sodium and potassium. As the total quantity of these constituents increases, the proportion of potassium becomes less. In waters carrying from 30 to 50 parts per million of the two the quantity of potassium may be from one fourth to one tenth the quantity of sodium; waters carrying more sodium may contain even smaller proportions of potassium.

A calculated quantity of sodium and potassium is given in some analyses—the quantity of sodium that is needed, in addition to the calcium and magnesium, to balance the acid radicles bicarbonate, sulphate, chloride, and nitrate. The quantity thus calculated is affected by any errors in the determination of the individual constituents. The calculation sometimes leads to a negative quantity for sodium, especially if no nitrate is reported in the analysis. In a few such analyses the sodium and potassium have been reported as less than 5 parts per million.

Bicarbonate.—The carbon dioxide in most natural waters is present as bicarbonate (HCO_3) and free carbon dioxide (CO_2). A few natural waters contain the carbonate radicle (CO_3). The small quantities of carbonate reported for some samples may result from the action of the sample on the bottles.[8] Many waters that have been treated with lime contain carbonate or even hydroxide. Some analyses as originally reported showed the composition of the residue on evaporation and therefore gave carbonate instead of bicarbonate. Bicarbonate and carbonate are often reported as alkalinity, which is expressed as calcium carbonate ($CaCO_3$).

[8] Collins, W. D., and Riffenburg, H. B., Contamination of water samples with material dissolved from glass containers: Ind. and Eng. Chemistry, vol. 15, pp. 48–49, 1923.

For uniformity and simplicity all results of determinations of alkalinity, whether expressed in terms of bicarbonate (HCO_3), carbonate (CO_3), or equivalent calcium carbonate ($CaCO_3$), are given in the table of analyses as bicarbonate (HCO_3). If the carbonate in a water was over 5 parts per million, the quantity is indicated in a footnote.

For many of the supplies that vary in composition with the seasons, results are given in the descriptive matter for alkalinity as determined in the laboratories of the filtration plants. Reports from the filtration plants generally give alkalinity as $CaCO_3$, which includes both carbonate and bicarbonate. One part of alkalinity as $CaCO_3$ corresponds to 1.22 parts of bicarbonate (HCO_3).

Bicarbonate is the chief acid radicle in nearly all the waters used for public supplies. Its relations to hardness and to water softening are discussed on pages 11 and 28.

Sulphate.—Sulphate is found in all the waters for which analyses are given in table 5, but it is a minor constituent of many of the bicarbonate waters used for public supplies. Water that has dissolved gypsum may carry as much sulphate as bicarbonate or even more. Some surface waters that have received acid drainage from mines may have much more sulphate than bicarbonate. Water from arid or semiarid regions is likely to carry comparatively large quantities of sodium sulphate, but not many waters of this character are used for public supplies.

Sulphate in hard water affects the formation of boiler scale and may influence the choice of the method of treatment for boiler feed water. The use of aluminum sulphate as a coagulant in the treatment of water for public supplies increases the sulphate content and decreases the bicarbonate, as is noted in the table wherever it has been necessary to use analyses of the raw water to represent a supply which is filtered.

Chloride.—Uncontaminated surface waters usually contain only a few parts per million of chloride. Streams in arid or semiarid regions may have several hundred parts per million of sodium chloride that has been leached from the soil, especially where they receive return drainage from irrigated lands.[9] Sewage may increase the chloride content of a river water by 10 parts per million; drainage from oil wells or other deep wells and wastes from industrial establishments may add large quantities of chloride. Nevertheless, most of the public supplies from surface sources for which analyses are given in this report have less than 25 parts per million of chloride. Ground-water supplies may have over 100 parts per million of chloride. The larger quantities of chloride may affect the industrial

[9] Scofield, C. S., Stream pollution by irrigation residues: Ind. and Eng. Chemistry, vol. 24, pp. 1223–1224, 1932.

use of water by increasing the corrosiveness of waters that contain large quantities of calcium and magnesium.

Nitrate.—The effect on industrial use produced by the nitrate in water from the large public supplies is practically negligible. A few waters contain enough nitrate to affect the calculated quantity of sodium or to increase the apparent error in an analysis in which sodium is determined and nitrate is not reported.

CONSTITUENTS AND CHARACTERISTICS NOT GIVEN IN TABLE OF ANALYSES

In connection with the purification of waters, many laboratories make regular determinations of color, odor, and hydrogen-ion concentration as pH. Results for odor are not given in this report, because there is very little regularity about the occurrence of odors in public supplies, and the subject of prevention and removal of odors is at present engaging so much attention that figures relating to the odors found in 1932 would be of little value in any other year. In the descriptive material results are given for color and pH of supplies for which they were obtained.

Color.—In water analysis the term "color" refers to the appearance of water that is free from suspended matter. Many turbid waters that appear yellow, red, or brown are practically colorless after the suspended matter is removed. The natural color of waters is caused almost wholly by organic matter extracted from decomposing leaves and from other natural materials in or on the ground. Color is regularly expressed in units of the platinum-cobalt standard proposed by Hazen [10] in 1892. One unit in this scale corresponds to the color produced by 1 milligram of platinum per liter when dissolved as platinic chloride with the addition of enough cobalt chloride to give a color matching the shade of the natural water. This has been the commonly adopted standard in the United States for many years, and any published figures for color are understood to represent units of the platinum-cobalt scale. In most of the public supplies described in this report the color is quite negligible. A number of the impounded supplies that are not filtered or are filtered without coagulation are appreciably colored when served to consumers.

Hydrogen-ion concentration (pH).—The hydrogen-ion concentration [11] is of interest and importance with reference to the corrosiveness of waters as delivered to mains and to consumers. In waterworks practice hydrogen-ion concentration is always expressed in Sörensen's unit as pH. The pH of a water is the negative exponent

[10] Hazen, Allen, A new color standard for natural waters: Am. Chem. Jour., vol. 12, pp. 427–428, 1892.

[11] Clark, W. M., The determination of hydrogen ions, Williams & Wilkins Co., 1928. LaMotte, F. S., Kenny, W. R., and Reed, A. B., pH and its practical application, Williams & Wilkins Co., 1932. Acree, S. F., and Fawcett, E. H., The problem of dilution in colorimetric H-ion measurements, II, Use of isohydric indicators and superpure water for accurate measurement of hydrogen-ion concentration and salt errors: Ind. and Eng. Chemistry, Anal. ed., vol. 2, pp. 78–85, 1930.

of the concentration of hydrogen-ions in grams per liter. Thus, a low value of pH means a high concentration of hydrogen-ions, or acidity, and a high value of pH indicates a low concentration of hydrogen-ions. A neutral water has a pH of 7.0. As the determination of pH must be made almost as soon as samples are collected, very few results are available except those obtained at water works. On account of the importance of this characteristic as regards corrosion, it is customary at many plants to give a final treatment for adjustment of the pH. An effort was made to obtain information on this point, and wherever such information was obtained, the fact that the water is treated for the adjustment of the pH is given in the descriptive material in the table of analyses, and the figure is given to which it is intended to adjust the pH or the range within which the pH is supposed to be kept.

Suspended matter (turbidity).—Practically all the public supplies as served to consumers are free from noticeable suspended matter or turbidity. A few supplies contain enough iron to give an appreciable precipitate when they are exposed to the air, and a very few are occasionally turbid from the ordinary suspended matter of streams. Although determinations of turbidity of the filtered water are regularly made at most of the large filtration plants, the turbidity is rarely perceptible to the consumer, and therefore no results for suspended matter or turbidity are given in this report. This is a serious omission from analyses which are given to show the composition of some of the surface streams before they are treated. The quantity of suspended matter is much more variable than the quantity of dissolved mineral matter and must be taken into account in any plans for utilization of the unfiltered waters.

Manganese.—Manganese has not been determined regularly in water analyses and is not given in the table of analytical data. In recent years trouble with manganese in public water supplies and treatment for its removal have become more common, as indicated in the discussion on page 25. If manganese was reported in an analysis given in the table the quantity is indicated in a footnote.

Free acid.—Acid drainage from coal mines is discharged into many streams, especially in Pennsylvania and West Virginia. At times the only effect may be a decrease in alkalinity of the water. At other times the river water may be acid. In any event this acid drainage [12] must be taken into account if the water is filtered. A few supplies from sources that are slightly acid are used for public supplies without treatment. The quantities of free acid in these supplies are indicated in footnotes in the table of analyses.

[12] Drake, C. F., Effect of acid mine drainage on river water supply: Am. Water Works Assoc. Jour., vol. 23, pp. 1474–1493, 1931.

Fluoride.—Attention has been given recently to the presence of fluoride [13] in natural and treated waters, but the quantity found in most large supplies is probably negligible.

Zinc.—A large part of the zinc found in tap waters probably results from the solution by the water of the zinc coating on galvanized pipe, but it is likely that zinc is much more widely distributed in natural waters [14] than is commonly realized.

Residual chemicals from treatment.—Small quantities of aluminum [15] or copper [16] may at times be found in treated waters, but the quantities are normally too small to have any effect on the industrial use of the waters.

HARDNESS

Hardness is the characteristic of water that receives the most attention with reference to industrial use. It is usually recognized by the increased quantity of soap required to produce lather and by the deposits of insoluble salts formed when a hard water is heated or evaporated.

Hardness is caused almost entirely by calcium and magnesium. Other constituents, such as iron, aluminum, strontium, barium, zinc, or free acid, also cause hardness, but in the water of public supplies as delivered to the mains these constituents are not usually present in quantities large enough to have any appreciable effect. Occasionally the hardness is increased by zinc that has been dissolved from new galvanized pipes. Hardness is reported as the amount of calcium carbonate equivalent to all the calcium, magnesium, and other constituents that cause hardness.

The hardness caused by the calcium and magnesium equivalent to the bicarbonate in a water is called "carbonate hardness" and the remainder "noncarbonate hardness." These terms are respectively roughly equivalent to the old terms "temporary hardness" and "permanent hardness", which were based on the fact that when hard water is boiled the bicarbonate is decomposed and most of the calcium corresponding to the bicarbonate is precipitated as calcium carbonate. The consumption of soap by water of a given hardness is normally the same whether the hardness is caused by calcium or

[13] Churchill, H. V., Occurrence of fluorides in some waters of the United States: Ind. and Eng. Chemistry, vol. 23, pp. 996–998, 1931. Smith, M. C., Lantz, E. M., and Smith, H. V., The cause of mottled enamel, a defect of human teeth: Arizona Univ. Agr. Exper. Sta. Tech. Bull. 32, 1931. Smith, H. V. and M. C., Mottled enamel in Arizona and its correlation with the concentration of fluorides in water supply: Arizona Univ. Agr. Exper. Sta. Tech. Bull. 43, 1932.

[14] Bartow, Edward, and Weigle, O. M., Zinc in water supplies: Ind. and Eng. Chemistry, vol. 24, pp. 463–465, 1932. Palmer, R. M., A study of zinc content of certain waters and its relation to United States Public Health Service standards [abstract]: Am. Jour. Public Health, vol. 23, p. 158, 1933. Drinker, C. K., and Fairhall, L. T., Zinc in relation to general and industrial hygiene: Public Health Repts., vol. 48, pp. 955–961, 1933.

[15] Kellogg, J. W., Residual alum in North Carolina filtered waters: Am. Water Works Assoc. Jour., vol. 23, pp. 92–102, 1931.

[16] Hale, F. E., and Muer, H. F., Copper in the distribution system following watershed treatment: Am. Water Works Assoc. Jour., vol. 15, pp. 650–653, 1926.

by magnesium and is the same for carbonate as for noncarbonate hardness. The character of scale formed in steam boilers is affected by the relation of the carbonate to the noncarbonate hardness; the addition of chemicals for softening is governed by the ratio of carbonate to noncarbonate hardness and of magnesium to calcium.

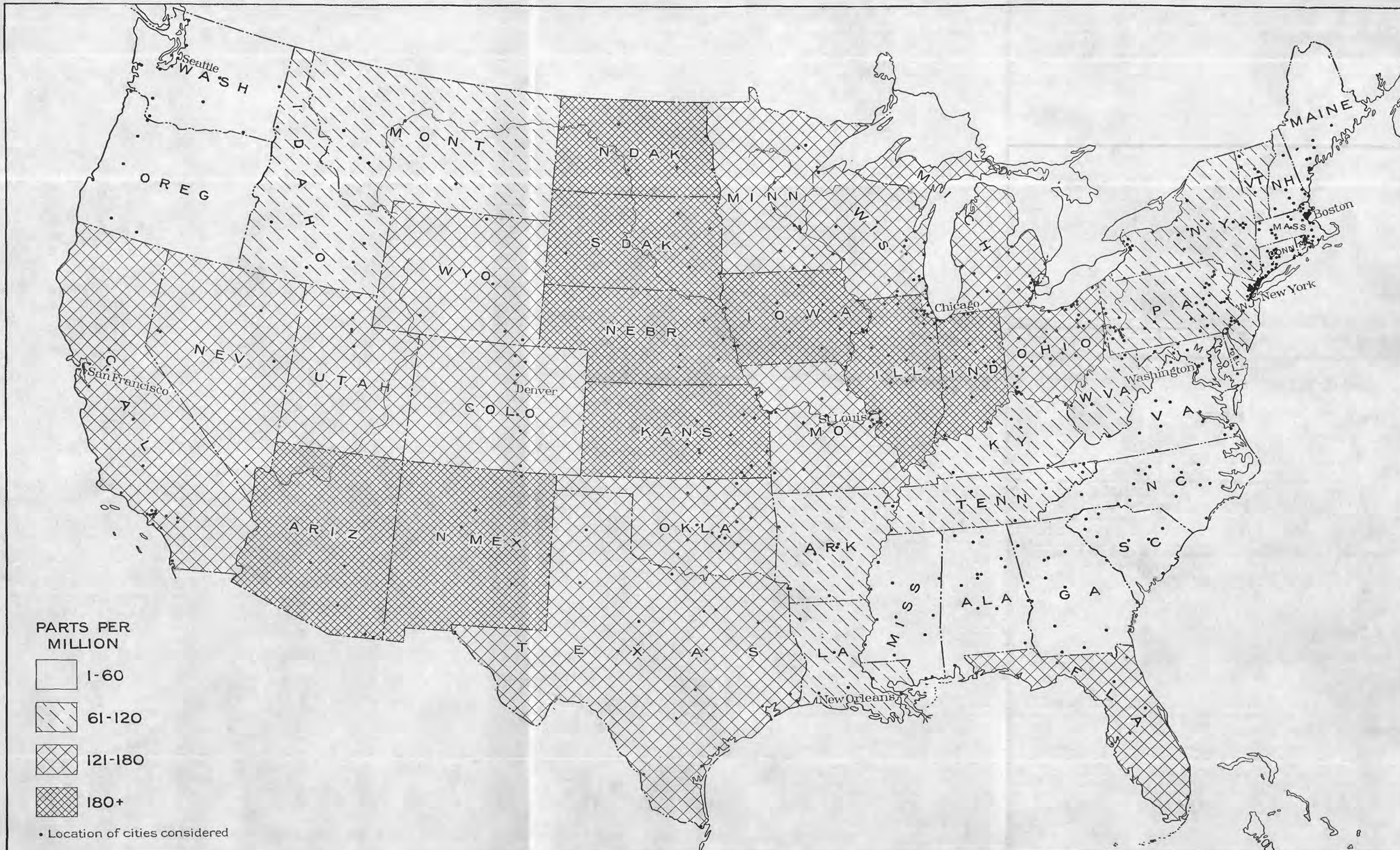
In a large proportion of the waters of moderate mineral content for which analyses are given in table 5 the calcium, magnesium, and bicarbonate account for nearly all the dissolved mineral matter, and therefore the hardness as calcium carbonate is nearly the same as the dissolved solids. In water of low mineral content the other constituents such as silica, sulphate, chloride, sodium, and potassium may amount to more than the calcium, magnesium, and bicarbonate. Water that carries large quantities of sodium and sulphate or chloride will also have higher total solids than hardness. The proportional difference between hardness and total solids may be greater for the sodium bicarbonate waters,[17] which appear to have been softened naturally and sometimes have almost no calcium or magnesium.

Although it is possible to determine the hardness of water with a standard soap solution, the calculation of hardness from the quantities of calcium and magnesium as determined is generally considered more reliable. Results for hardness in the analyses in table 5 are calculated if the calcium and magnesium were determined. Nearly all the results for hardness in the table that are designated "determined" were determined by the soap method. The results given in the descriptive material in the table to show the range in hardness of supplies from surface sources are practically all determinations made in the water-works laboratories by the soap method. Comparison of many of these results with those obtained by calculation from the calcium and magnesium in comparable samples shows a general tendency for the results of soap determinations obtained in the water-works laboratories to be lower than the results obtained by calculation. The results for any one laboratory, however, are probably consistent and give reliable indications of the range in hardness.

DISTRIBUTION OF HARD WATER

The data on hardness of the water of the larger public supplies in the United States as given in the table of analyses and descriptions have been summarized in different ways in tables 2 and 3 and in plate 1. Misleading and erroneous conclusions and inferences may easily be obtained from these summaries unless the nature of the base data is kept in mind. The data relate only to the larger public water

[17] Collins, W. D., and Howard, C. S., Natural sodium bicarbonate waters in the United States: Ind. and Eng. Chemistry, vol. 19, pp. 623-624, 1927.



WEIGHTED AVERAGE HARDNESS, BY STATES, OF WATER FURNISHED IN 1932 BY PUBLIC SUPPLY SYSTEMS IN OVER 600 CITIES IN THE UNITED STATES.

supplies in each State and include the supplies of only 46.2 percent of the total population of the United States. The percentage included for several of the States is much smaller. The averages shown in table 3 and plate 1 are averages of results that for some States cover large ranges of hardness. For some of the States the ranges are not very large.

In the preparation of these summaries the hardness of a supply was taken as the average for the year. Limiting the consideration to these average results covers up many extremes of hardness experienced at certain times. For many of the places with varying hardness the average figure used was that given in the descriptive matter rather than the hardness shown in a single analysis. The latter might represent a sample known to be collected at a time when the hardness was not close to the average. For a place supplied from two or more sources that serve different parts of the community the population was divided into groups representing as well as could be ascertained the average number of consumers served from each source for the whole year, and each group was assigned to its own supply for tabulation and calculation. If information was not obtained as to the relative quantities used from the different sources the average of the hardnesses was used for the total population of the place. For a few places using both ground water and surface water the division of the population between the two had to be estimated. On this basis all the consumers whose supplies are represented in the table of analyses have been divided into groups served with waters in different ranges of hardness as shown in table 2.

TABLE 2.—*Number of persons, in thousands, using water of different degrees of hardness from large public supplies in the United States*

Hardness in parts per million	Surface water	Ground water	Total	Hardness in parts per million	Surface water	Ground water	Total
1 to 10	932	242	1,174	251 to 300	1,043	694	1,737
11 to 20	8,797	164	8,961	301 to 350	44	872	916
21 to 30	2,407	139	2,546	351 to 400	0	600	600
31 to 40	1,314	410	1,724	401 to 450	33	333	366
41 to 50	1,639	183	1,822	451 to 500	0	22	22
51 to 60	3,968	177	4,145	501 to 550	0	195	195
61 to 80	4,288	1,348	5,636	551 to 600	0	81	81
81 to 100	6,532	305	6,837	601 to 650	14	22	36
101 to 120	5,592	471	6,063	651 to 700	0	6	6
121 to 140	7,101	561	7,662	701 to 750	0	0	0
141 to 160	739	486	1,225	751 to 800	0	16	16
161 to 180	1,222	470	1,692				
181 to 200	154	585	739		47,336	9,360	56,696
201 to 250	1,517	978	2,495				

Table 2 is reasonably accurate for the average use of water by consumers included but is decidedly inaccurate as an indication of the relative use of hard and soft waters by the total population of the United States. It can be noted from the table of analyses and table 3 that table 2 includes much higher percentages of the total population

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for the States where supplies are generally soft than for the States where the supplies are generally hard. Table 2 indicates that in general the harder supplies are ground water and the softer supplies are surface water. The proportions of users of surface water and ground water for the total population of the United States are very different from the ratio shown for the inhabitants of the larger cities. Some of the larger supplies included in this report are softened, and this makes the proportional number of users of the softer waters greater than if the results related to natural waters. Table 2 should not mislead anyone who will keep in mind that it applies only to the users of water from the public supplies included in the table of analyses.

A different summary of the data for hardness in the table of analyses has been prepared by calculating weighted averages for the hardness of surface-water supplies, of ground-water supplies, and of both from the analyses for each State. These calculated weighted averages are given in table 3.

TABLE 3.—*Weighted average hardness of water from large public supplies in each State*

State	Surface supplies			Ground supplies			All supplies		
	Average hardness as $CaCO_3$ (parts per million)	Population served: Thousands	Population served: Percentage of total population of State	Average hardness as $CaCO_3$ (parts per million)	Population served: Thousands	Population served: Percentage of total population of State	Average hardness as $CaCO_3$ (parts per million)	Population served: Thousands	Population served: Percentage of total population of State
Alabama	53	472	17.8	50	136	5.2	52	608	23.0
Arizona	------	------	------	207	106	24.3	207	106	24.3
Arkansas	133	155	8.4	44	66	3.5	106	221	11.9
California	128	2,537	44.7	150	871	15.3	133	3,408	60.0
Colorado	122	418	40.3	------	------	------	122	418	40.3
Connecticut	24	1,144	71.2	------	------	------	24	1,144	71.2
Delaware	48	107	44.7	85	16	7.0	53	123	51.7
District of Columbia	90	503	100.0	------	------	------	90	503	100.0
Florida	81	158	10.8	173	415	28.2	148	573	39.0
Georgia	18	509	17.5	116	157	5.4	41	666	22.9
Idaho	74	35	7.8	99	31	6.9	85	66	14.7
Illinois:									
Supplied from Lake Michigan	125	3,791	49.7	------	------	------	125	3,791	49.7
Not supplied from Lake Michigan	142	514	6.7	345	454	6.0	237	968	12.7
Whole State	127	4,305	56.4	345	454	6.0	148	4,759	62.4
Indiana	199	962	29.7	361	359	11.1	243	1,321	40.8
Iowa	160	249	10.1	347	415	16.8	277	664	26.9
Kansas	187	299	15.9	401	201	10.7	274	500	26.6
Kentucky	105	606	23.2	------	------	------	105	606	23.2
Louisiana	65	536	25.5	43	84	4.0	62	620	29.5
Maine	15	251	31.5	------	------	------	15	251	31.5
Maryland	53	959	58.7	21	11	0.7	53	970	59.4
Massachusetts	19	2,825	66.5	47	295	6.9	21	3,120	73.4
Michigan	114	2,437	50.3	303	335	6.9	137	2,772	57.2
Minnesota	154	858	33.5	290	139	5.4	173	997	38.9
Mississippi	52	82	4.1	27	137	6.8	36	219	10.9
Missouri	133	1,698	46.8	276	15	0.4	134	1,713	47.2
Montana	94	121	22.5	234	3	0.5	98	124	23.0
Nebraska	251	214	15.5	150	132	9.6	213	346	25.1
Nevada	83	14	16.0	187	20	21.8	143	34	37.8
New Hampshire	11	146	31.4	35	72	15.5	19	218	46.9
New Jersey	53	2,116	52.4	128	680	16.8	71	2,796	69.2
New Mexico	62	17	4.1	259	46	10.8	205	63	14.9

TABLE 3.—*Weighted average hardness of water from large public supplies in each State*—Continued

State	Surface supplies: Average hardness as $CaCO_3$ (parts per million)	Surface supplies: Population served: Thousands	Surface supplies: Population served: Percentage of total population of State	Ground supplies: Average hardness as $CaCO_3$ (parts per million)	Ground supplies: Population served: Thousands	Ground supplies: Population served: Percentage of total population of State	All supplies: Average hardness as $CaCO_3$ (parts per million)	All supplies: Population served: Thousands	All supplies: Population served: Percentage of total population of State
New York:									
New York City	29	5,972	47.4	108	958	7.6	40	6,930	55.0
Remainder of State	88	2,515	20.0	174	161	1.3	93	2,676	21.3
Whole State	47	8,487	67.4	117	1,119	8.9	55	9,606	76.3
North Carolina	25	504	15.9	95	23	.7	28	527	16.6
North Dakota	153	57	8.3	262	24	3.6	185	81	11.9
Ohio	125	3,054	45.9	333	617	9.3	160	3,671	55.2
Oklahoma	139	465	19.4	246	89	3.7	156	554	23.1
Oregon	10	343	36.0	29	53	5.6	13	396	41.6
Pennsylvania	78	5,109	53.0	203	220	2.3	83	5,329	55.3
Rhode Island	28	600	87.4	24	15	2.1	27	615	89.5
South Carolina	22	192	11.0	24	32	1.9	22	224	12.9
South Dakota	239	32	4.6	478	60	8.7	395	92	13.3
Tennessee	82	391	15.0	44	313	11.9	65	704	26.9
Texas	127	769	13.2	143	821	14.1	135	1,590	27.3
Utah	170	123	24.3	174	87	17.1	171	210	41.4
Vermont	63	69	19.3	-----	-----	-----	63	69	19.3
Virginia	43	592	24.4	164	68	2.8	56	660	27.2
Washington	22	618	39.5	112	164	10.5	41	782	50.0
West Virginia	71	288	16.7	172	78	4.5	93	366	21.2
Wisconsin	129	875	29.8	247	354	12.0	163	1,229	41.8
Wyoming	106	37	16.3	224	25	11.2	154	62	27.5
United States	85	47,338	38.6	191	9,358	7.6	102	56,696	46.2

To calculate the weighted average hardness of the surface-water supplies of a State 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 numbers of consumers to give the average. The same was done for the ground-water supplies. The totals of the products for surface water and for ground water were added and this sum divided by the total number of consumers to obtain the weighted average hardness of all supplies of a State. A place with more than one source of supply was treated the same as for table 2.

In a very general way the average-hardness figures for most of the States are representative of general conditions in the States. In some States the range of hardness for the supplies considered is only moderate; in other States the range is large. Of the places included in the table of analyses, no supply with a hardness of over 60 parts per million is shown for the States of Connecticut, Maine, Oregon, and Rhode Island. The range in hardness of the supplies reported in the table for Florida is from 7 to 520 parts per million; for Oklahoma the range is from 35 to 626. Averages for these two States are very inadequate for almost any purpose except perhaps for calculating the average amount of soap used by the consumers included in the report.

For Illinois and New York the State averages are each divided into two parts. The hardness of the water from Lake Michigan is much less than the hardness of practically all the other supplies in Illinois. About 50 percent of the total population of the State is supplied from Lake Michigan, and only about 13 percent use the other supplies listed in this report. The weighted average hardness for all the places in Illinois included in this report is 148, which is near the 125 for Lake Michigan. If the other 37 percent of the total population could be represented, it is quite certain that the average for the whole State would not be so near the average for Lake Michigan. The weighted average for the places not supplied from Lake Michigan is much nearer the probable average for the consumers not included in the report than is the weighted average given for the whole State.

Conditions in New York State are somewhat similar, but the difference in hardness between the supply of New York City and those of the other places is much less than the difference in Illinois. Picking out individual supplies from several other States would produce slight modifications of averages, but in no other State with a large population is the weighted average for the whole State so much influenced by a single supply or source.

An indication of the effect on the weighted average hardness resulting from addition or elimination of places is obtained by comparing the results in table 3 with the similar table in Water-Supply Paper 496, which was issued in 1923. The weighted average hardness for the United States in Water-Supply Paper 496 was 99; in the table for 1932 it is 102. Failure to note how the tables were prepared might lead to the conclusion that the hardness of the large public supplies in the United States had increased during the past 10 years. The simple explanation is that the increase in the number of places from 307 to 670 consisted in the addition of smaller places, which are likely to have harder water supplies, and in the addition of proportionally more places in the States where water is generally hard than in the States where soft water is available.

The weighted average hardness for the surface-water supplies is 85 in both reports. In the earlier report the cities supplied with surface water had 33 percent of the total population of the United States; in table 3 the percentage is 38. The weighted average hardness of the ground-water supplies in the earlier report was 225 and in this report is 191, but the proportion of the total population of the United States in the cities using the ground-water supplies considered has increased from 4 percent in Water-Supply Paper 496 to 7.6 percent in the present report. This added weight for the ground-water supplies increases the average hardness for all supplies, even though the average hardness of the ground-water supplies in this report is less than in the former report. The weighted average hardness for all the supplies in this report that were also included in Water-Supply Paper 496 is 97, a decrease of 2 parts per million. The average for surface-water supplies for the same places decreased from 85 to 84 and for ground-water supplies from 225 to 182. These figures show that the additional places included in this report have supplies that are harder than the supplies of the places that are included in both reports.

The results in table 3 are still further summarized in plate 1, which shows the States shaded to correspond to four ranges of average hardness. The map is accurate for the weighted average hardnesses of the supplies of the places included but should not be expected to show accurately the general hardness of water in different areas. It is with the object of making the shadings more representative of the general hardness that small parts of Illinois and New York corresponding to the supplies of Chicago and New York City are shaded according to the hardness of these single supplies, the rest of each State being shaded according to the weighted hardness for the other supplies. The fact that the shadings are drawn according to State averages, except as noted for Illinois and New York, makes abrupt changes at State boundaries, which obviously do not exist. Still the shadings indicate in a very general way the areas where soft water or hard water is likely to be used.

The public supplies of the larger places in the States in the first group—those that are unshaded on the map (hardness 1 to 60)—are generally considered soft, although the averages for the States may include some individual supplies whose hardness is beyond the upper limit indicated. In ordinary household use hardness below 60 parts per million is scarcely noticed. For supplies with hardness nearly up to 60 softening is profitable for laundries, for many steam-boiler plants, and for a few other industrial uses.

The States in the second group, shown by the lightest shading on the map, are those for which the weighted average hardness for the larger public supplies is from 61 to 120 parts per million. These States include some supplies whose hardness is outside these limits, but for most of the supplies the hardness is within the limits. Those who are accustomed to really soft water will notice the hardness of supplies in this range, especially in the upper part. To those who have regularly used water with hardness of several hundred parts per million the hardest of this group will seem soft. Where municipal supplies are softened it is customary to bring the hardness down well below the upper limit of this group. Softening is not now practiced for any municipal supply whose natural hardness is within the limit of this group. Household water softeners have been installed by some users of supplies with hardness near the upper limit for this group. Softening of any supply in this group is likely to be profitable for a laundry, and softening or treatment within the boiler is necessary for a steam-boiler plant.

The third group, shown by the medium shading, includes the States for which the weighted average of the hardness of water of the larger public supplies falls between 121 and 180. Some individual supplies in nearly all these States fall outside the limit, but the hardness of most of the supplies is within the range indicated. Nearly everyone notices hardness in this range, yet many supplies, especially those nearer the lower limit, cause little complaint when used without softening. Household softening is commonly found desirable by those using supplies that fall within this range of hardness. Any industrial plant in which hardness is detrimental will soften water whose hardness falls within the range for this group. Municipal softening may be profitable. It is now being considered in connection with plans for the filtration of some supplies whose hardness is near the lower limit for the group. Some of the States in this group would be in the fourth group if it were not that some of their larger supplies are softened and some of the supplies come from lakes or rivers that furnish water much softer than is generally available in the State.

The States in the fourth group cover the widest range in hardness, but there is little reason for making more than one group for States in which the weighted average hardness is more than 180 parts per million. All nine States in this group have one or more supplies with hardness below 180, eight have supplies in the group with hardness from 61 to 120, and two have supplies in the group with hardness less than 61. In the range above 180, eight of the States have supplies with hardness over 300 and six have one or more supplies with hardness over 500. Still, about half the consumers in four of these six States and about three quarters in two of the States use water with hardness between 200 and 350. Water with hardness greater than 180 parts per million is considered really hard. Most plans for new plants for the purification of water whose hardness is much over 180 include provision for immediate or future softening. It is necessary to soften such water for laundry use or for use in steam boilers. Some of the supplies of very hard water in this group would be unsatisfactory for some uses even after softening.

Although the shadings on the map are based on the data in the table of analyses, the map does not give at a glance an accurate impression of the relative use of soft and hard water in the places included in this report. Figure 1, with its table, summarizes the data of table 2 in the hardness groups represented on the map. This brings out the preponderance of users of the softer waters from the public supplies included in this report. It also shows that in the higher ranges of hardness ground water is used by larger percentages of the total than in the lower ranges of hardness. Because the areas where soft water is used are better represented in this report, as shown by the percentages in table 3, it may be that the map even with its limitations indicates the extent of the total use of hard water better than the results in the tables, which relate only to the places included in the report.

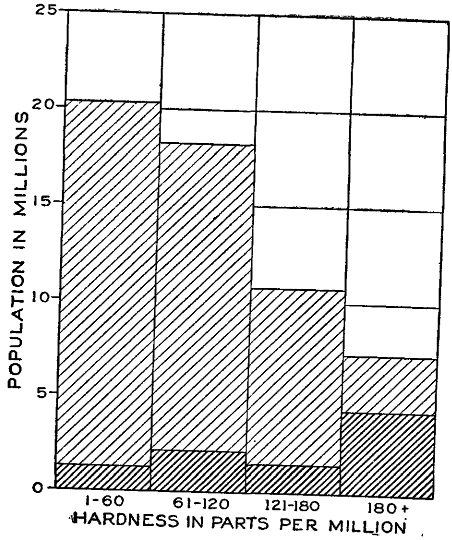

FIGURE 1.—Number of persons using water of certain degrees of hardness from large public supply systems in over 600 cities in the United States. Heavy shading indicates ground water; light shading, surface water.

Range of hardness (parts per million)	Population (thousands)		
	Surface	Ground	Total
1-60	19,057	1,315	20,372
61-120	16,413	2,123	18,536
121-180	9,062	1,517	10,579
More than 180	2,804	4,405	7,209
	47,336	9,360	56,696

SOURCES OF PUBLIC SUPPLIES

Table 4, which shows by groups the sources and general methods of treatment of the larger public water supplies in 1932, is compiled from the data in table 5.

TABLE 4.—*Source and treatment of the public water supplies of the larger cities in the United States in 1932*

Source and treatment	Number of places	Population served: Thousands	Population served: Percentage of total population of United States
Surface water:			
No treatment other than chlorination	160	21,932	17.9
Coagulation without filtration	6	126	.1
Filtration without coagulation	11	2,216	1.8
Filtration after coagulation	241	19,695	16.0
Filtration and softening	32	3,752	3.1
Total surface supplies	450	47,721	38.9
Wells less than 100 feet deep, infiltration galleries, and springs:			
No treatment other than chlorination	64	2,223	1.8
Iron removal	13	391	.3
Softening	3	203	.2
Total shallow ground supplies	80	2,817	2.3
Wells 100 feet or more deep:			
No treatment other than chlorination	119	5,473	4.5
Iron removal	16	575	.4
Softening	5	110	.1
Total deep ground supplies	140	6,158	5.0
Total ground supplies	220	8,975	7.3
Total supplies	670	56,696	46.2

NATURAL SURFACE WATER

About 40 percent of the population of the cities given in this report used for public supplies in 1932 surface water with no treatment other than chlorination. Practically all these supplies are taken from large lakes or from impounding reservoirs on small streams.

Some of the waters that are used without filtration are collected from areas underlain by comparatively insoluble rocks and therefore carry very little dissolved mineral matter. They are soft; some have very little color and others are highly colored. The freedom from hardness is an advantage for some industrial uses, such as laundering or dyeing. Before the introduction of softening with exchange silicates (see p. 32) these naturally soft waters determined the location of manufacturing plants that required water softer than could be obtained by the softening processes then in use.

The very soft waters are likely to be corrosive and may take up from mains and service pipes undesirable quantities of iron or even dangerous quantities of lead where lead pipe is in use. The waters that are not so corrosive may be unsatisfactory on account of their hardness.

There is a general tendency toward more exacting requirements, such as freedom from turbidity, color, hardness, and corrosiveness in the water of public supplies, which can be satisfied only by filtration of many supplies that are now served in their natural condition except for chlorination.

TREATED SURFACE WATER

In 1932 about 45 percent of the inhabitants of the larger cities in the United States were supplied with surface water that received treatment in addition to chlorination, 35 percent used water that had been filtered through rapid sand filters, 4 percent used water that had been less elaborately treated, and 6 percent used water softened in connection with standard rapid sand filtration. The use of filtered surface water for public supplies seems likely to increase, even if a few more cities obtain new or additional supplies from distant mountain streams that require no purification other than chlorination. It is generally recognized that filtration would be desirable for the supplies of several large cities that now use untreated surface water.

GROUND WATER

Ground water probably furnishes the domestic water supply for nearly half the population of the United States. Well water is used by most of the 43.8 percent of the population that live in rural districts and by a large proportion of those who live in places of 2,500 to 20,000 inhabitants. At most places the ground water is generally clearer and cooler than the surface water and more uniform in composition throughout the year. The most common objectionable characteristics of ground waters are hardness and excessive iron. Some carry objectionable quantities of hydrogen sulphide, and many of the shallow sources are exposed to dangerous pollution. The deeper well waters are more generally safe for use without purification.

The weighted average hardness of the ground-water supplies included in this report is shown in table 3 to be 191 parts per million, against a weighted average hardness of 85 for the surface-water supplies. It is obvious that these figures do not mean that all ground water is harder than any surface water. In regions where the surface water is very soft, the ground water is likely to be much softer than the surface water of regions where water is relatively hard. In general, however, at any place ground water is likely to be decidedly harder than surface water.

TREATMENT OF WATER FOR PUBLIC SUPPLIES

The general subject of public water supplies and their purification is discussed comprehensively in several books of technical [18] or popular character.[19] Other well-known books are devoted to special

[18] Am. Water Works Assoc., Water-works practice, 1926. Ellms, J. W., Water purification, 2d ed., McGraw-Hill Book Co., 1928. Flinn, A. D., Weston, R. S., and Bogert, Lathrop, Water-works handbook of design, construction, and operation, 3d ed., McGraw-Hill Book Co., 1927. Turneaure, F. E., and Russell, H. L., Public water supplies, 3d ed., John Wiley & Sons, 1924.

[19] Holway, Hope, The story of water supply, Harper & Brothers, 1929.

features such as the chemistry of water treatment,[20] the microscopy of drinking water,[21] and the control of the operation of filtration plants.[22] Current changes and improvements in processes are usually described in journals published by the American Water Works Association and the New England Water Works Association and also in journals devoted to general, sanitary, or municipal engineering.

The discussion in this report is given merely to explain terms used in the table of analyses and to indicate some of the unavoidable limitations of the data in the table. The brief descriptions accompanying the analyses in table 5 are intended to indicate the extent to which the analyses represent the composition of the water at all times. Detailed data on the design and actual operation in 1932 of 45 large rapid sand filtration plants in the United States and 3 in Canada were collected by Hardin,[23] with reference to the design of a new plant. Less detailed descriptions [24] have been collected for practically all the purification plants in the United States. A com pilation of water-supply statistics for several thousand supplies in the United States [25] gives concise data on type of source, kind of treatment, pumping equipment, distribution systems, rates of consumption, and other features.

FILTRATION (RAPID SAND FILTRATION)

It is seen from table 4 that of the 670 supplies for which data are given in table 5 the supplies for 273 places, with 21,911,000 consumers, are treated by rapid sand filtration; 160 supplies, with 21,932,000 consumers, receive no treatment other than chlorination; and only 11, with 2,216,000 consumers, are treated by slow sand filtration. Therefore the term "filtered" without qualification is used in the table of analyses to indicate that a supply has been treated by rapid sand filtration. Minor modifications are not noted, but additions to or departures from standard practice that may affect the industrial use of the treated water are indicated.

The essential features of rapid sand filtration are the addition of a coagulant, generally aluminum sulphate, which is commonly called "filter alum" or "alum," a period of settling for elimination of most

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[20] Buswell, A. M., The chemistry of water and sewage treatment: Am. Chem. Soc. Mon. 38, Chemical Catalog Co., 1928.

[21] Whipple, G. C., The microscopy of drinking water, 4th ed., revised by G. M. Fair and M. C. Whipple, John Wiley & Sons, 1927.

[22] Hopkins, E. S., Water purification control, Williams & Wilkins Co., 1932.

[23] Hardin, E. A., Design and operation data on large rapid sand filtration plants in the United States and Canada: Am. Water Works Assoc. Jour., vol. 24, pp. 1190–1207, 1932.

[24] Streeter, H. W., Report of the committee on water purification and treatment of the conference of State sanitary engineers, in Census of municipal water-purification plants in the United States, 1930–31, pp. 25–146, American Water Works Assoc., 1933.

[25] Kendall, T. R., and Sloan, E. L., Water-supply statistics of American municipalities, 2d ed., American City Magazine, 1929.

of the floc formed by the coagulation, and filtration through sand at a rate many times as rapid as the rate used in filtration without coagulation. The filter effluent is regularly given a small dose of chlorine gas.

Coagulants other than alum may be used, and with many waters it is necessary to add lime or soda ash with the coagulant to produce a floc, but these variations are not noted in the table. Softening and final treatment for the adjustment of pH are mentioned.

Sedimentation.—At many plants the water passes through fairly large settling basins or is held in a reservoir to permit the removal by sedimentation of a considerable proportion of the suspended matter. The sediment from a very turbid water may completely fill a small reservoir in 10 or 12 years.[26] Where sedimentation basins of moderate size are used with very turbid waters provision may be made for the continuous removal of the material that has settled.[27]

Coagulation.—The most widely used coagulant has always been aluminum sulphate, which is commonly referred to as "filter alum" or "alum." At most plants the filter alum is purchased. At some the coagulant is manufactured from bauxite and sulphuric acid.[28] Iron sulphate (copperas) has been used as a coagulant at some plants. It will not normally react with the water but requires the addition of lime to produce a floc. Chlorinated copperas [29] and ferric chloride [30] have also been used as coagulants, and at some plants sodium aluminate [31] is used in addition to alum.

Coagulation with alum increases the sulphate, decreases the alkalinity, and tends to make the water more corrosive. In the early filtration plants the addition of alum was based largely on the turbidity, and sometimes excessive quantities were used. Later the quantity of alum used was based on the alkalinity of the water, and when the alkalinity was not sufficient for the alum needed to give a satisfactory floc the alkalinity was increased by the addition of lime or soda ash. The additional lime might cause the finished water to be harder than the untreated water, or the addition could be made in such quantity as to reduce the total hardness. Better results followed the adoption of the practice of regulating the addition of the coagulant

[26] Taylor, T. U., Reservoir loses 84 percent of storage capacity in nine years: Eng. News Record, vol. 91, pp. 380–382, 1923. Meeker, R. I., Silting of reservoirs: Am. Soc. Civil Eng. Trans., vol. 93, pp. 1731–1733, 1929.

[27] Morrill, A. B., Sedimentation-basin research and design: Am. Water Works Assoc. Jour., vol. 24, pp. 1442–1458, 1932.

[28] Hoover, C. P., Process of purifying water: U.S. patent 1,197,123, 1916. Lauter, C. J., Manufacture of aluminum sulphate at the Dalecarlia filter plant, Washington, D.C.: Ind. and Eng. Chemistry, vol. 25, pp. 953–958, 1933.

[29] Hedgepeth, L. L., Olsen, N. C., and Olsen, W. C., Chlorinated copperas a new coagulant: Am. Water Works Assoc. Jour., vol. 20, pp. 467–472, 1928. Hopkins, E. S., and Whitmore, E. R., Study of the floc produced by chlorinated copperas: Ind. and Eng. Chemistry, vol. 22, pp. 79–81, 1930.

[30] Craig, E. C., Bean, E. L., and Sawyer, R. W., Iron and lime in removal of manganese: Am. Water Works Assoc. Jour., vol. 24, pp. 1762–1766, 1932.

[31] Ripple, O. J., Turre, C. J., and Christman, C. H., The use of liquid sodium aluminate in the clarification of the Denver water supply: Ind. and Eng. Chemistry, vol. 20, pp. 748–752, 1928.

by the hydrogen-ion concentration (pH) of the water.[32] The pH that will insure the best coagulation differs from one plant to another and at any plant may change from day to day.

It is now a common practice to determine experimentally the proper dosage of alum. Samples of the raw water in beakers are treated with different quantities of alum and stirred mechanically. From observation of floc formation in the beakers the operator determines the proper quantity of coagulant to add to the raw water for filtration. The quantity that gives the most satisfactory coagulation in the plant may not be in exactly the same proportion as the quantity that gives the best result in the beakers, because the mixing and temperature in the plant and in the beakers may not correspond exactly.

Mixing and settling basins and filters.—The design and operation of mixing devices and settling basins [33] and the operation of the filters, particularly as to washing,[34] are of the greatest importance for the effective operation of a plant, but they have little effect on the industrial utility of the finished water.

Chlorination.—Practically every filter effluent is chlorinated before delivery to the mains. The small quantity of chlorine added is almost always regulated with reference to the residual free chlorine, which is commonly only a few tenths of a part per million. This excess is generally determined by comparison with standards using the orthotolidine reagent, which was introduced by E. B. Phelps in 1909 and has been carefully studied with reference to its accuracy and reliability.[35] Incorrect and misleading results may be obtained when manganese is present in the water [36] or when the test is applied without correction to swimming-pool water which is treated with chlorine and ammonia and is recirculated.[37]

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[32] Wagner, A., and Enslow, L. H., Applied hydrogen-ion concentration—a study of its merits in practical filter-plant operation: Am. Water Works Assoc. Jour., vol. 9, pp. 373–391, 1922. Baylis, J. R., The use of acids with alum in water purification and the importance of hydrogen-ion concentration: Am. Water Works Assoc. Jour., vol. 20, pp. 365–392, 1923.

[33] Willcomb, G. E., Floc formation and mixing basin practice: Am. Water Works Assoc. Jour., vol. 24, pp. 1416–1437, 1932. Smith, M. C., Improved coagulation at the Richmond, Va., filter plant: Idem, vol. 25, pp. 254–259, 1933. Black, A. P., Rice, Owen, and Bartow, Edward, Formation of floc by aluminum sulphate: Idem, pp. 811–815, 1933. Nolte, A. G., and Kramer, W. A., Coagulation with aluminum sulphate: Idem, pp. 1263–1278, 1933; Floc formation studies in water purification: Ind. and Eng. Chemistry, vol. 25, pp. 1110–1112, 1933.

[34] Hulbert, Roberts, and Herring, F. W., Studies on the washing of rapid sand filters: Am. Water Works Assoc. Jour., vol. 21, pp. 1445–1487, 1929; discussion by F. W. Herring, J. R. Baylis, Wynkoop Kiersted, H. E. Jordan, E. S. Chase, W. W. DeBerard, C. P. Hoover, W. C. Hirn, G. G. Dixon, William Gore, M. G. Mansfield, J. F. Laboon, W. C. Lawrence, Abel Wolman, and S. T. Powell, pp. 1487–1513. Lawrence, W. C., Further experience with high rate of filter wash: Idem, vol. 24, pp. 1358–1361, 1932. Hulbert, Roberts, and Feben, Douglas, Hydraulics of rapid filter sand: Idem, vol. 25, pp. 19–45, 1933.

[35] Ellms, J. W., and Hauser, S. J., Orthotolidine as a reagent for the colorimetric estimation of small quantities of free chlorine: Jour. Ind. and Eng. Chemistry, vol. 5, pp. 915–917, 1030, 1913; The effect of ferric salts and nitrites on the orthotolidine and starch iodide tests for free chlorine: Idem, vol. 6, pp. 553–554, 1914.

[36] Baylis, J. R., Manganese in Baltimore water supply: Am. Water Works Assoc. Jour., vol. 12, pp. 211–232, 1924. Hopkins, E. S., Manganese interference in the *o*-tolidene test for available chlorine: Ind. and Eng. Chemistry, vol. 19, pp. 744–746, 1927.

[37] Jenne, L. L., and Welsford, H. R., Precautions needed in the ammonia-chlorine treatment of swimming pools: Ind. and Eng. Chemistry, vol. 23, pp. 32–34, 1931.

Apparatus has been developed [38] for automatically regulating the dosage of chlorine according to the residual chlorine indicated by the orthotolidine test.

Chlorination as normally practiced has no effect on the industrial value of the water except as it may affect the taste or odor. (See p. 26.)

Adjustment of pH.—For most waters the best floc is obtained by coagulation at a value of pH at which the water would actively attack iron pipes. Mains may be protected from this attack by different kinds of lining,[39] so that they will not lose carrying capacity from the accumulation of the products of corrosion [40] and will not give up large amounts of iron to be carried in solution by the water, but the corrosive water may still attack household water lines. It is therefore becoming increasingly common to give a final treatment, usually with lime, to bring the pH and calcium content of the water within a range that will insure freedom from corrosion of the mains and service lines.[41] In the table of analyses adjustment of pH is noted wherever an affirmative reply was received to a direct question as to final adjustment of pH. Results furnished by the filtration-plant laboratories are given to indicate the probable range in pH. At some plants an automatic recorder [42] shows continuously the pH of the filter effluent and serves as an accurate guide for the addition of lime.

Manganese removal.—Manganese in water may be exceedingly troublesome in laundry work or in textile plants. In the regular course of filtration when alum is used as a coagulant the manganese is likely to be carried through the plant into the mains, although it has been known to accumulate in the filter beds, to be later taken up and carried into the mains.[43] If the water receives final treatment to increase the pH the manganese will slowly separate after the water leaves the plant. This trouble is being prevented at some plants [44] by using as a coagulant an iron salt that gives a good floc with lime at a pH that causes precipitation of the manganese.

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[38] Cutler, J. W., and Green, F. W., Operating experiences with a new automatic residual chlorine recorder and controller: Am. Water Works Assoc. Jour., vol. 22, pp. 755–766, 1930. Harrington, J. H., Photoelectric control of chlorine feed: Idem, vol. 23, pp. 736–739, 1931.

[39] Stokes, D. B., and Reddick, H. G., Linings for cast-iron pipe: Am. Water Works Assoc. Jour., vol. 24, pp. 1582–1589, 1932.

[40] Redington, H. R., Birkinbine, J. L. W., and Speller, F. N., Corrosion of water mains: Am. Water Works Assoc. Jour., vol. 23, pp. 1649–1693, 1931.

[41] Baylis, J. R., Prevention of corrosion and "red water": Am. Water Works Assoc. Jour., vol. 15, pp. 598–633, 1926. Hopkins, E. S., Reduction of corrosion in water pipe: Ind. and Eng. Chemistry, vol. 25, p. 1050, 1933. Cox, C. R., The removal of aggressive carbon dioxide by contact beds of limestone or marble: Am. Water Works Assoc. Jour., vol. 25, pp. 1505–1522, 1933.

[42] Lauter, C. J., Manufacture of aluminum sulphate at the Dalecarlia filter plant, Washington, D.C.: Ind. and Eng. Chemistry, vol. 25, pp. 953–958, 1933.

[43] Janzig, A. C., and Montank, I. A., High manganese effluent from idle filters: Am. Water Works Assoc. Jour., vol. 21, 1319–1328, 1929.

[44] Craig, E. C., Bean, E. L., and Sawyer, R. W., Iron and lime in removal of manganese: Am. Water Works Assoc. Jour., vol. 24, pp. 1762–1766, 1932.

Undesirably large quantities of manganese are often found in ground water [45] as well as in surface waters.[46]

Prevention of tastes and odors.—The most noticeable effect of tastes and odors in water supplies is in domestic use. Industrial use is not so seriously affected except in the food industries. Two classes of odors that have received the most attention are the natural odors produced by organisms,[47] largely microscopic, and the disagreeable odors resulting from the chlorination of waters that contain wastes from coke ovens, gas works, and similar plants. Quantities of these wastes so small as to give no perceptible taste or odor in the untreated water may produce very offensive tastes or odors when the water is chlorinated.

Reviews by Baylis [48] and by Gibbons [49] describe different methods used for the elimination of tastes and odors and list a number of articles on the subject published up to 1932. The obvious and simple method of aeration [50] is sufficient for some needs,[51] although it is far from a panacea.[52] Carbon in different forms has been used widely.[53] At a number of plants finely divided activated carbon [54] is applied at about the time of coagulation and removed in part with the floc that separates in the settling basins and in part with the floc that settles on the filters, to be removed by the back washing of the filters. At one plant [55] bleaching clay of the type used for the purification of oils was found effective in removing odors.

The use of copper sulphate [56] to prevent odors caused by microscopic organisms is a common practice. When treatment with copper sulphate is applied after a growth has become sufficient to cause an

[45] Weston, R. S., Manganese in water, its occurrence and removal: Am. Water Works Assoc. Jour., vol. 23, pp. 1272–1282, 1931.

[46] Baylis, J. R., Manganese in Baltimore water supply: Am. Water Works Assoc. Jour., vol. 12, pp. 211–232, 1924. Frisk, P. W., The elimination of manganese in reservoirs: Idem, vol. 24, pp. 425–435, 1932. Hopkins, E. S., and McCall, G. B., Seasonal manganese in a public water supply: Ind. and Eng. Chemistry, vol. 24, pp. 106–108, 1932. Boynton, Perkins, and Carpenter, L. V., Manganese and its relations to filters: Am. Water Works Assoc. Jour., vol. 24, pp. 1341–1348, 1932. Hale, F. E., Manganese in the Croton water of New York City: Am. Water Works Assoc. Jour., vol. 20, pp. 661–670, 1928. Zapffe, Carl, The history of manganese in water supplies and methods for its removal: Idem, vol. 25, pp. 655–676, 1933.

[47] Whipple, G. C., The microscopy of drinking water, 4th ed., revised by G. M. Fair and M. C. Whipple, John Wiley & Sons, 1927.

[48] Baylis, J. R., Taste and odor elimination: Am. Water Works Assoc. Jour., vol. 24, pp. 635–656, 1932.

[49] Gibbons, M. M., Elimination of tastes and odors of industrial origin from public water supplies: Ind. and Eng. Chemistry, vol. 24, pp. 977–982, 1932.

[50] Langlier, W. F., The theory and practice of aeration: Am. Water Works Assoc. Jour., vol. 24, pp. 62–72, 1932.

[51] Thuma, R. A., Aeration with compressed air for removing odors: Idem, pp. 682–691.

[52] Hale, F. E., Present status of aeration: Idem, pp. 1401–1415.

[53] Baylis, J. R., The use of charcoal and activated carbon in water treatment: Water Works and Sewerage, vol. 78, pp. 287–292, 320–324, 357–362, 1931; vol. 79, pp. 14–18, 1932.

[54] Spalding, G. R., Activated char as a deodorant in water purification: Am. Water Works Assoc. Jour., vol. 22, pp. 646–648, 1930; Experience with activated carbon: Idem, vol. 24, pp. 1394–1400, 1932.

[55] Norcom, G. D., Bleaching clay in water purification: Water Works and Sewerage, vol. 80, pp. 53–54, 1933.

[56] Moore, G. T., and Kellerman, K. F., A method of destroying or preventing the growth of algae and certain pathogenic bacteria in water supplies: U.S. Dept. Agr. Bur. Plant Industry Bull. 64, 1904; Copper as an algicide and disinfectant in water supplies: U.S. Dept. Agr. Bur. Plant Industry Bull. 76, 1905.

appreciable odor, the first effect may be a great increase in the odor on account of the sudden destruction of large numbers of organisms.

Heavy prechlorination [57] has sometimes been used for prevention of tastes due to so-called "phenolic compounds." This heavy treatment has usually been followed by dechlorination either with sulphur dioxide or with thiosulphate. The use of ammonia in connection with chlorine has been found effective in some plants [58] in preventing these tastes.

Tastes and odors are so irregular in occurrence at any plant, and methods for their prevention or elimination are being so rapidly developed that no information could be given in the table of analyses with any assurance that the statement about a particular supply would be true by the time it was printed.

FILTRATION WITHOUT COAGULATION (SLOW SAND FILTRATION)

The earlier water-filtration plants consisted of sand filters and nothing more. The water with no preliminary treatment other than plain sedimentation without coagulation was allowed to filter through beds of sand at a rate much slower than is used for the rapid sand filter. These slow sand filters serve reasonably well for clear waters with little color. They may be operated without chemical control and with much less expert attention than is required for a rapid sand filter. They require much larger filtering areas and therefore involve a greater cost of installation. Partly because of the cost, but more because of their lack of adaptability to different modifications of treatment, very few slow sand filters have been constructed in recent years, and several of the older plants have been modified to permit some use of features of rapid sand filtration. For industrial users the slow sand filter had some advantages over the rapid filter as first developed. The dissolved mineral constituents in the water served to consumers were the same as in the raw water, whereas in the water from rapid filters some of the carbonate hardness had been changed to noncarbonate hardness, and the water was likely to be corrosive. The present increasing attention to softening and to the prevention of corrosion is enabling the rapid sand filtration plant to deliver water that is much better than the natural water as regards hardness and corrosiveness.

NATURAL PURIFICATION

It has long been recognized that storage in a large open reservoir will greatly improve the sanitary quality of water, and many supplies at one time depended on this method for the purification of water

[57] Howard, N. J., Progress in superchlorination treatment for taste prevention at Toronto, Ontario: Am. Water Works Assoc. Jour., vol. 23, pp. 378–395, 1931.

[58] Berliner, J. F. T., The chemistry of chloramines: Am. Water Works Assoc. Jour., vol. 23, pp. 1261–1271, 1931. Gerstein, H. H., The bactericidal efficiency of the ammonia-chlorine treatment: Idem, pp. 1334–1352. Lawrence, W. C., The ammonia-chlorine treatment at Cleveland: Idem, pp. 1382–1387.

that was exposed to slight contamination at rare intervals. The water was at the same time improved for industrial use by the removal of suspended matter and some color. However, even with the most careful control of conditions in the areas tributary to the reservoirs it is no longer customary to rely on the natural purification of surface waters, and impounded supplies are regularly chlorinated before distribution. Some of the supplies from large lakes or from impounding reservoirs that receive no treatment other than chlorination are not considered wholly satisfactory, and plans for their filtration are being considered.

MUNICIPAL SOFTENING

It is commonly recognized that the use of hard water from a public supply involves a cost to the community that is greater than the cost of softening the whole supply. A discussion of this question published several years ago[59] was based on considerations of the quantity of soap used in an average household and the cost of softening the amount of water that would probably be softened by soap in the course of a day. A more recent study[60] has shown the actual differences in the money spent for soap in communities using waters of different degrees of hardness, with comparisons of conditions before and after softening for one city and for one institution. The results, based on the total retail sales of soap in the communities, furnish some definite data as to the cost to the communities of the use of waters with different degrees of hardness.

The partial softening of public water supplies has been practiced for many years, but it is only comparatively recently that many supplies have been softened. An early instance was the softening at the St. Louis Chain of Rocks plant in 1904.[61] Reduction of hardness has been practiced at St. Louis ever since with modification of the treatment from time to time.

Many of the processes used in water softening in connection with the filtration of surface waters have been developed or tested at the water-purification plant in Columbus, Ohio.[62] From studies at Columbus and at other plants a general plan of treatment has been evolved which is followed at most municipal softening plants.

Lime is used to remove the carbonate hardness so far as possible under the conditions of precipitation and filtration. Soda ash may be used with the lime in order to reduce the noncarbonate hardness.

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[59] Whipple, G. C., The value of pure water, pp. 24–28, John Wiley & Sons, 1907.

[60] Hudson, H. W., Quality of water and soap consumption: Am. Water Works Assoc. Jour., vol. 25, pp. 645–654, 1933.

[61] Graf, A. V., Municipal water softening at St. Louis: Ind. and Eng. Chemistry, vol. 20, pp. 758–759, 1928.

[62] Hoover, C. P., Use of lime in water softening and water purification: Ind. and Eng. Chemistry, vol. 19, pp. 567–570, 1927; Recarbonation of softened water: Idem, pp. 784–786, 1927; Developments in water softening: Am. Water Works Assoc. Jour., vol. 20, pp. 642–652, 1928; Present status of municipal water softening: Idem, vol. 24, no. 2, pp. 181–191, 1933.

The excess lime treatment[63] serves to reduce the magnesium and also the residual hardness more than is possible by the use of smaller quantities of lime as originally practiced. Recarbonation of the softened water is necessary to prevent deposits of calcium carbonate in the distribution system, and where the excess lime treatment is used it is customary to carbonate after precipitation of the magnesium in order to precipitate some of the calcium present as excess calcium hydroxide. A second carbonation stabilizes the water for distribution.

An exchange silicate[64] may be used instead of soda ash for reduction of the noncarbonate hardness, but this practice is not common for plants that combine softening with rapid sand filtration of a surface water under constant chemical control.

For the softening of a ground water the exchange-silicate softener has in its favor the fact that it requires less careful control of its operation than is required for a lime-soda softener. It also provides more flexibility of operation without expert chemical supervision. Part of the supply can be completely softened and mixed with different proportions of unsoftened water to give without further reaction an effluent of any determined hardness. This can also be accomplished by operating softening units after they cease delivering completely softened water.[65]

Removal of the noncarbonate hardness by lime reduces the total quantity of dissolved mineral matter in the water. The total quantity is altered very little by treatment with an exchange silicate, which merely exchanges sodium for the calcium and magnesium originally in the water. Soda ash used for removal of noncarbonate hardness makes little change in the total mineral content.

When the softening of municipal supplies was first introduced the commonly accepted standard was a residual hardness of about 100 parts per million. Most consumers, especially if they had been using water with hardness of several hundred parts per million, were very well pleased with water of this hardness, but after continued use of the softened water they were inclined to complain when the hardness rose to 110 or 120. With better regulation of the different steps of the process the present tendency is to reduce the hardness below 80 parts per million, but only a few large plants in 1932 were furnishing water of such hardness.

The extent to which softening is practiced for the larger supplies and the field for development in softening may be learned from table 4 and figure 1. Table 4 shows softening of 32 supplies of surface water

[63] Hoover, C. P., and Montgomery, J. M., Reduction of carbonate hardness by lime softening to the theoretical limit: Am. Water Works Assoc. Jour., vol. 21, pp. 1218–1224, 1929.

[64] Hoover, C. P., Hansley, V. L., and Sheely, C. Q., Zeolite softening of lime-treated water at Columbus, Ohio, water softening and purification works: Ind. and Eng. Chemistry, vol. 20, pp. 1102–1105, 1928.

[65] Campbell, J. T., and Davis, D. E., Softening municipal supplies by zeolite: Am. Water Works Assoc. Jour., vol. 21, pp. 1035–1053, 1929.

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serving 3,752,000 consumers and 8 supplies of ground water serving 313,000 consumers. Figure 1 shows 2,804,000 consumers using surface water and 4,405,000 consumers using ground water with hardness over 180 parts per million. In the range of hardness from 121 to 180 parts per million, in which the need for softening is less acute, there are 9,062,000 users of surface water and 1,517,000 users of ground water. These figures relate only to the 670 places considered in this report. As has been indicated, the supplies for which analyses are given are on the whole probably decidedly softer than the supplies, public and private, not here included.

Municipal softening is not sufficient for the more exacting industrial demands. It may, however, make a decided saving in costs of installation and operation of an industrial softening plant, because of the decrease from the hardness of the raw water and also because a municipally softened surface water is likely to be less variable in hardness than the untreated water.

IRON REMOVAL

Iron in surface-water supplies rarely demands attention. Unfiltered waters from large reservoirs usually have very little iron in solution, and in the regular treatment of waters that are filtered the iron is removed without special attention. Some of these waters may dissolve iron from mains and service pipes.

Many ground waters contain considerable quantities of iron that is held in solution, usually as iron bicarbonate under the reducing conditions that prevail in the ground. When these waters are exposed to the air the iron is oxidized, some of the carbon dioxide is lost, and the iron separates as a reddish flocculent precipitate of hydrated iron oxide. The occurrence of iron in ground water is decidedly erratic and difficult to predict. Wells of about the same depth that are fairly near one another may differ widely in their content of iron.

The general principle of the removal of iron is simple enough. As a rule it is only necessary to secure fairly complete mixing of air and water and then allow opportunity for settling of the precipitated iron. The clear water may be drawn off for use, or the iron may be removed by filtration. The details of carrying out the process on a fairly large scale in such a way as to make certain that the sanitary quality of the water is not affected may require careful planning.[66]

In some supplies a considerable amount of manganese occurs with the iron. Where it is necessary to remove manganese also the process is likely to be somewhat more complicated and to require more careful regulation.[67] If the water is softened the manganese and iron are removed in the softening process.

[66] Cunningham, F. G., and Donaldson, Wellington, The Memphis water supply: Am. Water Works Assoc. Jour., vol. 24, pp. 1539-1550, 1932.

[67] Weston, R. S., Manganese in water, its occurrence and removal: Am. Water Works Assoc. Jour., vol. 23, pp. 1272-1282, 1931.

INDUSTRIAL TREATMENT OF WATER FROM PUBLIC SUPPLIES

Because water from public supplies is used for many purposes for which its chemical character is of no importance, the treatment of a public supply is commonly planned to give maximum returns for the expenditures, mainly with reference to domestic use. Consequently the water delivered to consumers is far from satisfactory for many industrial uses, even though it may be quite satisfactory to the average domestic consumer. The additional treatment of the water by the industrial user may range from almost nothing to complete rapid sand filtration, including softening and adjustment of pH.

BOILER FEED WATER

Of all the industrial uses of water from public supplies the use in steam boilers to furnish power or heat is the commonest, and the treatment of water for use in boilers has received more attention than any other phase of the treatment of water for industrial use.

Methods and apparatus for the treatment of boiler-feed water are described in detail in books,[68] in articles in current engineering and chemical journals, and in printed matter distributed by the manufacturers of materials and equipment for the treatment of boiler-feed water.

Scale, corrosion, embrittlement, and foaming.—Boiler scale has attracted more attention for a longer time than any other trouble caused by feed water. In general, scale consists of deposits of calcium and magnesium carbonate or sulphate with smaller or larger quantities of silica and iron. Scale from a water low in sulphate is likely to be comparatively soft and easily removed. If the sulphate, and therefore the noncarbonate hardness, is high the scale is likely to be hard and adherent.[69]

Water with noncarbonate hardness caused by chlorides and nitrates of calcium and magnesium or water containing free acid would corrode a boiler, but such water is not often served for public supplies or used in a boiler without treatment. Purification of feed water and the use of a large proportion of condensed steam in the make-up may result in corrosion unless the gases are removed.[70]

In recent years attention has been directed to a type of failure of boilers that has been attributed to embrittlement of the boiler plate.[71] This failure has been associated with the use of waters that originally carried considerable quantities of sodium bicarbonate or sodium carbonate or else contained these compounds as a result of treatment of

[68] Powell, S. T., Boiler feed water purification, McGraw-Hill Book Co., 1927. Cochrane Corporation, Finding and stopping waste in modern boiler rooms, pp. 645–780, 1928.

[69] Partridge, E. P., Formation and properties of boiler scale: Michigan Univ. Eng. Research Bull. 15, 1930.

[70] McDermet, J. R., Degasification of boiler-feed water: Mech. Eng., vol. 44, pp. 648–650, 1922.

[71] Parr, S. W., The embrittling action of sodium hydroxide on soft steel: Illinois Univ. Eng. Exper. Sta. Bull. 94, 1917.

waters that originally had large quantities of calcium or magnesium bicarbonate. Straub [72] gives a summary of a 5-year investigation of the characteristics and cause of this type of failure and of ways of preventing it.

For a long time the foaming and priming of boiler waters has been a serious problem, especially in locomotive boilers. It has been attributed in a general way to excessive concentration of soluble salts together with the presence of finely divided solid particles in the water, and the standard method for its prevention has been by blowing off to reduce the concentration of soluble salts and by adding "antifoaming" compounds to the water in the boiler. Foulk and his coworkers at the Ohio State University are reporting progress in the study of the causes and mechanism of foaming and its prevention.[73]

Softening.—Treatment with lime and soda ash, with or without filtration, was for many years the only method used to soften water for boiler feed. The practical limit of residual hardness for softening in the cold was about 50 parts per million and by the hot process about 25 parts per million. The development of the exchange-silicate (zeolite) softener made it possible to reduce the hardness practically to zero. Either method greatly reduced or eliminated the formation of scale in a boiler. The choice between the two, with the possibility of a combination of lime and exchange-silicate treatment, has depended on the character of the water to be softened, the required daily or hourly output, and the kind of attention that could be given to the plant. The exchange silicate requires clear water and therefore would not normally be chosen for the treatment of a turbid surface water.

In general the exchange-silicate softener requires less skilled attention than the lime-soda softener. Within its limit of total and hourly capacity the exchange silicate will soften almost any water likely to be served for a public supply, regardless of its hardness. The addition of chemicals to the lime-soda softener must be governed by the hardness of the water and will need frequent adjustment to avoid overtreatment or undertreatment of a supply from a source that may have at one time twice the hardness found at some other time. The size of the lime-soda softener is governed by the capacity required and is independent of the hardness of the water. The size of an exchange-silicate softener to furnish water at a given daily or hourly rate depends directly on the hardness.

Internal treatment.—When the lime-soda process was the only method of water softening it was not generally practicable for small

[72] Straub, F. G., Embrittlement in boilers: Illinois Univ. Eng. Exper. Sta. Bull. 216, 1930.

[73] Foulk, C. W., and Miller, J. N., Experimental evidence in support of the balanced-layer theory of liquid-film formation: Ind. and Eng. Chemistry, vol. 23, pp. 1283–1288, 1931. Foulk, C. W., and Hansley, V. L., Solid matter in boiler-water foaming: Idem, vol. 24, pp. 277–281, 1932. Foulk, C. W., and Groves, Kermit, Foaming and priming in boiler water—peculiar behavior in an experimental boiler: Idem, vol. 25, pp. 800–803, 1933.

boiler plants to install softeners, and boiler compounds were widely used. Some of these were effective, and some were valueless or even harmful. In general they were prescribed and used without much reference to the composition of the water. There was a common saying that a boiler should not be used as a vessel for chemical reactions, but the scale-forming substances should be removed before the water entered the boiler.

Some of those who advocated the use of internal treatment adapted to each water and boiler plant realized the inadequacy of the lime-soda process as the sole treatment for a boiler-feed water and appreciated some of the advantages of internal treatment that are now generally recognized.[74]

Studies of a specific problem of boiler operation by the United States Bureau of Mines at Pittsburgh [75] led to the adoption of principles and practices relating to the internal treatment of boiler water that are now widely recognized and followed. The comparatively recent great increase in working pressures for steam boilers has made necessary new equipment for providing the proper conditions within the boiler.[76] These changes have stimulated studies of reactions within the boiler [77] and of methods for the analysis of water for boilers.[78] Some of the investigations to which reference is made in this discussion have been sponsored by a Joint Research Committee on Boiler Feed Water Studies [79] under the chairmanship of S. T. Powell, which represents several technical societies and is carrying on an extensive program of research on boiler-water problems.

Thus there has developed from the boiler-compound business and the old water-softening business the present practice with reference to boiler-feed water, which involves treatment outside the boiler to remove scale-forming and corrosive constituents and treatment within the boiler to insure freedom from scale, corrosion, or foaming. The choice of the best equipment and methods for a particular installation involves consideration of such information as is given in the table of analyses and descriptions in this report in connection with the type of boiler and operating requirements.

[74] French, D. K., Internal treatment of boiler water—proper and improper: Ind. and Eng. Chemistry, vol. 15, pp. 1239–1243, 1923.

[75] Hall, R. E., A system of boiler-water treatment based on chemical equilibrium: Ind. and Eng. Chemistry, vol. 17, pp. 283–290, 1925; Boiler-water conditioning with special reference to high operating pressure and corrosion: Mechanical Engineering, vol. 48, pp. 317–325, 1926.

[76] Yoder, J. D., Improved equipment for the treatment of feed water for modern steam boilers: Ind. and Eng. Chemistry, vol. 21, pp. 829–834, 1929.

[77] Straub, F. G., Behavior of calcium salts at boiler temperatures: Ind. and Eng. Chemistry, vol. 24, pp. 1174–1178, 1932; Solubility of calcium sulfate and calcium carbonate at temperatures between 182° and 316° C.: Idem, pp. 914–917.

[78] Partridge, E. P., and Schroeder, W. C., Determination of hydroxide and carbonate in boiler waters: Ind. and Eng. Chemistry, Anal. ed., vol. 4, pp. 271–278, 1932. Straub, F. G., Determination of alkalinity in boiler waters: Idem, pp. 290–294. Rummel, J. K., Control tests for the treatment of feed and boiler water: Am. Water Works Assoc. Jour., vol. 24, pp. 2004–2024, 1932.

[79] Powell, S. T., Progress report of the Boiler Feed Water Studies Committee, year 1932: Am. Water Works Assoc. Jour., vol. 25, pp. 279–281, 1933.

WATER FOR INDUSTRIAL PROCESSES

The most common improvement of water from public supplies for use in manufacturing processes is softening. This may be accomplished in the same way as for boiler use, but the requirements of some processes may demand more care than is necessary in softening water for boiler feed.

The most exacting requirements for process water are probably in the production of textiles or fine paper, where the very large quantities of water used for a given quantity of product makes it possible for exceedingly small quantities of impurities to cause serious damage to the product. Color, iron, or manganese, and suspended matter may do the most harm in washing processes. Hardness is detrimental in the washing and dyeing of textiles. Softening by exchange silicates is a widely practiced treatment of water for laundries. It has been found profitable in laundries to soften waters that before treatment would be considered soft by ordinary standards.

Nearly all of the purification of water for industrial use is directed to the removal of calcium and magnesium and leaves the sodium either unchanged in quantity or, more generally, considerably increased. For processes like ice manufacture, in which sodium salts are about as troublesome as calcium salts, it has been customary either to remove only the calcium present as bicarbonate or to use distilled water. Distillation is still the most widely used method of obtaining water free from sodium salts, although other methods have been described. The removal of sodium bicarbonate has been accomplished [80] by treating the water with a magnesium exchange silicate, which replaces the sodium by magnesium. This is now precipitated by lime, which itself remains as carbonate in the precipitate. The exchange silicate is regenerated by a solution of magnesium chloride. The process of electroösmosis [81] removes continuously any soluble salts of calcium, magnesium, or sodium that may be in a water. The apparatus may be adjusted to give different degrees of purification as desired.

Water for the preparation of food products is often treated with ozone,[82] which has the advantage over some other treatments of not adding any taste or odor to the water and of assisting in the removal of tastes and odors that may be in the water. Use is also being made of activated carbon [83] to remove tastes and odors from water used in

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[80] Burks, Dana, Jr., Treatment of water for ice manufacture: Illinois Univ. Eng. Exper. Sta. Bull. 219, 1930; The treatment of water for ice manufacture, II: Idem, Bull. 253, 1933.

[81] Behrman, A. S., Water purification by electroösmosis: Ind. and Eng. Chemistry, vol. 19, pp. 1229–1230, 1927. Bartow, Edward, and Perisho, F. W., Relative concentrations of negative ions in different parts of an electroösmosis apparatus: Idem, vol. 23, pp. 1305–1309, 1931. Bartow, Edward, and Fry, M. A., Removal of positive ions by electroösmose apparatus: Idem, vol. 25, pp. 336–338, 1933.

[82] Sharp, Jonathan, Purifying water for food manufacture by ozone and "electrolytic" filtration: Food Industries, vol. 1, pp. 625–627, 1929.

[83] Behrman, A. S., Activated carbon in industrial-water purification: Water Works and Sewerage, vol. 80, pp. 55–59, 1933.

the preparation of food products. The activated carbon has appeared to increase greatly the action of water on metallic equipment,[84] but this has been corrected by suitable coatings on the metal.

DOMESTIC TREATMENT OF WATER FROM PUBLIC SUPPLIES

With increasing attention to the treatment of water for public supplies the time may come when there will be no occasion for treatment in the home of water served for the public supply. At the time of the preparation of this report, however, a considerable number of supplies can profitably be improved for home use.

It is not likely that any supply described in this report is unsafe for drinking. It is not at present feasible to do much in the home to improve the taste or odor of water from a public supply which is unsatisfactory in these respects. The practical and widely used treatments of water from public supplies to improve them for domestic use are softening and the prevention of corrosion.

DOMESTIC SOFTENING

Hardness of water is objectionable in the home mainly in connection with the use of soap, although some very hard waters give trouble from scale in appliances where the water is heated, especially in tanks or other arrangements for furnishing a supply of hot water for household use. Because of its simplicity and comparatively low cost of installation and operation the exchange-silicate softener is widely adopted for domestic use in places where the public water supply is hard, and many users consider it worth while further to soften waters from public supplies that are already softened in connection with their purification. The commercial exchange-silicate softeners completely remove the hardness of water and require almost no attention except regeneration of the active material with a solution of common salt about once a week. The size of softener must be adjusted to the rate of use and the hardness of the water in order to give the most satisfaction. Because the softening action is merely an exchange of calcium and magnesium for sodium, the taste of the water is not affected.

Somewhat crude softening of water has been practiced for many years by the addition of chemicals before using soap with the water. The softening of water with these chemicals has two advantages. It is cheaper to soften with the other chemicals than it is to soften with soap, and the softened water is more satisfactory for use, especially in laundry work. The precipitate that is formed by the chemicals is granular and much less troublesome than the heavy curds formed when soap is used. The chemicals used in the past for softening water in

[84] Behrman, A. S., and Gustafson, H., Behavior of activated carbon with metallic water-purification equipment: Ind. and Eng. Chemistry, vol. 25, pp. 59–60, 1933.

the home were chiefly ammonia, borax, and sodium carbonate in the form of washing soda. More recently there has been a decided increase in the use of trisodium phosphate for cleaning and for water softening. Large quantities of this chemical are sold in packages under various trade names. These chemicals that are used for treating water in the home and that are also used to some extent in the manufacture of soap are discussed in considerable detail by Smither.[85]

PREVENTION OF CORROSION

The effects of the corrosive action of waters on household plumbing are the appearance of "red water" caused by the separation of dissolved iron when the water is exposed to the air, stoppage of pipes by accumulation of products of corrosion, and leaks that may develop in the pipes. "Red water" may be caused by iron that is in solution in the water when it is delivered to the mains. This occurs most frequently in ground waters. The trouble may be caused by iron which has been dissolved from the mains. "Red water" in the home from either of these causes cannot be remedied except by the addition of chemicals and a somewhat complicated system of filtration.

A considerable part of the trouble from "red water", however, occurs only in hot-water lines. The water is not sufficiently corrosive to dissolve troublesome quantities of iron from the mains or from cold-water pipes, but when the temperature is raised the corrosive activity of the water is greatly increased, and enough iron is dissolved from pipes to be objectionable. This difficulty can be prevented by the deposition of a coating of silicate on the inside of the iron pipes exposed to corrosion.[86] Fairly simple automatic equipment for treating hot-water supplies is sold by plumbing-supply houses, just as the household softeners are. The application of the silicate coating to cold-water lines is not so simple, but installations of this kind have been made successfully.

Prevention of "red water" resulting wholly from corrosion of household plumbing is generally possible by the use of either brass or copper pipes. A few waters very high in carbon dioxide seem to have a solvent action on copper pipe and dissolve a small amount of copper, which is objectionable. Brass pipe that contains fairly high percentages of zinc may be attacked severely by water that would corrode iron pipes. The water may come through the pipes without any color, because the dissolved zinc does not make a colored precipitate after it separates. In time, however, the zinc may be dissolved at many places in the pipe, leaving a skeleton of copper which is porous, so that the pipes develop many small leaks. It is reported that some

[85] Smither, F. W., Washing, cleaning, and polishing materials: U.S. Bur. Standards Circ. 383, 47 pp., 1930.

[86] Speller, F. N., Film protection as a factor in corrosion: Am. Electrochem. Soc. Trans., vol. 46, pp. 225-237, 1924.

success has been obtained in treating brass pipes with silicate for prevention of this action. Brass that is low in zinc appears to withstand the corrosive action of water much better than ordinary yellow brass, which is comparatively high in zinc. Corrosion has been prevented in some buildings by permitting the water to attack sheets of iron in a suitable container until the oxygen necessary for corrosion is exhausted.[87]

It is difficult to set any definite limits by which to judge the probable corrosiveness of the waters for which analyses are given in the table. In general the more corrosive waters are those that are low in calcium carbonate and low in pH. The hard waters with fairly high alkalinity are generally the less corrosive.

ANALYSES OF PUBLIC SUPPLIES

In the following table are given in detail the data upon which this report is based. The population of each city according to the 1930 census is given in parentheses after the name. Ownership of the supply is indicated as "municipal" or by the name of a water district or a private water company. Brief mention of the source or sources is followed by notes on the treatment. "Filtered" means the usual rapid sand filtration described on pages 22–27. Chlorination is not mentioned. The other types of treatment are discussed on pages 27–37. The headings of the columns of analytical results and the analytical terms used in the descriptive material are discussed on pages 5–12. The date given for an analysis is usually the date of collection of the sample.

[87] West, Percy, Prevention of corrosion of metals by water in a closed system: Jour. Ind. and Eng. Chemistry, vol. 14, pp. 601–607, 1922.

TABLE 5.—*Public water supplies of the*

No.	Description
	ALABAMA
	[The information and cooperation necessary for the inclusion of some of the places was obtained through the assistance of H. G. Menke, assistant sanitary engineer of the Alabama Board of Health]
1	Anniston (22,345); Alabama Water Service Co. (controlled by Federal Water Service Corporation, 27 William St., New York, N.Y.). Supplies also Blue Mountain and Oxford. Total population supplied about 24,700. Cold Water Spring. Analyzed by Southern Testing Laboratories, Inc., Birmingham, Apr. 29, 1925.
2	Bessemer (20,721); Alabama Water Service Co. (controlled by Federal Water Service Corporation, 27 William St., New York, N.Y.). Water purchased from Birmingham Water Works Co. (See Birmingham.)
3	Birmingham (259,678); Birmingham Water Works Co. (controlled by American Water Works & Electric Co., 50 Broad St., New York, N.Y.). Supplies also Bessemer, Fairfield, Homewood, and Tarrant City. Total population supplied about 305,000. Cahaba River in conjunction with Lake Purdy, reserve supply from Fivemile Creek; filtered. The reserve supply from Fivemile Creek is harder and has a higher mineral content than the Cahaba River-Lake Purdy supply. Analyzed by E. W. Lohr. A, Sample of about average hardness, May 18, 1932; B, sample of about maximum hardness, October 1931. The composition of the water varies throughout the year. Daily determinations for the period May 1, 1930, to Aug. 31, 1931: Alkalinity 26 to 99, average 59; hardness 34 to 107, average 69; pH 6.8 to 7.6, average 7.2.
4	Decatur (15,593); Alabama Water Service Co. (controlled by Federal Water Service Corporation, 27 William St., New York, N.Y.). Tennessee River; filtered. Analyzed in the Picard Laboratories, Birmingham, Feb. 4, 1927.
5	Dothan (16,046); municipal; 3 wells (nos. 4 to 6), 325, 332, and 326 feet deep, respectively; 3 wells (nos. 1 to 3) held in reserve as an emergency supply, 625, 626, and 640 feet deep. All wells except no. 6, which is pumped directly into the mains, are pumped to a 1,000,000-gallon reservoir. The water from the deeper wells has a much higher mineral content than that shown by the analysis. Analysis of a sample from wells 4, 5, and 6, representing the usual supply, by L. A. Shinn, U.S. Geological Survey, Apr. 7, 1931.
6	Fairfield (11,059); supplied by Birmingham Water Works Co. (See Birmingham)
7	Florence (11,729); municipal; creek; filtered. Analyzed by L. A. Shinn, U.S. Geological Survey, Apr. 15, 1931.
8	Gadsden (24,042); municipal. Supplies also Alabama City and Attalla. Total population supplied about 37,000. Coosa River; filtered; adjustment of pH. Analyzed by E. W. Lohr, Apr. 20, 1932. Daily determinations on the treated water for the year 1931: Alkalinity 23 to 70, average 35; pH 7.1 to 7.4.
9	Huntsville (11,554); municipal; Big Spring. Analyzed by Margaret D. Foster, U.S. Geological Survey, July 15, 1929.
10	Mobile (68,202); municipal; creeks impounded. Analyzed by Margaret D. Foster, U.S. Geological Survey, Feb. 21, 1922. A, Spring Hill Creek; B, Bienville Creek.
11	Montgomery (66,079); municipal; 26 wells about 200 to 700 feet deep penetrating 3 different water-bearing strata at about 200, 400, and 600 feet; 1 well 60 to 80 feet deep (about 20 percent of supply). Water is obtained in about equal amounts from the 200 and 600 foot strata. The 400-foot stratum furnishes only a small proportion of the supply. Analyzed by Southern Testing Laboratory, Birmingham, December 1930. A, Water from 60 to 80 foot stratum; B, water from 200-foot stratum; C, water from 600-foot stratum.
12	Phenix City (13,862); municipal; Chattahoochee River; filtered. The mineral content of the water is low, and the range in concentration not great, so that a single analysis may safely be used to represent the composition of the water throughout the year. Analyzed by L. A. Shinn, U.S. Geological Survey, Apr. 14, 1931. An average of analyses of the river water at West Point, Ga., for 1906–7 is similar to the analysis made in 1931.
13	Selma (18,012); municipal; 5 wells 450 feet deep; aerated, filtered without coagulation. Analyzed by Picard Laboratories, Birmingham, Sept. 24, 1929.
14	Tuscaloosa (20,659); municipal; Yellow Creek, impounded; filtered, final adjustment of pH to about 7.8 by application of lime. The impounding reservoir is so large and the mineral content of the water so low that the single analysis may be considered representative of the composition of the water regularly furnished to consumers. Analysis of tap sample by E. W. Lohr, Jan. 18, 1932.
	ARIZONA
15	Bisbee (8,023); Arizona Edison Co.; well (mine shaft) 200 feet deep with two drifts or tunnels, about 500 feet each, running north and south from the bottom. The well is in Naco, and the water is pumped to a reservoir near the well. Analysis dated Aug. 5, 1926, furnished by the Arizona Edison Co.
16	Douglas (9,828); municipal; 3 wells 325 feet deep, 3 miles west of city. Analysis of tap sample by El Paso Testing Laboratories, El Paso, Tex., April 1930.
17	Globe (7,157); municipal (water purchased from Old Dominion Mining Co.); Old Dominion mine shaft 850 feet deep, supplied to a reservoir. Analysis of tap sample by E. W. Lohr, Aug. 3, 1932.
18	Phoenix (48,118); municipal; wells averaging 80 feet deep and an infiltration gallery adjacent to Verde River. Analysis of sample from reservoir by University of Arizona, December 1931.

larger cities of the United States, 1932

	Analyses (parts per million)												No.
	Total dissolved solids	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulphate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Total hardness as $CaCO_3$[a]	
----------	136	2.5	[b]0.20	22	13	3.5		43	70	5.5	------	108	1
----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	2
A-------	140	7.8	.07	17	5.9	19	1.3	54	61	2.0	0.45	67	3
B-------	124	5.8	.01	33	6.0	4.1	1.2	120	15	2.0	.40	107	
----------	[a]128	9.9	.34	30	2.3	5.5		69	27	8.4	------	84	4
----------	40	7.6	.02	4.8	.9	4.2	.6	12	1.7	6.0	4.4	16	5
----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	6
----------	46	4.9	.01	11	.7	1.5	.8	25	11	1.2	1.6	30	7
----------	68	8.1	.01	15	4.1	2.0	.9	56	10	1.6	.64	54	8
----------	139	15	.06	39	5.5	1.4	.6	129	5.3	1.7	7.3	120	9
A-------	22	6.0	.16	1.6	.4	1.9	.3	2.4	1.1	4.5	.16	6	10
B-------	20	5.8	.11	.9	.4	1.9	.3	2.4	1.4	3.2	.14	4	
A-------	[a]50	14	[b].50	1.9	1.0	11		20	2.5	8.9	------	9	11
B-------	[a]182	19	[b].40	8.9	1.1	57		147	6.7	20	------	27	
C-------	[a]282	14	[b].40	1.3	.3	110		264	22	12	------	4	
----------	51	12	.02	6.6	1.1	3.9	1.2	20	10	2.5	.50	21	12
----------	[a]107	11	2.0	27	4.4	2.7		101	3.1	4.2	------	86	13
----------	33	5.9	.42	5.9	.8	1.7	.6	13	9.3	1.6	.20	18	14
----------	[a]240	20	Trace	68	4.0	13		227	10	13	------	186	15
----------	846	6.9	[b]3.5	9.2	3.3	283		191	173	222	------	37	16
----------	609	29	.04	106	26	48	3.5	229	224	30	11	372	17
----------	424	------	------	53	19	37		236	55	26	------	210	18

[a] Calculated. [b] Iron and aluminum oxides.

TABLE 5.—*Public water supplies of the larger*

No.	Description
	ARIZONA—continued
19	Tucson (32,506); municipal; South Side plant consisting of 11 wells 165 to 476 feet deep (about 85 percent); North Side plant consisting of 4 wells 500 feet deep (about 15 percent). Analyzed by Smith-Emery Co., Los Angeles, Calif., September 1931. A, South Side group; B, North Side Reservoir.
	ARKANSAS
	[Some of the information given below was obtained from Dr. Harrison Hale, of the University of Arkansas, Fayetteville, Ark., and analyses for three of the places were taken from his report entitled "City water supplies of Arkansas" (Arkansas Univ. Bull., vol. 20, no. 18, 100 pp., 1926). The report gives descriptions and analyses for 82 public supplies in 1926]
20	Blytheville (10,098); Associated Utilities, Inc.; 3 wells 1,400 feet deep; coke and rapid sand filtration without coagulation. Analyzed by L. A. Shinn, U.S. Geological Survey, Feb. 12, 1931.
21	El Dorado (16,421); Arkansas Power & Light Co.; 4 wells 650 to 700 feet deep. Analyzed by Elmer Haynes and Newell Gibson, June 1925 (Arkansas Univ. Bull., vol. 20, no. 18, p. 31, 1926).
22	Fort Smith (31,429); municipal; Poteau and Arkansas Rivers; filtered. Analyzed by E. W. Lohr, Nov. 12, 1931. The analysis represents a concentration less than the average. The intake is located in Poteau River near the junction with the Arkansas. At times it receives backwater from the Arkansas. The composition of the water is variable, and the mineral content of the Arkansas is high. (For analysis, see Little Rock.) During a period in 1930 when the intake was receiving backwater the water delivered to consumers reached a maximum chloride of 369 and a maximum hardness of 294. Daily determinations for 1929 show the following range in concentration of the treated water: Hardness 50 to 240, average 89; chloride 5 to 236, average 15.
23	Hot Springs (20,238); Hot Springs Water Co.; 3 impounded lakes, auxiliary supply from mountain streams; filtered. Analyzed by Ford Loudermilk and Elmer Haynes, April 1925 (Arkansas Univ. Bull., vol. 20, no. 18, p. 51, 1926).
24	Jonesboro (10,326); municipal; wells 129 to 223 feet deep in 3 groups. Analysis of sample from a well 129 feet deep at plant 2 by L. A. Shinn, U.S. Geological Survey, Jan. 2, 1931. Partial analyses of samples collected Jan. 3, 1931, from each of the other groups of wells indicate that the analysis given represents fairly well the composition of the water delivered to consumers.
25	Little Rock (81,679); Arkansaw Water Co.; (controlled by American Water Works & Electric Co., 50 Broad Street, New York, N.Y.) Supplies also North Little Rock. Total population supplied about 101,000. Arkansas River, wells (used to reduce the chloride content of the water during periods of low flow by dilution of the river water with well water); filtered. The coagulation and filtration reduce the silica and iron, the bicarbonate may also be reduced, and the sulphate is increased, but the analysis indicates the general character of the river water. Average of 22 analyses of composites of daily samples of raw water from Arkansas River near Little Rock by the U.S. Geological Survey in 1906–7 (Water-Supply Paper 236, p. 49, 1909). Daily determinations for the 5-year period 1926–30 show the following range in composition of the treated water: Alkalinity 30 to 340, average 101; hardness 56 to 334, average 169; chloride 30 to 400, average 193.
26	North Little Rock (19,418); supplied by Arkansaw Water Co. (See Little Rock)
27	Pine Bluff (20,760); Arkansas Power & Light Co.; wells 900 feet deep; aerated, treated with lime. Analyzed by Elmer Haynes, June 1925 (Arkansas Univ. Bull., vol. 20, no. 18, p. 73, 1926).
28	Texarkana (10,764 [total population of Texarkana, Ark., and Texarkana, Tex., 27,366]); Texarkana Water Corporation (controlled by American Water Works & Electric Co., 50 Broad Street, New York, N.Y.). Arkansas station supplied by 24 wells 30 to 40 feet deep, Bringle station supplied by 14 wells approximately 30 feet deep and by Clear Creek impounded. The chemical character of the ground water and the impounded surface water at this station is about the same. At the Arkansas station the water is aerated and treated with lime; the pH is adjusted to maintain an alkalinity to phenolphthalein. At the Bringle station the ground water is aerated and the surface water is coagulated with alum, all the water is treated with lime and filtered, and the pH is adjusted to maintain an alkalinity to phenolphthalein. The two stations furnish about equal quantities of water. During winter the Arkansas station furnishes the larger proportion of water; in summer this proportion is reversed. Analyzed by L. A. Shinn, U.S. Geological Survey, Mar. 12, 1931. A, Arkansas station; B, Bringle station.
	CALIFORNIA
29	Alameda (35,033); East Bay Municipal Utility District. (See Oakland)
30	Alhambra (29,472); municipal; wells. Analyzed by P. M. Gardner, Los Angeles County Health Department, Los Angeles, Apr. 20, 1931. A, Reservoir 5, Kewen Canyon Raymond Basin Supply (upper basin) fed by wells 6 and 25, 300 and 209 feet deep; B, Garfield Reservoir (lower basin) fed by Garfield, Langden, and Graves wells, 561, 801, and 505 feet deep.
31	Bakersfield (26,015); California Water Service Co. (controlled by Federal Water Service Corporation, 27 William St., New York, N.Y.). Supplies also about 1,700 consumers outside of city limits. Total population supplied about 27,700. 22 wells 52 to 59 feet deep, 6 wells 66 to 72 feet, 2 wells 96 to 120 feet, 7 wells 155 to 204 feet, 3 wells 300 to 385 feet, and 1 well 643 feet. Analyzed by P. Villarruz, California Water Service Co., Stockton, Apr. 22, 1931. A, West Bakersfield tap (about 60 percent of supply); B, East Bakersfield tap (about 40 percent of supply).

cities of the United States, 1932—Continued

	Analyses (parts per million)												
	Total dissolved solids	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulphate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Total hardness as $CaCO_3$[a]	No.
A-------	[a] 468	27	[b] 5.1	74	14	67		275	124	21	-------	242	19
B-------	[a] 237	14	[b] 3.6	36	4.5	42		166	43	12	-------	108	
----------	117	11	.01	9.2	3.1	26	3.4	103	13	2.0	0.50	36	20
----------	274	13	[b] .45	4.7	Trace	[a] 107		233	6.9	32	-------	12	21
----------	109	6.2	.01	21	3.6	5.7	2.6	40	39	6.8	.94	67	22
----------	40	5.2	[b] 1.8	8.4	1.4	[a] 2.2		27	4.5	3.3	-------	27	23
----------	146	24	.06	21	9.4	13	.9	99	17	18	1.0	91	24
Av------	630	28	.82	55	13	144		148	93	203	2.0	191	25
----------	-------	-------	-------	-------	-------	-------		-------	-------	-------	-------	-------	26
----------	122	22	[b] 3.3	14	1.6	[a] 17		40	37	4.5	-------	42	27
A-------	171	39	.05	17	3.9	19	2.0	50	5.8	32	15	58	28
B-------	102	1.7	.02	23	3.0	5.2	1.6	52	23	8.0	3.2	70	
----------	-------	-------	-------	-------	-------	-------		-------	-------	-------	-------	-------	29
A-------	232	24	.08	42	13	[a] 17		165	32	19	-------	158	30
B-------	271	32	.05	34	8.6	[a] 41		158	29	35	-------	120	
A-------	[a] 184	21	.01	24	4.8	[a] 32		120	29	14	-------	80	31
B-------	295	23	.02	54	5.1	[a] 35		103	93	36	-------	156	

[a] Calculated.
[b] Iron and aluminum oxides.

TABLE 5.—*Public water supplies of the larger*

No.	Description
	CALIFORNIA—continued
32	Belvedere District (65,000 consumers); California Water Service Co. (controlled by Federal Water Service Corporation, 27 William St., New York, N.Y.). This district is outside of and adjacent to the city limits of Los Angeles. 11 wells 126 to 450 feet deep, 5 wells 530 to 1,250 feet deep. Analyzed by P. Villarruz, California Water Service Co., Stockton, Apr. 22, 1931. The analyses are representative of the quality of the water in different sections of the distributing system.
33	Berkeley (82,109); East Bay Municipal Utility District. (See Oakland)
34	Contra Costa District (20,000 consumers); California Water Service Co. (controlled by Federal Water Service Corporation, 27 William St., New York, N.Y.). This district includes Bay Point, Concord, Crockett, Martinez, Port Costa, Walnut Creek, and intervening territory. Sacramento River impounded in Chenery Reservoir (aerated, filtered), 5 wells 93 to 99 feet deep at Bay Point, 17 wells 160 to 498 feet deep at Galindo, 4 wells 158 to 480 feet deep at Fenway, 3 wells 78 to 207 feet deep at Hollar Field, 1 well 314 feet deep at Pacheco, 2 wells 75 to 98 feet deep at Moore Ranch, 13 wells 114 to 610 feet deep at Government Ranch. Chenery Reservoir is filled by pumping from Sacramento River during winter, when the water is fresh. The reservoir furnishes about 75 percent of the total supply. Analyzed by P. Villarruz, California Water Service Co., Stockton. A, Chenery Reservoir (treated water), Feb. 4, 1931; B, mixed well water from Galindo pumping station, Feb. 14, 1931.
35	Fresno (52,513); municipal; 53 wells 75 to 310 feet deep at 30 pumping stations in different parts of the city. Analyzed by K. W. Brown, California Water Service Co., Stockton. A, Station 16, Sept. 19, 1927; B, station 17, Sept. 21, 1927; C, station 21, Sept. 21, 1927; D, station 28, Oct. 12, 1927. The analyses are representative of the quality of the water in different sections of the distributing system.
36	Glendale (62,736); municipal; wells. The maximum and minimum analyses do not represent the absolute extremes in concentration of the waters from all the wells but give the range in concentration of the water from the wells that regularly furnish the supply. The water delivered to consumers will generally be between the limits indicated by the analyses, the concentration depending on how the wells are pumped. Analyses for May 1930 on 10 of the wells show the following range in concentration: Alkalinity 107 to 175, hardness 102 to 215, chloride 10 to 115. Analyzed by Biological Laboratory, Department of Public Service, Los Angeles, May 1930.
37	Huntington Park (24,591); municipal; 7 wells 556, 556, 900, 1,246, 1,014, 1,136, and 1,500 feet deep. Analysis of sample from the 1,500-foot well by L. A. Shinn, U.S. Geological Survey, Nov. 5, 1930. Partial analyses for Nov. 3, 4, and 5, 1930, indicate that the composition of the water from each of the wells is about the same and that the analysis represents reasonably well the water delivered to consumers.
38	Long Beach (142,032); municipal; 33 wells as follows: Development group, 6 wells (nos. 3 to 8), 650 to 1,016 feet deep; Citizens group, 7 wells (nos. 1 to 7), 420 to 1,422 feet deep; Alamitos group, 7 wells (nos. 1, 2, 6, 8, 9, 11, and 12), 273 to 1,184 feet deep; North Long Beach group, 4 wells (nos. 1 to 4), 200 to 1,000 feet deep; Commission group, 6 wells (nos. 1 to 6), 324 to 1,668 feet deep; Wise Ranch group, 2 wells (nos. 1 and 2), 1,086 and 1,041 feet deep; and Wilson Ranch well (no. 1), 1,690 feet deep. There is considerable difference in the composition of the water from the individual wells. Analyzed by City of Long Beach Engineering Laboratory. A, Development well 7, 650 feet deep, Nov. 17, 1931; B, citizens well 6, 1,422 feet deep, Nov. 9, 1931; C, Alamitos well 11, 500 feet deep, Oct. 26, 1931; D, North Long Beach well 4, Dec. 1, 1932; E, Commission well 6, 986 feet deep, May 18, 1932; F, Wilson Ranch well 1, 1,690 feet deep, May 27, 1932.
39	Los Angeles (1,238,048); municipal; Owens River about 200,000,000 gallons a day during peak loads, tunnels beneath Los Angeles River about 50,000,000 gallons a day. During periods of drought, when the surface flow of Owens River is less than the demand, the supply is supplemented by a series of some 200 wells in Owens Valley. These wells are relatively shallow and represent the underground contribution to Owens River. The distributing system is interconnected; the western and southern sections of the city receive water from Owens River; the northern section of the city and Boyle Heights receive water from the Los Angeles River supply; the central and eastern parts of the city receive the mixed water. The annual average hardness of the Los Angeles River supply is reported to be 200 to 210; that of the Owens River supply is reported to be 135 to 150. Analyses furnished by Carl Wilson, Bureau of Water Works and Supply. A, Owens River supply; B, Los Angeles River supply.
40	Oakland (284,063); East Bay Municipal Utility District, which includes also Alameda, Albany, Berkeley, El Cerrito, Emeryville, Piedmont, Richmond, and San Leandro. Total population supplied about 456,900. Pardee Reservoir impounding Mokelumne River, San Pablo Reservoir, Upper San Leandro Reservoir, and Chabot Reservoir; aerated, filtered, final adjustment of pH to 7.2–8.2. San Pablo plant furnishes about 80 percent of the supply. The mineral content of Mokelumne River is so low and the impounding reservoir so large that the composition of the water from this source is practically uniform throughout the year. Water from this supply is diverted into the local storage reservoirs, which also receive the run-off from the surrounding drainage areas. This local water is more concentrated and considerably harder than the Mokelumne River water, and the composition of the water delivered to consumers varies from year to year according to amount of local run-off. The analyses represent a period of very little local run-off. The approximate hardness of the local water is as follows: San Pablo 176, Upper San Leandro 170, Chabot 195. Analyzed by East Bay Municipal Utility District, July 1931. A, Pardee Reservoir; B, San Pablo Reservoir; C, Upper San Leandro Reservoir; D, Chabot Reservoir.

cities of the United States, 1932—Continued

	Analyses (parts per million)												No.
	Total dissolved solids	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulphate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Total hardness as $CaCO_3$[a]	
----------	300	32	0.03	35	15	[a] 46		188	43	35	-------	149	32
----------	365	33	.08	53	19	[a] 46		251	58	32	-------	210	
----------	390	30	.08	64	19	[a] 41		215	74	53	-------	238	
----------	-------	-------	-------	-------	-------	-------		-------	-------	-------	-------	-------	33
A-------	293	2.9	.02	26	20	[a] 56		137	40	81	-------	147	34
B-------	544	30	.03	58	40	[a] 82		339	70	97	-------	309	
A-------	227	77	.02	21	13	[a] 21		158	5	12	-------	106	35
B-------	154	63	.01	11	7	[a] 15		93	5	6	-------	56	
C-------	285	82	.02	28	10	[a] 40		187	9	24	-------	111	
D-------	193	75	.05	15	9	[a] 19		112	9	11	-------	74	
Max.----	466	-------	-------	64	6	77		202	102	57	-------	185	36
Min.----	189	-------	-------	41	0	22		131	18	17	-------	102	
----------	366	23	.02	65	17	37	3.2	236	87	23	0.10	232	37
A-------	[a] 222	6.0	[b] 2.5	11	1.3	77		194	.8	28	-------	33	38
B-------	[a] 173	4.0	[b] 1.2	11	.1	59		147	Trace	25	-------	28	
C-------	[a] 187	2.8	[b] 1.8	10	.6	65		161	5.4	22	-------	27	
D-------	[a] 233	5.0	[b] .5	40	5.4	43		194	19	25	-------	122	
E-------	[a] 243	11	[b] 2.0	50	7.7	30		221	18	15	-------	157	
F-------	[a] 369	8.0	[b] .2	8.6	1.7	142		363	1.7	28	-------	28	
A-------	[a] 302	-------	.04	27	12	74		215	39	44	-------	117	39
B-------	[a] 421	-------	.0	75	21	46		223	130	39	-------	274	
A-------	[a] 62	10	[b] 1.8	8.5	2.1	7.7		31	10	7.0	-------	30	40
B-------	[a] 86	17	[b] 5.3	14	5.1	2.3		46	11	9.0	-------	56	
C-------	[a] 68	8.3	[b] 1.8	14	3.6	2.7		46	8.2	7.0	-------	50	
D-------	[a] 117	4.8	[b] 1.7	28	7.8	2.0		86	18	12	-------	102	

[a] Calculated. [b] Iron and aluminum oxides.

TABLE 5.—*Public water supplies of the larger*

No.	Description
	CALIFORNIA—continued
41	Pasadena (76,086); municipal; wells, impounded surface streams, infiltration galleries, and a spring. Pine Canyon Reservoir on San Gabriel River, now under construction, is to be used as the main source of supply. It is expected to be ready for service in 1934. The other sources will be used for auxiliary supplies when needed. A, Villa well, July 1, 1930; B, Atlanta well, Sept. 22, 1930; C, Garfield well, Aug. 25, 1930; D, Arroyo Seco (mountain stream), Oct. 27, 1930. Analyses A to D by F. E. Marks, city chemist, Pasadena. E, Average of analyses of composites of daily samples of water from San Gabriel River near Azusa by U.S. Geological Survey, 1907–8 (Water-Supply Paper 237, p. 99, 1910).
42	Pomona (20,804); municipal; 7 wells (nos. 1 to 3, 5, 7 to 9) 834, 1,200, 676, 498, 734, 900, and 600 feet deep; reserve supply from tunnel with wells. All the wells are reported to furnish water of about the same composition. Analysis of a tap sample by L. V. Wilcox, Rubidoux Laboratory, U.S. Department of Agriculture, Riverside, Oct. 17, 1930.
43	Richmond (20,093); East Bay Municipal Utility District. (See Oakland)
44	Riverside (29,696); municipal; 39 wells in San Bernardino artesian basin, emergency supply from 2 wells in Riverside. The wells range from 350 to 1,200 feet deep. All wells in the artesian basin are reported to furnish water of about the same composition. Analyzed by Edward S. Babcock & Sons, June 3, 1927.
45	Sacramento (93,750); municipal; Sacramento River just below mouth of American River; aerated, filtered. At times irrigation drainage imparts a decided odor to the raw water. Average of analyses by Sacramento Water Department. A, Average for year 1929; B, average for year 1930; C, average for year 1931. There is considerable variation in the composition of the water. Daily determinations for the year 1929: Alkalinity 8 to 94, hardness 14 to 100, chloride 3 to 36. Daily determinations for the year 1931: Alkalinity 10 to 178, hardness 18 to 198, chloride 4 to 99, pH 6.3 to 7.2, average 6.9.
46	San Bernardino (37,481); municipal; Devil Canyon Creek, Lytle Creek, wells. Analyzed by C. E. Griffin, San Bernardino Valley Junior College, July and August 1926. A, Lytle Creek; B, Newmark well; C, sample marked "Perris Hill."
47	San Diego (147,995); municipal; reservoirs (filtered), wells (treated with lime and filtered without other coagulation). Analyses of samples of the raw water by Carl Wilson, Los Angeles Bureau of Water Works and Supply.

	Source	Percent of total supply	Date of collection
A	Lower Otay Reservoir	56	July 10, 1929
B	San Dieguito and Hodges Reservoirs	15	Nov. 1, 1928
C	San Diego River wells	29	Do.

No.	Description
48	San Francisco (634,394); municipal; Hetch Hetchy supply from Tuolumne River impounded, Spring Valley supply. The Spring Valley water is derived from various sources and mixed in varying proportions throughout the year; the composition of the water varies accordingly. The Hetch Hetchy water will be mixed with the Spring Valley water at Crystal Springs Reservoir. A, Hetch Hetchy supply, Dec. 1, 1930; B, tap sample from Spring Valley supply, Oct. 2, 1930; C, sample marked "Univ. Mound." (Spring Valley supply), May 20, 1931; D, Lake Honda (Spring Valley supply), May 20, 1931. A analyzed by L. A. Shinn, U.S. Geological Survey; B to D analyzed by C. L. Cook, San Francisco Department of Public Works.
49	San Jose (57,651); San Jose Water Works (private company). Supplies also Los Gatos, Willow Glen, and an unincorporated population. Total population supplied about 100,000. Impounding reservoirs on Los Gatos Creek and its tributaries, wells, and a small additional supply from an impounding reservoir on Saratoga Creek and from a reservoir supplied by Aguaje del Monte Spring. Analyzed by California Board of Health. A, Los Gatos Creek, March 1929; B, Beardsley Gulch, March 1929; C, well M at main station yard, Apr. 4, 1919. Partial analyses of samples collected June 9, 1931, indicate that the waters are similar in general character and in hardness.
50	Santa Ana (30,322); municipal; wells.

Source	Depth (feet)	Percent of supply	Average percent of supply
Well 7	960	3–11	9
Well 8	150	0–10	2
Well 11	1,100	2–4	3
Well 12	466	1–8	2
Well 13	950	2–7	4
Well 14	1,050	44–93	58
Well 15	1,142	4–30	20
Well 16	978		2

Analyzed by Smith-Emery Co., Los Angeles. A, Well 14, Apr. 7, 1932; B, well 15 (well of maximum total solids and hardness), Apr. 7, 1932; C, well 11 (well of minimum total solids and hardness), Apr. 11, 1932.

cities of the United States, 1932—Continued

	Analyses (parts per million)												No.
	Total dissolved solids	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulphate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Total hardness as $CaCO_3$[a]	
A	225	33	[b] 5.8	32	7.5	24		115	31	14		111	41
B	[a] 249	31	[b] 2.4	40	9.8	32		214	14	14		140	
C	[a] 172	28	[b] 2.0	34	8.6	17		108	15	14		120	
D	316	33	[b] 3.6	43	15	33		227	25	17		169	
E	208	21	.16	45	12	18		183	32	4.3	1.1	162	
	[a] 180			25	4.4	[a] 32		146	22	5.3		81	42
													43
	[a] 233	25		26	4	48		134	36	28		81	44
A	104	24	.05	12	5.3	8.6		60	23	13		52	45
B	110	24	.03	11	5.3	11		60	21	17		49	
C	149	26	.03	16	7.7	16		80	27	28		72	
A	208	15	[b] 9	41	5.1	17		178	18	8		123	46
B	220	16	[b] 11	50	8.1	19		218	13	8		158	
C	200	19	[b] 7	25	4.6	35		132	31	11		81	
A	303		.07	38	10	53		202	19	48		136	47
B	[c] 383		.28	29	19	68		207	16	80	Trace	150	
C	[d] 771	2.4		77	28	117		183	168	168	Trace	307	
A	17	5.2	.02	1.9	.4	1.2	0.5	7.0	2.0	.8	.10	6.4	48
B	[a] 248	8.0	[b] 4.3	53	9.1	24		192	34	21		170	
C	304	12	[b] 2.5	51	22	18		215	42	31	1.8	218	
D	213	16	[b] 2.0	33	18	20		156	27	34	.81	156	
A	[a] 315		Trace	50	24	25		234	66	14		223	49
B	[a] 300		Trace	55	18	24		230	56	13		211	
C	300		.0	44	16	39		262	20	16		176	
A	[a] 331	9.9	.0	64	3.9	52		232	53	32		176	50
B	[a] 392	11	.0	77	7.4	55		256	72	41		223	
C	[a] 306	11	.0	54	3.1	54		226	49	21		148	

[a] Calculated. [b] Iron and aluminum oxides. [c] Includes 0.3 part of manganese.
[d] Includes large amount of iron and manganese which is removed by the treatment.

TABLE 5.—*Public water supplies of the larger*

No.	Description
	CALIFORNIA—continued
51	Santa Barbara (33,613); municipal; Santa Ynez River impounded, auxiliary supply from wells in the city, used in times of drought. The water from the wells is aerated when used. Analysis of sample from Santa Ynez River supply by J. A. Dodge, Nov. 29, 1927. A partial analysis of a sample collected in February 1929 is similar to the analysis given.
52	Santa Monica (37,146); municipal; 8 wells 380 feet deep. Analysis of tap sample by Smith-Emery Co., Los Angeles, Calif., July 30, 1930.
53	Stockton (47,963); California Water Service Co. (controlled by Federal Water Service Corporation, 27 William St., New York, N.Y.); station 1, 9 wells 647 to 1,148 feet deep; station 2, 3 wells 875 to 961 feet deep; station 4, 1 well 535 feet deep; emergency supply from station 3, 2 wells 459 and 491 feet deep, and station 5, 1 well 210 feet deep. Analyzed by California Water Service Co., Stockton. A, Distribution tap, Apr. 17, 1931; B, station 1, Feb. 8, 1929; C, station 2, Feb. 8, 1929; D, station 4, Feb. 9, 1929. A analyzed by P. Villarruz; B, C, and D analyzed by O. C. Blumberg.
	COLORADO
54	Boulder (11,223); municipal; two chains of lakes consisting of Silver, Island, Goose, and Albion Lakes. The water is supplied to the city from Silver Lake. Analysis of tap sample by C. F. Poe, University of Colorado, Jan. 15, 1931. The total capacity of the impounding lakes is so large and the mineral content of the water so low that the analysis represents reasonably well the composition of the water regularly delivered to consumers.
55	Colorado Springs (33,237); municipal; impounding reservoirs 2, 4, 5, 7, and 8, Lake Moraine. Analyzed by E. W. Lohr, Mar. 14, 1932. Monthly averages of regular determinations for the year 1930: Hardness 21 to 42, average 25; chloride 0.4 to 1.6, average 0.9.
56	Denver (287,861); municipal; Antero Reservoir, Lake Cheesman, Platte Canyon Reservoir, and Marston Lake impounding South Platte River and its tributaries, with infiltration galleries near the river and near Cherry Creek. Rapid sand filtration plants with daily capacities of 20,000,000, 25,000,000, and 64,000,000 gallons; a slow sand filtration plant with daily capacity of 30,000,000 gallons; infiltration galleries near the river have a total capacity of about 4,000,000 gallons a day, and on Cherry Creek 4,500,000 gallons a day. Water aerated before filtration. The pH based on daily determinations of the water taken from a tap in laboratory ranged from 7.1 to 7.8 for the year 1931. Analyzed by G. J. Turre, Denver Water Department. A, Samples taken monthly from tap in laboratory during 1931; B, sample from Cherry Creek, Mar. 18, 1931.
57	Fort Collins (11,489); municipal; Cache la Poudre River; filtered. Analysis of tap sample by W. L. Lamar, June 29, 1932. The composition of the water varies throughout the year, and the analysis given probably represents a concentration less than the average. Biweekly determinations for the year 1931: Alkalinity 8 to 40, average 24.
58	Greeley (12,203); municipal; Cache la Poudre River; slow sand filtration. Analysis of tap sample by E. W. Lohr, Feb. 20, 1932. The analysis given probably represents a concentration greater than the average.
59	Pueblo (50,096); municipal; Arkansas River; filtered. There are two water districts in Pueblo, each supplied by its own system. The two systems are very similar, and the water is taken from the same source at practically the same location. Analyses furnished by Pueblo Water Works. A, Sample dated March 1925; B, sample collected Nov. 7, 1921; C, sample dated June 1919. There is considerable variation in the composition of the water. Regular determinations for the year 1931: Alkalinity 75 to 181, average 148; hardness 91 to 394, average 279.
60	Trinidad (11,732); municipal; North Lake. Analyzed by F. C. Miller, Trinidad Water Works, June 1931.
	CONNECTICUT
	[Descriptive material relating to the supplies and the results for color were furnished by W. J. Scott, director, Bureau of Sanitary Engineering, Connecticut Department of Health]
61	Ansonia (19,898); Ansonia Water Co. Supplies also a small section of Derby and Seymour. Total population supplied about 21,000. Peat Swamp (aerated), Middle, Quillinan, and Bungay Reservoirs, Fountain Lake. Peat Swamp Reservoir is the principal source of supply. Analysis of tap sample by E. W. Lohr, July 31, 1931. Monthly determinations for 1931: Color 5 to 40, average 21.
62	Bridgeport (146,716); Bridgeport Hydraulic Co. Supplies also Fairfield town, Shelton, Stratford town, part of Trumbull town (Long Hill and Nichols), and Westport town. Total population supplied about 185,000. Hemlocks, Easton, and Trap Falls Reservoirs. Analyzed by F. C. Barrows, Bridgeport Hydraulic Co., Sept. 15, 1931. The mineral content of the water is fairly uniform throughout the year. Regular determinations for a period of a year or longer: Alkalinity 8 to 12, average 10 (1930); hardness 15 to 23, average 20 (1926–30); color 20 to 30, average 23 (1930); pH 6.1 to 7.5, average 6.5 (1930).
63	Bristol (28,451); municipal; impounding reservoirs 1, 2, 3, 4, and 5 on Poland River and its tributaries, infiltration gallery (10 by 12 by 12 feet deep) along Poland Brook. The water is distributed from reservoir 1. Analysis of sample from reservoir 1 by E. W. Lohr, Aug. 10, 1931. Monthly determinations for 1931: Color 10 to 40, average 22.
64	Danbury (22,261); municipal; West Lake, East Lake, Padanaram Reservoir, Upper and Lower Kohanza Reservoirs, auxiliary supply from Parks Pond. Analysis of tap sample by E. W. Lohr, Aug. 12, 1931. Monthly determinations for 1931: Color 15 to 50, average 25.

cities of the United States, 1932—Continued

	Analyses (parts per million)												No.
	Total dissolved solids	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulphate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Total hardness as $CaCO_3$[a]	
----------	[a] 660	1.0	0.41	136	20	67	Trace	357	246	14	Trace	422	51
----------	[a] 610	34	[b] 1.4	87	33	72		293	184	54	-------	353	52
A-------	380	57	.03	21	9.9	[a] 96		202	4.9	93	-------	93	53
B-------	290	60	.03	11	5.8	[a] 75		198	4.7	33	-------	51	
C-------	220	55	.04	13	8.1	[a] 42		161	6.5	13	-------	66	
D-------	201	55	.04	15	7.1	[a] 34		149	7.5	8	-------	67	
----------	24	3.8	[b] 1.6	3.9	.4	[a] 3.4		17	1.5	2.4	-------	11	54
----------	[c] 34	9.1	4.1	5.7	.8	2.7	1.3	17	4.0	.4	0.40	18	55
A Av---	[a] 202	7.0	.11	32	10	23	2.4	103	43	31	.43	121	56
A Max--	[a] 239	7.7	.05	38	12	28	3.0	132	51	32	.3	144	
A Min--	[a] 157	8.5	.21	24	8.1	18	2.0	76	32	24	.2	93	
B-------	[a] 274	8.7	[b] 1.8	54	9.1	31	3.5	203	46	18	1.8	172	
----------	42	6.4	.21	5.2	.9	1.9	.8	12	11	1.0	.15	17	57
----------	93	17	.01	17	4.9	7.9	1.5	78	8.4	3.0	.40	63	58
A-------	[a] 555	30	[b] 1.5	45	29	89		134	271	24	race	231	59
B-------	447	11	[b] 1.5	56	23	44		105	209	15	Trace	234	
C-------	191	15	[b] 2.1	28	8.2	11		56	68	9.1	Trace	104	
----------	[a] 78	1.6	[b] .04	17	1.2	13		90	.2	1.0	.0	47	60
----------	42	8.3	.04	5.5	1.4	2.8	1.2	11	12	3.5	.10	19	61
----------	56	12	.3	5.5	.2	2.9	1.1	[a] 8.3	10	3.5	.1	15	62
----------	26	4.0	.38	3.1	1.1	2.5	.7	10	6.3	1.8	.40	12	63
----------	45	6.5	.44	6.9	2.1	2.9	.8	20	11	2.0	.40	26	64

[a] Calculated. [b] Iron and aluminum oxides. [c] Includes 2.2 parts of fluoride.

TABLE 5.—*Public water supplies of the larger*

No.	Description
	CONNECTICUT—continued
65	Greenwich town (33,112); Greenwich Water Co. (controlled by Community Water Service Co., 100 William St., New York, N.Y.); Putnam and Rockwood Lakes fed by adjacent streams and by pumping from Mianus River; aerated, filtered, final adjustment of pH by addition of lime. Analysis of tap sample by E. W. Lohr, Aug. 12, 1932. Regular determinations for the year 1931: Alkalinity (daily tests) 10 to 23, average 17; hardness (biweekly tests) 31 to 46, average 38; pH (daily tests) 7.5 to 8.8, average 8.1.
66	Hartford (164,072); Metropolitan District of Hartford County, which includes towns of Bloomfield, part of Newington, West Hartford, Wethersfield, and Windsor. Total population supplied about 208,000. Nepaug Reservoir, reserve supply from West Hartford system consisting of impounding reservoirs 2, 3, 5, and 6; aeration, slow sand filtration. The water may be supplied from one or both systems. Analysis of tap sample from Nepaug Reservoir by E. W. Lohr, Mar. 2, 1932. Weekly reports for the year 1931: Alkalinity 8 to 28, average 19; hardness 10 to 36, average 18; color 6 to 23, average 10; pH 6.5 to 6.8, average 6.7.
67	Meriden (38,481); municipal; Broad Brook (about 50 percent of supply); Merimere, Hallmere, Kenmere, and Elmere Reservoirs. The water furnished by the Broad Brook Reservoir is aerated and filtered. Analysis of tap sample from the Broad Brook Reservoir by E. W. Lohr, Aug. 7, 1931. A partial analysis of tap sample collected at the same time from Meriden Reservoir agreed closely with the analysis given. Monthly determinations for 1931: Color 0 to 20, average 10.
68	Middletown (24,554); municipal; Mount Higby Reservoir, reserve supply from Laurel Brook Reservoir. Analysis of tap sample from Mount Higby Reservoir by E. W. Lohr, Aug. 6, 1931. The average of monthly determinations of color in 1931 was 23.
69	New Britain (68,128); municipal; Wolcott, Shuttle Meadow, and Whigville Reservoirs, Whites Bridge driven-well system (about 50 feet deep). Supplies also part of Berlin town (Kensington and Worthington fire districts), East Berlin, and part of Newington town (first fire district). Total population supplied about 73,000. Analyzed by E. W. Lohr, Nov. 24, 1931. A, Whigville Reservoir; B, Whites Bridge well supply. A partial analysis of a sample representing the mixed water from Wolcott and Shuttle Meadow Reservoirs collected Nov. 24, 1931, indicates a concentration greater than that shown by analysis A and less than that shown by analysis B. Monthly determinations for 1931: Color 0 to 25, average 12.
70	New Haven (162,655); New Haven Water Co. Supplies also towns of Branford, Cheshire, East Haven, Hamden, Milford, North Haven, and West Haven. Total population supplied about 242,000. Lake Whitney (slow sand filtration, about 20 percent of supply), Lake Saltonstall, Lake Wintergreen, Maltby Lakes (3), Lake Dawson, Lake Prospect, Lake Gaillard, Twin Lakes, and Beaver Brook Lake. Analyzed by U.S. Geological Survey. Monthly determinations for 1931: Color 0 to 35, average 18.

	Source	Date of collection	Analyst
A	Lake Whitney [a]	Nov. 29, 1921	Margaret D. Foster.
B	Lake Dawson	Aug. 25, 1931	E. W. Lohr.
C	Lake Gaillard	do	Do.

[a] Composition of water checked by partial analysis, Aug. 25, 1931.

No.	Description
71	New London (29,640); municipal; Barnes Brook Reservoir, Bogue Brook Reservoir, Lake Konomoc. All water is fed to Lake Konomoc and is furnished to consumers from this source. The composition of the water is fairly uniform throughout the year. Analysis of tap sample by E. W. Lohr, Aug. 7, 1931. Results based on different numbers of determinations over a period of a year: Alkalinity 8 to 19 (1930); hardness 8 to 21 (1930); color 15 to 55, average 23 (1931).
72	Norwalk (36,019). First taxing district: Silvermine River impounded in Scott, Brown, and Grupe Reservoirs. All water is fed to Grupe Reservoir and is furnished to consumers from this source. A, Analysis of sample from Grupe Reservoir by E. W. Lohr, Nov. 5, 1931. Monthly determinations for 1931: Color 25 to 60, average 33. Second taxing district: City Lake; aeration, slow sand filtration. B, Analysis of tap sample by E. W. Lohr, Aug. 29, 1931. Monthly determinations for the year 1930–31: Alkalinity 11 to 27, average 18; color 0 to 20, average 12; pH 6.3 to 6.7, average 6.5.
73	Norwich (23,021); municipal; Meadow Brook, Fairview, Stony Brook, and Deep River Reservoirs. Analysis of tap sample from Fairview and Stony Brook Reservoirs by E. W. Lohr, Aug. 11, 1931. A partial analysis of a sample collected Aug. 11, 1931, from Deep River Reservoir agrees with the analysis given.
74	Stamford (46,346); Stamford Water Co.; supplies also Darien town, Noroton, Springdale, and Tokeneke. Total population supplied about 54,000. Mill River and tributaries impounded in Mead Pond, Trinity Lake, Laurel Reservoir, and North Stamford Reservoir. Water from all sources is distributed from the North Stamford Reservoir. Analysis of tap sample by Newlands Sanitary Laboratory, Hartford, Jan. 19, 1931. The chemical content of the water is fairly uniform throughout the year. Monthly determinations for the year 1930–31: Alkalinity 14 to 28, average 22; color 5 to 35, average 20; pH 6.5 to 7.1, average 6.7.

cities of the United States, 1932—Continued

	Analyses (parts per million)												
	Total dissolved solids	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulphate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Total hardness as $CaCO_3$ [a]	No.
----------	72	3.5	0.01	13	2.9	4.1	1.6	21	30	4.8	0.10	44	65
----------	33	6.3	.19	4.3	1.5	2.5	1.0	15	8.0	1.6	.40	17	66
----------	68	4.8	.06	13	2.3	3.9	.7	32	19	3.2	.50	42	67
----------	45	5.7	.02	5.8	2.0	2.8	.5	15	12	3.0	.30	23	68
A-------	26	7.7	.17	2.6	1.0	2.4	.9	11	3.9	2.8	.0	11	69
B-------	60	13	.01	9.4	2.1	4.1	.8	25	13	4.1	2.6	32	
A-------	94	6.7	.06	22	3.3	4.0	1.8	62	13	7.6	1.6	69	70
B-------	42	6.7	.22	6.2	1.7	2.9	.8	19	9.7	3.0	.30	22	
C-------	66	2.2	.12	12	4.5	4.0	1.2	46	13	3.8	.40	48	
----------	41	10	.11	4.2	1.1	3.8	.8	12	6.9	4.2	.20	15	71
A-------	48	4.3	.17	6.6	2.5	3.0	.9	21	10	3.4	.20	27	72
B-------	44	4.1	.02	7.1	2.5	3.0	1.4	23	11	2.8	.50	28	
----------	34	7.8	.20	3.4	1.0	3.1	.8	8.0	7.6	4.5	.20	13	73
----------	[a] 52	6.5	[b] .20	9.1	2.4	3.6		22	15	4.6	-------	33	74

[a] Calculated.

[b] Iron and aluminum oxides

TABLE 5.—*Public water supplies of the larger*

No.	Description
	CONNECTICUT—continued
75	Torrington (26,040); Torrington Water Co.; North Pond, Whist Pond, Lake Hatchaloosie, Marshall Lake. Analysis of tap sample by E. W. Lohr, Aug. 11, 1931. Monthly determinations for 1931: Color 5 to 40, average 19.
76	Waterbury (99,902); municipal; low service supplied by Morris and Wigwam impounding reservoirs, high service supplied by East Mountain and Prospect impounding reservoirs and by pumping from low service. Low service furnishes the greater proportion of water, which is distributed from Wigwam Reservoir. The mineral content of the water from both systems is very low and fairly uniform throughout the year. Analysis of low-service tap sample by E. W. Lohr, Aug. 10, 1931. Ten samples collected from low service during 1930 show the following range in composition of the water: Alkalinity 12 to 17, average 15; chloride 2.4 to 3.8, average 3.0; color 5 to 15, average 10; pH 6.4 to 6.8, average 6.6.
77	West Hartford town (24,941); Metropolitan district of Hartford County. (See Hartford)
78	West Haven town (25,808); supplied by New Haven Water Co. (See New Haven)
	DELAWARE
	[Descriptions of several of the supplies in Delaware were furnished by R. C. Beckett, State sanitary engineer, who collected most of the samples that were analyzed by the U.S. Geological Survey]
79	Dover (4,800); municipal; 1 well 200 feet deep, auxiliary supply from 4 wells about 207 feet deep and 1 dug well 22 feet deep and 12 feet in diameter. Analysis of sample from the 200-foot well by W. L. Lamar, Apr. 27, 1931.
80	Milford (3,719); municipal; 2 wells 228 feet deep, auxiliary supply from 1 well 228 feet deep. The water is distributed from a reservoir. Analyzed by L. A. Shinn, U.S. Geological Survey, Apr. 13, 1931.
81	Newark (3,899); municipal; 4 wells 63, 63, 72, and 67 feet deep. Analyzed by L. A. Shinn, U.S. Geological Survey, Apr. 23, 1931.
82	New Castle (4,131); municipal; dug wells 24 feet deep and 14 feet in diameter, infiltration gallery 300 feet long and 24 feet deep connected to one of the dug wells; aerated. The water is distributed from a standpipe and a reservoir. Analyzed by L. A. Shinn, U.S. Geological Survey, Apr. 23, 1931.
83	Wilmington (106,597); municipal; Brandywine Creek; slow sand and rapid sand filtration. The slow sand filters supply the high service, and the rapid sand filters supply the low service. During periods of high flow in Brandywine Creek water is pumped from this source to Hoopes Reservoir (capacity 2,000,000,000 gallons). The water is held in storage at this reservoir until periods of low flow in Brandywine Creek, when it is pumped to the filter plants to augment the depleted creek supply. Analysis of tap sample (effluent from slow sand filters) by E. W. Lohr, May 16, 1932. Regular determinations for the year 1931: Slow sand filters, alkalinity 17 to 66, average 46; chloride 6 to 28, average 15; pH 7.1 to 8.1, average 7.4. Rapid sand filters, alkalinity 8 to 61, average 34; chloride 6 to 28, average 15; pH 6.1 to 7.1, average 6.7.
	DISTRICT OF COLUMBIA
	[The descriptions and the analyses were furnished by C. J. Lauter, chief chemist, Washington filtration plants]
84	Washington (486,869); U.S. War Department filtration plants operated by civilian staff of the U.S. Engineer Office, distribution system owned and operated by the District of Columbia. Supplies also a large number of small unincorporated communities in Arlington County, Va. Total population supplied about 503,000. Potomac River. Dalecarlia filtration plant (60 percent of supply); filtered, final adjustment of pH by addition of lime to give 1 to 2 parts free CO_2 in effluent. McMillan filtration plant (40 percent of supply); slow sand filters. Coagulation with alum is necessary for the McMillan plant on an average of about 100 days during the year. A small amount of lime is used occasionally at this plant to increase the pH value. Analyses of monthly composites of daily samples by G. E. Harrington, Dalecarlia filtration plant, 1931. A, Average for Dalecarlia plant; B, sample of maximum hardness for Dalecarlia plant, November; C, sample of minimum hardness for Dalecarlia plant, May; D, average for McMillan plant. Daily determinations for the year 1931: Dalecarlia plant, alkalinity 26 to 118; hardness 54 to 128; pH 7.3 to 8.4, average 7.7. McMillan plant, alkalinity 24 to 120; hardness 45 to 131; pH 6.5 to 7.8, average 7.3.
	FLORIDA
	[Descriptions of most of the supplies were furnished by E. L. Filby, former chief engineer of the Florida Board of Health. Mr. Filby also collected or arranged for the collection of most of the samples that were analyzed by the U.S. Geological Survey]
85	Daytona Beach (16,598); municipal; mainland plant supplied by 10 wells 162 to 252 feet deep (aerated, softened, settled), Seabreeze plant supplied by 7 wells 160 to 250 feet deep (aerated, softened, pressure filters). Analyzed by L. A. Shinn, U.S. Geological Survey, Oct. 28, 1930. A, Treated sample of the mixed water from both plants; B, raw water from mainland plant; C, raw water from Seabreeze plant.

cities of the United States, 1932—Continued

	Analyses (parts per million)												No.
	Total dissolved solids	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulphate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Total hardness as $CaCO_3$[a]	
----------	51	3.0	0.17	7.2	3.2	2.5	1.0	36	7.7	1.2	0.20	31	75
----------	38	5.5	.33	5.7	1.6	2.4	1.2	14	10	2.9	.50	21	76
----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	77
----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	78
----------	200	49	.49	35	5.4	14	2.9	165	6.3	2.8	.15	110	79
----------	220	54	.01	46	4.0	11	2.8	194	3.0	2.5	.10	131	80
----------	80	8.5	.02	6.2	4.6	8.7	1.4	7.0	3.6	13	35	34	81
----------	146	14	.03	11	8.1	18	1.2	20	40	27	15	61	82
----------	79	11	.01	12	4.4	5.6	2.0	40	16	5.9	4.5	48	83
A-------	[a]130	7.0	[b]2.7	34	1.9	[a]6.8		79	34	5.2	-------	93	84
B-------	[a]175	9.8	[b]3.2	41	2.6	[a]16		129	33	5.6	-------	113	
C-------	[a]110	6.6	[b]2.4	23	1.2	[a]10		45	39	5.2	-------	62	
D-------	[a]119	8.5	[b]2.4	31	2.1	[a]5.7		78	26	5.2	-------	86	
A-------	365	18	.02	24	17	62	2.6	[f]71	14	134	2.1	130	85
B-------	584	23	.27	106	20	62	2.5	366	10	132	.20	347	
C-------	617	21	.02	98	25	73	2.6	337	18	160	.20	348	

[a] Calculated. [b] Iron and aluminum oxides. [f] Includes equivalent of 13 parts of carbonate (CO_3).

TABLE 5.—*Public water supplies of the larger*

No.	Description
	FLORIDA—continued
86	Gainesville (10,465); municipal; Boulware Spring, 2 wells 367 and 405 feet deep. Boulware Spring furnishes about half the total supply. Analyzed by Margaret D. Foster, U.S. Geological Survey, Aug. 10, 1923. A, Boulware Spring; B, well supply. Partial analyses of samples from both wells taken Oct. 31, 1930, indicate that the composition of the well water has not changed since 1923.
87	Jacksonville (129,549); municipal; Springfield Park Reservoir supplied by 12 wells 1,000 to 1,250 feet deep, MacDuff Avenue Reservoir supplied by 4 wells about 1,000 feet deep; aerated. Analyzed by L. A. Shinn, U.S. Geological Survey, Oct. 2, 1930. A, Springfield Park Reservoir before aeration; B, MacDuff Avenue Reservoir before aeration.
88	Key West (12,831). A system of mains supplies water of high salt content for fire protection and similar uses from a well 2,600 feet deep. In addition there are 60 auxiliary deep wells distributed throughout the city but not connected to the mains. The water from these wells is also high in salt content and is used for fire protection. There is no public supply of drinking water. The residents depend upon rain-water cisterns. The water from these individual supplies is used for drinking and bathing. Private shallow wells furnish very hard water that is used for bathing, watering yards, and similar uses. The Florida East Coast Railway Co. transports softened water from a railway supply at Homestead. This water is furnished to the Florida East Coast Railway, Peninsular & Occidental Steamship Co., and Florida East Coast hotel property. Analysis of the softened water furnished by the Florida East Coast Railway Co.
89	Lakeland (18,554); municipal; 2 wells 741 and 1,201 feet deep; water from 741-foot well is aerated. Analysis of water from 741-foot well by C. S. Howard, U.S. Geological Survey, Aug. 23, 1923 (Water-Supply Paper 596, p. 227, 1928). Partial analyses of samples from each well taken Oct. 23, 1930, indicate that the composition of the water is the same as shown by the analysis of the 741-foot well for August 1923.
90	Miami (110,637); municipal, Hialeah plant distributing system owned by Miami Water Co. Supplies also Coral Gables, Hialeah, and Miami Beach. Total population supplied about 125,000. Hialeah plant supplied by 11 wells 62 to 120 feet deep (aerated, softened with lime, recarbonated, filtered). Coconut Grove plant supplied by 2 wells 59 feet deep (aerated, softened with lime, settled). The Hialeah plant furnishes about 97 percent of the total supply. The Coconut Grove plant furnishes only a small section of Miami known as Coconut Grove. Analyzed by L. A. Shinn, U.S. Geological Survey. A, Softened water from Hialeah plant, Oct. 9, 1930; B, raw water from Hialeah plant, Oct. 9, 1930; C, softened water from Coconut Grove plant, Feb. 11, 1931; D, raw water from well 2 at Coconut Grove plant, Feb. 11, 1931. Partial analyses of samples collected May 17, 1930, from each of the wells at the Hialeah plant indicate that the wells all furnish water of about the same composition. A partial analyis of a sample collected Feb. 11, 1931, from well 1 at the Coconut Grove plant agrees with the analysis for well 2 at that plant.
91	Orlando (27,330); municipal; Lake Underhill, Lake Ivanhoe; aerated, filtered. Each lake is used about half the time. The change from one lake to the other is made by gradually mixing increasing amounts of water from the lake coming into service with decreasing amounts from the lake going out of service. Analyzed by L. A. Shinn, U.S. Geological Survey. A, Lake Underhill, Feb. 17, 1931; B, Lake Ivanhoe, Jan. 22, 1931.
92	Pensacola (31,579); municipal; 3 wells (nos. 3, 4, and 5), about 240 feet deep. Analysis of sample from well 4 by E. W. Lohr, Jan. 21, 1932.
93	St. Augustine (12,111); municipal; 3 wells 300 feet deep. Analyzed by L. A. Shinn, U.S. Geological Survey, Jan. 21, 1931. The water is reported to contain hydrogen sulphide.
94	St. Petersburg (40,425); municipal distributing system; water furnished by Pinellas Water Co., 11 wells (nos. 1-9, 11-12) 296 to 354 feet deep, Lake Rogers. The wells furnish a large proportion of the total supply. Lake water is added to the well water in different amounts with the intention of keeping the hardness of the water delivered to the city mains below 160. Wells 1, 2, and 12 and Lake Rogers were in service when the samples were collected. Analyzed by S. K. Love, U.S. Geological Survey, Oct. 14, 1932. A, Well 1; B, well 2; C, well 12; D, Lake Rogers. 48 analyses of samples collected during 1930, 1931, and 1932 from wells 1 to 9 and 12, indicate that the composition of the water from each of these wells is about the same. These analyses show the following ranges in the hardness of the well water: No. 1, 179 to 188; no. 2, 176 to 192; no. 3, 200 to 210; no. 4, 193 to 237; no. 5, 178 to 205; no. 6, 197 to 200; no. 7, 199; no. 8, 196 to 231; no. 9, 196 to 199; no. 12, 164 to 189. 3 analyses of samples collected from Lake Rogers during 1931 and 1932 indicate a range in hardness from 14 to 24.
95	Sanford (10,100); municipal; 7 wells 100 to 140 feet deep. The water is distributed from a reservoir. Analysis of sample from the reservoir by L. A. Shinn, U.S. Geological Survey, Oct. 24, 1930.
96	Tallahassee (10,700); municipal; 2 wells about 235 feet deep. Both wells furnish water of about the same composition. Analysis of sample from well 5 by E. W. Lohr, Oct. 3, 1931.
97	Tampa (101,161); municipal; Hillsborough River; filtered, final adjustment of pH to about 7.7 by addition of lime. The treatment is varied according to the color and hardness of the water. When the hardness is much above 100 it is reduced to about this figure. Analysis of about an average sample by Margaret D. Foster, U.S. Geological Survey, June 29, 1927 (Water-Supply Paper 596, p. 217, 1928). Monthly averages of daily determinations for the year 1930: Alkalinity 39 to 74, average 56; hardness 70 to 116, average 101; color 10 to 17, average 13; pH 7.6 to 7.9, average 7.7. For the same year the color of the raw water based on monthly averages of daily determinations ranged from 23 to 148.
98	West Palm Beach (26,610); West Palm Beach Water Co.; Clear Lake, Lake Mangonea; aerated, filtered, aerated, final adjustment of pH to about 9.5 by addition of hydrated lime. Analysis of tap sample from pumping station by L. A. Shinn, U.S. Geological Survey, Oct. 10, 1930.

cities of the United States, 1932—Continued

	Analyses (parts per million)												No.
	Total dissolved solids	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulphate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Total hardness as $CaCO_3$[a]	
A	94	6.4	0.06	17	11	2.8		89	2.4	8.8	5.4	88	86
B	273	24	.07	57	20	6.3		218	43	9.6	Trace	224	
A	398	25	.03	68	26	15	4.3	176	142	17	.10	277	87
B	388	21	.02	65	26	11	4.3	152	156	12	.05	269	
	[a] 135	13	[b] 2.2	15	.5	28		([c])	6.9	20	-------	40	88
	199	24	.08	41	15	8.0		199	2.8	7.0	1.2	164	89
A	191	9.0	.02	35	4.8	12	1.5	47	61	20	4.5	107	90
B	373	10	.83	102	7.5	12	1.4	286	47	19	4.1	286	
C	134	6.6	.02	23	2.9	19	1.8	56	17	35	.0	69	
D	297	4.2	.04	86	3.8	19	4.6	255	20	35	.0	231	
A	47	2.4	.10	5.6	2.5	5.7	1.7	10	15	8.0	.0	24	91
B	90	1.3	.01	16	4.7	8.0	2.4	45	20	13	.20	59	
	27	7.5	.01	1.1	1.0	4.1	.4	3.0	3.0	6.1	3.2	7	92
	947	28	.08	116	56	105	4.4	175	291	225	.10	520	93
A	213	13	.03	65	4.1	7.4	.9	218	1.1	10	.05	179	94
B	[a] 207	-------	.04	67	3.0	[a] 5.4		217	.7	9.0	.05	180	
C	[a] 219	-------	.12	70	3.3	[a] 6.7		229	.9	10	.05	189	
D	40	.9	.03	3.8	1.1	6.1	.6	8.0	4.2	11	.05	14	
	459	12	.23	52	17	80	3.7	152	32	160	1.0	200	95
	148	16	.01	36	9.6	4.4	.7	145	4.1	5.5	3.2	129	96
	149	7.3	.03	32	5.5	7.3	1.0	70	45	10	.10	103	97
	91	1.4	.04	15	2.2	7.2	1.0	14	32	12	1.2	47	98

[a] Calculated.
[b] Iron and aluminum oxides.
[c] 33 parts of carbonate (CO_3) and 3.6 parts of hydroxide (OH).

TABLE 5.—*Public water supplies of the larger*

No.	Description
	GEORGIA
	[Descriptions of several of the supplies and some of the analytical data in the descriptive text below were furnished by W. H. Weir, assistant director, Division of Sanitary Engineering, Georgia Board of Health]
99	Albany (14,507); municipal; 5 wells (nos. 1 to 5), 800, 800, 900, 460, and 800 feet deep. Well 5 furnishes about 65 percent and well 1 about 30 percent of the total supply. Wells 2, 3, and 4 furnish the auxiliary supply. Analyzed by the McCandless Laboratory, Atlanta, Ga., May 2, 1928. A, Well 5; B, well 1.
100	Athens (18,192); municipal; Sandy Creek; filtered. The mineral content of the water is so low that a single analysis represents reasonably well the composition of the water. Analyzed by L. A. Shinn, U.S. Geological Survey, Mar. 14, 1931.
101	Atlanta (270,366); municipal; Chattahoochee River; filtered, adjustment of pH to about 7.4–7.6 by addition of lime. Analysis of a monthly composite sample by Paul Weir, Atlanta Water Works, February 1932. The single analysis represents reasonably well the composition of the water regularly delivered to consumers. Daily determinations on the filtered water for the year 1931: Alkalinity 8.5 to 15, average 12; hardness 9.5 to 16, average 14; pH 7.1 to 7.6, average 7.4.
102	Augusta (60,342); municipal; Savannah River; filtered. The coagulation and filtration reduce the silica and iron; the bicarbonate may be decreased and the sulphate is increased. Average of analyses of composites of daily samples of raw water from Savannah River near Augusta by the U.S. Geological Survey, 1906–7 (Water-Supply Paper 236, p. 99, 1909). There is some variation in the composition of the water throughout the year. Daily determinations on the filtered water for the year 1932: Alkalinity 4 to 8, average 5.8; pH 5.8 to 6.8, average 6.3.
103	Brunswick (14,022); Peoples Water Service Co.; 1 well 1,027 feet deep (60 percent of supply); 4 wells 750 feet deep. Analyzed by L. A. Shinn, U.S. Geological Survey, Feb. 13, 1931. A, Well 1, Grant and F Sts. (1,027 feet deep); B, well 2, Norwich and F Sts. (750 feet deep).
104	Columbus (43,131); municipal; Chattahoochee River; filtered, final adjustment of pH to about 7.8 by addition of hydrated lime. Analyzed by A. J. Smalshaf, Columbus Water Works, Mar. 11, 1931. The mineral content is low, and the range in concentration is not great, so that the analysis may safely be taken to represent the mineral content of the water delivered to consumers at any time. Regular determinations for the year 1930: Alkalinity 11 to 19, average 15; hardness 15 to 18.
105	Decatur (13,276); municipal; Burnt Fork Creek, reserve supply from Peachtree Creek; filtered. The mineral content of the water is so low that the single analysis may be taken as reasonably representative of the composition of the water regularly delivered to consumers. Analysis of tap sample by L. A. Shinn, U.S. Geological Survey, May 18, 1931.
106	Griffin (10,321); municipal; Flint River; filtered, final adjustment of pH. The coagulation and filtration reduce the silica and iron; the bicarbonate may be decreased and the sulphate is increased. Average of analyses of composites of daily samples of raw water from Flint River near Albany, by U.S. Geological Survey, Oct. 23, 1906, to May 12, 1907 (Water-Supply Paper 236, p. 62, 1909). There is some variation in the composition of the water throughout the year. Daily determinations on the filtered water for the year 1931: Alkalinity 5 to 22, average 15; pH 7.3 to 8.4, average 8.1.
107	LaGrange (20,131); municipal; Long Cane Creek (about 85 percent of supply); filtered, final adjustment of pH by addition of soda ash. Well 370 feet deep (about 15 per cent of snpply). The water from the well is supplied direct to the mains. Analyzed by E. W. Lohr, June 23, 1932. A, Long Cane Creek supply (filtered); B, well supply.
108	Macon (53,829); municipal; Ocmulgee River; filtered. The composition of the water is reasonably uniform, although there is some variation. A, Single analysis of treated water by Morris-Flinn Co., Macon, March 1931; B, average of analyses of raw water by U.S. Geological Survey, 1906–7 (Water-Supply Paper 236, p. 86, 1909).
109	Rome (21,843); municipal; Oostanaula River; filtered. The coagulation and filtration reduce the silica and iron; the bicarbonate may be decreased, and the sulphate is increased. Analyses of composites of daily samples of raw water from Oostanaula River near Rome by U.S. Geological Survey, 1906–7 (Water-Supply Paper 236, p. 87, 1909). A, Average, 1906–7; B, composite sample of maximum total solids, July 8–17, 1907; C, composite sample of minimum total solids, Mar. 5–14, 1907. Daily determinations on the filtered water for the year 1931: Alkalinity 10 to 65, average 40; pH 6.6 to 7.6, average 7.3.
110	Savannah (85,024); municipal; 7 wells 540 to 600 feet deep, 1 well 1,300 feet deep, emergency supply from a group of 8 wells. Analyzed by L. A. Shinn, U.S. Geological Survey, Mar. 9, 1931. A, Well 21, 550 feet deep; B, well 13, 1,300 feet deep; C, reservoir fed by group of 8 wells (emergency supply).
111	Thomasville (11,733); municipal; 3 wells (nos. 1 to 3), 500, 300, and 550 feet deep; softened, filtered. The water is softened to a hardness around 75. The main supply is obtained from well 3. Analyzed by L. B. Lockhart, Law & Co., Inc., Atlanta, Mar. 13, 1932. A, Softened water; B, raw water from well 3.
112	Valdosta (13,482); municipal; 1 well 408 feet deep, emergency supply from 1 well 500 feet deep. Analysis of tap sample from 408-foot well by E. W. Lohr, Aug. 11, 1932.
113	Waycross (15,510); municipal; 1 well 686 feet deep (about 95 percent of supply), 2 wells about 700 feet deep. Analysis of tap sample by Dearborn Chemical Co., Chicago, Ill., Apr. 22, 1927.

cities of the United States, 1932—Continued

	Analyses (parts per million)												No.
	Total dissolved solids	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulphate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Total hardness as $CaCO_3$[a]	
A-------	[a] 173	18	[b] 0.70	24	4.6	30	1.8	156	11	5.2	-------	79	99
B-------	[a] 220	11	[b] 1.7	28	3.8	46	1.8	182	11	10	17	86	
----------	36	11	.02	3.5	1.7	2.2	1.2	14	6.5	2.0	1.2	16	100
----------	[h] 26	9.0	.12	3.6	1.3	2.7		12	[a] 6.6	2.0	.86	14	101
Av------	60	23	.44	5.7	.8	12		30	6.0	2.1	.6	18	102
A-------	312	37	.02	56	17	15	2.2	146	96	16	.05	210	103
B-------	270	25	.02	34	22	19	2.1	138	80	16	.0	175	
----------	43	10	.1	4.2	1.0	7.0		18	10	2.5	.2	15	104
----------	39	12	.02	3.8	1.5	3.1	1.1	17	5.7	2.0	.80	16	105
Av------	67	24	.86	8.8	1.4	[i] 7		31	[i] .6	2.8	6	28	106
A-------	80	19	.76	11	2.5	7.5	1.3	46	11	2.2	.30	38	107
B-------	137	43	.01	19	11	3.9	1.0	109	3.3	2.8	2.0	93	
A-------	49	6.4	1.8	4.0	1.4	5.3		17	7.2	4.0	-------	16	108
B-------	69	26	.9	6.3	1.2	8.3		28	4.9	2.8	.7	21	
A-------	82	24	.7	12	2.6	9.2		53	4.1	1.8	.4	41	109
B-------	122	39	.8	13	3.9	12		78	5.5	2.0	.4	48	
C-------	47	16	.9	7.6	Trace	------	------	24	-------	2.0	.4	19	
A-------	180	56	.04	30	11	4.3	2.0	139	7.2	6.0	.10	120	110
B-------	216	51	.04	26	12	25	2.3	143	17	21	.10	114	
C-------	177	53	.02	28	9.0	7.5	3.0	133	8.9	6.0	.0	107	
A-------	173	11	.07	16	6.6	[a] 28		39	78	10	-------	67	111
B-------	276	22	.07	44	21	[a] 11		158	70	12	-------	196	
----------	132	15	.06	30	4.2	2.7	.6	78	24	4.5	.10	92	112
----------	318	21	[b] 1.2	44	12	39		175	59	28	Trace.	159	113

[a] Calculated. [b] Iron and aluminum oxides. [h] Includes 0.04 part of manganese. [i] Estimated.

TABLE 5.—*Public water supplies of the larger*

No.	Description
	IDAHO
	[Descriptions and analyses for four of the supplies were furnished by W. V. Leonard, State chemist and sanitary engineer, Idaho Department of Public Welfare]
114	Boise (21,544); Boise Water Corporation; dug well 30 feet deep and 30 feet in diameter near Boise River (75 percent of supply), reservoir fed by artesian wells about 600 feet deep (25 per cent of supply). Analyzed by E. W. Lohr, Jan. 26, 1933. A, Dug well; B, artesian wells.
115	Idaho Falls (9,429); municipal; 2 wells about 180 feet deep supplying mains directly. Analysis of tap sample by A. W. Klotz, Idaho Department of Public Welfare, April 1931.
116	Lewiston (9,403); municipal; Clearwater River. Analyzed by W. L. Lamar, July 22, 1932. Regular determinations for the year 1931–32: Alkalinity 20 to 44, average 32; pH 7.2. to 8.5, average 7.4.
117	Pocatello (16,471); municipal; Mink Creek augmented in summer by wells 160 feet deep. Analysis of tap sample from creek supply by A. W. Klotz, Idaho Department of Public Welfare, April 1931.
118	Twin Falls (8,787); municipal; Snake River water from High Line Canal; filtered. The composition of the water varies throughout the year. Analysis of tap sample by A. W. Klotz, Idaho Department of Public Welfare, April 1931.
	ILLINOIS
	[Most of the descriptions and analyses were furnished by A. M. Buswell, director, Illinois State Water Survey]
119	Alton (30,151); Alton Water Co. (controlled by American Water Works & Electric Co., 50 Broad St., New York, N.Y.); Mississippi River; filtered. Daily determinations on the filtered water for the year 1931: Alkalinity 123 to 212, average 158; hardness 122 to 282, average 176. (For average of analyses of raw water from Mississippi River near Quincy, see Quincy, analysis C.)
120	Aurora (46,589); 7 wells (nos. 6 to 12) 2,200, 2,262, 2,280, 2,285, 2,280, 2,240, and 2,230 feet deep. Analyzed by E. L. Pearson, Illinois State Water Survey, Nov. 22, 1930. A, Well 12; B, well 8 (maximum total solids); C, well 6 (minimum total solids).
121	Belleville (28,425); supplied by East St. Louis & Interurban Water Co. (See East St. Louis)
122	Berwyn (47,027); municipal; Chicago supply. (See Chicago)
123	Bloomington (30,930); municipal; impounding reservoir; softened with excess lime, recarbonated, filtered, final adjustment of pH to about 9.1. Analyzed by G. E. Symons, Illinois State Water Survey, July 27, 1932. The analysis probably represents about an average concentration. Regular determinations on monthly composites of the treated water for the year 1930–31: Hardness 55 to 93, average 82. For the same period the raw water had an average hardness of 231.
124	Champaign (20,348); Illinois Water Service Co. (controlled by Federal Water Service Corporation, 27 William St., New York, N.Y.). Supplies also Urbana. Total population supplied about 33,400. 38 wells, as follows: East plant group, 18 wells 157 to 177 feet deep; School House group, 8 wells 169 to 173 feet deep; West plant group, 6 wells 163 to 169 feet deep; West Bradley well, 200 feet deep; and East Bradley group, 5 wells 202 to 212 feet deep; aerated, filtered without coagulation. Analysis of raw water from well 40 by O. W. Rees, Illinois State Water Survey, Dec. 5, 1927. Other available results indicate that the analysis represents the average composition of the water.
125	Chicago (3,376,438); municipal. Supplies also Berwyn, Blue Island, Broadview, Burnham, Calumet City, Calumet Park, Cicero, Dolton, East Hazel Crest, Elmwood Park, Evergreen Park, Forest Park, Forest View, Harvey, Markham, Niles, Niles Center, North Riverside, Oak Park, Park Ridge, Posen, Phoenix, Riverdale, River Forest, Specialville, Stickney, Summit, Tessville, and Westchester. Total population supplied about 3,679,000. Lake Michigan. The composition of the water is fairly uniform throughout the year. The pH ranges from about 7.8 to 8.2, with an average about 8.0. Analyzed by Chicago Water Department, Mar. 6, 1928. Plans are now being developed for the filtration of the water. It is proposed to construct several filter plants.
126	Chicago Heights (22,321); municipal; 5 wells about 200 feet deep; 1 well 1,832 feet deep used as an auxiliary supply. Analysis of water from 200-foot well by Illinois State Water Survey, June 23, 1920. Analyses of samples collected from the auxiliary well Nov. 3, 1930, indicate that its water is of the same general type, but about 10 percent softer.
127	Cicero (66,602); municipal; Chicago supply. (See Chicago)
128	Danville (36,765); Inter-State Water Co. Supplies also Westville. Total population supplied about 40,700. Impounding reservoirs on North Fork of Vermilion River; aerated at times, filtered. Analyzed by G. E. Symons, Illinois State Water Survey, Nov. 6, 1931. The composition of the water varies throughout the year. Daily determinations of alkalinity of the treated water for the 2-year period 1929–30, 70 to 300, average 178.
129	Decatur (57,510); municipal; impounding reservoir on Sangamon River; softened, filtered, final adjustment of pH to about 8.5. The composition of the water varies throughout the year. Analyzed by G. E. Symons, Illinois State Water Survey, July 25, 1932.

cities of the United States, 1932—Continued

	Analyses (parts per million)												
	Total dissolved solids	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulphate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Total hardness as $CaCO_3$[a]	No.
A-------	95	18	0.02	18	3.5	8.8	1.9	74	12	2.0	1.9	59	114
B-------	183	32	.42	35	4.5	14	2.9	106	39	4.0	1.0	106	
----------	[a] 319	14	-------	42	14	[a] 57		254	44	23	-------	162	115
----------	57	10	.08	9.4	1.3	2.6	.9	26	14	1.4	.14	29	116
----------	[a] 152	29	[b] 2	22	6.9	[a] 17		123	6.8	8	-------	83	117
----------	[a] 233	32	-------	39	1.7	[a] 39		160	5.8	37	-------	104	118
----------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	119
A-------	517	8	.8	70	30	86		325	36	130	1.8	298	120
B-------	821	20	1.4	117	59	80		405	146	155	9.4	534	
C-------	369	8	Trace	55	20	59		315	41	32	1.2	220	
----------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	121
----------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	122
----------	108	6.0	.0	11	12	2.8		[j] 54	36	5.0	.4	77	123
----------	367	.19	([k])	60	36	28	2.7	456	.4	3.0	.9	298	124
----------	157	6.4	.2	34	9.7	5.1		146	12	4.5	-------	125	125
----------	818	18	.4	136	66	30		473	255	7.0	1.4	611	126
----------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	127
----------	290	8	.0	57	25	7.8		215	64	5.0	1.8	245	128
----------	145	5	.0	17	18	7.0		[l] 88	39	4	2.4	116	129

[a] Calculated.
[b] Iron and aluminum oxides.
[j] Includes equivalent of 16 parts of carbonate (CO_3).
[k] Average iron for 1932 in effluent 0.02 part.
[l] Includes equivalent of 8 parts of carbonate (CO_3).

TABLE 5.—*Public water supplies of the larger*

No.	Description
	ILLINOIS—continued
130	East St. Louis (74,347); East St. Louis & Interurban Water Co. (controlled by American Water Works & Electric Co., 50 Broad St., New York, N.Y.). Supplies also Belleville, Brooklyn, Dupo, Fairmount City, Granite City, Lovejoy, Madison, Nameoki, National City, O'Fallon, Swansea, and Venice. Total population supplied about 153,000. Mississippi River; filtered. The coagulation and filtration reduce the silica and iron; the bicarbonate may also be slightly reduced, and the sulphate is increased. With these exceptions the analysis probably represents reasonably well the average composition of the water delivered to consumers. Average of analyses of raw water from Mississippi River at Chester made by U.S. Geological Survey in 1906–7 (Water-Supply Paper 239, p. 83, 1910). Daily determinations for the 2-year period 1929–30: Alkalinity 84 to 192, average 136; hardness 118 to 258, average 172.
131	Elgin (35,929); municipal; wells. Analyzed by Illinois State Water Survey

	Source	Depth (feet)	Capacity (million gallons per day)	Date of collection
A	Slade Ave. wells (4) (analysis of well 1)	1,960	4.1	Jan. 18, 1933
B	Lavoie St. well	675	1.1	Sept. 6, 1931
C	Shuler St. well	1,940	.9	Oct. 5, 1931
D	Laurel St. well	53	.9	Aug. 13, 1930
	Borden wells (4)	36–46	.6	
E	Slade Ave. well	41	.3	Jan. 18, 1933
	Crighton Ave. well	53	.3	
	North State St. well	33	.1	

No.	Description
132	Evanston (63,338); municipal. Supplies also Wilmette. Total population supplied about 78,600. Lake Michigan; filtered. The composition of the water is fairly uniform throughout the year. The filtered water had an average alkalinity of 111 for 1928 and 1929. Analyzed by C. R. Breden, Illinois State Water Survey, Oct. 28, 1930.
133	Freeport (22,045); Illinois Water Service Co. (controlled by Federal Water Service Corporation, 27 William St., New York, N.Y.); 3 wells (nos. 2, 3, and 4), 303, 503, and 100 feet deep; aerated, filtered. The analyses represent samples of aerated water not coagulated or filtered. Analyzed by C. R. Breden, Illinois State Water Survey, Apr. 17, 1931. A, Well 2, B, well 4.
134	Galesburg (28,830); municipal; 2 wells (nos. 1 and 2), 2,414 and 2,408 feet deep. Analyzed by O. W. Rees, Illinois State Water Survey. A, Potsdam well 1, Aug. 9, 1932; B, Potsdam well 2, Mar. 23, 1929.
135	Granite City (25,130); supplied by East St. Louis & Interurban Water Co. (See East St. Louis)
136	Joliet (42,993); municipal; 11 wells 1,547 to 1,785 feet deep. Analyzed by E. L. Pearson, Illinois State Water Survey, Dec. 17, 1930.

	Source	Depth (feet)	Approximate percentage of supply	Approximate concentration
A	Washington St. well 5	1,685	21	Average.
B	Williamson and Charlesworth Ave. well	1,565	23	Maximum.
C	Jasper and South Center St. well	1,565	28	Minimum.

No.	Description
137	Kankakee (20,620); Kankakee Water Co.; Kankakee River; softened with lime and soda ash, recarbonated, filtered. The water is regularly softened to a hardness less than 80. The composition of the raw water varies throughout the year, and the analysis probably shows more than the average mineral content of the filtered water. Analysis of tap sample by C. R. Breden, Illinois State Water Survey, Jan. 21, 1932.

cities of the United States, 1932—Continued

	Analyses (parts per million)												
	Total dissolved solids	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulphate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Total hardness as $CaCO_3$[a]	No.
Av------	269	22	0.39	44	16	21		174	56	9.8	2.7	176	130
A-------	310	9	.0	61	24	28		356	10	7.0	.4	251	131
B-------	329	9	Trace	49	24	48		395	-------	3	.4	221	
C-------	346	16	.0	41	20	65		371	15	5.0	.3	184	
D-------	638	14	.0	114	60	14		437	153	25	11	531	
E-------	466	17	1.0	95	46	4.1		398	90	9.0	4.1	426	
---------	168	3.7	.0	33	7.9	15	3.1	132	20	5.0	1.1	115	132
A-------	474	15	.6	93	50	6.4		415	58	28	13	438	133
B-------	[m] 436	14	2.6	83	49	1.6		383	58	11	1.5	408	
A-------	1,030	12	Trace	53	24	271		300	314	175	1.7	231	134
B-------	1,073	12	.1	57	27	281	18	276	344	210	.4	253	
---------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	135
A-------	507	24	.2	79	26	59		332	117	30	1.5	304	136
B-------	613	11	Trace	94	39	56		359	175	27	1.5	395	
C-------	486	11	.2	62	21	81		339	89	36	.9	241	
---------	287	11	.0	14	10	42	26	[n] 66	140	3.0	16	76	137

[a] Calculated. [m] Includes 0.7 part of manganese.
[n] Includes equivalent of 10 parts of carbonate (CO_3).

TABLE 5.—*Public water supplies of the larger*

No.	Description

ILLINOIS—continued

138 Maywood (25,829); municipal; wells. Analyzed by Illinois State Water Survey

	Source	Depth (feet)	Approximate percentage of supply	Date of collection	Analyst
A	Well 6	2,090	49	Oct. 11, 1928	O. W. Rees.
B	Well 3	1,600	27	July 8, 1931	C. R. Breden.
C	Well 5	2,076	24	Oct. 11, 1928	O. W. Rees.
D	Well 4	2,048	Auxiliary.	do	Do.

139 Moline (32,236); municipal; Mississippi River; filtered. The coagulation and filtration reduce the silica and iron, the bicarbonate may be decreased, and the sulphate is increased. The composition of the water varies throughout the year. Average of analyses of composites of daily samples by U.S. Geological Survey, Feb. 1 to July 31, 1907 (Water-Supply Paper 239, p. 81, 1910).

140 Oak Park (63,982); municipal; Chicago supply. (See Chicago)

141 Peoria (104,969); Peoria Water Works Co. (controlled by Community Water Service Co., 100 William St., New York, N.Y.). Supplies also Bartonville and Peoria Heights. Total populaton supplied about 110,000. 9 wells 45 to 95 feet deep. The Main well and wells 7, 8, and 9 furnish about 95 percent of the total supply. A, Analysis of tap sample (Main well and wells 7 and 8 in service) by Illinois State Water Survey, Dec. 1, 1924 (Illinois State Water Survey Bull. 21, p. 512, 1925); B, well 7, May 12, 1931; C, well 8, June 23, 1931; D, well 9, May 12, 1931. B, C, and D analyzed by C. R. Breden, Illinois State Water Survey.

142 Quincy (39,241); municipal; Mississippi River; softened with lime, recarbonated, filtered. A, Softened water; B, raw water; C, average of analyses of composites of daily samples of raw water from the Mississippi River near Quincy by U.S. Geological Survey, 1906–7 (Water-Supply Paper 239, p. 82, 1910). A and B analyzed by C. R. Breden, Illinois State Water Survey, Jan. 25, 1932. The composition of the water varies throughout the year. Regular determinations for year 1932: Softened water, alkalinity 20 to 160, average 44; hardness 36 to 138, average 71; pH 7.2 to 9.6, average 9.1. Raw water, alkalinity 85 to 191, average 141; hardness 92 to 220, average 157.

143 Rockford (85,864); municipal; 9 wells 1,600 feet deep. The wells all furnish water of about the same general character. The analyses represent approximately an average concentration, the most concentrated water, and the least concentrated. Analyzed by E. L. Pearson, Illinois State Water Survey, June 20, 1930. A, Well 5; B, well 4; C, well 1.

144 Rock Island (37,953); municipal; Mississippi River; filtered. Analysis of tap sample by J. G. Weart, Illinois Department of Public Health, Dec. 30, 1929. The composition of the water varies throughout the year, and the analysis probably represents about a maximum concentration. (For analysis of the river water see Moline.)

145 Springfield (71,864); municipal; Sangamon River (80 percent of supply), wells and infiltration galleries along Sangamon River (20 percent of supply); softened with lime, recarbonated, filtered, final adjustment of pH to about 9.0. Analyses of 3 composites of daily samples by C. H. Spaulding, Water Department, Mar. 1 to Aug. 31, 1932. A, Softened water; B, raw water; C, Sangamon River water. Regular determinations on the treated water for the year 1930-31: Alkalinity (based on monthly averages) 27 to 55, average 40; hardness 73 to 122, average 99; pH 8.4 to 9.7, average 9.0. For the same period the raw water had an average hardness of 255.

146 Waukegan (33,499); municipal; Lake Michigan; filtered. Analyzed by Illinois State Water Survey, Nov. 18, 1930. Monthly average of regular determinations on the filtered water for the year 1929: Alkalinity 106 to 118, pH 7.2 to 7.7.

INDIANA

[Descriptive material for all the supplies was furnished by Elliott Parks, director of laboratories, Department of Sanitary Engineering, Indiana Board of Health]

147 Anderson (39,804); municipal; White River (filtered); 5 deep wells. There is some variation in the composition of the river water. Analysis of treated water from White River by Margaret D. Foster, U.S. Geological Survey, Feb. 27, 1922.

148 Bloomington (18,227); municipal; Griffy Creek reservoir (coagulated, filtered), "Old Plant" reservoir (coagulated, settled). Analyzed by E. W. Lohr, Oct. 28, 1931. A, Griffy Creek reservoir; B, "Old Plant" reservoir. Average of several determinations of hardness: Griffy Creek reservoir 131, "Old Plant" reservoir 166.

149 East Chicago (54,784); municipal; Lake Michigan; filtered; analyzed by E. W. Lohr, Sept. 28, 1931. The composition of the water is fairly uniform throughout the year.

150 Elkhart (32,949); municipal; 4 dug wells 28 to 32 feet deep and 28 to 41 feet in diameter, 5 driven wells about 55 feet deep. Analyzed by Indiana Board of Health.

151 Evansville (102,249); municipal; Ohio River; filtered. Analysis of about an average sample by E. W. Lohr, July 6, 1931. The composition of the water varies throughout the year. Regular determinations for the year 1931: Alkalinity 32 to 82, average 55; hardness 78 to 214, average 144.

cities of the United States, 1932—Continued

	Analyses (parts per million)												
	Total dissolved solids	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulphate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Total hardness as $CaCO_3$ [a]	No.
A	983	9.4	0.2	96	27	183	18	334	121	280	0.2	351	138
B	577	8	.4	79	29	89		341	153	53	.9	316	
C	822	13	.8	102	46	84	10	317	253	70	1.2	444	
D	684	12	.0	80	30	108	17	344	165	82	.4	323	
Av	179	16	.39	33	13	10		152	24	3.7	1.8	136	139
----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	140
A	456	13	.1	87	41	26	3.8	420	52	21	4.2	386	141
B	457	15	.0	88	43	13		439	38	16	4.4	396	
C	[e] 408	14	.0	72	37	27		432	5.4	23	.0	332	
D	453	17	.0	97	46	11		439	45	14	1.3	431	
A	138	9.3	.0	23	5.0	10	3.9	[p] 61	43	9.0	3.3	78	142
B	262	18	Trace	47	20	8.2	4.9	206	36	7.0	11	200	
C	203	18	.46	36	16	11		175	25	4.4	2.2	156	
A	352	12	.0	66	39	.7		346	29	8.0	3.1	325	143
B	420	12	.2	70	43	4.4		361	42	15	5.3	351	
C	280	12	Trace	51	36	7.1		344	6.4	3.0	1.5	275	
----------	216	----------	.3	42	19	[a] 11		195	32	9	1.3	183	144
A	176	9.2	.0	17	16	14		50	66	10	4.4	108	145
B	[q] 318	10	----------	57	27	15		240	60	9	11	253	
C	288	14	.1	58	24	12		210	49	8	11	243	
----------	151	3.4	.0	33	11	11	7.9	116	18	4.0	.5	128	146
----------	348	7.0	.17	72	29	5.1	2.0	262	72	20	11	299	147
A	149	3.7	.01	37	6.8	3.1	2.1	98	41	3.0	.82	120	148
B	----------	----------	----------	[r] 35	----------	----------	----------	131	[r] 16	3.0	----------	----------	
----------	141	4.5	.04	34	11	3.0	1.1	131	19	4.1	.50	130	149
----------	254	15	.1	55	21	4.3		249	20	6.0	1.0	224	150
----------	221	4.0	.03	39	9.1	12	2.5	56	85	18	1.6	135	151

[a] Calculated.
[e] Includes 0.2 part of manganese.
[p] Includes equivalent of 15 parts of carbonate (CO_3).
[q] Includes 0.9 part of manganese.
[r] By turbidity.

TABLE 5.—*Public water supplies of the larger*

No.	Description
	INDIANA—continued
152	Fort Wayne (114,946); municipal; St. Joseph River impounded; softened with lime, recarbonated, filtered. This source and the treatment are now under development and will be in service in 1934. The composition of the river water varies throughout the year. Analyses made in connection with the study of plans for the system indicate an average total hardness of about 275, of which the noncarbonate hardness is 75. It is expected that the softening plant will reduce the total hardness to about 100 without reduction of the noncarbonate hardness.
153	Gary (100,426); Gary Heat, Light & Water Co.; Lake Michigan. The chemical composition of the water is fairly uniform and is practically the same as at Hammond. (For analysis see Hammond.)
154	Hammond (64,560); municipal; Lake Michigan. Analyzed by E. M. Partridge, Paige & Jones Chemical Co., Hammond, Aug. 14, 1930. The composition of the water is fairly uniform throughout the year. At times when the lake is stirred up the suspended matter reaches a maximum of of about 500 to 700 parts.
155	Indianapolis (364,161); Indianapolis Water Co.; White River impounded, slow sand filtration (about 80 percent); wells (about 20 percent). There is some variation in the composition of the river water throughout the year. The average concentration of the river water has been about the same for a number of years. The pH of the filtered water is reported to range from 6.8 to 7.8, and the pH of the well water around 7.2. Analyzed by Indianapolis Water Co. A, Average based on monthly composites of daily samples of the filtered water, 1928; B, average based on monthly composites of daily samples from Fall Creek station wells over a period of 2 years.
156	Kokomo (32,843); Kokomo Water Works Co. (controlled by American Water Works & Electric Co., 50 Broad St., New York, N.Y.); 11 wells 130 to 500 feet deep; iron removal. Analysis of tap sample by Indiana Board of Health, Dec. 22, 1930. The supply is obtained from 2 groups of wells which furnish waters that differ in composition, but the analysis may be taken to represent the general character of the water delivered to consumers.
157	LaFayette (26,240); municipal; 14 wells 100 feet deep. Analyzed by L. A. Shinn, U.S. Geological Survey, Nov. 24, 1930.
158	Logansport (18,508); municipal; Eel River; filtered. Analyzed by Indiana Board of Health, January 1931. The chemical composition of the water varies throughout the year. Daily determinations for the year 1930: Alkalinity 50 to 270, average 169.
159	Marion (24,496); municipal; 3 wells (nos. 3 to 5) 139 feet deep, emergency supply from 14 wells; aerated, softened with lime, recarbonated, settled. Well 3 furnishes about 80 percent of the total supply. Analyzed by L. A. Shinn, U.S. Geological Survey, Mar. 4, 1931. A, Softened water from tap in City Hall; B, raw water from well 3.
160	Michigan City (26,735); municipal; Lake Michigan. The chemical composition of the water is fairly uniform throughout the year and is practically the same as at Hammond. (For analysis see Hammond.)
161	Mishawaka (28,630); municipal; 30 wells 80 to 100 feet deep, 7 wells 290 to 315 feet deep. Analyzed by Dearborn Chemical Co., Chicago, Ill., July 1915. A, Analysis representative of the 30 relatively shallow wells; B, analysis representative of the 7 deep wells.
162	Muncie (46,548); Muncie Water Works Co. (controlled by American Water Works & Electric Co., 50 Broad St., New York, N.Y.); White River (about 90 percent), wells (about 10 percent); filtered. The alkalinity of the treated water is reported to range from 80 to 300, with an average of about 250. The average of analyses of monthly composite samples given for the filtered water at Indianapolis may be taken as fairly representative of the average composition of the water at Muncie. (See Indianapolis, analysis A.)
163	New Albany (25,819); Interstate Public Service Co., Ohio River; filtered. Analyses of the water furnished to consumers at Cincinnati, Ohio, may be taken as representative of the mineral content at New Albany. Analyzed by Cincinnati Water Works. Average of monthly composites, 1928–32. For additional analyses see Cincinnati, Ohio.
164	Richmond (32,493); Richmond Water Works Corporation (controlled by American Water Works & Electric Co., 50 Broad St., New York, N.Y.); infiltration galleries, spring, 1 dug well 13 feet deep, 4 wells about 25 feet deep. Analysis of tap sample by L. A. Shinn, U.S. Geological Survey, Nov. 29, 1930.
165	South Bend (104,193); municipal; 118 wells 85 to 175 feet deep. Analyzed by Department of Chemistry, University of Notre Dame, Notre Dame.

	Station	Number of wells	Range in depth (feet)	Percent of supply (1931)	Date of analysis
A	North	52	100–150	45	May 6, 1930
B	Oliver Park	27	125–175	38	Do.
C	Central	35	100–150	8	Do.
D	South	3	85	8	Do.
E	Coquillard Woods	1	206	1	May —, 1932

No.	Description
166	Terre Haute (62,810); Terre Haute Water Works Corporation (controlled by American Water Works & Electric Co., 50 Broad St., New York, N.Y.). Wabash River, filtered. Analyses furnished by Terre Haute Water Works Corporation; based on monthly composites of daily samples collected during 1920. Averages of daily determinations on the treated water during the year 1929: Alkalinity 167, hardness 231, chloride 13.

cities of the United States, 1932—Continued

	Analyses (parts per million)												
	Total dissolved solids	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulphate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Total hardness as $CaCO_3$[a]	No.
													152
													153
----------	153	7.9	[b]3.4	31	13	6.5		145	18	5.9	-------	131	154
A	351	6.8	.48	71	25	9		260	65	11	2.8	280	155
B	361	14	1.2	74	32	16		380	29	6.5	.3	316	
----------	932	13	.0	196	6.7	[a]107		351	412	22	.1	517	156
----------	484	24	.10	98	33	30	4.7	366	88	21	20	380	157
----------	[a]416	14	.3	104	6.3	[a]39		334	70	16	.3	286	158
A	362	12	.08	47	32	19	2.0	100	141	42	.50	249	159
B	610	16	.02	135	42	19	1.8	444	123	40	.30	510	
													160
A	[a]420	7.2	[b]1.6	82	29	24		300	106	7.1	11	324	161
B	[a]308	3.5	[b]1.7	62	26	23		356	1.1	14	.0	262	
													162
Av	207	-------	.05	34	[a]6.1	[a]15		45	72	22	-------	[c]110	163
----------	337	15	.10	84	32	3.0	2.1	336	52	4.0	4.9	341	164
A	[a]353	3.9	[b]1.4	107	25	6.7		289	57	10	-------	370	165
B	[a]644	12	[b]2.4	139	50	5.5		349	255	8.5	-------	553	
C	[a]548	9.6	[b]2.1	109	37	22		337	167	35	-------	424	
D	[a]341	1.5	[b]7.0	84	24	4.3		284	73	6.7	-------	308	
E	[a]271	2.8	[b]4.0	56	27	11		307	12	7.3	-------	251	
Av	383	11	[b].29	70	26	6.9		221	85	12	-------	280	166
Max	440	18	[b]2.0	87	38	9.1		290	99	15	-------	341	
Min	284	4	[b]Trace	44	18	4.4		141	71	8	-------	184	

[a] Calculated. [b] Iron and aluminum oxides. [c] Determined.

TABLE 5.—*Public water supplies of the larger*

No.	Description
	IOWA
167	Burlington (26,755); Citizens' Water Co.; Mississippi River; filtered, final treatment with lime to control pH. The composition of the water varies considerably throughout the year. The treatment undoubtedly removes more silica and slightly more iron than the laboratory filtration of the samples analyzed in 1907. The snlphate is increased. Average of analyses of composite samples of raw water from Mississippi River at Moline, Ill., by U.S. Geological Survey, February to July 1907 (Water-Supply Paper 239, p. 81, 1910).
168	Cedar Rapids (56,097); municipal; Cedar River; aerated, softened with lime, recarbonated, filtered. Analyzed by E. W. Lohr, July 5, 1932. A, Softened water; B, raw water. There is considerable variation in the composition of the water throughout the year. Regular determinations for the year 1931: Softened water, alkalinity 31 to 71, average 41; hardness 56 to 101, average 72; pH 8.5 to 8.7, average 8.6. Raw water, alkalinity 101 to 235, average 138; hardness 117 to 266, average 173.
169	Clinton (25,726); Clinton Water Works Co. (controlled by American Water Works & Electric Co., 50 Broad St., New York, N.Y.). 5 wells 1,240 to 2,101 feet deep. Analysis of a sample from well 6, 2,101 feet deep, by E. W. Lohr, May 28, 1932.
170	Council Bluffs (42,048); municipal; Missouri River; coagulated, settled, aerated. There is considerable variation in the composition of the water throughout the year. The coagulation reduces the silica and iron; the bicarbonate may be decreased, and the sulphate is increased. Analyses of composite samples of raw water from Missouri River near Florence, Nebr., by U.S. Geological Survey, 1906–7 (Water-Supply Paper 236, p. 78, 1909). A, Average of analyses of composite samples, 1906–7; B, composite sample of maximum concentration, Dec. 14–23, 1906; C, composite sample of minimum concentration, Aug. 24 to Sept. 3, 1907.
'171	Davenport (60,751); Davenport Water Co. (controlled by American Water Works & Electric Co., 50 Broad St., New York, N.Y.); Mississippi River; filtered. The composition of the water is not very different from that at Burlington. (See Burlington.)
172	Des Moines (142,559); municipal; infiltration galleries. Average of 4 analyses made by M. K. Tenny, Des Moines Water Works, Mar. 7, June 1, Sept. 1, Dec. 1, 1932.
173	Dubuque (41,679); municipal; 5 wells averaging about 1,450 feet deep, springs. The wells furnish about 80 percent of the total supply. Analyzed by L. A. Shinn, U.S. Geological Survey, Nov. 22, 1930. A, Wells; B, springs.
174	Fort Dodge (21,895); municipal; 5 wells 1,400, 215, 1,436, 260, and 512 feet deep; iron removal. Analyzed by L. A. Shinn, U.S. Geological Survey, Feb. 4, 1931.
175	Iowa City (15,340); municipal; Iowa River; filtered. There is also a filtration plant on Iowa River at the State University. The municipal filtration plant pumps about 1,300,000 gallons a day, and the University plant about 600,000 gallons a day. The two plants furnish a total population of about 20,000. The coagulation and filtration of the water reduce the silica and iron; the bicarbonate may be decreased, and the sulphate is increased. Analyses of composites of daily samples of raw water by U.S. Geological Survey, 1906–7 (Water-Supply Paper 236, p. 66, 1909). A, Average; B, composite of maximum total solids and hardness, Oct. 17–26, 1906; C, composite of minimum total solids and hardness, Jan. 16–28, 1907. Regular determinations on the filtered water for the year 1932: Municipal plant, alkalinity 36 to 298, average 162. University plant, alkalinity 44 to 302, average 160; pH 6.8 to 8.1.
176	Keokuk (15,106); Keokuk Water Co. (controlled by American Water Works & Electric Co., 50 Broad St., New York, N.Y.); Mississippi River; filtered. The composition of the water varies throughout the year. The coagulation and filtration reduce the silica and iron; the bicarbonate may be decreased, and the sulphate is increased. Average of analyses of raw water from the Mississippi near Quincy, Ill., by U.S. Geological Survey, 1906–7 (Water-Supply Paper 239, p. 82, 1910).
177	Marshalltown (17,373); municipal; group of 9 wells 100 feet deep, 1 well 50 feet deep, 1 well 223 feet deep; iron removal. It is proposed to soften the supply. Analysis of tap sample by E. W. Lohr, Nov. 25, 1932.
178	Mason City (23,304); municipal; 3 wells, 1,200 feet deep. Analysis furnished by Mason City Water Department, dated 1923 or 1924.
179	Muscatine (16,778); municipal; 15 wells 50 feet deep. All wells are connected to a common suction line. Analysis of tap sample by E. W. Lohr, Apr. 26, 1932.
180	Ottumwa (28,075); municipal; Des Moines River; filtered. It is proposed to soften the supply. Analyses of composite samples of raw water from Des Moines River at Keosauqua by U.S. Geological Survey, 1906–7 (Water-Supply Paper 236, p. 61, 1909).
181	Sioux City (79,183); municipal; 8 wells 305, 302, 343, 349, 323, 267, 377, and 419 feet deep. All water supplied to reservoirs. Analyzed by W. L. Lamar, Apr. 30, 1931. 18 analyses for Nov. 18 and 19, 1930, and Apr. 16, 1926, show variation in composition of the water from the different wells, but the analysis may be taken to represent reasonably well about the average composition of the water delivered to consumers.
182	Waterloo (46,191); municipal; main supply from 1 well 85 feet deep; auxiliary supply from 4 wells 1,400 feet deep. A, Analysis of sample from main supply by H. C. Maffitt, consulting chemist, July 28, 1929; B, analysis of sample from auxiliary supply by D. L. Maffitt, Des Moines municipal water plant, Jan. 5, 1926.

cities of the United States, 1932—Continued

	Analyses (parts per million)												
	Total dissolved solids	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulphate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Total hardness as $CaCO_3$[a]	No.
Av.	179	16	0.39	33	13	10		152	24	3.7	1.8	136	167
A.	154	8.3	.01	28	4.3	6.0	2.3	36	53	6.0	13	88	168
B.	299	17	.02	65	18	5.9	2.1	231	38	5.2	13	236	
	382	12	.21	64	30	31	8.1	335	50	28	.60	283	169
A.	454	31	.44	65	20	49		203	168	8.9	1.8	244	170
B.	663	25	.10	102	38	58		337	237	12	1.0	411	
C.	300	25	.38	46	14	36		146	96	8.8	.9	172	
----------	------	------	------	------	------	------	------	------	------	------	------	------	171
(Av.)	362	14	[b] 3.5	75	29	20		255	98	6.0	1.5	306	172
A.	291	26	.10	59	37	4.0	3.3	[t] 330	22	5.0	.10	299	173
B.	460	16	.10	87	50	7.1	2.7	[u] 387	104	8.0	.56	422	
	573	17	.02	118	40	32	4.5	472	139	5.0	2.7	459	174
A.	247	19	.25	49	17	14		210	36	3.6	2.8	192	175
B.	[a] 327	36	Trace	64	26	13		283	44	3.9	.5	267	
C.	134	18	.7	21	7.5	[a] 9.8		83	30	2.7	1.7	83	
Av.	203	18	.46	36	16	11		175	25	4.4	2.2	156	176
	467	19	.02	95	31	15	2.7	306	133	3.9	2.8	365	177
	[a] 429	2.4	[b] 3.0	74	31	44		402	68	7.0	-------	312	178
	204	15	.01	42	15	5.1	1.4	165	25	4.5	12	166	179
Av.	312	22	.36	58	21	17		216	71	4.8	3.3	231	180
Max.	492	18	.10	100	38	27		412	107	8.1	2.6	406	
Min.	207	29	1.2	30	10	11		99	52	4.0	3.9	116	
	792	17	.72	152	41	39	8.3	386	298	9.7	1.5	548	181
A.	223	13	[b] 2.1	58	16		12	207	25	4.4	15	211	182
B.	480	1.0	[b] 2.2	72	35		52	349	128	9.2	4.4	324	

[a] Calculated.
[b] Iron and aluminum oxides.
[t] Includes equivalent of 9 parts of carbonate (CO_3).
[u] Includes equivalent of 18 parts of carbonate (CO_3).

TABLE 5.—*Public water supplies of the larger*

No.	Description
	KANSAS
	[Complete descriptions and the analyses were furnished by Selma Gottlieb, chemist, Kansas Board of Health]
183	Arkansas City (13,946); municipal; wells into Arkansas River underflow about 50 feet deep. Analyzed by Selma Gottlieb, March 1931. A, Well 1; B, well 2; C, well 3; D, well 4.
184	Atchison (13,024); Atchison Water Co. Missouri River; coagulated; settled. Analysis of treated water by Selma Gottlieb, Mar. 1, 1932. Weekly determinations for the year 1932: Alkalinity 96 to 230, average 148. Analyses of raw water from Missouri River near Kansas City indicate the range in composition and general character of the water. (See Kansas City, analyses B.)
185	Coffeyville (16,198); municipal; Verdigris River; filtered. Analyzed by Selma Gottlieb, June 8, 1931. The river receives highly mineralized water from oil wells. Weekly determinations for the year 1932: Alkalinity 58 to 236, average 151; chloride 54 to 211, average 117. Daily determinations of pH for the year 1930: 6.8 to 8.2, average around 7.2.
186	Emporia (14,067); municipal; Neosho River; filtered. A, Analysis of filtered water by Selma Gottlieb, June 6, 1932; B, average of analyses of raw water by University of Kansas, 1906–7 (Water-Supply Paper 273, p. 327, 1911). There is considerable variation in the composition of the water throughout the year. Weekly determinations of alkalinity on the filtered water for the year 1932: 110 to 284, average 207. Daily determinations of pH for the year 1930: 7.4 to 8.6, average 7.9.
187	Fort Scott (10,763); municipal; Marmaton River; coagulated, settled, adjustment of pH to around 7.2 when it falls below 7.0. A, Analysis of treated water by Selma Gottlieb, June 7, 1932; B, average of analyses of raw water by University of Kansas, 1907–8 (Water-Supply Paper 273, p. 268, 1911). The composition of the water varies considerably throughout the year. Weekly determinations of alkalinity on the treated water for the year 1932: 58 to 192, average 131. Daily determinations of pH on the treated water for the year 1930: 6.6 to 8.2, average 7.3.
188	Hutchinson (27,085); United Power & Light Corporation; wells in Arkansas River underflow, about 70 feet deep, at 7 pumping stations. The relative proportions of water pumped from the different stations varies from year to year. Water from South station is considerably harder and more concentrated. Water from Lorraine Street station is practically the same as at the Northeast station. Analyzed by Selma Gottlieb, May 1931.

	Station	Percent of total supply		
		1928	1929	1930
A	Northwest	18	22	38
B	Cleveland Street	6	6	22
C	Fourth and Adams Streets	11	45	19
D	Main Street	41	13	12
E	Northeast	1	--------	6
	Lorraine Street	22	12	2
	South	1	2	1

No.	Description
189	Independence (12,782); municipal; Verdigris River; filtered. Analyzed by Selma Gottlieb, May 31, 1932. The river receives highly mineralized water from oil wells. Weekly determinations for the year 1932: Alkalinity 38 to 144, average 87; chloride 51 to 193, average 112.
190	Kansas City (121,857); municipal; Missouri River; filtered. A, Analysis of filtered water by Selma Gottlieb, May 1930; B, analyses of raw water from Missouri River near Kansas City by U.S. Geological Survey, 1906–7 (Water-Supply Paper 236, p. 79, 1909). Analyses of the raw water indicate the range in composition and general character of the water. Weekly determinations of alkalinity on the filtered water for the year 1932: 90 to 246, average 151. Daily determinations of pH on the filtered water for the year 1930: 7.4 to 8.0, average 7.7.
191	Lawrence (13,726); municipal; Kansas River; softened with lime, recarbonated, filtered. A, Analysis of a single sample of the softened water by Selma Gottlieb, May 1931; B, average of analyses of composites of daily samples of raw water from Kansas River near Holliday, by University of Kansas, 1906–7 (Water-Supply Paper 273, p. 243, 1911). The composition of the water varies throughout the year. Regular determinations on the treated water for the year 1931–32: Alkalinity 34 to 96, average 58; average hardness 104; chloride 15 to 127, average 52; average pH 8.3.
192	Leavenworth (17,466); municipal; Missouri River; coagulated, settled. Analyzed by Selma Gottlieb, June 1930. Weekly determinations for the year 1932: Alkalinity 90 to 244, average 150; chloride 7 to 36, average 18. Analyses of raw water from Missouri River near Kansas City indicate the range in composition and general character of the water. (See Kansas City, analyses B.)

cities of the United States, 1932—Continued

	Analyses (parts per million)												
	Total dissolved solids	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulphate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Total hardness as $CaCO_3$[a]	No.
A	1,592	13	0.1	144	40	[a] 357		249	359	510	4	524	183
B	854	16	.0	136	24	[a] 122		356	148	171	18	438	
C	1,812	13	.0	160	48	[a] 397		237	489	535	3	597	
D	1,827	11	.0	158	48	[a] 404		237	476	550	3	592	
	391	14		55	18	[a] 45		175	131	19	7	211	184
	440	7	.05	72	13	[a] 56		171	55	110	3	233	185
A	286	9		69	13	[a] 3		200	43	7	4	226	186
B	267	23	1.8	67	13	25		255	27	7.3	3.5	221	
A	284	7		73	9	[a] 1		165	75	6	1	219	187
B	267	14	1.1	81	8.7	23		251	35	5.2	1.9	238	
A	561	11	.0	85	17	[a] 83		253	83	111	11	282	188
B	729	12	.0	110	22	[a] 96		251	142	137	31	365	
C	805	12	.0	109	19	[a] 126		242	111	217	7	350	
D	591	9	.0	90	16	[a] 78		228	95	114	18	291	
E	782	12	.0	108	21	[a] 137		327	150	153	18	356	
	483	9	.0	56	16	[a] 55		109	54	125	3	206	189
A	445	9	Trace.	56	17	[a] 53		[b] 177	154	15	0	210	190
B. Av.	426	37	.73	62	18	44		202	135	13	2.2	229	
B. Max.	579	41	.08	90	30	55		326	176	23	2.2	348	
B. Min.	291	21	.28	44	14	[a] 25		136	95	7.0	.9	167	
A	234	10	.2	27	10	[a] 28		37	91	31	2	108	191
B	[a] 403	29	1.0	73	16	51		261	61	41	2.3	248	
	395	9	.0	53	15	[a] 53		166	147	12	2	194	192

[a] Calculated. [b] Includes equivalent of 7 parts of carbonate (CO_3).

TABLE 5.—*Public water supplies of the larger*

No.	Description
	KANSAS—continued
193	Newton (11,034); municipal; wells 130 feet deep. Analyzed by Selma Gottlieb, May 1930
194	Parsons (14,903); municipal; main supply from Labette Creek, auxiliary supply from Neosho River; filtered. A, Tap sample of filtered water, July 1930; B, tap sample of filtered water, Aug. 4, 1930; C, average of analyses of raw water from Neosho River near Oswego by University of Kansas, 1906–7 (Water-Supply Paper 273, p. 330, 1911). A and B analyzed by Selma Gottlieb. The composition of the water varies considerably throughout the year. Weekly determinations on the filtered water for the year 1932: Alkalinity 28 to 204, average 121.
195	Pittsburg (18,145); municipal; wells 1,300 to 1,500 feet deep. Analyzed by Selma Gottlieb, September 1929.
196	Salina (20,155); municipal; wells 60 to 70 feet deep. Analyzed by Selma Gottlieb, November 1930
197	Topeka (64,120); municipal; Kansas River; softened with lime, recarbonated, filtered. A, Analysis of a single sample of the softened water by Selma Gottlieb, May 1931; B, average of analyses of composites of daily samples of raw water from Kansas River near Holliday by University of Kansas, 1906–7 (Water-Supply Paper 273, p. 243, 1911). Regular determinations for the year 1931–32: Softened water, alkalinity 28 to 95, average 49; hardness 56 to 116, average 92; chloride 37 to 140, average 69. Raw water, alkalinity 100 to 296, average 200; hardness 154 to 309, average 241.
198	Wichita (111,110); Wichita Water Co. (controlled by American Water Works & Electric Co., 50 Broad St., New York, N.Y.); wells in Arkansas River underflow, about 50 feet deep. Analyzed by Selma Gottlieb, Nov. 16, 1932.
	KENTUCKY
	[Descriptive material for the supplies was furnished by F. C. Dugan, director, Bureau of Sanitary Engineering, Kentucky Board of Health]
199	Ashland (29,074); municipal; Ohio River, filtered. Analyses of treated water at Cincinnati, Ohio, may be taken to represent the chemical character of the water at Ashland. Analyzed by Cincinnati Water Works. A, Average of monthly composites, 1928–32; B, average of monthly composites, 1930; C, average of monthly composites, 1928; D, monthly composite, December 1930; E, monthly composite, April 1932.
200	Covington (65,252); municipal. Supplies also Erlanger, Fort Thomas, Ludlow, Park Hills, South Fort Mitchell, and a few smaller communities. Total population supplied about 85,000. Ohio River; filtered. The composition of the water is practically the same as that of the Ohio River supply of Cincinnati, Ohio. (For analyses see Ashland.)
201	Fort Thomas (10,008); supplied by Covington. (See Covington and Ashland)
202	Frankfort (11,626); Frankfort Water Co.; Kentucky River; filtered. The coagulation and the filtration reduce the silica and iron; the bicarbonate may be decreased, and the sulphate is increased. There is some variation in the composition of the water throughout the year. Average of analyses of composites of daily samples of the raw water by U.S. Geological Survey, 1906–7 (Water-Supply Paper 236, p. 69, 1909).
203	Henderson (11,668); municipal; Ohio River; filtered. The composition of the water varies throughout the year and is practically the same as at Evansville, Ind. Analysis of a nearly average tap sample of the filtered water from the Ohio River supply at Evansville by E. W. Lohr, July 6, 1931.
204	Hopkinsville (10,746); Hopkinsville Water Co.; West Branch of Little River; coagulated, settled. The river is impounded in a 50,000,000-gallon reservoir and in addition has two natural lakes on its headwaters, making a total storage capacity for the entire system of about 700,000,000 gallons. Analyzed by L. A. Shinn, U.S. Geological Survey, Apr. 14, 1931.
205	Lexington (45,736); Lexington Water Co. (controlled by Community Water Service Co., 100 William St., New York, N.Y.). Supplies also about 10,000 consumers in the suburban area adjacent to the city of Lexington. Total population supplied about 56,000. 4 lakes, auxiliary supply from Kentucky River; filtered, adjustment of pH by addition of lime. During the year 1931 the river was used 24 hours a day Jan. 1 to Apr. 8 and 10 hours a day May 20 to Oct. 8. Pumping from the river during the latter period was done at night. Analysis of tap sample from lake supply by E. W. Lohr, May 4, 1932. Daily determinations for the year 1931: Alkalinity 20 to 111, average 54; pH 6.4 to 8.4, average 7.1. The hardness based on monthly determinations for the year 1931–32 ranged from 74 to 138 with an average of 105.
206	Louisville (307,745); Louisville Water Co. (municipal); Ohio River; filtered. Analyses of the filtered water at Cincinnati, Ohio, may be considered fairly representative of the composition of the water at Louisville. (For analyses see Ashland.) Regular determinations for the year 1931: Alkalinity (daily tests) 14 to 82, average 43; hardness (determined on monthly composites of daily samples) 69 to 142, average 104; pH (daily tests) 6.5 to 8.5, average 7.3.
207	Middlesboro (10,350); Kentucky Utilities Co.; Yellow Creek impounded in Fern Lake (artificial). Analyzed by W. L. Lamar, May 9, 1931.
208	Newport (29,744); municipal. Supplies also Bellevue, Dayton, and Southgate. Total population supplied about 50,000. Ohio River; filtered. The composition of the water is practically the same as that of the Ohio River supply of Cincinnati, Ohio. (For analyses see Ashland.)
209	Paducah (33,541); municipal; Ohio River; filtered. Analyzed by Dearborn Chemical Co., Chicago, Ill., Sept. 26, 1931.

cities of the United States, 1932—Continued

	Analyses (parts per million)												
	Total dissolved solids	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulphate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Total hardness as $CaCO_3$[a]	No.
----------	291	20	0.0	58	10	[a] 22		235	28	9	0	186	193
A-------	306	5	Trace	37	11	[a] 58		193	53	37	0	138	194
B-------	329	4	-------	62	14	[a] 18		185	63	24	2	212	
C-------	304	20	1.6	71	15	27		223	65	9.7	3.0	239	
----------	539	9	Trace	70	33	[a] 80		328	86	89	0	310	195
----------	761	25	Trace	172	32	[a] 22		433	191	38	0	561	196
A-------	245	9	.0	41	4	[a] 25		34	101	27	2	119	197
B-------	[a] 403	29	1.0	73	16	51		261	61	41	2.3	248	
----------	[w]1,499	14	.15	117	29	[a] 374		244	234	552	2	411	198
A-------	207	-------	.05	34	[a] 6.1	[a] 15		45	72	22	-------	[e] 110	199
B-------	258	-------	.05	42	[a] 6.1	[a] 22		52	86	32	-------	[e] 130	
C-------	172	-------	.05	30	[a] 5.3	[a] 12		43	63	16	-------	[e] 97	
D-------	407	-------	.03	60	[a] 12	[a] 42		52	144	70	-------	[e] 200	
E-------	133	-------	.05	21	[a] 3.8	[a] 13		29	53	12	-------	[e] 68	
----------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	200
----------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	201
Av------	104	16	.49	21	3.7	6.8		78	8.3	2.0	2.5	68	202
----------	221	4.0	.03	39	9.1	12	2.5	56	85	18	1.6	135	203
----------	117	4.1	.04	26	3.8	6.5	1.3	51	40	3.0	4.0	81	204
----------	130	1.2	.03	36	3.9	2.2	1.8	96	23	3.2	4.6	106	205
----------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	206
----------	22	4.5	.26	1.2	1.0	1.2	.9	6.0	3.8	.7	.64	7	207
----------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	208
----------	110	4.8	[b] .79	25	4.0	8.0		77	15	12	-------	79	209

[a] Calculated. [e] Determined. [w] Includes 1.0 part of fluoride.
[b] Iron and aluminum oxides.

TABLE 5.—*Public water supplies of the larger*

No.	Description
	LOUISIANA
	[Descriptive material was furnished by J. H. O'Neill, sanitary engineer, Louisiana Board of Health]
210	Alexandria (23,025); municipal; 9 wells 500 to 1,227 feet deep supplied to a reservoir. Analyzed by W. L. Lamar, May 20, 1931. A, Reservoir; B, Monroe St. well, 750 feet deep (most concentrated water); C, St. Ann St. well, 750 feet deep (least concentrated water). Partial analyses of samples collected Nov. 24 and Apr. 16, 1931, from each of the wells indicate that all the wells furnish sodium bicarbonate water. Analysis A probably represents about the average concentration of the water regularly delivered to consumers.
211	Baton Rouge (30,729); Baton Rouge Water Works Co.; Lula Ave. station supplied by 5 wells (nos. 1 to 5) 1,600 feet deep and 1 well (no. 6) 2,100 feet deep, Lafayette St. station supplied by 4 wells (nos. 4 to 7) 2,100 feet deep, reserve supply from 3 wells (nos. 8 to 10) at the Lafayette Street station 900, 900, and 350 feet deep. Analyzed by H. S. Haller, U.S. Geological Survey, Feb. 25, 1931. A, Lula Ave. station; B, Lafayette St. station (wells 4 to 7). Partial analyses of samples collected Nov. 5, 1930, from the individual wells used for the regular supply indicate that the analyses given represent the composition of the water delivered to consumers.
212	Lafayette (14,635); municipal; 1 well 158 feet deep known as Filtration Plant well; aeration, lime added for iron removal, filtration without other coagulation. Auxiliary supply from Hopkins St. well, 164 feet deep, connected to filtration plant and also directly to city reservoir, and from Simcoe St. well, 226 feet deep, connected directly to city reservoir. Analysis of tap sample by W. L. Lamar, July 27, 1932 (Filtration Plant well in service).
213	Lake Charles (15,791); Gulf States Utilities Co.; 9 wells (nos. 1 to 9), 650, 650, 680, 680, 680, 680, 700, 525, 700 feet deep; filtered. Well 9 is of sufficient capacity to furnish the total supply. Analyzed by Fort Worth Laboratories, Fort Worth, Tex., Feb. 13, 1929.
214	New Orleans (458,762); municipal; Mississippi River; softened with lime, filtered. Analyzed by A. A. Hirsch, Sewage and Water Board of New Orleans, 1931. The samples were composited over a period of a year. A, Treated water; B, raw water. Daily determinations on the treated water for the year 1930: Alkalinity 21 to 56, average 34. Daily determinations on the raw water for the year 1930: Alkalinity 55 to 156, average 103.
215	Shreveport (76,655); municipal; Cross Lake; filtered, aerated, adjustment of pH by addition of hydrated lime at McNeil St. station. Analysis of tap sample by H. H. Pier, Department of Water and Sewerage, Jan. 24, 1933. Average results for the year 1932: Alkalinity 36, hardness 36, chloride 21, color 8.0, pH 8.0.
	MAINE
	[Descriptive material for all the supplies and the results for color given below were furnished by Elmer W. Campbell, director, Division of Sanitary Engineering, Maine Board of Health]
216	Auburn (18,571); Auburn Water District; Lake Auburn. Analyzed by E. W. Lohr, June 22, 1931. Color of semiannual samples in 1931 was 0 and 5.
217	Augusta (17,198); Augusta Water District; Carleton Pond, Lake Cobbosseecontee. Analysis of sample from Carleton Pond by E. W. Lohr, July 14, 1931. A partial analysis of a sample collected July 15, 1931, from Lake Cobbosseecontee indicates that the composition of the water is practically the same as that of Carleton Pond. Color of semiannual samples in 1931 was 15.
218	Bangor (28,749); municipal; Penobscot River; aerated, filtered, regulation of pH to around 6.3 by addition of soda ash. Average of several concordant analyses by James M. Caird, Troy, N.Y., 1929. The quality of the water is affected by sulphite waste. An average of analyses for the 10-year period 1919–28 is very similar to the analysis given. The composition of the water is fairly uniform throughout the year. Regular determinations for the year 1931. Alkalinity 3 to 14, average 7.5; hardness (monthly averages) 29 to 36; pH (monthly averages) 6.0 to 6.6, average 6.3; color 5 to 40, average 12. For the same period the color of the raw water ranged from 43 to 135 with an average of 61.
219	Biddeford (17,633); Biddeford & Saco Water Co. Supplies also Old Orchard, Saco, and part of Scarboro. Total population supplied about 27,000 in winter and about 50,000 in summer. Saco River; filtered. Analyzed by L. A. Shinn, U.S. Geological Survey, Dec. 3, 1930. The mineral content of the water is low and the range in concentration not great, so that the analysis may safely be considered as representative of the water regularly delivered to consumers. Color of semiannual samples in 1931 was 5 and 20.
220	Lewiston (34,948); Lewiston Water District; Lake Auburn. The water is practically the same as at Auburn. (See Auburn.)
221	Portland (70,810); Portland Water District, which includes Cape Elizabeth, Cumberland, Falmouth, Gorham, Higgins Beach, Prout's Neck, part of Scarboro, South Portland, Westbrook, and Windham. Total population supplied about 103,000. Lake Sebago. Analyzed by James M. Caird, Troy, N.Y. (23d Ann. Rept. of Portland Water District, p. 40, 1929). Color of semiannual samples in 1931 was 5 and 15.
222	South Portland (13,840); supplied by Portland Water District. (See Portland)
223	Waterville (15,454); Kennebec Water District, which includes Benton, part of Fairfield, Vassalboro, and Winslow. Total population supplied about 21,700. China Lake. Analyzed by H. S. Haller, U.S. Geological Survey, Feb. 27, 1931. Color of semiannual samples in 1931 was 10.
224	Westbrook (10,807); supplied by Portland Water District. (See Portland)

cities of the United States, 1932—Continued

	Analyses (parts per million)												No.
	Total dissolved solids	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulphate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Total hardness as $CaCO_3$[a]	
A	298	50	0.07	1.2	0.5	100	1.1	[l] 239	3.7	20	0.71	5	210
B	849	40	.25	4.9	.7	322	4.8	[x] 787	1.4	70	3.5	15	
C	225	52	.08	.4	.4	67	1.0	160	4.7	13	1.2	3	
A	210	39	.02	.9	.2	70	2.4	[y] 177	11	4.5	.10	3	211
B	260	24	.02	1.0	.1	97	3.0	[z] 246	11	6.1	.20	3	
	184	40	.16	36	6.6	10	1.5	[n] 146	8.8	9.0	1.2	117	212
	366	37	.1	31	7.6	67		181	5.3	72	.0	109	213
A	158	7.8		17	7.1	[a] 23		45	43	28		72	214
B	221	5.9		39	10	[a] 18		116	42	28		138	
	65	3.2	Trace	8.4	1.1		14	24	5.4	20	Trace	26	215
	28	2.0	.04	5.0	.9	2.3	.8	17	5.0	1.9	.10	16	216
	31	3.8	.01	5.0	1.0	2.4	.8	15	5.8	1.4	.50	17	217
Av	68	1.8	.11	6.9	.8	[a] 7.6		5.5	24	5.3	.02	21	218
	36	6.6	.01	3.0	1.2	1.8	1.0	1.0	13	1.8	.10	12	219
													220
	22	2.0	.05	2.8	1.3	1.2		3.4	6.8	1.5	.66	12	221
													222
	35	2.3	.02	6.4	1.1	2.0	1.3	20	6.4	2.2	.10	21	223
													224

[a] Calculated.
[l] Includes equivalent of 8 parts of carbonate (CO_3).
[n] Includes equivalent of 10 parts of carbonate (CO_3).
[x] Includes equivalent of 56 parts of carbonate (CO_3).
[y] Includes equivalent of 11 parts of carbonate (CO_3).
[z] Includes equivalent of 36 parts of carbonate (CO_3).

TABLE 5.—*Public water supplies of the larger*

No.	Description
	MARYLAND
225	Annapolis (12,531); municipal; small streams impounded into reservoirs having a total capacity of about 80,000,000 gallons, auxiliary supply from 2 wells (nos. 1 and 2), 257 and 246 feet deep; filtered, final adjustment of pH by addition of hydrated lime. The surface water is used regularly, and the wells are used only when there is a shortage of surface water or when there is considerable trouble with tastes and odors in the surface water. The well water, when used, is mixed with the surface water before filtration in proportions depending upon conditions. Analyzed by E. W. Lohr, Apr. 25, 1932. A, Reservoir supply (filtered); B, well 1 (raw water); C, well 2 (raw water).
226	Baltimore (804,874); municipal; Gunpowder River impounded; filtered, final adjustment of pH to about 7.8 by addition of lime to the filtered water. Analyses of monthly composites of samples taken every 2 hours by Baltimore Bureau of Water Supply, 1931. Daily determinations for the same year: Alkalinity 21 to 48, average 35; manganese 0.00 to 0.76, average 0.07; color 2 to 8, average 4.
227	Cumberland (37,747); municipal; Evitts Creek impounded; filtered. Analyzed by U.S. Geological Survey. A, Analysis of tap sample by E. W. Lohr, Jan. 18, 1933; B, analysis of tap sample by L. A. Shinn, Jan. 20, 1931.
228	Frederick (14,434); municipal; Tuscarora and Fishing Creeks, auxiliary supply from Linganore Creek (filtered). The auxiliary supply is used to supplement the regular supply during the period of peak load in summer. Analyzed by L. A. Shinn, U.S. Geological Survey. A, Tap sample from Tuscarora and Fishing Creeks, Apr. 15, 1931; B, sample of raw water from Linganore Creek, Apr. 19, 1931.
229	Hagerstown (30,861); municipal. Supplies also Funkstown, Smithsburg, and Williamsport. Total population supplied about 34,000. Potomac River (filtered, final adjustment of pH to about 7.3–8.2 by addition of lime); mountain supply consisting of Raven Rock and Warner Hollow Creeks. Potomac River furnishes about 70 percent of the total supply. The river and mountain streams furnish different sections of the city. These two systems are interconnected, and consumers are furnished with river, mountain streams, or the mixed water. The composition of the river water varies, but the composition of the mountain-stream water is fairly uniform throughout the year. The pH of the mountain-stream water is reported to range from about 6.7 to 7.1. The average of analyses of monthly composites of daily samples of the filtered water from the Dalecarlia filter plant, Washington, D.C., may be considered fairly representative of the Potomac River supply at Hagerstown. A, Potomac River (filtered), analyzed in laboratory of Dalecarlia filter plant, Washington, D.C., 1931; B, mountain supply, analyzed by E. W. Lohr, July 18, 1931.
230	Hyattsville (4,264); Washington Suburban Sanitary District, which includes also Bethesda, Bladensburg, Brentwood, Capitol Heights, Chevy Chase, College Park, Colmar Manor, Cottage City, Edmonston, Fairmount Heights, Kensington, Mount Rainier, North Brentwood, Riverdale, Silver Spring, Takoma Park, and a number of smaller communities. The district does not recognize any corporate town boundaries. It comprises about 102 square miles of suburban Washington in Maryland. Total population served about 55,000. Northwest Branch of Anacostia River; filtered, final adjustment of pH by addition of lime. In times of drought the supply is supplemented by filtered water from the Potomac River supply of Washington, D.C. There are two filtration plants, one at Burnt Mills (capacity, 3,500,000 gallons) and the other at Hyattsville (capacity, 1,000,000 gallons). Analysis of tap sample by E. W. Lohr, Apr. 18, 1932. Daily determinations for the year 1931: Burnt Mills plant, alkalinity 13 to 76, average 32; hardness 20 to 44, average 32; pH 6.2 to 8.6, average 7.3. Hyattsville plant, alkalinity 11 to 57, average 29; hardness 23 to 67, average 33; pH 6.0 to 8.4, average 7.4.
231	Salisbury (10,997); municipal; 5 wells 58, 57, 43, 48, and 60 feet deep, fed to reservoir; aerated through coke and treated with lime to raise the pH to about 8.0. Analyzed by E. W. Lohr, June 11, 1931.
	MASSACHUSETTS
	[Descriptions of the supplies were obtained from reports of H. W. Clark, director and chief chemist, Division of Water and Sewage Laboratories, published in annual reports of the Massachusetts Department of Public Health. The analyses are from the report for the year ending Nov. 30, 1931]
232	Arlington town (36,094); Metropolitan Water District. (See Boston)
233	Attleboro (21,769); municipal; wells about 25 to 40 feet deep, infiltration gallery. Sample for analysis collected Feb. 25, 1931.
234	Belmont town (21,748); Metropolitan Water District. (See Boston)
235	Beverly (25,086); municipal; Wenham Lake, Longham Reservoir, Ipswich River. Sample for analysis collected Feb. 17, 1931. Averages for the year 1931: Wenham Lake, hardness 31, chloride 9.6; Longham Reservoir, hardness 26, chloride 11; Ipswich River, hardness 62, chloride 8.3.

cities of the United States, 1932—Continued

	Analyses (parts per million)												
	Total dissolved solids	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulphate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Total hardness as $CaCO_3$[a]	No.
A-------	[aa] 51	12	0.05	7.6	1.6	2.1	1.8	12	17	3.0	0.0	26	225
B-------	[bb] 66	16	26	9.9	4.2	2.3	2.6	44	11	2.0	.0	42	
C-------	[aa] 62	13	11	10	2.6	2.1	1.9	28	17	2.0	.0	36	
Av------	[a] 70	4.8	.04	15	4.0	2.6		52	12	5.5	.4	54	226
Max----	[a] 77	3.4	.06	17	4.1	2.9		61	13	6.0	.2	59	
Min-----	[a] 63	6.1	.04	12	3.6	2.3		45	11	5.0	.4	45	
A-------	94	3.3	.14	25	3.6	1.5	1.9	82	11	1.5	1.6	77	227
B-------	129	5.8	.02	36	5.9	1.7	1.3	101	24	3.0	2.2	114	
A-------	15	2.6	.01	1.1	.7	1.1	1.1	4.0	3.2	1.5	.10	6	228
B-------	78	3.8	.14	15	4.2	4.8	1.4	53	8.2	3.5	10	55	
A-------	[a] 130	7.0	[b] 2.7	34	1.9	[a] 6.8		79	34	5.2	-------	93	229
B-------	55	12	.33	6.2	2.5	2.3	1.1	18	7.4	5.9	.69	26	
----------	60	12	.02	8.6	2.3	4.4	1.5	23	15	4.8	1.6	31	230
----------	71	21	.01	6.2	1.4	7.5	1.7	24	3.3	6.3	11	21	231
----------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	232
----------	52	4.5	.04	13	1.9	3.4	.8	16	16	5.5	.33	40	233
----------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	234
----------	88	4.3	.22	14	3.0	6.8	1.2	26	22	11	.66	47	235

[a] Calculated.
[b] Iron and aluminum oxide.
[aa] Includes less than 0.01 part of manganese.
[bb] Includes 0.02 part of manganese.

TABLE 5.—*Public water supplies of the larger*

No.	Description
	MASSACHUSETTS—continued
236	Boston (781,188); Metropolitan Water District, which includes Arlington town, Belmont town, Chelsea, Everett, Lexington town, Malden, Medford, Melrose, Milton town, Nahant town, Quincy, Revere, Somerville, Stoneham town, Swampscott town, Watertown town, and Winthrop town. Total population supplied about 1,385,000. Brookline (47,490) and Newton (65,276) are included in the Metropolitan Water District but used little water from the Metropolitan supply in 1932. Nashua River impounded in Wachusett Reservoir, which also receives water from the Ware River Basin and will later receive water from the Swift River Basin, Sudbury Reservoirs, and Lake Cochituate. The Wachusett Reservoir supplies the greater portion of the water. The mineral content of the water is low, and the range in concentration is not great, so that the single analysis given may be taken as reasonably representative of the composition of the water regularly delivered to consumers. Sample for analysis collected Feb. 13, 1930.
237	Brockton (63,797); municipal; Silver Lake, emergency supply from Avon Reservoir. Sample for analysis collected Jan. 14, 1931. Average for the year 1931: Hardness 6, chloride 5.8.
238	Brookline town (47,490); municipal; wells about 25 to 40 feet deep, filtration gallery; slow sand filtration, aeration, coke filtration. Sample for analysis collected in 1931.
239	Cambridge (113,643); municipal; Hobbs Brook and Stony Brook Reservoirs, auxiliary supply from Fresh Pond; filtered, aerated, final adjustment of pH to about 8.3 by addition of lime. The water from Hobbs Brook Reservoir passes into Stony Brook Reservoir. Sample for analysis collected Jan. 5, 1931. Determinations on the treated water for the year 1932: Alkalinity (daily tests) 16 to 36, average 24; hardness (occasional tests) 38 to 58, average 47; pH (daily tests) 7.1 to 8.8, average 8.6.
240	Chelsea (45,816); Metropolitan Water Water District. (See Boston)
241	Chicopee (43,930); municipal; Morton Brook and Cooley Brook Reservoirs. Sample for analysis collected Jan. 13, 1931. Averages for the two sources for the year 1931: Hardness 18 to 20, chloride 2.3 to 3.2.
242	Everett (48,424); Metropolitan Water District. (See Boston)
243	Fall River (115,274); municipal; North Watuppa Lake. Sample for analysis collected Jan. 16, 1931. Average for the year 1931: Hardness 10, chloride 5.3.
244	Fitchburg (40,692); municipal; Ashby, Scott, Falulah, and Lovell Reservoirs, Meetinghouse Pond, Wachusett Lake. Sample for analysis collected Dec. 19, 1930. Averages for different sources for the year 1931: Hardness 8 to 11, chloride 2.0 to 2.2.
245	Framingham town (22,210); municipal; Sudbury Aqueduct of Metropolitan Water District, emergency supply from filter galleries along Farm Pond. Sample for analysis collected Dec. 19, 1930.
246	Gloucester (24,204); municipal; Wallace Brook, Haskell Brook, Dikes Brook, and Babson Reservoirs. Sample for analysis collected Jan. 27, 1931.
247	Haverhill (48,710); municipal; Round, Johnsons, and Chadwick Ponds, Kenoza and Crystal Lakes, Millvale Reservoir, emergency supply from Lake Saltonstall. Sample for analysis collected Jan 22, 1931. Averages for different sources for the year 1931: Hardness 14 to 33, chloride 3.8 to 6.7.
248	Holyoke (56,537); municipal; High Service, Lower Whiting Street, Upper Whiting Street, Manham, and White Reservoirs, Ashley Ponds. Sample for analysis collected Jan. 23, 1931. Averages for different sources for the year 1931; Hardness 14 to 30, chloride 1.5 to 2.4.
249	Lawrence (85,068); municipal; Merrimack River; slow sand filters. Sample for analysis collected Nov. 28, 1931. Average for the year 1931: Hardness 21, chloride 5.9.
250	Leominster (21,810); municipal; Haynes, Morse, Distributing, Fall Brook, and No Town Reservoirs. Sample for analysis collected Jan. 23, 1931.
251	Lowell (100,234); municipal; wells about 25 to 40 feet deep; aeration, coke filtration, modified slow sand filtration. Sample of raw water for analysis collected Feb. 24, 1931. For the year 1931 an average iron content of 4.6 in the raw water was reduced to 0.34 in the filtered water.
252	Lynn (102,320); municipal; Hawkes, Breeds, Walden, and Birch Ponds, Ipswich River. Sample for analysis collected Jan. 30, 1931. Averages for different sources for the year 1931: Hardness 22 to 37, chloride 7.4 to 8.4.
253	Malden (58,036); Metropolitan Water District. (See Boston)
254	Medford (59,714); Metropolitan Water District. (See Boston)
255	Melrose (23,170); Metropolitan Water District. (See Boston)
256	Methuen town (21,069); municipal; tubular wells at Harris Brook about 25 to 40 feet deep, tubular wells at Pine Island about 25 to 40 feet deep, dug wells. Samples for analysis collected Oct. 28, 1931. Averages for the year 1931: Harris Brook tubular wells, hardness 32, chloride 5.7; Pine Island tubular wells, hardness 53, chloride 10.
257	New Bedford (112,597); municipal; Great Quittacas and Little Quittacas Ponds. Sample for analysis collected Feb. 2, 1931. Averages for the two sources for the year 1931: Hardness 10, chloride 5.0 to 5.1.
258	Newton (65,276); municipal; wells about 25 to 40 feet deep, infiltration gallery. Sample for analysis collected Feb. 18, 1931.
259	North Adams (21,621); municipal; Notch Brook, Mount Williams, Broad Brook, and James Brook Reservoirs, emergency supply from wells. Sample for analysis collected Nov. 27, 1931.
260	Northampton (24,381); municipal; Mountain St. and Avery Brook Reservoirs. Sample for analysis collected Feb. 9, 1931. Averages for different sources for the year 1931: Hardness 21, chloride 1.2 to 1.7.
261	Peabody (21,345); municipal; Spring Pond, Suntaug Lake, Tapley Brook Reservoir, emergency supply from Ipswich River and Cedar Pond. Sample for analysis collected Feb. 13, 1931. Averages for two sources for the year 1931: Hardness 25 to 26; chloride 8.1 to 8.3.

cities of the United States, 1932—Continued

	Analyses (parts per million)												No.
	Total dissolved solids	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulphate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Total hardness as $CaCO_3$[a]	
----------	43	2.1	0.12	4.4	1.0	3.9		16	9.8	3.2	0.31	15	236
----------	36	3.8	.07	2.1	.9	4.1	1.2	8.5	6.5	7.4	.0	9	237
----------	120	12	.04	24	3.4	8.8	1.9	46	29	10	.66	74	238
----------	91	5.8	.12	15	2.5	5.5	1.8	22	26	7.4	1.1	48	239
----------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	240
----------	48	9.4	.10	6.4	.9	2.7	.6	18	6.0	3.2	2.5	20	241
----------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	242
----------	40	1.7	.14	3.0	.7	4.0	.8	8.5	11	6.4	.0	10	243
----------	35	3.6	.20	3.0	.6	2.1	.8	9.8	9.2	2.0	.09	10	244
----------	40	2.4	.20	4.7	.4	3.5	1.0	15	9.6	3.0	.09	13	245
----------	60	2.8	.38	2.7	1.3	5.7	2.7	7.3	10	12	1.1	12	246
----------	58	.8	.09	9.8	1.4	3.5	1.7	21	11	5.6	.09	30	247
----------	48	6.1	.09	6.8	1.4	1.8	.5	22	7.6	2.7	.09	23	248
----------	55	6.3	.57	6.0	.9	4.1	2.4	18	10	6.6	1.1	19	249
----------	60	7.2	.18	4.8	.8	2.9	.7	9.8	13	2.5	.13	15	250
----------	124	11	4.2	12	1.2	5.7	2.5	43	8.3	8.7	.97	35	251
----------	76	4.3	.34	8.7	3.3	5.2	1.0	20	16	8.1	.13	35	252
----------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	253
----------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	254
----------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	255
----------	86	12	.65	16	1.1	4.4	2.4	30	9.9	7.0	1.6	45	256
----------	43	2.2	.11	3.4	1.1	4.2	1.0	12	10	6.2	.0	13	257
----------	108	11	.16	12	2.8	6.2	1.2	27	18	9.2	.97	41	258
----------	42	4.6	.05	6.9	1.2	1.3	.8	23	7.2	1.2	.0	22	259
----------	50	6.5	.10	9.4	1.2	1.7	.9	27	6.9	2.4	.09	28	260
----------	81	6.8	.20	8.1	3.2	5.0	2.3	17	16	10	1.2	33	261

[a] Calculated.

TABLE 5.—*Public water supplies of the larger*

No.	Description
	MASSACHUSETTS—continued
262	Pittsfield (49,677); municipal; Ashley, Sackett, Hathaway, Mill Brook, and Farnham Reservoirs, Ashley Lake, emergency supply from Onota Lake. Sample for analysis collected Feb. 5, 1931. Averages for the year 1932: Ashley Reservoir, hardness 45, chloride 1.4; Sackett Reservoir, hardness 51, chloride 1.2; Hathaway Reservoir, hardness 67, chloride 1.3; Mill Brook Reservoir, hardness 17, chloride 1.2; Farnham Reservoir, hardness 16, chloride 1.2; Ashley Lake, hardness 40, chloride 1.2.
263	Quincy (71,983); Metropolitan Water District. (See Boston)
264	Revere (35,680); Metropolitan Water District. (See Boston)
265	Salem (43,353); municipal; Wenham Lake, Longham Reservoir, Ipswich River. (For analysis see Beverly.)
266	Somerville (103,908); Metropolitan Water District. (See Boston)
267	Springfield (149,900); municipal; impounding reservoirs on Westfield Little River; aerated, filtered. Sample for analysis collected Nov. 30, 1931.
268	Taunton (37,355); municipal; Assawompsett and Elders Ponds. Sample for analysis collected Oct. 26, 1931. Averages for the two sources for the year 1931: Hardness 7 to 8, chloride 4.9 to 5.0.
269	Waltham (39,247); municipal; wells about 25 to 40 feet deep. Sample for analysis collected Feb. 24, 1931.
270	Watertown town (34,913); Metropolitan Water District. (See Boston)
271	Weymouth town (20,882); municipal; Great Pond. Sample for analysis collected Feb. 13, 1931. Average for the year 1931: Hardness 11, chloride 5.3.
272	Worcester (195,311); municipal; several impounding reservoirs. Sample for analysis collected Oct. 26, 1931. Averages for different sources for the year 1931: Hardness 10 to 28, chloride 2.1 to 2.9.
	MICHIGAN
	[Descriptions of the system and nearly all the analyses were furnished by Edward D. Rich, director, Bureau of Engineering, Michigan Department of Health]
273	Ann Arbor (26,944); municipal; 3 wells 175 feet deep. Analyzed by A. Exworthy, Michigan Department of Health, 1930.
274	Battle Creek (43,573); municipal; 24 wells 84 to 140 feet deep; iron removal for Goguac Lake wells. Analyzed by E. F. Eldridge, Michigan Department of Health, 1927.
275	Bay City (47,355); municipal. Supplies also Essexville. Total population supplied about 49,000. Saginaw Bay; softened with lime and soda ash at times, filtered, adjustment of pH. The treatment is designed to soften the water to an average hardness around 110. When a shift in the wind brings the Saginaw River water to the intake the supply is softened to a hardness of about 110. Analysis of tap sample by A. Exworthy, Michigan Department of Health, Nov. 4, 1931. Daily determinations for the year 1931: Alkalinity 63 to 102, average 91; hardness 76 to 143, average 101; pH 7.7 to 8.0, average 7.8.
276	Dearborn (50,358); municipal; Detroit supply. (See Detroit)
277	Detroit (1,568,662); municipal. Supplies also Allen Park, Dearborn, part of East Detroit, Ecorse, Ferndale, part of Garden City, Grosse Pointe Park, part of Grosse Pointe Shores, Hamtramck, Huntington Woods, small part of Inkster, Lincoln Park, Lochmoor, Melvindale, part of Oak Park, River Rouge, Riverview, part of Roseville, part of Royal Oak (see Royal Oak), unincorporated part of Royal Oak township, St. Clair Shores, and also about 9,000 consumers in the unincorporated parts of townships in Macomb, Oakland, and Wayne Counties. Total population supplied about 1,798,000. Detroit River; filtered. The composition of the water is fairly uniform throughout the year. Average of analyses of monthly composite samples by W. M. Wallace, Detroit Water Department, 1931–32. The pH of the treated water determined on the monthly composite samples was from 7.1 to 7.6 with an average of 7.4 for the year.
278	Ferndale (20,855); supplied by Detroit. (See Detroit)
279	Flint (156,492); municipal; Flint River; filtered. Average of analyses of monthly composite samples by S. J. Shank, Water Department, 1931–32. Daily determinations for the year 1931–32: Alkalinity 117 to 230; average pH. 7.7.
280	Grand Rapids (168,592); municipal; Grand River; softened, recarbonated, filtered. Analyzed by A. Exworthy, Michigan Department of Health, 1927. Daily determinations for the year 1930–31: Alkalinity 24 to 105, average 58; hardness 85 to 158, average 118; pH 7.6 to 8.9, average 8.6.
281	Hamtramck (56,268); supplied by Detroit. (See Detroit)
282	Highland Park (52,959); municipal; Lake St. Clair; filtered. Analyzed by E. F. Eldridge, Michigan Department of Health, 1926. Daily determinations for the year 1930–31: Alkalinity 74 to 83, average 78; hardness 91 to 103, average 93; pH 7.1 to 7.7, average 7.4.
283	Jackson (55,187); municipal; wells 350 to 400 feet deep. Analyzed by A. Exworthy, Michigan Department of Health, 1931.
284	Kalamazoo (54,786); municipal; 12 wells 130 to 160 feet deep, emergency supply from 6 wells. Analyzed by A. Exworthy, Michigan Department of Health, 1930. A, Central station (about 80 percent of supply); B, Born St. station (about 10 percent of supply); C, Balch St. station (about 10 percent of supply).
285	Lansing (78,397); municipal; 55 wel s 393 to 425 feet deep, in groups at various points. Analyzed by A. Exworthy, Michigan Department of Health, 1930. A, East-side wells (about 55 percent of supply); B, west-side wells (about 31 percent of supply); C, north-side wells (about 8 percent of supply); D, south-side wells (about 6 percent of supply).

cities of the United States, 1932—Continued

	Analyses (parts per million)												
	Total dissolved solids	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulphate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Total hardness as $CaCO_3$[a]	No.
----------	66	3.4	0.13	16	4.7	1.0	0.6	49	10	2.4	0.09	59	262
----------	------	------	------	------	------	------	------	------	------	------	------	------	263
----------	------	------	------	------	------	------	------	------	------	------	------	------	264
----------	------	------	------	------	------	------	------	------	------	------	------	------	265
----------	------	------	------	------	------	------	------	------	------	------	------	------	266
----------	42	3.6	.12	5.2	1.2	2.0	1.0	12	11	1.5	.15	18	267
----------	32	1.6	.17	2.0	.9	3.9	.9	7.3	7.6	4.5	.09	9	268
----------	96	8.4	.03	19	3.5	4.3	3.1	29	25	8.2	2.1	62	269
----------	------	------	------	------	------	------	------	------	------	------	------	------	270
----------	56	4.7	.30	3.4	1.5	3.2	1.2	7.3	14	6.1	.09	15	271
----------	30	2.4	.11	3.4	.6	3.3	1.0	8.5	8.1	1.9	.0	11	272
----------	370	12	.68	91	27	15		385	30	16	-------	338	273
----------	274	2.4	.97	64	15	([cc])		251	14	Trace	-------	222	274
----------	158	1.6	Trace	36	11	6.9		126	20	16	-------	135	275
----------	------	------	------	------	------	------		------	------	------	-------	------	276
Av------	119	2.7	.03	27	7.2	[a]3.2		92	19	6.2	-------	97	277
----------	------	------	------	------	------	------		------	------	------	-------	------	278
Av------	358	6.8	.0	70	30	[a]9.2		248	94	12	-------	298	279
----------	156	4	.32	23	16	5		[y]81	56	9.5	-------	123	280
----------	------	------	------	------	------	------		------	------	------	-------	------	281
----------	115	7.2	.0	28	7.7	3.0		105	13	6.0	-------	102	282
----------	434	8.8	3.7	74	23	58		[dd]340	37	62	-------	279	283
A-------	476	14	.57	102	36	12		362	104	16	-------	403	284
B-------	398	12	1.1	88	30	12		334	71	14	-------	343	
C-------	342	12	1.0	74	27	8.5		315	35	13	-------	296	
A-------	394	9.6	.91	108	32	[a]3		392	49	16	-------	401	285
B-------	[a]341	10	.74	76	27	[a]17		364	14	17	-------	301	
C-------	296	25	.85	69	22	[a]6		322	4.3	5.0	-------	263	
D-------	386	14	.63	93	34	([cc])		402	26	11	-------	372	

[a] Calculated.
[y] Includes equivalent of 11 parts of carbonate (CO_3).
[cc] Less than 5 parts.
[dd] Includes equivalent of 6 parts of carbonate (CO_3).

TABLE 5.—*Public water supplies of the larger*

No.	Description
	MICHIGAN—continued
286	Monroe (18,110); municipal; Lake Erie; filtered. The composition of the water is fairly uniform throughout the year. Analyzed by Michigan Department of Health, Oct. 27, 1924.
287	Muskegon (41,390); municipal; Lake Michigan. The composition of the water is influenced to some extent by Muskegon River. Analyzed by E. F. Eldridge, Michigan Department of Health, 1927.
288	Pontiac (64,928); municipal; wells 170 to 260 feet deep. Analyzed by M. Bidwell, Michigan Department of Health, 1929.
289	Port Huron (31,361); municipal; St. Clair River. Analyzed by E. F. Eldridge, Michigan Department of Health, 1927.
290	Royal Oak (22,904); municipal; 3 wells 134 to 230 feet deep (about 50 percent of supply). The other 50 percent of the supply is furnished by Detroit. Analysis of tap sample by A. Exworthy, Michigan Department of Health, 1930. The analysis represents the mixed water as delivered to consumers.
291	Saginaw (80,715); municipal; Saginaw River; softened, recarbonated, filtered. Analyzed by J. C. Richardson, Saginaw Water Department, 1931. Daily determinations for the year 1930–31 on the treated water: Alkalinity 15 to 41, average 27; hardness 87 to 114, average 100; pH 8.1 to 9.6, average 9.0.
292	Wyandotte (28,368); municipal; Detroit River; filtered. Analysis of composite sample by H. W. Ward, Water Department, September 1932. The composition of the water is fairly uniform throughout the year. Daily determinations for the year 1930–31: pH 7.4 to 7.8, average 7.6.
	MINNESOTA
	[Descriptions of the supplies were furnished by H. A. Whittaker, director, Division of Sanitation, Minnesota Board of Health, whose representative collected the samples that were analyzed by the U.S. Geological Survey]
293	Albert Lea (10,169); municipal; 1 well 305 feet deep. Analysis of tap sample by L. A. Shinn, U.S. Geological Survey, Nov. 19, 1930.
294	Austin (12,276); municipal; Sargent Springs. Analysis of tap sample by L. A. Shinn, U.S. Geological Survey, Nov. 19, 1930.
295	Brainerd (10,221); municipal; small reservoir fed by 8 wells 70 to 105 feed deep (33 percent), and by 2 wells 22 and 28 feet deep and 40 feet in diameter (67 percent); iron and manganese removal. The 28-foot well has 8-inch pipes driven for 50 feet from the bottom of the well. The raw water contains objectionable amounts of iron and manganese. The wells furnish water of about the same composition. Analysis of tap sample by L. A. Shinn, U.S. Geological Survey, Nov. 12, 1930.
296	Duluth (101,463); municipal; Lake Superior. The composition of the water is fairly uniform throughout the year. Analyzed by L. A. Shinn, U.S. Geological Survey, Nov. 10, 1930.
297	Faribault (12,767); municipal; 3 wells 1,000, 750, and 1,385 feet deep, emergency supply consists of 1 dug well 21 feet deep and 18 feet in diameter and 1 dug well 21 feet deep and 22 feet in diameter. Analysis of tap sample representing main supply by L. A. Shinn, U.S. Geological Survey, Nov. 19, 1930.
298	Hibbing (15,666); municipal; mine shaft 340 feet deep (67 percent), 8 wells 88 to 138 feet deep (33 percent). Analyzed by U.S. Geological Survey. A, Analysis of sample from mine shaft by E. W. Lohr, Jan. 23, 1933; B, analysis of sample from wells 88 to 138 feet deep by L. A. Shinn, Nov. 1, 1930.
299	Mankato (14,038); municipal; 4 wells 60 feet deep, auxiliary supply from 2 wells 320 feet deep. Analysis of tap sample from 60-foot wells by L. A. Shinn, U.S. Geological Survey, Dec. 19, 1930. A partial analysis of a sample collected at the same time from one of the 320-foot wells indicates water of the same general character as shown by the analysis for the 60-foot wells.
300	Minneapolis (464,356); municipal; Mississippi River; filtered. Average of analyses of monthly composites of daily samples by Minneapolis Water Department, 1931. The analyses of the monthly composite samples show the following range in concentration of the water for the year 1931; Alkalinity 57 to 199, hardness 142 to 207, sulphate 12 to 79. The pH of the treated water determined 4 times a month during the year 1931 was 6.0 to 7.5, average 6.9.
301	Rochester (20,621); municipal; group of 3 dug wells 40 feet deep and 18 to 22 feet in diameter, group of 5 drilled wells 415 feet deep, group of 4 drilled wells 50 feet deep, and 1 well 500 feet deep. The groups of wells furnish about equal quantities of water. Analyzed by L. A. Shinn, U.S. Geological Survey, Dec. 17, 1930. A, Group of wells 415 feet deep; B, group of wells 50 feet deep. A partial analysis of a sample collected on the same date from the 500-foot well indicates that the composition of the water from this well can be represented fairly well by analysis B.
302	St. Cloud (21,000); municipal; Mississippi River; aerated, filtered. Analyzed by L. A. Shinn, U.S. Geological Survey, Nov. 12, 1930. The composition of the water varies throughout the year. Regular determinations for the year 1930: Alkalinity 72 to 194; pH 6.8 to 8.0, average 7.1.
303	St. Paul (271,606); municipal; chain of 4 lakes maintained at normal level by pumpage from Mississippi River, emergency supply from a second chain of lakes and also 40 wells; aerated, filtered. Average of monthly composites of daily samples by R. A. Thuma, water department, 1931. Regular determinations for the year 1931: Alkalinity 128 to 158, hardness 151 to 175, pH 6.9 to 7.1.
304	South St. Paul (10,009); municipal; 2 wells (nos. 1 and 2) 982 feet deep. Well 2 furnishes about 66 percent of the total supply. Analyzed by E. W. Lohr, Feb. 4, 1933. A, Well 1; B, well 2.

cities of the United States, 1932—Continued

	Analyses (parts per million)												
	Total dissolved solids	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulphate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Total hardness as $CaCO_3$[a]	No.
----------	[a]146	8.0	Trace	32	10	5.5		107	23	15	-------	121	286
----------	172	10	0.34	40	13	2		148	20	8	-------	153	287
----------	346	11	.78	66	26	34		349	6.8	37	-------	272	288
----------	104	4.8	Trace	28	7.5	2.5		105	14	5.5	-------	101	289
----------	[a]336	6.4	.28	22	6.3	103		196	12	90	-------	81	290
----------	263	5.0	.0	23	12	50		[ee]43	82	70	-------	107	291
----------	106	2.1	[b].8	21	9.1	6.9		92	15	6.5	-------	90	292
----------	404	28	.12	98	33	10	3.5	464	23	1.0	3.6	380	293
----------	244	15	.08	59	21	3.4	2.2	273	14	1.0	3.3	234	294
----------	252	19	.08	62	14	4.7	2.6	241	25	2.0	1.0	212	295
----------	44	3.7	.08	16	3.8	.9	1.0	53	3.3	2.0	1.0	56	296
----------	372	13	.08	92	30	7.2	3.8	385	35	3.0	14	353	297
A-------	150	14	.04	26	13	6.0	2.1	98	32	11	.10	118	298
B-------	258	25	.08	51	23	5.6	2.4	218	46	1.1	.50	222	
----------	519	28	.02	94	34	21	4.4	314	156	4.0	1.6	374	299
Av------	[aa]210	9.7	.07	44	15	4.0		167	36	3.8	.20	172	300
A-------	267	20	.02	71	18	3.8	1.6	248	22	5.0	22	251	301
B-------	346	16	.06	83	22	11	3.8	[n]304	41	21	9.1	298	
----------	188	4.2	.04	38	17	3.9	2.7	183	23	1.0	.10	165	302
Av------	187	1.7	.04	36	17	5.2		177	19	4.5	.25	160	303
A-------	442	18	.02	91	32	26	3.0	351	37	48	18	359	304
B-------	245	7.6	.49	56	20	7.4	5.8	264	8.6	9.0	.0	222	

[a] Calculated.
[b] Iron and aluminum oxides.
[n] Includes equivalent of 10 parts of carbonate (CO_3).
[aa] Includes less than 0.01 part of manganese.
[ee] Includes equivalent of 12 parts of carbonate (CO_3).

TABLE 5.—*Public water supplies of the larger*

No.	Description
	MINNESOTA—continued
305	Virginia (11,963); municipal; 2 wells 273 feet deep (owned by Oliver Iron Mining Co.), reserve supply from 4 wells 750, 450, 450, and 400 feet deep; coagulated, settled. Analysis of tap sample by L. A. Shinn, U.S. Geological Survey, Nov. 12, 1930.
306	Winona (20,850); municipal; 6 wells about 500 feet deep, supplying a reservoir. Analysis of tap sample by L. A. Shinn, U.S. Geological Survey, Dec. 17, 1930.
	MISSISSIPPI
	[Most of the analyses were furnished by W. F. Hand, State chemist. Several of these were made especially for this report. Some of the descriptive material was furnished by H. A. Kroeze, director, Bureau of Sanitary Engineering, Mississippi Board of Health]
307	Biloxi (14,850): municipal; station 1, 1 well 1,219 feet deep and 3 wells about 900 feet deep; station 2, 2 wells 1,178 and about 900 feet deep. All the water flows to small reservoirs and is pumped directly from the reservoirs to the mains. Analyzed by W. F. Hand, Mississippi State Chemical Laboratory, July 28, 1932.
308	Clarksdale (10,043); municipal; main well (no. 1) 870 feet deep supplied to mains, reserve well (no. 2) supplied to mains or storage reservoir, 3 wells about 1,380 feet deep supplied to a reservoir but furnish only a very small proportion of the total supply. Analyzed by W. F. Hand, Mississippi State Chemical Laboratory. A, Well 1, Apr. 23, 1930; B, well 2, Apr. 23, 1930; C, well 1,380 feet deep, January 1915.
309	Columbus (10,743); municipal; Luxapalila Creek; filtered. Analyzed by W. F. Hand, Mississippi State Chemical Laboratory, Sept. 9, 1932.
310	Greenville (14,807); municipal; 5 wells (nos. 1 to 5) about 520 feet deep. Analysis of tap sample by W. F. Hand, Mississippi State Chemical Laboratory, July 29, 1932.
311	Greenwood (11,123); municipal; 5 wells 730 to 760 feet deep, 1 well 1,590 feet deep. A, Analysis of sample from 760-foot well by W. F. Hand, Mississippi State Chemical Laboratory, May 25, 1932; B, analysis of sample from 1,590 foot well by Dearborn Chemical Co., Chicago, Ill., Sept. 6, 1928.
312	Gulfport (12,547); municipal; wells probably 500 to 1,300 feet deep. Analyzed by W. F. Hand, Mississippi State Chemical Laboratory, Apr. 24, 1930.
313	Jackson (48,282); municipal; Pearl River; filtered, final adjustment of pH to about 7.4–7.6 by addition of hydrated lime. A, Sample of treated water of about average composition, analyzed by W. F. Hand, Mississippi State Chemical Laboratory, Sept. 18, 1929; B, analyses of raw water from Pearl River near Jackson by U.S. Geological Survey, 1906–7 (Water-Supply Paper 236, p. 89, 1909). The analyses of the raw water indicate the range in composition and general character of the water.
314	Laurel (18,017); municipal; 7 wells 400 feet deep, 1 well 220 feet deep. Analysis of sample from Layne well 2, 400 feet deep, by W. F. Hand, Mississippi State Chemical Laboratory, Oct. 13, 1930.
315	McComb (10,057); municipal; 2 wells about 90 feet deep. Analyzed by W. F. Hand, Mississippi State Chemical Laboratory, May 3, 1929.
316	Meridian (31,954); municipal; springs impounded; filtered. Analyzed by W. F. Hand, Mississippi State Chemical Laboratory, Oct. 4, 1930.
317	Natchez (13,422); municipal; Riverside plant supplied by 5 wells (nos. 2, 4, 5, 7, and 8) about 275 to 315 feet deep, Briel Avenue plant supplied by 1 well (no. 1) 417 feet deep. All the wells are near Mississippi River. Analysis of tap sample by E. W. Lohr, Aug. 21, 1931. Partial analyses of samples collected Aug. 21 and 22, 1931, from each of the wells indicate that the composition of the water from the individual wells is about the same.
318	Vicksburg (22,943); municipal; Mississippi River; filtered. Analyses of samples of treated water collected at different river stages. A, Gage height 20.0 feet, Mar. 9, 1931; B, gage height 5.9 feet, Feb. 7, 1931; C, gage height 30.8 feet, Apr. 22, 1931. Analyzed by U.S. Geological Survey. A and B analyzed by L. A. Shinn, C analyzed by W. L. Lamar.
	MISSOURI
	[Descriptions of most of the supplies and a number of the analyses were furnished by W. Scott Johnson, chief public health engineer, Missouri Board of Health]
319	Cape Girardeau (16,227); Missouri Utilities Co.; Mississippi River; filtered. The composition of the water varies throughout the year. The coagulation and filtration reduce the silica and iron; the bicarbonate may be decreased, and the sulphate is increased. Average of analyses of raw water from Mississippi River near Chester, Ill., by U.S. Geological Survey, 1906–7 (Water-Supply Paper 239, p. 83, 1910).
320	Columbia (14,967); municipal; 6 wells 850 to 1,200 feet deep. Analysis of tap sample by H. W. Mundt, Missouri Bureau of Geology and Mines, June 10, 1930.
321	Hannibal (22,761); municipal; Mississippi River; filtered. The coagulation and filtration reduce the silica and iron, the bicarbonate may be reduced, and the sulphate is increased. Average of analyses of composite samples of raw water from Mississippi River near Quincy, Ill., by U.S. Geological Survey, 1906–7 (Water-Supply Paper 239, p. 82, 1910). Regular determinations on weekly composite samples for the year 1932: Alkalinity 80 to 202, average 146; hardness 113 to 284, average 180; sulphate 25 to 48, average 37.

cities of the United States, 1932—Continued

	Analyses (parts per million)												No.
	Total dissolved solids	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulphate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Total hardness as $CaCO_3$[a]	
----------	201	12	0.12	43	18	7.1	2.7	177	23	18	0.50	181	305
----------	543	19	.15	98	40	30	9.0	349	112	40	25	409	306
----------	444	27	.17	2.1	0.2	167		272	2.7	114	1.3	6	307
A-------	424	25	4.5	12	5.2	152		346	4.9	64	-------	51	308
B-------	378	34	2.8	5.7	2.8	141		366	1.2	26	-------	26	
C-------	474	78	2.6	.6	.6	168		354	2.5	52	-------	4	
----------	30	2.2	.76	1.9	.7		4.5	4.9	13	4.5	-------	8	309
----------	283	10	.61	.7	.2	109		271	.4	24	.0	3	310
A-------	211	13	1.4	.9	.2	83		[n] 215	6.2	8.0	.0	3	311
B-------	1,138	11	[b] 1.2	8.8	2.9	448		589	6.5	367	Trace	34	
----------	310	18	2.1	1.4	.4	116		278	10	-------	13	5	312
A-------	60	3.9	1.2	5.2	1.3	8.7		16	14	8.0	.0	18	313
B Av.--	59	18	.37	7.1	1.1	8.9		32	6.4	3.4	.7	22	
B Max.	76	20	Trace	9.7	1.6	13		56	6.2	3.2	.5	31	
B Min.	36	14	.20	4.4	Trace	------	------	12	-------	4.0	.2	11	
----------	150	50	.17	2.7	.9	33		81	13	7.0	.0	10	314
----------	50	8.3	.04	5.7	[a] 1.9	8.4		16	9.5	10	.0	[•] 22	315
----------	25	3.4	.5	1.6	.7	3.0		7.1	6.5	4.4	.0	7	316
----------	358	51	1.1	40	15	63	9.9	339	14	4.7	3.0	162	317
A-------	222	6.8	.01	40	8.8	18	2.2	80	75	25	4.2	136	318
B-------	278	6.6	.02	48	14	26	2.4	132	74	35	2.5	177	
C-------	236	14	.04	45	6.7	14	2.4	80	69	22	3.1	140	
Av------	269	22	.39	44	16	21		174	56	9.8	2.7	176	319
----------	411	13	.25	63	29	46		[••] 355	35	29	4.3	276	320
Av------	203	18	.46	36	16	11		175	25	4.4	2.2	156	321

[a] Calculated.
[b] Iron and aluminum oxides.
[n] Includes equivalent of 10 parts of carbonate (CO_3).
[•] Determined.
[••] Includes equivalent of 12 parts of carbonate (CO_3).

TABLE 5.—*Public water supplies of the larger*

No.	Description
	MISSOURI—continued
322	Independence (15,296); supplied by Kansas City. (See Kansas City)
323	Jefferson City (21,596); Capital City Water Co.; Missouri River; softened with lime, recarbonated, filtered. Analysis of tap sample by R. T. Rolufs, Missouri Bureau of Geology and Mines, Apr. 25, 1932. There is considerable variation in the composition of the water throughout the year. The treatment is designed to soften the water delivered to consumers to a hardness between 100 and 120. Daily determinations on the treated water for the period Jan. 2 to Apr. 22, 1932: Alkalinity 40 to 65, hardness 88 to 141. Daily determinations on the raw water for the same period: Alkalinity 88 to 246, hardness 136 to 306.
324	Joplin (33,454); Joplin Water Works Co. (controlled by American Water Works & Electric Co., 50 Broad St., New York, N.Y.); Shoal Creek; filtered. Analyzed by Margaret D. Foster, U.S. Geological Survey, Mar. 10, 1922. Analytical data for the year 1931 indicate that the composition of the water varies throughout the year and that the average concentration of the water is probably somewhat less than is shown by the analysis.
325	Kansas City (399,746); municipal. Supplies also Independence, Lees Summit, and Sugar Creek. Total population supplied about 418,700. Missouri River; filtered. The composition of the water varies throughout the year. The pH of the filtered water for the year 1930–31 ranged from 7.6 to 8.2, with an average of 7.9. Analyses of monthly composites by Kansas City Water Department, 1930–31.
326	Maplewood (12,657); supplied by St. Louis County Water Co. (See University City)
327	Moberly (13,772); municipal; 3 impounding reservoirs; filtered, adjustment of pH to 7.6–8.4 at 1 plant. Analyses of tap samples by Missouri Bureau of Geology and Mines. A, July 22, 1929; B, May 24, 1930; C, Feb. 3, 1931. A and B analyzed by H. W. Mundt; C analyzed by R. T. Rolufs. Regular determinations for a year on the filtered water: Alkalinity 70 to 110, hardness 120 to 210, pH (average) 8.2.
328	St. Charles (10,491); municipal; Missouri River; coagulated, settled. The composition of the water varies throughout the year. Analyzed by H. W. Mundt, Missouri Bureau of Geology and Mines. A, Tap sample, July 29, 1929; B, tap sample, July 15, 1930. (See also analysis D for St. Louis.)
329	St. Joseph (80,935); St. Joseph Water Co. (controlled by American Water Works & Electric Co., 50 Broad St., New York, N.Y.); Missouri River; filtered. The composition of the water varies throughout the year but is probably not very different from that of the water at Kansas City. (For analyses see Kansas City.)
330	St. Louis (821,960); municipal. Chain of Rocks plant supplied by Mississippi River (about 60 percent), Howard Bend plant supplied by Missouri River (about 40 percent); softened with lime, recarbonated at Howard Bend plant, filtered. Average of analyses by St. Louis Water Department, 1931–32. A, Mississippi River (softened water); B, Mississippi River (raw water); C, Missouri River (softened water); D, Missouri River (raw water). The composition of the water varies throughout the year. Regular determinations on the effluents for the year 1931–32: Chain of Rocks plant, alkalinity 22 to 59, hardness 52 to 114, pH 8.0 to 9.7, average 9.1; Howard Bend plant, alkalinity 24 to 67, hardness 51 to 117, pH 7.8 to 9.8, average 8.9.
331	Sedalia (20,806); Sedalia Water Co.; Spring Fork Lake, emergency supply from Lake Tebo; filtered. Analysis of tap sample by R. T. Rolufs, Missouri Bureau of Geology and Mines, May 4, 1932. Other analyses made in 1929, 1930, and 1931 are similar. Daily determinations for the year 1931-32: Alkalinity 40 to 50, average 45; hardness 55 to 75, average 65; pH 7.6 to 8.2, average 7.9.
332	Springfield (57,527); Springfield City Water Co.; McDaniel Lake, reserve supply from Valley and Ritter Reservoirs, Fulbright Spring, and 3 wells 1,300 to 1,500 feet deep; filtered, adjustment of pH to 7–8. Analysis of tap sample from McDaniel Lake by E. W. Lohr, June 18, 1932. Daily determinations for the period Sept. 1, 1931, to Feb. 29, 1932: Alkalinity 102 to 186, average 129; pH 7.1 to 7.7, average 7.4.
333	University City (25,809); St. Louis County Water Co. Supplies also Clayton, Ferguson, Glendale, Maplewood, Richmond Heights, Shrewsbury, Webster Groves, and an unincorporated population. Total population supplied about 180,000. Missouri River; softened with lime, recarbonated, filtered. The composition of the water can probably be represented fairly well by the average of analyses for the Missouri River supply at St. Louis. (See analyses C and D for St. Louis). Daily determinations on the treated water for the year 1932: Hardness 80 to 186, average 111; pH 7.5 to 9.9, average 8.8.
334	Webster Groves (16,487); supplied by St. Louis County Water Co. (See University City)
	MONTANA
	[Descriptions and analyses for 4 supplies were furnished by H. B. Foote, director, Division of Water and Sewage, Montana Department of Public Health]
335	Anaconda (12,494); Anaconda Copper Mining Co.; Silver Lake 60 percent, Lake Hearst 40 percent. Analyzed by W. M. Cobleigh, Montana State College, Oct. 20, 1921. A, Silver Lake; B, Lake Hearst.
336	Billings (16,380); municipal; Yellowstone River; filtered. Single analysis of the raw water by J. W. Forbes for Montana Board of Health, Mar. 21, 1930. The composition of the water varies throughout the year, and the analysis probably represents a concentration higher than the average. Regular determinations on the treated water for the year 1931–32: Alkalinity 49 to 170, average 125.

cities of the United States, 1932—Continued

	Analyses (parts per million)												
	Total dissolved solids	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulphate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Total hardness as $CaCO_3$[a]	No.
------	------	------	------	------	------	------	------	------	------	------	------	------	322
------	301	4.4	0.07	42	0	44		57	124	14	2.5	105	323
------	175	8.6	.12	49	5.6	4.1	1.3	149	20	3.0	6.4	145	324
Av.	[a] 422	13	[b] 3.1	62	16	54		187	164	18	------	221	325
Max.	[a] 534	16	[b] 2.0	82	24	62		262	195	24	------	303	
Min.	[a] 355	10	[b] 4.0	50	12	42		146	129	16	------	174	
------	------	------	------	------	------	------	------	------	------	------	------	------	326
A	182	7.6	------	44	5.9	3.9		64	80	2.1	1.3	134	327
B	253	2.8	.20	55	9.3	11		93	107	3.9	.84	176	
C	240	3.6	.05	51	5.7	18		[g] 124	71	4.5	2.1	151	
A	[a] 314	9.6	------	59	11	27		111	143	8.5	1.4	193	328
B	[a] 370	8.8	.20	63	12	40		109	179	12	1.8	207	
------	------	------	------	------	------	------	------	------	------	------	------	------	329
A	228	8.0	[b] 2.5	21	7.5	36		[gg] 48	94	18	4.9	83	330
B	310	14	[b] 1.7	47	10	40		153	91	18	4.6	158	
C	222	9.7	[b] 2.5	21	8.0	38		[gg] 51	94	18	3.5	85	
D	307	12	[b] 1.5	48	12	39		158	88	18	3.9	169	
------	118	2.4	.20	17	6.9	7.9		58	31	2.3	1.5	71	331
------	123	5.3	.12	33	5.9	2.1	1.5	114	10	3.2	2.9	107	332
------	------	------	------	------	------	------	------	------	------	------	------	------	333
------	------	------	------	------	------	------	------	------	------	------	------	------	334
A	140	------	Trace	30	7.0	14		149	9.0	1.0	------	104	335
B	55	------	Trace	9.4	3.0	2.3		30	15	Trace	------	36	
------	305	------	.6	48	27	24		159	134	8.0	------	231	336

[a] Calculated.
[b] Iron and aluminum oxides.
[g] Includes equivalent of 11 parts of carbonate (CO_3).
[gg] Includes equivalent of 12 parts of carbonate (CO_3).

TABLE 5.—*Public water supplies of the larger*

No.	Description
	MONTANA—continued
337	Butte (39,532); Butte Water Co.; Big Hole River (50 percent), impounding reservoir on Basin Creek (35 percent), Moulton supply from impounding reservoir on headwaters of Yankee Doodle Creek (15 percent). There is some variation in the composition of the water throughout the year. Analyzed by Montana Board of Health, Feb. 18, 1932. A, Big Hole River; B, Basin Creek; C, Moulton supply.
338	Great Falls (28,822); municipal; Missouri River; filtered. The composition of the water varies throughout the year. The average pH for the filtered water for the year 1931–32 was 7.6. A, Analyzed by Montana Board of Health, Sept. 29, 1931; B, analyzed by W. M. Cobleigh, Montana State College, Aug. 28, 1920.
339	Helena (11,803); municipal; Tenmile Creek and tributaries 66 percent, Bed Rock well 14 percent, Eureka well 11 percent, Hale Reservoir 9 percent, Woolstan well (rarely used). Analyzed for Montana Board of Health, 1930. A, Tenmile Creek; B, Bed Rock well; C, Eureka well; D, Hale Reservoir.
340	Missoula (14,657); Montana Power Co.; Rattlesnake Creek. Analyzed by J. W. Forbes for Montana Board of Health, Feb. 18, 1932.
	NEBRASKA
	[Descriptive material for the supplies was furnished by L. O. Vose, director of laboratories, Bureau of Health, Nebraska Department of Public Welfare]
341	Fremont (11,407); municipal; 20 wells about 70 feet deep. Analyzed by Dearborn Chemical Co., Chicago, Ill., 1930.
342	Grand Island (18,041); municipal; 7 wells 70, 101, 72, 88, 89, 72, and 91 feet deep. Analyzed by E. W. Lohr, May 20, 1931.
343	Hastings (15,490); municipal; 5 wells 184 to 192 feet deep. Analyzed by Dearborn Chemical Co., Chicago, Ill. Sample collected about June 1930.
344	Lincoln (75,933); municipal; 5 wells known as Ashland wells (nos. 1 to 5) 50 to 86 feet deep, supplemented occasionally by wells 175 to 200 feet deep at A St. Reservoir. Analyzed by C. J. Frankforter, University of Nebraska. A, Average for 5 Ashland wells, February 1932; B, Ashland well 2 (Ashland well of maximum concentration), February 1932; C, Ashland well 5 (Ashland well of minimum concentration), February 1932; D, A St. Reservoir, September 9, 1930.
345	Norfolk (10,717); municipal; 2 wells 100 and 130 feet deep. Analyzed by E. W. Lohr, May 1931...
346	Omaha (214,006); municipal; Missouri River at Florence; filtered. Analyzed by Water Department, 1931. A, Average; B, month of maximum hardness (January); C, month of minimum hardness (July).
	NEVADA
	[Descriptions of the supplies and analyses were furnished by S. C. Dinsmore, State food and drug commissioner]
347	Elko (3,217); municipal; 4 wells (nos. 1, 5, 9, and 10) 30, 160, 157, and 397 feet deep. Well 10 is reported to furnish harder water than the other wells. Analysis of tap sample by W. B. Adams, Division of Food and Drug Control, Reno, August 1928.
348	Ely (3,045); Ely Water Co.; deep-seated springs fed to a small reservoir, auxiliary supply from springs in bottom of Georgetown Ranch Reservoir. Analyzed by W. B. Adams, Division of Food and Drug Control, Reno. A, Deep-seated springs, May 1929; B, Georgetown Ranch Reservoir, July 1931.
349	Las Vegas (5,165); Las Vegas Land & Water Co. (controlled by Union Pacific System, Omaha, Nebr.); 1 well 635 feet deep. Analyzed by W. M. Barr, Union Pacific System, Jan. 26, 1928.
350	Reno (18,529); Sierra Pacific Power Co. (under executive management of Stone & Webster Service Corporation, 90 Broad St., New York, N.Y.). Supplies also Sparks. Total population supplied about 23,000. Truckee River and Hunter Creek impounded, 2 wells (nos. 1 and 2) 590 and 400 feet deep. The water is a mixture of varying proportions from each of the sources, and the composition of the water furnished consumers varies accordingly. Analyzed by W. B. Adams, Division of Food and Drug Control, Reno. A, Truckee River, July 1930; B, Hunter Creek, July 1930; C, well 1, June 1930; D, well 2, January 1931.
351	Sparks (4,508); Sierra Pacific Power Co. (See Reno)...
	NEW HAMPSHIRE
	[Descriptive material relating to the supplies was furnished by C. D. Howard, director of division of chemistry and sanitation, New Hampshire Board of Health, who also furnished the analytical results in the descriptive text below]
352	Berlin (20,018); municipal; Upper Ammonoosuc River (about 60 percent), group of four small reservoirs (about 40 percent). Analysis of tap sample from Upper Ammonoosuc River by E. W. Lohr, Jan. 22, 1932. A partial analysis of a tap sample from the reservoir supply collected at the same time shows about the same composition. Examination of occasional spot samples during the year 1930–31: Hardness 14 to 19; color 20 to 45, average 30.
353	Concord (25,228); municipal; Penacook Lake, 150 driven wells 37½ feet deep. Analysis of water from Penacook Lake by W. L. Lamar, May 13, 1931. A partial analysis of a sample collected the same day from the driven wells indicates that the analysis given represents the composition of the water delivered regularly to consumers. Examination of occasional spot samples during the year 1930–31: Hardness 14 to 18; color 0 to 10, average 7.

cities of the United States, 1932—Continued

	Analyses (parts per million)												
	Total dissolved solids	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulphate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Total hardness as $CaCO_3$[a]	No.
A-------	136	6.8	0.0	19	5.4	[a] 21		104	26	2.0	-------	70	337
B-------	116	7.6	.0	17	4.0	[a] 16		76	28	1.0	-------	59	
C-------	122	38	.0	18	1.0	[a] 19		64	36	1.0	-------	49	
A-------	276	-------	.0	22	15	[a] 51		177	57	16	-------	116	338
B-------	193	-------	Trace	37	14	[a] 2.6		137	33	6.3	-------	150	
A-------	91	30	Trace	8.0	3.0	11		27	29	1.0	-------	32	339
B-------	276	27	Trace	62	22	10		275	29	5.0	-------	245	
C-------	288	15	Trace	55	20	10		256	36	6.0	-------	220	
D-------	243	26	Trace	51	13	14		194	42	5.0	-------	181	
----------	60	9.0	.0	3.0	4.0	[a] 16		37	27	.0	-------	24	340
----------	355	18	[b] 1.2	77	3.8	32		205	67	21	13	208	341
----------	261	33	.02	47	8.1	15	8.5	135	31	16	31	151	342
----------	278	21	[b] 6.2	32	6.8	55		209	36	11	5.1	108	343
A-------	[a] 230	34	[b] 2.9	54	.1	17		115	53	12	.12	135	344
B-------	[a] 280	35	[b] 1.4	60	Trace	29		107	85	17	.0	150	
C-------	[a] 190	35	[b] 2.8	44	Trace	13		111	29	11	.38	110	
D-------	[a] 224	32	[b] 2.2	51	7.8	11		163	23	17	.0	159	
----------	316	33	.75	77	15	13	6.9	293	39	3.1	.10	254	345
A-------	[a] 484	12	[b] 3.6	66	21	65		192	206	16	-------	251	346
B-------	[a] 559	14	[b] 2.9	82	33	59		259	224	17	-------	340	
C-------	[a] 334	12	[b] 2.2	44	12	50		130	138	12	-------	159	
----------	730	80	Trace	54	11	[a] 204		532	119	45	-------	180	347
A-------	210	16	Trace	48	18	[a] 12		236	18	4	2	194	348
B-------	321	25	Trace	69	21	[a] 17		268	45	20	-------	259	
----------	276	14	[b] 6.3	47	26	[a] 11		231	35	15	1.0	224	349
A-------	84	21	[b] .8	13	4	[a] 3		52	11	2.5	0	49	350
B-------	118	33	[b] .3	19	3	[a] 5		34	40	1.5	0	60	
C-------	302	43	Trace	54	13	[a] 17		151	73	18	0	188	
D-------	647	47	Trace	42	13	[a] 151		195	269	33	-------	158	
----------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	351
----------	27	7.5	.05	2.6	.8	1.4	.4	7.0	5.3	.5	.50	10	352
----------	28	2.0	.05	3.0	1.0	2.7	.8	9.0	7.2	1.8	.05	12	353

[a] Calculated. [b] Iron and aluminum oxides.

TABLE 5.—*Public water supplies of the larger*

No.	Description
	NEW HAMPSHIRE—continued
354	Dover (13,573); municipal; Layne well, 85 feet deep (about 80 percent), Hussey Springs (about 20 percent), emergency supply from Willands Pond; aeration, slow sand filtration. Analysis of sample from well supply by E. W. Lohr, Aug. 13, 1931. All sources of supply furnish water of low mineral content.
355	Keene (13,794); municipal; Echo Lake; slow sand filtration. Analyzed by L. A. Shinn, U.S. Geological Survey, Nov. 1, 1930. The mineral content of the water is fairly uniform throughout the year. Examination of occasional spot samples during the year 1930–31: Color 5 to 15, average 12.
356	Laconia (12,471); Laconia Water Co.; Lake Paugus. Analyzed by E. W. Lohr, Aug. 14, 1931. Examination of occasional spot samples during the year 1930–31: Color 8 to 10, average 9.
357	Manchester (76,834); municipal; Lake Massabesic. Analyzed by L. A. Shinn, U.S. Geological Survey, Oct. 20, 1930. Examination of occasional spot samples during the year 1930–31: Color 15 to 25, average 20.
358	Nashua (31,463); Pennichuck Water Works; 15 wells (nos. 1 to 15) 16 to 38 feet deep. The wells are close to one another except no. 15, which is only about 200 feet away. Analysis of sample from well 13 by L. A. Shinn, U.S. Geological Survey, Oct. 10, 1930. Partial analyses of samples collected Oct. 10, 1930, from wells 2 and 15 indicate that the analysis given represents reasonably well the composition of the water delivered to consumers. Examination of occasional spot samples during the year 1930–31: Hardness 18 to 31; color 5 to 15, average 7.
359	Portsmouth (14,495); municipal; driven, drilled, and Layne wells, emergency supply from Peverly Brook. At times water from Peverly Brook, which is rather highly colored, is fed to the driven-well tract to supplement the ground water. Analysis of tap sample by E. W. Lohr, Aug. 25, 1931. Examination of occasional spot samples during the year 1930–31: Color 0 to 15, average 7.
360	Rochester (10,209); municipal; reservoir (pond 1) supplied by Round Pond (pond 2) and brooks. Analyzed by L. A. Shinn, U.S. Geological Survey, Nov. 15, 1930. A, Pond 1; B, pond 2. The mineral content of the water delivered to consumers is fairly uniform throughout the year. Examination of occasional spot samples during the year 1930–31: Color 20 to 35, average 27.
	NEW JERSEY
	[Descriptive material was furnished by J. Lynn Mahaffey, director of health, New Jersey Board of Health]
361	Atlantic City (66,198); municipal; 1 well (no. 1) 675 feet deep, 10 wells (nos. 2–5, 7, 9–13) 100 and 200 feet deep, Doughty Pond. The water from wells 1, 3, 4, and 13 is aerated. Consumers receive the mixed water. In 1931 the wells furnished 3,183,668,000 gallons and Doughty Pond furnished 1,669,738,000 gallons. Analyzed by E. W. Lohr, Oct. 17, 1932. A, Tap sample (wells 1, 2, 3, 4, and 13 and Doughty Pond in service); B, composite sample from wells 1, 2, 3, 4, and 13; C, Doughty Pond. Daily determinations for the year 1931–32: Color 5 to 42, average 15; pH 5.3 to 6.3, average 6.0. Samples collected during the later part of 1932 from each of the sources of supply show, with the exception of well 4, a range in chloride from 2.5 to 12. For well 4 the chloride was 40.
362	Bayonne (88,979); water purchased from North Jersey District Water Supply Commission. (See Newark, *b*.)
363	Belleville (26,974); supplied by Newark. (See Newark, *a*)
364	Bloomfield (38,077); supplied by Newark. (See Newark, *a*)
365	Camden (118,700): Municipal. Supplies all but the 11th and 12th wards. Total population supplied about 95,400. Morris station, 9 wells (nos. 1 to 9) 105 to 143 feet deep (about 49 percent), city wells (nos. 1 to 8) 116 to 182 feet deep (about 23 percent), Delair station, 3 wells (nos. 1 to 3) 129 to 144 feet deep (about 16 percent), Puchack Run station, 5 wells (nos. 1 to 5) 138 to 185 feet deep (about 12 percent). The wells belonging to the Morris station are in the same well field, and all discharge into a collecting basin. The city wells are in different parts of Camden and are pumped intermittently and direct to the mains. The wells at Delhair and Puchack Run stations are near together in their respective well fields. At each of these stations the water is pumped to a common supply line. Analyzed by K. T. Williams, U.S. Geological Survey, Nov. 21, 1932. A, Morris station well 6-N, 133 feet deep; B, city well 5, 174 feet deep; C, city well 8, 177 feet deep; D, Delair station well 1, 139 feet deep; E, Puchack Run station well 1, 138 feet deep. Analyses were also made on samples collected Nov. 21, 1932, from each of the other wells. The wells at the Morris station furnish waters that differ in composition but are similar in general character; the hardness ranged from 33 to 84, with an average of 51. The composition of the mixed water pumped to the city will change as different wells are used. Waters from the 3 wells at the Delair station ranged in hardness from 56 to 88, with an average of 70, and are similar in general character. The waters from the 5 wells at the Puchack Run station are even more closely alike; their hardness ranged from 22 to 39, with an average of 30. The waters from the city wells differ widely in chemical character and in hardness; the hardness ranged from 40 to 194, with an average of 107. Each city well when in use affects the composition of the water used in its immediate neighborhood. Some of the city wells furnish water softer than that otherwise delivered near them; others furnish much harder water than is otherwise available. The weighted average hardness for all the water furnished by the municipal system was 64. Iron for the different wells ranged from 0.04 to 5.4, average 0.78, except for Morris station well 4, in which the iron was 15. Manganese ranged from 0.0 to 4.6, average 0.61, except for Morris station well 4, in which the manganese was 5.6.

cities of the United States, 1932—Continued

	Analyses (parts per million)												
	Total dissolved solids	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulphate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Total hardness as $CaCO_3$[a]	No.
----------	37	12	0.17	3.7	0.9	2.9	1.6	16	5.0	2.1	0.54	13	354
----------	25	3.5	.01	2.4	1.4	1.8	1.0	6.0	8.8	1.6	.20	12	355
----------	22	.9	.27	3.4	.7	1.7	.8	10	4.7	1.5	.05	11	356
----------	51	22	.04	2.6	1.2	2.3	.6	9.0	6.5	3.0	.10	11	357
----------	42	9.5	.01	7.0	1.2	2.5	1.0	23	8.1	1.9	.10	22	358
----------	139	13	.02	31	6.3	5.9	2.1	99	24	5.5	3.9	103	359
A-------	42	14	.25	3.9	1.3	1.8	.9	14	5.6	2.2	.20	15	360
B-------	18	1.6	.01	2.0	.9	1.7	1.0	7.0	4.4	1.9	.10	9	
A-------	49	8.9	.62	2.0	1.6	7.5	1.4	5.0	6.6	12	3.0	12	361
B-------	70	5.9	.56	3.4	2.5	11	1.8	11	8.6	15	5.0	19	
C-------	23	2.1	.07	.6	.8	3.3	.8	1.0	3.2	6.1	.10	5	
----------	------	------	------	------	------	------	------	------	------	------	------	------	362
----------	------	------	------	------	------	------	------	------	------	------	------	------	363
----------	------	------	------	------	------	------	------	------	------	------	------	------	364
A-------	70	3.8	.39	10	4.6	5.0	1.8	32	18	7.0	2.9	44	365
B-------	215	9.4	.45	19	9.6	31	2.7	32	77	26	18	87	
C-------	[c]224	4.4	.53	35	15	24	5.0	168	27	29	4.4	149	
D-------	[ff]117	5.6	.28	14	7.6	12	2.0	61	27	7.0	12	66	
E-------	71	7.3	.66	6.4	3.0	6.8	1.6	6.0	10	12	16	28	
F-------	125	9.5	.03	9.0	4.8	16	2.6	3.0	32	17	32	42	

[a] Calculated.
[c] Includes 0.3 part of manganese.
[ff] Includes 1.0 part of manganese.

TABLE 5.—*Public water supplies of the larger*

No.	Description
	NEW JERSEY—continued
365	Camden—Continued. New Jersey Water Co. (controlled by Community Water Service Co., 100 William St., New York, N.Y.), Camden division. Supplies 11th and 12th wards in Camden and small part of Pensauken township. Total population supplied about 24,000. Main station, 24 wells of which 23 are 102 to 184 feet deep and 1 is 52 feet deep, 1 well (no. 27) 135 feet deep. The water from the wells at the main station is discharged into a common suction line and then fed to a receiving basin. Well 27 is isolated and is pumped direct to the mains. This well is not used in winter. F, Analysis of tap sample from main station by E. W. Lohr, Oct. 22, 1932. Regular determinations for the year 1931–32: Main station, alkalinity 2 to 15, average 6; hardness 40 to 63, average 49; chloride 13 to 22, average 18. Well 27, alkalinity 19 to 32, average 25; hardness 34 to 54, average 42; chloride 5 to 17, average 11.
366	Clifton (46,875); water purchased from North Jersey District Water Supply Commission. (See Newark, *b*.)
367	East Orange (68,020); municipal; 40 wells 115 to 260 feet deep. Analysis of tap sample by Margaret D. Foster, U.S. Geological Survey, Feb. 23, 1922. Determinations for the 10-year period 1922–31: Alkalinity 75 to 96, average 86; hardness 86 to 132, average 111.
368	Elizabeth (114,589); distributing system owned by the city: Elizabethtown Water Co., Consolidated (about 57 percent of supply). Supplies also Hillside and Union townships. Total population supplied about 91,000. Wells as follows: Hummocks group, 20 wells 90 to 500 feet deep; Springfield group, 22 wells 90 to 500 feet deep. Analysis of tap sample by E. W. Lohr, Feb. 22, 1932. Weekly determinations for the year 1931: Hummocks wells, alkalinity 118 to 134, average 130; hardness 210 to 240, average 228; pH 7.6 to 7.7; Springfield wells, alkalinity 105 to 117, average 110; hardness 192 to 216, average 200; pH 7.3 to 7.5. North Jersey District Water Supply Commission (about 38 percent of supply). (See Newark, *b*.) Plainfield-Union Water Co. (about 5 percent of supply). (See Plainfield.)
369	Garfield (29,739); municipal; 15 wells at East Paterson plant, 10 wells at reserve station in Garfield, all 290 to 400 feet deep. The water is supplied to a reservoir. Analysis of sample from East Paterson plant, by E. W. Lohr, May 4, 1932.
370	Hackensack (24,568); Hackensack Water Co. Supplies also Alpine, Bergenfield, Bogota, Carlstadt, Cliffside Park, Closter, Cresskill, Demarest, Dumont, East Rutherford, Edgewater, Emerson, Englewood, Englewood Cliffs, Fairview, Fort Lee, Guttenberg, Harrington Park, Hasbrouck Heights, Haworth, Hillsdale, Leonia, Little Ferry, Lodi, Lodi township, Maywood, Midland Park, Moonachie, New Milford, North Bergen township, Northvale, Norwood, Oradell, Palisades Park, Paramus, Ridgefield, Ridgefield Park, Riverside, part of Rivervale township, Rutherford, part of Rochelle Park township, Secaucus, Teaneck township, Tenafly, Union City, Washington township, Westwood, West New York, Weehawken township, and Wood-Ridge. Total population supplied about 414,000. Hackensack River (impounded) at Milford; filtered, adjustment of pH during summer by addition of hydrated lime. Analyzed by G. R. Spalding, Hackensack Water Co. A, Average of weekly analyses for 1931; B, average of weekly analyses for the month of maximum hardness, September 1931; C, average of weekly analyses for the month of minimum hardness, April 1931. Monthly averages of weekly determinations for the year 1932: Manganese, trace; pH 6.8 to 8.0, average 7.5.
371	Haddon Heights (5,394); New Jersey Water Co. (controlled by Community Water Service Co., 100 William St., New York, N.Y.), Haddon Heights division. Supplies also Audubon, Barrington, Bellmawr, small part of Delaware township, Haddonfield, part of Haddon township, Mount Ephraim, Oaklyn, and Runnemede. Total population supplied about 30,000. Main supply from 3 wells (nos. 5, 8, and 10) 264, 240, and 279 feet deep; aerated, filtered without coagulation. Auxiliary supply from 1 well (no. 6) 230 feet deep; aerated, filtered without coagulation. Emergency supply for Runnemede from 1 well (no. 7) 316 feet deep. Wells 5, 8, and 10 are near together and are pumped to 1 filtration plant. Analysis of tap sample (wells 5, 8, and 10 in service) by E. W. Lohr, Oct. 19, 1932. Regular determinations on the main supply for the year 1931–32: Alkalinity 74 to 87, average 81; hardness 86 to 123, average 93; pH 6.8 to 7.6, average 7.3.
372	Hoboken (59,261); supplied by Jersey City. (See Jersey City)
373	Irvington (56,733); Commonwealth Water Co. (controlled by American Water Works & Electric Co., 50 Broad St., New York, N.Y.). Supplies also New Providence, Short Hills, Summit, West Orange, and the following townships: Part of Hillside, Livingston, Maplewood, Milburn, New Providence, Passaic, part of Springfield, and part of Union. Total population supplied about 131,000. Twenty-three wells 80 to 380 feet deep, Canoe Brook impounded (filtered). Water furnished to consumers from the Canoe Brook station is a mixture of about 26 percent filtered water from Canoe Brook and about 74 percent well water from Canoe Brook well field. The water is supplied to the distribution system from 3 stations, which are interconnected. Analyzed by E. W. Lohr. Daily determinations on the water delivered to consumers from the Canoe Brook station for the year 1931: Alkalinity 30 to 96, average 60; hardness 75 to 197, average 148.

cities of the United States, 1932—Continued

	Analyses (parts per million)												No.
	Total dissolved solids	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulphate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Total hardness as $CaCO_3$[a]	
----------													366
----------	153	24	0.06	29	9.6	5.0	1.2	112	20	4.7	3.6	112	367
----------	283	23	.01	70	9.1	9.7	1.3	168	62	9.4	15	212	368
				37	12	8.3	1.1	90	62	7.6	14	142	369
----------	211	18	.01										
				24	5.1	[a] 8.3		59	34	10	1.4	81	370
				29	5.7	[a] 7.6		80	31	9.9	.66	96	
A-------	124	6.3	Trace	18	4.0	[a] 9.7		34	35	12	1.5	61	
B-------	132	2.7	Trace										
C-------	104	5.8	Trace										
				26	5.8	5.7	8.0	98	27	1.6	.63	88	371
----------	130	9.8	.06										
----------													372
A-------	241	16	.02	37	14	17	1.0	82	101	7.9	1.4	150	373
B-------	249	24	.01	53	12	10	.8	153	52	12	9.8	182	
C-------	118	28	.01	20	5.9	6.0	.5	73	19	4.0	1.6	74	

[a] Calculated.

TABLE 5.—*Public water supplies of the larger*

No.	Description
	NEW JERSEY—continued
373	Irvington—Continued.

	Source	Approximate percentage of total supply	Date of collection
A	Canoe Brook station (surface and well supply)	65	Feb. 26, 1932
B	Short Hills station (well supply)	20	Feb. 17, 1932
C	Baltusrol station (well supply)	15	Do.

No.	Description
374	Jersey City (316,715); municipal. Supplies also Hoboken, Lyndhurst township, North Arlington, and Union township. Total population supplied about 404,000. Rockaway River impounded in Boonton Reservoir and Split Rock Pond. Analyzed by Margaret D. Foster, U.S. Geological Survey, Feb. 7, 1922. Weekly determinations for the year 1931: Alkalinity 21 to 40, average 29.
375	Kearney (40,716); supplied by North Jersey District Water Supply Commission. (See Newark, *b*.)
376	Linden (21,206); Elizabethtown Water Co., Consolidated. Supplies also Clark township, part of Dunellen, and a small part of two other places. Total population supplied about 24,000. Millstone and Raritan Rivers at their junction; aerated, filtered, final adjustment of pH to about 8.5. Analysis of tap sample from Millstone River by E. W. Lohr, Feb. 22, 1932. Daily determinations for the year 1931: Alkalinity 16 to 36, average 24; hardness 61 to 70, average 65; pH 7.8 to 8.8, average 8.2. The Plainfield-Union Water Co. supplies about 1,000 people in Linden. (See Plainfield.)
377	Maplewood township (21,321); supplied by Commonwealth Water Co. (See Irvington)
378	Montclair (42,017); supplied by North Jersey District Water Supply Commission. (See Newark, *b*).
379	Newark (442,337); distributing system owned by the city: (*a*) Pequannock supply (municipal), furnishes also Belleville, Bloomfield, Nutley, and Wayne township. Total population supplied about 400,000. Pequannock River impounded. The Pequannock collection system consists of 4 impounding reservoirs and several large ponds with a total storage capacity of 11,000,000,000 gallons, all feeding into Pequannock River. A, Average of analyses of monthly samples by J. F. Bauermann, Newark Water Laboratory, 1929. Monthly determinations for the year 1929: Color 18 to 28, average 23; pH 6.7 to 7.0, average 6.9. (*b*) North Jersey District Water Supply Commission, furnishes Bayonne, Cedar Grove township, Clifton, part of Elizabeth (about 38 percent of supply), Glen Ridge, Harrison, Kearney, Little Falls township, Montclair, part of Newark (estimated about 15,000,000 gallons a day), Paterson, Passaic, Prospect Park, Totawa, and West Paterson. Total population supplied about 645,000. Wanaque River impounded in Wanaque Reservoir; aerated at times, final adjustment of pH to about 9.0 by addition of lime. The reservoir has a storage capacity of 29,000,000,000 gallons. The estimated total yield is 100,000,000 gallons a day, which is allotted as follows: Newark 44,500,000 (including Bloomfield's allotment), Paterson 20,000,000, Kearney 12,000,000, Passaic 11,000,000, Clifton 6,750,000, Montclair 5,000,000, and Glen Ridge 750,000. B, Single analysis by A. E. Griffin, North Jersey District Water Supply Commission, Feb. 24, 1932.
380	New Brunswick (34,555); municipal; Lawrence Brook; aerated, filtered, adjustment of pH by addition of lime. Analyzed by E. W. Lohr, Feb. 16, 1932. Daily determinations for the year 1931: Alkalinity 10 to 58, average 22; color 0 to 30, average 5; pH 7.1 to 9.4, average 8.3. For the same period the color of the raw water ranged from 2 to 90, with an average of 40.
381	North Bergen township (40,714); supplied by Hackensack Water Co. (See Hackensack)
382	Nutley (20,572); supplied by Newark. (See Newark, *a*)
383	Orange (35,399); municipal; West Branch of Rahway River (about 75 percent), 3 wells (about 25 percent) 49, 117, and 365 feet deep; filtered, final adjustment of pH by addition of soda ash. The 49 and 117 foot wells are operated about 8 months and the 365-foot well about 2 months of the year. The river and well waters are mixed before treatment, and the filtered water is supplied to a distributing reservoir. Analysis furnished by Orange Water Department, dated Oct. 15, 1929. Regular determinations for the year 1931: Alkalinity 20 to 75, average 50; pH 6.2 to 7.8, average 7.0.
384	Passaic (62,959); water purchased from North Jersey District Water Supply Commission. (See Newark, *b*.)
385	Paterson (138,513); Passaic Valley Water Commission. Domestic system supplied from Wanaque Reservoir of North Jersey District Water Supply Commission. (See Newark, *b*). Industrial system supplied by Passaic River at Little Falls; filtered. A, Analysis of tap sample from the domestic supply by A. E. Griffin, North Jersey District Water Supply Commission, Feb. 24, 1932; B, average of analyses of monthly samples from the industrial supply by F. W. Green, Passaic Valley Water Commission, 1932. Ranges in concentration of the monthly samples from industrial supply: Alkalinity 9 to 47; hardness 47 to 104; sulphate 32 to 50; pH 5.9 to 7.2, average 6.5.

cities of the United States, 1932—Continued

	Analyses (parts per million)												No.
	Total dissolved solids	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulphate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Total hardness as $CaCO_3$[a]	
----------	81	6.5	0.08	13	5.6	3.6	1.0	40	22	5.1	1.1	55	374
----------	------	------	------	------	------	------	------	------	------	------	------	------	375
----------	113	13	.02	17	5.3	7.7	1.9	26	43	7.8	4.3	64	376
----------	------	------	------	------	------	------	------	------	------	------	------	------	377
----------	------	------	------	------	------	------	------	------	------	------	------	------	378
A-------	50	4.8	.19	7.7	2.4	[a] 2.3		20	12	3.4	.48	29	379
B-------	[aa] 50	4.9	.04	9.8	6.2	([cc])		30	11	3.1	.05	50	
----------	88	8.3	.17	12	3.3	5.2	2.1	10	36	7.8	1.6	44	380
----------	------	------	------	------	------	------	------	------	------	------	------	------	381
----------	------	------	------	------	------	------	------	------	------	------	------	------	382
----------	112	5.9	[b].8	19	2.9	13		44	36	11	Trace	59	383
----------	------	------	------	------	------	------	------	------	------	------	------	------	384
A-------	[aa] 50	4.9	.04	9.8	6.2	([cc])		30	11	3.1	.05	50	385
B-------	113	3.2	.07	21	5.7	10		35	38	5.9	1.5	76	

[a] Calculated.
[b] Iron and aluminum oxides.
[cc] Less than 5 parts.
[aa] Includes 0.1 part of manganese.

TABLE 5.—*Public water supplies of the larger*

No.	Description
	NEW JERSEY—continued
386	Perth Amboy (43,516); municipal; Runyon pumping station supplied by 80 wells 80 feet deep, 1 well 50 feet deep, and 1 well (used as an emergency supply) 350 feet deep; Deep Run pumping station supplied by 20 wells 45 feet deep; South River pumping station supplied by 7 wells 50 feet deep; treatment with lime, filtered without other coagulation, adjustment of pH to a minimum of not less than 7.6. All the water is treated at the iron-removal plant at Runyon. Analysis of tap sample by E. W. Lohr, Feb. 24, 1932.
387	Plainfield (34,422); Plainfield-Union Water Co. Supplies also part of Clark township, Cranford, part of Elizabeth (about 5 percent), Fanwood, Garwood, Kenilworth, small part of Linden (about 1,000 consumers), part of Mountainside, North Plainfield, part of Piscataway township, Roselle, Roselle Park, Scotch Plains, South Plainfield, Watchung, and Westfield. Total population supplied about 115,000. 16 wells 250 to 500 feet deep. Analyzed by E. W. Lohr, Feb. 15, 1932.
388	Trenton (123,356); municipal. Supplies also part of Ewing, Hamilton, and Lawrence townships. Total population supplied about 145,000. Delaware River; filtered. The treatment decreases the silica and bicarbonate and increases the sulphate. Average of analyses of composites of daily samples of raw water from Delaware River at Lambertville by U.S. Geological Survey, 1906–7 (Water-Supply Paper 236, p. 60, 1909). The composition of the water varies throughout the year. Daily determinations on the filtered water for the year 1931: Alkalinity 4 to 60, average 31; pH 4.9 to 7.3, average 6.7.
389	Union City (58,659); supplied by Hackensack Water Co. (See Hackensack)
390	West New York (37,107); supplied by Hackensack Water Co. (See Hackensack)
391	West Orange (24,327); supplied by Commonwealth Water Co. (See Irvington)
	NEW MEXICO
	[Descriptions of the supplies were furnished by Paul S. Fox, chief, Division of Sanitary Engineering and Sanitation, New Mexico Bureau of Public Health, who also made arrangements for collection of the samples that were analyzed by the U.S. Geological Survey]
392	Albuquerque (26,570); municipal; 3 wells (nos. 1 to 3) 426, 446, and 551 feet deep; filtered without coagulation. It is proposed to drill 2 more wells about 550 feet deep. Analysis of tap sample (wells 1 and 2 in service) by M. P. Beam, Van Atta Laboratories, Sept. 12, 1932.
393	Clovis (8,027); New Mexico Utilities Co.; 3 wells 340 feet deep. Analysis of tap sample by E. W. Lohr, Dec. 9, 1931.
394	Raton (6,090); municipal; impounding reservoir on Chicorico Creek; filtered. The composition of the water varies throughout the year. The alkalinity of the treated water is reported to range from about 30 to 100 with an average around 50. Analysis of tap sample by E. W. Lohr, Dec. 12, 1931.
395	Roswell (11,173); municipal; 6 wells (nos. 1 to 6) 316, 319, 309, 321, 400, and 250 feet deep. Analysis of tap sample by E. W. Lohr, Dec. 26, 1931. Partial analyses of samples collected on the same date from each of the wells indicate that the analysis given represents reasonably well the composition of the water delivered to consumers.
396	Santa Fe (11,176); New Mexico Power Co.; impounding reservoirs on Santa Fe Creek. Analyzed by E. W. Lohr, Dec. 7, 1931.
	NEW YORK
	[Descriptive material was furnished by C. A. Holmquist, director, Division of Sanitation, New York Department of Health, whose assistance made it possible to obtain the data necessary for the inclusion of several of the places]
397	Albany (127,412); municipal; Hannacrois Creek impounded; aerated, filtered, final adjustment of pH to about 8.5 by addition of lime. Analysis of tap sample by G. E. Willcomb, Albany Department of Public Works, 1932.
398	Amsterdam (34,817); municipal; Hans Creek impounded in Glen Wild Reservoirs. Analysis of tap sample by E. W. Lohr, Feb. 4, 1932.
399	Auburn (36,652); municipal; Owasco Lake; slow sand filtration. Analyzed by E. W. Lohr, Sept. 14, 1931. The composition of the water is fairly uniform throughout the year. Regular determinations for the year 1930: Alkalinity (weekly) 93 to 100, average 96; hardness (monthly) 100 to 130, average 113; average chloride 1.3.
400	Binghamton (76,662); municipal; Susquehanna River (filtered), small and variable amounts of well water. A, Analysis of about an average sample of the filtered water by B. E. Nelson and A. G. Lauder, Water Department, Aug. 12, 1931; B, average of analyses of raw water from Susquehanna River at West Pittston, Pa., by U.S. Geological Survey in 1906–7 (Water-Supply Paper 236, p. 102, 1909).
401	Buffalo (573,076); municipal; Lake Erie; filtered. An analysis of the filtered water at Erie, Pa., by L. A. Shinn, U.S. Geological Survey, Mar. 18, 1931, may be taken to represent the composition of the water at Buffalo. Monthly averages of regular determinations for the year 1927–28: Alkalinity 85 to 98, chloride 12 to 14.
402	Cheektowaga town (20,849); supplied by Western New York Water Co. (See Lackawanna)
403	Cohoes (23,226); municipal; Mohawk River; filtered. Analysis of a sample from filtered-water basin by E. W. Lohr, Aug. 27, 1932. The analysis given probably represents about a maximum concentration. Regular determinations for the year 1931: Alkalinity 35 to 72, average 57; hardness 68 to 103, average 88; pH 6.9 to 7.5, average 7.1.

cities of the United States, 1932—Continued

	Analyses (parts per million)												
	Total dissolved solids	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulphate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Total hardness as $CaCO_3$[a]	No.
----------	77	4.2	0.61	19	1.7	2.8	1.1	36	23	5.5	0.40	54	386
----------	273	22	.01	68	7.7	10	.8	170	57	9.2	14	202	387
(Av)----	70	9.0	.07	12	3.3	5.4		46	12	2.9	1.1	44	388
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----------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	390
----------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	391
----------	[a] 491	74	[b] 35	31	19	96		180	130	17	-------	155	392
----------	270	37	.01	30	21	34	5.7	234	24	10	8.8	161	393
	129	16	.24	24	7.8	7.6	1.3	108	17	2.4	.64	92	394
----------	948	14	1.8	155	46	78	2.6	210	389	117	3.4	576	395
----------	68	10	.29	13	3.1	3.5	.9	52	7.2	1.2	.10	45	396
----------	83	1.6	.12	19	5.0	1.2		40	27	1.9	.08	68	397
----------	33	5.4	.19	3.5	1.0	.9	.6	3.0	8.9	1.5	.20	13	398
----------	131	8.7	.02	35	7.2	2.0	1.3	120	17	1.8	1.1	117	399
A-------	100	5.3	.07	23	2.7	4.6	1.9	67	8.7	5.7	1.3	69	400
B-------	90	10	.12	18	3.4	6.3		63	14	4.2	1.5	59	
----------	147	1.0	.01	34	8.0	5.7	1.1	109	19	14	1.0	118	401
----------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	402
----------	135	1.8	.11	33	5.6	5.4	1.6	98	27	5.9	2.0	105	403

[a] Calculated. [b] Iron and aluminum oxides.

TABLE 5.—*Public water supplies of the larger*

No.	Description
	NEW YORK—continued
404	Eastchester town (20,340); supplied by New Rochelle Water Co. (See New Rochelle and analysis A for New York City.)
405	Elmira (47,397); municipal; Supplies also Elmira Heights and Southport town. Total population supplied about 58,000. Chemung River (66 percent), impounding reservoir on Hoffman Creek (34 percent); filtered, aerated. Only one source is used at a time. Analyzed by E. W. Lohr. A, Chemung River supply, June 15, 1932; B, reservoir supply, June 17, 1932. The composition of the water varies throughout the year, and the analyses given probably represent a concentration higher than the average.
406	Ithaca (20,708); municipal; Sixmile Creek impounded in two small reservoirs: filtered. Analysis of tap sample by E. W. Lohr, Aug. 9, 1932. There is considerable variation in the composition of the water throughout the year. Regular determinations for the year 1931: Alkalinity 24 to 126, average 91; pH 6 to 8, average 7.1.
407	Jamestown (45,155); municipal; 9 wells about 130 feet deep and 10 wells about 220 feet deep. All water is obtained from the same gravel strata. Analysis of sample from the shallow wells by E. W. Lohr, July 31, 1931.
408	Kingston (28,088); municipal; Cooper Lake, emergency supply from Sawkill Creek; pressure filtration, aeration, final adjustment of pH at times to over 7.3 by addition of lime. Analysis of tap sample from Cooper Lake by E. W. Lohr, Apr. 26, 1932. The mineral content of the water is fairly uniform throughout the year. Daily determinations for the year 1931: Alkalinity 7 to 11, chloride 1.5 to 2.0, color 0 to 10.
409	Lackawanna (23,948); Western New York Water Co. (controlled by Federal Water Service Corporation, 27 William St., New York, N.Y.). Supplies also the following towns: Small part of Allen, Amherst, Cheektowaga, part of Clarence, small part of Hamburg, most of Lancaster, Tonawanda, and West Seneca. Total population supplied about 120,000. Lake Erie; filtered. The composition of the water is fairly uniform throughout the year. Analyzed by N. S. Chamberlin, Federal Water Service Corporation, Mar. 1, 1932.
410	Lockport (23,160); municipal; Niagara River; filtered. The water is practically the same as that used at Niagara Falls. (For analysis see Niagara Falls.)
411	Mamaroneck (11,766); Westchester Joint Water Works No. 1. Supplies also Harrison town, unincorporated part of Mamaroneck town, and Pelham. Total population supplied about 28,000. Mamaroneck River supplemented by about 1,000,000 gallons a day from Kensico Reservoir (Catskill supply) of the New York City water-supply system; filtered. The supplementary supply is discharged into Mamaroneck River at its upper reaches. Analyzed by Westchester Joint Water Works No. 1, April 1932. The composition of the water varies throughout the year. Daily determinations for the year 1931-32: Alkalinity 16 to 73, hardness 35 to 100, pH 6.7 to 8.1.
412	Mount Vernon (61,499) supplied from the New York City Catskill Aqueduct. (See New York City, analysis A.)
413	Newburgh (31,275); municipal; Silver and Patton Brooks impounded, filtered. Analyzed by J. F. Kingsley, Newburgh Board of Health, 1930.
414	New Rochelle (54,000); New Rochelle Water Co. (controlled by Community Water Service Co., 100 William St., New York, N.Y.). Supplies also Eastchester town, North Pelham, and Pelham Manor. Total population supplied about 84,000. Practically all the water is obtained from the Catskill Aqueduct of the New York City supply. An impounding reservoir on Hutchinson River is used for an emergency supply. The water from Hutchinson River is more concentrated and harder than the Catskill water. (See New York City, analysis A.)
415	New York (6,930,446); municipal (94 percent of supply) and private companies (6 percent):

Source	Quantities supplied in 1930 (million gallons a day)	
	Total	To sections of city
Catskill supply	587.8	Manhattan and Bronx 306, Brooklyn 190, Queens 66, Richmond 26.
Croton supply	258.8	Manhattan and Bronx.
Long Island supply (ground and surface sources).	78.9	Brooklyn 67, Queens 12.
Well supply for Richmond	5.9	Richmond.
Well supply furnished by private companies.	64.5	Brooklyn 27, Queens 38.

Municipal. Supplies about 6,570,000 consumers in New York City, also Eastchester town, Mount Kisco, Mount Vernon, New Rochelle, North Tarrytown, Ossining, part of White Plains, part of Yonkers, and several water districts and small communities. These outside consumers were furnished an average of about 21,400,000 gallons a day in 1930, of which 90 percent was from the Catskill system. Catskill supply impounded surface water, aerated; Croton supply impounded surface water, aerated (some water from the Croton supply is carried to the city in the Catskill Aqueduct); Ridgewood supply of impounded surface water and a larger quantity of

cities of the United States, 1932—Continued

	Analyses (parts per million)												No.
	Total dissolved solids	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulphate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Total hardness as $CaCO_3$[a]	
---	---	---	---	---	---	---	---	---	---	---	---	---	404
A---	163	2.2	0.02	34	8.2	7.6	2.0	99	37	12	1.4	119	405
B---	105	2.7	.02	19	5.1	4.6	1.7	51	30	6.2	.88	68	
---	133	4.9	.04	35	6.4	3.0	1.5	117	21	2.0	.50	114	406
---	133	12	.02	31	6.2	5.0	.8	106	21	3.0	.20	103	407
---	30	3.8	.02	4.5	1.0	3.3	.5	10	11	1.5	.60	15	408
---	156	5.7	Trace	35	8.1	[a] 5.9		106	27	12	1.4	121	409
---	---	---	---	---	---	---	---	---	---	---	---	---	410
---	174	---	.10	---	---	---	---	68	---	9.8	5.8	[c] 70	411
---	---	---	---	---	---	---	---	---	---	---	---	---	412
---	[a] 81	4.5	[b] 2.7	14	2.1	10		44	19	7.3	---	44	413
---	---	---	---	---	---	---	---	---	---	---	---	---	414
A---	31	2.4	.14	5.8	1.4	1.7	.7	14	9.7	2.0	.54	20	415
B---	73	6.2	.20	13	4.5	3.3	1.3	42	17	4.0	1.3	51	
C---	134	12	.77	17	6.6	14	2.1	38	32	21	10	70	
D---	258	---	.30	---	---	---	---	115	---	33	7.0	[c] 165	
E---	111	---	.09	---	---	---	---	32	---	15	7.2	[c] 54	
F---	364	---	.11	---	---	---	---	150	---	22	29	[c] 268	
G---	358	16	.15	51	11	[a] 46		122	45	75	26	173	
H---	135	19	Trace	26	7.8	[a] 14		144	1.9	5.0	.06	97	
I---	304	---	.65	---	---	---	---	52	---	33	25	[c] 149	
J---	385	---	.10	---	---	---	---	96	---	20	57	[c] 217	
K---	56	---	.10	---	---	---	---	9.8	---	4.6	4.3	[c] 17	

[a] Calculated.
[b] Iron and aluminum oxides.
[c] Determined.

TABLE 5.—*Public water supplies of the larger*

No.	Description
	NEW YORK—continued
415	New York, etc.—Continued. ground water from Long Island pumped to the Ridgewood Reservoir; many wells and groups of wells are pumped directly into the distribution system. A, Catskill supply; B, Croton supply; C, Ridgewood supply (46,100,000 gallons a day); D, Forest Hills steam pumping station no. 3 (2,800,000 gallons a day); E, Douglaston steam pumping station no. 8 (5,600,000 gallons a day). A to C analyzed by E. W. Lohr, June 27 and 29, 1932; D and E, average of monthly analyses by New York City Bureau of Water Supply, 1931. Regular determinations for the year 1931: Catskill supply, alkalinity 8 to 15, average 11; hardness 16 to 30, average 25; pH 6.7 to 7.0, average 6.9. Croton supply, alkalinity 28 to 35, average 32; hardness 40 to 53, average 47; pH 6.7 to 7.3, average 7.0. Ridgewood supply, alkalinity 8 to 31, average 19; hardness 31 to 70, average 47; pH 6.1 to 6.7, average 6.4. Range in hardness of the well supplies in Brooklyn, Queens, and Richmond 23 to 234. New York Water Service Corporation (controlled by Federal Water Service Corporation, 27 William St., New York, N.Y.). Supplies about 224,000 consumers in the Flatbush area of Brooklyn. Wells as follows: Steam station group, 83 wells 80 to 150 feet deep, 20 individual electric wells 90 to 418 feet deep. F, Electric well 12, 103 feet deep; G, electric well 24, 287 feet deep, Sept. 29, 1931; H, tap at 265 Ocean Ave., Feb. 1, 1932. F, Average of monthly analyses by New York City Bureau of Water Supply, 1931; G and H analyzed by N. S. Chamberlin, Federal Water Service Corporation. The hardness of the well supplies, based on averages of monthly analyses for the year 1931, ranged from 63 to 409. Jamaica Water Supply Co. Supplies about 84,000 consumers. Wells about 90 to 630 feet deep. Average of monthly analyses by New York City Bureau of Water Supply, 1931. I, Steam pumping station 2; J, electric well 3, about 97 feet deep; K, electric well 15, about 400 feet deep. The hardness of the well supplies, based on averages of monthly analyses for the year 1931, ranged from 13 to 217.
416	Niagara Falls (75,460); municipal; Niagara River, filtered. Analyzed by E. W. Lohr, Nov. 6, 1931
417	Olean (21,790); municipal; Olean Creek; aerated, filtered, final adjustment of pH by addition of lime. Analysis of tap sample by E. W. Lohr, June 10, 1931. Daily determinations for the year 1931: Alkalinity 13 to 93, average 59; pH 6.6 to 7.3, average 7.0.
418	Oswego (22,652); municipal; Lake Ontario. Analysis of tap sample by E. W. Lohr, Feb. 1, 1932
419	Port Chester (22,662); Port Chester Water Works (controlled by Community Water Service Co., 100 William St., New York, N.Y.). Supplies also parts of Harrison and Rye towns. Total population supplied about 33,000. Putnam and Rockwood Lakes fed by adjacent streams and by pumping from Mianus River; aerated, filtered, final adjustment of pH by addition of lime. The raw water is pumped to the filtration plant from Putnam Lake. The lakes and filtration plant are in the town of Greenwich, Conn. Analysis of tap sample by E. W. Lohr, Aug. 12, 1932. Regular determinations for the year 1931; Alkalinity (daily tests) 10 to 23, average 17; hardness (biweekly tests) 31 to 46, average 38; pH (daily tests) 7.5 to 8.8, average 8.1.
420	Poughkeepsie (40,288); municipal; Hudson River; slow sand filtration preceded by coagulation, sedimentation, preliminary filtration, and aeration, final adjustment of pH by addition of lime. The coagulation and filtration reduce the silica and iron; the bicarbonate may be decreased, and the sulphate is increased. Average of analyses of raw water from Hudson River at Hudson by U.S. Geological Survey, 1906–7 (Water-Supply Paper 236, p. 64, 1909). The composition of the water varies throughout the year. Regular determinations on the treated water for the year 1931: Alkalinity 24 to 51, average 38; hardness 39 to 73, average 62.
421	Rochester (328,132): Municipal. Supplies about 288,000 consumers in Rochester. Hemlock Lake (augmented by Canadice Lake). The water from Canadice Lake is discharged into Hemlock Lake, from which consumers are supplied. Averages of analyses by Walter Fischer, Rochester Department of Public Works, February, May, August, October 1932. A, Hemlock Lake; B, Canadice Lake. Rochester and Lake Ontario Water Service Co. (controlled by Federal Water Service Corporation, 27 William St., New York, N.Y.). Supplies about 40,000 consumers in Rochester and also the towns of Brighton, Gates, Greece, Irondequoit, part of Penfield, part of Perinton, and Pittsford. Total population supplied about 94,000. Lake Ontario; pressure filtration. The composition of the water is fairly uniform throughout the year. Analyzed by N. S. Chamberlin, Federal Water Service Corporation, September 11, 1931. C. Lake Ontario (filtered).
422	Rome (23,338); municipal; Fish Creek. Analysis of tap sample by W. L. Lamar July 1, 1932.
423	Schenectady (95,692); municipal; 3 dug wells; analyzed by G. E. Willcomb, Albany Department of Public works, Jan. 5, 1931. Examination of 12 samples collected at 15-day intervals between May 21 and Nov. 6, 1931, gave the following results: Alkalinity 121 to 139, average 127; hardness 164 to 186, average 177; pH 7.4.
424	Syracuse (209,326); municipal; Skaneateles Lake. The composition of the water is fairly uniform throughout the year. Analyzed by E. W. Lohr, Apr. 27, 1932.
425	Tonawanda town (25,006); supplied by Western New York Water Co. (See Lackawanna)
426	Troy (72,763); municipal; 3 distinct systems as follows: Lower service furnished by Tomhannock Reservoir (83 percent), high service furnished by Brunswick and Vanderheyden Reservoirs (15 percent), upper high service furnished by Martin-Dunham Reservoir (2 percent). Analysis of tap sample from Tomhannock Reservoir by E. W. Lohr, May 31, 1932. Results for the year 1931, based on examination of the waters at least twice each week: Tomhannock supply, alkalinity 20 to 28, average 25; hardness 36 to 42; color 10 to 18, average 14. Brunswick and Vanderheyden supply, alkalinity 15 to 30, average 22; hardness 34 to 44, average 39; color 12 to 20, average 15. Martin-Dunham supply, alkalinity 4.0 to 8.0, average 5.4; hardness 31 to 33; color 15 to 28, average 21.

cities of the United States, 1932—Continued

	Analyses (parts per million)												
	Total dissolved solids	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulphate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Total hardness as $CaCO_3$[a]	No.
----------	165	12	0.02	36	8.1	6.5	1.2	119	22	13	0.10	123	416
----------	92	4.0	.01	21	3.4	4.4	1.3	56	25	2.9	.75	66	417
----------	159	6.4	.42	37	8.4	6.4	1.2	114	22	13	.84	127	418
----------	72	3.5	.01	13	2.9	4.1	1.6	21	30	4.8	.10	44	419
Av------	108	11	.15	21	3.8	7.9		73	16	4.0	.8	68	420
A-------	94	2.0	[b] 2.1	19	6.7	5.4		62	22	5.4	.37	75	421
B-------	74	1.7	[b] 2.1	11	6.5	4.8		30	17	4.4	.34	54	
C-------	165	2.3	.0	33	5.6	[a] 12		109	25	12	Trace	105	
----------	54	5.3	.07	10	3.1	1.7	.2	41	5.4	1.6	.79	38	422
----------	219	6.2	.05	51	16	7.8		128	62	12	.10	193	423
----------	126	6.0	.02	34	6.8	2.0	1.0	116	15	1.6	1.5	113	424
----------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	425
----------	50	4.7	.15	9.4	2.0	2.6	1.0	23	14	2.2	.9	32	426

[a] Calculated. [b] Iron and aluminum oxides.

TABLE 5.—*Public water supplies of the larger*

No.	Description

NEW YORK—continued

427 Utica (101,740); Consolidated Water Co. of Utica, N.Y. Supplies also New Hartford, New York Mills, Oriskany, Whitesboro, and Yorkville. Total population supplied about 116,000. West Canada Creek (north supply, about 90 percent), 4 impounding reservoirs (south supply). The composition of the water from the north supply is fairly uniform throughout the year; the south supply varies. Analyzed by Margaret D. Foster, U.S. Geological Survey, May 8, 1922; analysis B (reservoir 4 of south supply) probably represents about a minimum concentration. Daily determinations for the year 1930:

	Source	Percent of supply	Alkalinity			Hardness			pH		
			Average	Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum
A	North supply	90	24	34	20	32	33	30	6.8	6.9	6.5
B	South supply	10				99	168	64			

428 Watertown (32,205); municipal; Black River; aerated, filtered, final adjustment of pH to 7.8–8.4 by addition of soda ash. Analysis of tap sample by W. L. Lamar, July 8, 1932.

429 White Plains (35,830); municipal distribution system:

Municipal; 2 impounding reservoirs, 5 dug wells averaging 22 feet deep. The municipal system furnishes about 1,500,000 gallons a day.

New York Water Service Corporation (controlled by Federal Water Service Corporation, 27 William St., New York, N.Y.); 19 wells 58 to 154 feet deep, furnishing about 1,000,000 gallons a day. About 2,000,000 gallons a day is obtained from the Catskill supply of New York City. The water from the New York Water Service Corporation wells is mixed with the Catskill water as it passes through the pumping station, and the resulting supply represents about 1 part well water and 2 parts Catskill water. Analysis of the mixed water from the New York Water Service Corporation wells by N. S. Chamberlin, Federal Water Service Corporation, Apr. 19, 1932. (For analysis of the Catskill water see New York City, analysis A.)

430 Yonkers (134,646); municipal; Sawmill River, 60 percent (slow sand filtration); Grassy Sprain Reservoir supplied by Sprain Brook and Grassy Sprain Brook, 20 percent; Catskill water purchased from New York City, 20 percent. Analyzed by E. W. Lohr, Aug. 3, 1931. A, Sawmill River; B, Grassy Sprain Reservoir. (For analysis of Catskill supply, see New York City, analysis A.)

NORTH CAROLINA

[Descriptions of most of the supplies and many of the analytical results given in the text below were furnished by H. E. Miller, chief engineer, Bureau of Sanitary Engineering and Inspection of the North Carolina Board of Health. Several analyses were furnished by Thorndike Saville and by Charles E. Ray, Jr., successively chief engineers, Division of Water Resources and Engineering of the North Carolina Department of Conservation and Development, whose interest and assistance made possible the inclusion of several of the cities]

431 Asheville (50,193); municipal; impounding reservoir supplied by mountain streams. Analyzed by Margaret D. Foster, U.S. Geological Survey, Apr. 18, 1922. An analysis of a sample collected Sept. 15, 1928, and a partial analysis of one collected Sept. 22, 1931, show the composition of the water to be practically the same as is indicated by the analysis made in 1922.

432 Charlotte (82,675); municipal; Catawba River, impounded; filtered, adjustment of pH by addition of lime. Analyzed by L. A. Shinn, U.S. Geological Survey, Mar. 17, 1931. Monthly averages of daily determinations for the year 1929: Hardness 17 to 27, average 23; pH 7.3 to 7.7, average 7.5.

433 Durham (52,037); municipal; Flat River impounded in Lake Michie (capacity 5,000,000,000 gallons); filtered, adjustment of pH by addition of lime. Analyzed by E. W. Lohr, May 22, 1931.

434 Fayetteville (13,049); municipal; small stream; filtered, final adjustment of pH to about 9.6 by addition of lime. Analysis of tap sample by L. L. Hedgepeth, North Carolina Department of Conservation and Development, June 29, 1929.

435 Gastonia (17,093); municipal; Long Creek impounded; filtered, adjustment of pH to about 8.0–8.2 by addition of lime. Analyzed by E. W. Lohr, May 26, 1931. Monthly averages of daily determinations for the year 1929: Alkalinity 16 to 25, average 22; pH 7.8 to 8.4, average 8.1.

436 Goldsboro (14,985); municipal; Little River; filtered, adjustment of pH to 7.8–8.8 by addition of lime. Analyzed by E. W. Lohr, Sept. 18, 1931.

437 Greensboro (53,569); municipal; Reedy Fork Creek, impounded; filtered, adjustment of pH by addition of lime. Analyzed by E. W. Lohr, May 25, 1931. Monthly averages of daily determinations for the year 1929: Alkalinity 19 to 26, average 22; hardness 26 to 32, average 28; pH 7.0 to 8.0, average 7.5.

438 High Point (36,745); municipal; Deep River impounded; filtered, adjustment of pH by addition of lime. Analyzed by E. E. Randolph, North Carolina State College, July 27, 1927 (North Carolina Dept. Conservation and Development Econ. Paper 61, p. 36, 1927). Monthly averages of daily determinations for the year 1929: Alkalinity 6.2 to 28, average 14; pH 7.1 to 8.0, average 7.6.

cities of the United States, 1932—Continued

	Analyses (parts per million)												No.
	Total dissolved solids	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulphate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Total hardness as $CaCO_3$[a]	
A	50	5.2	0.26	8.8	2.2	1.3	0.2	23	11	0.7	1.0	31	427
B	78	3.6	.11	15	5.4	1.7	.6	46	23	1.2	1.1	60	
	71	3.2	.10	14	1.7	4.1	1.0	34	22	2.6	.28	42	428
	326	22	.0	64	21	[a] 12		200	72	14	18	246	429
A	234	9.9	.01	42	15	11	3.6	146	46	14	4.1	166	430
B	108	8.5	.02	16	6.2	5.6	2.3	52	28	5.8	1.5	65	
	19	7.8	.05	.8	.6	1.8	.5	7.3	1.7	.7	Trace	4	431
	48	14	.01	7.1	1.2	2.6	.9	25	7.0	2.0	.50	23	432
	64	13	.02	11	1.6	4.2	.9	28	15	3.3	.20	34	433
	123	22	.15	30	.3	12	1.7	[••] 30	26	12	.27	76	434
	55	14	.05	8.6	1.8	3.8	1.0	30	11	1.8	.50	29	435
	83	16	.03	15	1.0	4.3	1.4	22	28	4.0	.30	42	436
	56	13	.02	7.6	2.1	3.9	1.5	21	17	1.7	.50	28	437
	60	11	.3	6.6	2.1	2.5	1.1	25	6.4	4	.2	25	438

[a] Calculated.

[••] Includes equivalent of 12 parts of carbonate (CO_3).

TABLE 5.—*Public water supplies of the larger*

No.	Description
	NORTH CAROLINA—continued
439	Kinston (11,362); municipal; 8 wells, 362, 190, 190, 300, 300, 562, 562, and 170 feet deep. The large 362-foot well furnishes about 80 percent of the total supply. Analysis of tap sample by E. W. Lohr, Sept. 16, 1931. Partial analyses for the same date made on representative samples from the wells indicate that the analysis given represents reasonably well the composition of the water delivered regularly to consumers. Well 3, 170 feet deep (about 8 percent of total supply), furnishes water that is considerably harder than the water from the other wells.
440	New Bern (11,981); municipal; 5 wells about 100 feet deep. Analysis of tap sample by E. W. Lohr, Jan. 17, 1933.
441	Raleigh (37,379); municipal; Walnut Creek impounded; filtered, aerated, adjustment of pH by addition of lime. Analyzed by E. E. Randolph, North Carolina State College, Dec. 10, 1928. Monthly averages of daily determinations for the year 1929: Alkalinity 14 to 28, average 19; hardness 19 to 30, average 24; pH 6.9 to 8.8, average 8.3.
442	Rocky Mount (21,412); municipal; Tar River; pressure filtration, adjustment of pH to 6.6–7 by addition of lime. Analyzed by W. L. Lamar, May 22, 1931.
443	Salisbury (16,951); municipal; North Fork of Yadkin River impounded (intake at junction of North Fork of Yadkin River and South River to form Yakdin River); filtered. Analyzed by L. L. Hedgepeth, North Carolina Department of Conservation and Development, Mar. 5, 1929. Monthly averages of daily determinations for the year 1929: Alkalinity 9 to 17, average 12; pH 6.8 to 7.2, average 7.1.
444	Wilmington (32,270); municipal; Cape Fear River; filtered, adjustment of pH by addition of lime. Analyzed by E. W. Lohr, May 26, 1931. Monthly averages of daily determinations for the year 1929: Alkalinity 19 to 24, average 21; pH 7.2 to 7.7, average 7.5.
445	Winston-Salem (75,274); municipal; Salem Lake (artificial); filtered, aerated, adjustment of pH by addition of lime. Analyzed by North Carolina Department of Conservation and Development, July 1928.
	NORTH DAKOTA
446	Bismarck (11,090); municipal; Missouri River; partial softening with lime, filtered. Analyzed by E. M. Stanton, Bismarck, Mar. 28, 1932. The composition of the raw water varies considerably throughout the year. Daily determinations on the treated water for the year 1930–31: Alkalinity 30 to 130, average 75; hardness 90 to 270, average 172. The turbidity of the raw water is reported to range from 20 to 24,000.
447	Fargo (28,619); municipal; Red River; softened, filtered. Analyzed by E. W. Lohr, July 28, 1932. A, Softened water; B, raw water. The pH of the filtered water is maintained at 8.6–9.8. The composition of the raw water varies throughout the year. Daily determinations for the year 1931: Softened water, alkalinity 92 to 230, average 139; raw water, alkalinity 172 to 385, average 236.
448	Grand Forks (17,112); municipal; Red Lake River; aerated, softened with lime, recarbonated, filtered, adjustment of pH to about 8.0–8.6. The composition of the water varies throughout the year. Analyzed by E. W. Lohr, Mar. 10, 1932. A, Softened water; B, raw water.
449	Jamestown (8,187); municipal; 5 drilled wells 80 to 90 feet deep, 1 dug well 37 feet deep and 25 feet in diameter, all in the same well field. The wells are reported to furnish water of about the same general composition. Analysis furnished by the city of Jamestown, dated Dec. 6, 1929.
450	Minot (16,099); municipal; 3 wells (nos. 1 to 3) 132, 132, and 158 feet deep. For most of the year well 1 furnishes about 75 percent and well 3 about 25 percent of the total supply. During summer well 1 furnishes about 50 percent, well 2 about 25 percent, and well 3 about 25 percent. Analyzed by G. A. Abbott, University of North Dakota, Jan. 15, 1932. A, Well 1; B, well 2; C, well 3.
	OHIO
	[Descriptions of the supplies and analyses for several were furnished by F. H. Waring, chief engineer, Ohio Department of Health, who also assisted in obtaining the information necessary for the inclusion of some of the places]
451	Akron (255,040); municipal; Cuyahoga River impounded; filtered. Average of analyses of monthly composite samples over a period of 5 years by J. S. Gettrust, Akron Water Works, 1926–30. Regular determinations for the year 1930: Alkalinity 25 to 112, hardness 64 to 152, sulphate 33 to 50, pH 6.9 to 8.0, with a 5-year average of 7.6.
452	Alliance (23,047); municipal; Mahoning River impounded; filtered. There is considerable variation in the composition of the water throughout the year. Industrial wastes affect the quality of the water. Regular determinations for the year 1929: Alkalinity (daily records) 10 to 164, average 76; hardness (monthly averages) 100 to 258, average 165; pH (monthly averages) 6.4 to 7.2, average 6.8. It was not possible to arrange for the collection of samples for analysis.
453	Ashtabula (23,301); Ashtabula Water Co. (controlled by American Water Works & Electric Co., 50 Broad St., New York, N.Y.); Lake Erie; filtered. The composition of the water is fairly uniform throughout the year and is practically the same as at Cleveland. (For analysis see Cleveland.)
454	Barberton (23,934); municipal; Wolf Creek impounded, aerated, filtered. The composition of the water varies throughout the year. Analysis of tap sample by E. W. Lohr, Aug. 18, 1932.

cities of the United States, 1932—Continued

	Analyses (parts per million)												No.
	Total dissolved solids	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulphate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Total hardness as $CaCO_3$[a]	
----------	140	16	0.01	3.3	2.8	38	9.1	121	4.0	7.5	0.20	20	439
----------	308	10	.11	61	3.6	36	1.8	120	35	80	.60	167	440
----------	[a] 43	14	.32	6.1	1.2	1.8	1.0	19	4.1	4.5	.4	20	441
----------	71	16	.04	4.2	1.6	11	.9	26	17	4.0	.20	17	442
----------	41	8.7	.05	3.1	.2	3.8	.6	15	8.6	9.0	.05	9	443
----------	59	8.4	.02	10	1.3	3.7	.9	22	17	3.5	.50	30	444
----------	57	10	Trace	8.9	.4	4.3		27	8.0	2.5	-------	24	445
----------	[a] 251	4.9	Trace	42	15	[a] 20		105	109	8.0	-------	166	446
A-------	314	11	.14	19	37	29	7.2	[hh]151	121	13	.48	199	447
B-------	415	13	.23	48	39	32	7.3	266	115	14	.20	280	
A-------	136	11	.01	18	5.1	15	4.6	[i] 68	38	7.0	1.0	66	448
B-------	327	18	.43	62	29	12	4.9	304	33	5.9	6.6	274	
----------	780	21	1.9	94	31	[a] 138		434	241	40	-------	362	449
A-------	657	-------	1.0	37	18	[a] 182		536	17	76	-------	166	450
B-------	924	-------	2.0	75	31	[a] 248		704	96	124	-------	315	
C-------	1,555	-------	2.3	93	28	[a] 473		982	143	300	-------	347	
Av.------	131	-------	.02	[a] 31	5.6	[a] 4.9		81	38	3.6	-------	[e] 100	451
----------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	---------	452
----------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	---------	453
----------	192	2.1	.02	46	10	4.3	2.1	130	52	4.8	.15	156	454

[a] Calculated.
[e] Determined.
[i] Includes equivalent of 9 parts of carbonate (CO_3).
[hh] Includes equivalent of 20 parts of carbonate (CO_3).

TABLE 5.—*Public water supplies of the larger*

No.	Description
	OHIO—continued
455	Canton (104,906); municipal; wells. Analyzed by E. W. Lohr, June 1, 1931. A, Tap at City Hall; B, Ninth St. station; C, Harrisburg station.

Station	Number of wells	Depth (feet)	Approximate percentage of total supply
Ninth St. (B)	12	150 (av.)	50
Harrisburg (C)	8	110–400	40
Avondale	1	385	10

No.	Description
456	Cincinnati (451,160); municipal; Ohio River; filtered; final adjustment of pH to 8.2–8.5 by addition of lime. Analyses of monthly composites by Cincinnati Water Works. A, Average of monthly composites, 1928–32; B, average of monthly composites, 1930; C, average of monthly composites, 1928; D, monthly composite, December 1930; E, monthly composite, April 1932. Weekly figures for nitrate gave averages of 2.8 for 1920 and 1.9 for 1921.
457	Cleveland (900,429); municipal. Supplies also Cleveland Heights, East Cleveland, Lakewood, North Olmsted, Shaker Heights, and about 118,000 additional consumers in the adjacent suburban area. Total population supplied about 1,200,000. Lake Erie; filtered. Average of analyses by Cleveland Water Works, 1930. Regular determinations for the year 1930: Alkalinity 70 to 95, hardness 102 to 124, sulphate 21 to 38, pH 7.1 to 7.9, average 7.5.
458	Cleveland Heights (50,945); supplied by Cleveland. (See Cleveland)
459	Columbus (290,564); municipal; Scioto River impounded; softened with lime and soda ash, recarbonated, filtered. Analysis of about an average sample by C. P. Hoover, Water Softening & Purification Works, 1931. Daily determinations on the treated water for the year 1930: Alkalinity 19 to 69, average 36; hardness 59 to 108, average 85. Daily determinations on the raw water for the year 1930: Alkalinity 56 to 215, average 171; hardness 72 to 355, average 268.
460	Dayton (200,982); municipal; wells 30 to 60 feet deep in Mad River Valley. Average of analyses of bimonthly samples by Water Works Laboratory, 1932.
461	East Cleveland (39,667); supplied by Cleveland. (See Cleveland)
462	East Liverpool (23,329); municipal; Ohio River; filtered. The composition of the water varies throughout the year and is about the same as at Steubenville. (For analysis, see Steubenville.)
463	Elyria (25,633); municipal; Lake Erie; filtered. The composition of the water is fairly uniform throughout the year. Analyzed by N. J. Humason, Apr. 29, 1931.
464	Hamilton (52,176); municipal; 5 wells about 110 feet deep. Analysis of tap sample from wells 1 and 2 by E. W. Lohr, Jan. 7, 1932.
465	Lakewood (70,509); supplied by Cleveland. (See Cleveland)
466	Lima (42,287); municipal; Ottawa River impounded; filtered. Emergency supply from wells. Analyzed by E. E. Smith, 2d, Lima Water Department. Regular determinations for the year 1932: Alkalinity 99 to 143, hardness 198 to 252, pH 6.9 to 7.3, average 7.1.
467	Lorain (44,512); municipal; Lake Erie; filtered. The composition of the water is fairly uniform throughout the year and is practically the same as at Elyria and Cleveland. (For analyses, see Elyria and Cleveland.)
468	Mansfield (33,525); municipal; 14 wells 100 to 250 feet deep, 6 of the wells in the city, the remainder in the surrounding territory within 5 miles of the city; 2 of the wells are pumped direct to the mains; the rest are pumped to 2 reservoirs. Analyzed by E. W. Lohr. A, North Main St. Reservoir; B, well 105 feet deep at Hershey unit; C, Maxwell well; D, well 132 feet deep at Hedges station. A to C collected May 4, 1932; D collected May 5, 1932.
469	Marion (31,084); Marion Water Co. (controlled by Community Water Service Co., 100 William St., New York, N.Y.); 13 wells 115 to 225 feet deep in a 56-acre well field; aerated, softened with lime and soda ash, recarbonated, settled. The softening is carried out to produce an effluent having a hardness of about 204. There is considerable variation in the composition of the water from the different wells. The alkalinity of the raw water from the different wells is reported to range from about 250 to 325, the hardness from about 700 to 1,000, and the sulphate from about 400 to 1,000. Some of the individual wells are reported to vary considerably in noncarbonate hardness from day to day and even from hour to hour. The wells are put into service in accordance with their hardness, the softest wells being used first. Owing to decrease in industrial consumption and to other economies, only the three softest wells were in service when the samples for which the analyses are given were collected. Analyzed by E. W. Lohr, Apr. 6, 1932. A, Softened water; B, raw water.
470	Massillon (26,400); Ohio Water Service Co. (controlled by Federal Water Service Corporation, 27 William St., New York, N.Y.); well 1, 177.5 feet deep, emergency supply from 12 wells; aerated, softened with lime and soda ash, recarbonated, filtered. An additional emergency supply is obtained from a well 180 feet deep which is pumped directly to the mains. Analyses of monthly composite samples by E. W. Lohr, May 1932. A, Softened water; B, raw water.

cities of the United States, 1932—Continued

	Analyses (parts per million)												No.
	Total dissolved solids	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulphate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Total hardness as $CaCO_3$[a]	
A	426	12	0.08	100	22	10	3.2	298	99	7.8	0.30	340	455
B	666	14	1.6	148	32	16	4.8	363	195	25	.20	501	
C	405	12	.02	96	21	7.0	2.2	278	97	6.0	.10	326	
A	207	-------	.05	34	[a] 6.1	[a] 15		45	72	22	-------	[e] 110	456
B	258	-------	.05	42	[a] 6.1	[a] 22		52	86	32	-------	[e] 130	
C	172	-------	.05	30	[a] 5.3	[a] 12		43	63	16	-------	[e] 97	
D	407	-------	.03	60	[a] 12	[a] 42		52	144	70	-------	[e] 200	
E	133	-------	.05	21	[a] 3.8	[a] 13		29	53	12	-------	[e] 68	
Av	159	3.1	.24	34	8.6	[a] 7.5		104	29	15	-------	120	457
----------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	458
----------	245	-------	.0	19	9	42		[n] 44	120	12	10	84	459
Av	[a] 416	10	.8	90	35	7.3		339	83	9.6	13	368	460
----------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	461
----------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	462
----------	171	3.0	.2	32	8.6	10		105	33	16	-------	115	463
----------	421	16	2.6	100	35	5.2	1.8	376	76	6.5	.10	394	464
----------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	465
Av	324	-------	.12	60	19	[a] 32		134	144	27	-------	228	466
----------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	467
A	497	15	.17	99	34	19	2.4	318	142	9.4	2.3	387	468
B	277	15	.25	63	20	7.2	1.8	227	54	3.8	1.8	240	
C	218	11	.02	53	16	2.8	1.6	206	27	1.6	3.7	198	
D	147	2.6	.40	24	15	7.9	1.7	[i] 127	13	17	.10	122	
A	720	6.2	.02	70	9.0	132	2.6	44	446	4.5	.10	212	469
B	1,018	16	4.3	209	60	16	3.2	380	445	4.0	.30	768	
A	264	8.2	.01	18	8.3	55	1.9	[n] 32	107	47	.10	79	470
B	469	15	1.1	92	28	19	2.0	258	102	49	.20	345	

[a] Calculated.
[i] Includes equivalent of 8 parts of carbonate (CO_3).
[n] Includes equivalent of 10 parts of carbonate (CO_3).
[e] Determined.

TABLE 5.—*Public water supplies of the larger*

No.	Description
	OHIO—continued
471	Middletown (29,992); municipal; wells 1 and 3 and 14 6-inch wells, about 49 feet deep; well 2, 180 feet deep. Wells 1 and 3 and the 6-inch wells draw water from the same formation. Well 2 draws from a second water-bearing formation and is sealed off entirely from the upper formation; this well normally furnishes approximately 40 percent of the total supply. Analyzed by W. L. Lamar, July 25, 1932. A, Well 1; B, well 2.
472	Newark (30,596); municipal; Licking River; softened, filtered. The composition of the raw water varies throughout the year. Average of analyses of catch samples by C. T. Kaiser, Newark Water Department.
473	Norwood (33,411); municipal; 15 wells 270 to 400 feet deep. A analyzed by Ohio Department of Health, March 1931; B, analysis furnished by Norwood Department of Health.
474	Portsmouth (42,560); municipal; Ohio River; filtered. Analyses of the treated water at Cincinnati represent reasonably well the mineral content of the water at Portsmouth. (For analyses, see Cincinnati.)
475	Sandusky (24,622); municipal; Sandusky Bay; softened with lime and soda ash, recarbonated, filtered. The pH of the effluent is reported to average around 8.8. The water is softened to a hardness around 85. Analyzed by E. W. Lohr, Mar. 11, 1932. A, Softened water; B, raw water.
476	Springfield (68,743); municipal; infiltration gallery in valley of Buck Creek. Analyzed by Arthur D. Little, Inc., Cambridge, Mass., Nov. 7, 1930.
477	Steubenville (35,422); municipal; Ohio River; filtered. The composition of the water varies throughout the year and is probably similar to that of the water furnished to consumers at Wheeling, W.Va. Analysis of a sample of the filtered water at Wheeling by W. L. Lamar, July 19, 1932.
478	Toledo (290,718); municipal; Maumee River; filtered. Analysis of tap sample by E. W. Lohr, May 8, 1932. There is considerable variation in the composition of the water throughout the year. Regular determinations for the year 1931: Hardness 193 to 270, average 239; chloride 20 to 36, average 27; pH 7.3 to 8.2, average 7.8.
479	Warren (41,062); municipal; Mahoning River; filtered. Analysis of monthly composite sample by P. J. O'Connor, Warren Water Works, October to November 1928. There is considerable variation in the composition of the water throughout the year. The raw water is acid at times, owing to discharge of industrial wastes. Regular determinations for the year 1929: Alkalinity 10 to 87, hardness 83 to 181, pH (1930 figures) 6.8 to 8.5, average 7.4.
480	Youngstown (170,002); Mahoning Valley Sanitary District, which includes also Niles. Total population supplied about 186,000. Meander Creek Reservoir impounding Meander Creek; softened with lime and soda ash, recarbonated, filtered. The pH of the filtered water is around 9. Analyzed by W. I. Van Arnum, Mahoning Valley Sanitary District, Feb. 17, 1933. A, Softened water; B, raw water.
481	Zanesville (36,440) municipal; 16 wells 150 feet deep along Muskingum River. Analysis of tap sample by E. W. Lohr, Jan. 9, 1932.
	OKLAHOMA
	[Some descriptive material was furnished by H. J. Darcey, State sanitary engineer, who arranged for the collection of some of the samples that were analyzed by the U.S. Geological Survey]
482	Ada (11,261); municipal; Byrds Mill Spring. Analyzed by W. L. Lamar, May 10, 1931
483	Ardmore (15,741); municipal; City Lake, Hickory Creek Reservoir. Analyzed by L. A. Shinn, October 1930.
484	Bartlesville (14,763); Bartlesville Water Co.; Caney River impounded; aerated, filtered. There is considerable variation in the composition of the water throughout the year. The alkalinity of the water is reported to range from 100 to 200 and the hardness from 50 to 500 and 600. Analysis of tap sample by E. W. Lohr, Mar. 5, 1932.
485	Chickasha (14,099); municipal; Washita River; filtered. The composition of the water varies throughout the year. Analysis of tap sample by E. W. Lohr, Mar. 5, 1932.
486	Enid (26,339); municipal; wells 45 to 60 feet deep. Analyzed by L. A. Shinn. U.S. Geological Survey, October 1930.
487	Lawton (12,121); municipal; Lake Lawtonka; filtered. There is some variation in the composition of the water throughout the year. Analyzed by C. A. Kinser, U.S. Geological Survey, Sept. 3, 1931.
488	McAlester (11,804); municipal; Lakes McAlester, Talawanda, and no. 2; filtered. Lake McAlester impounds 4,500,000,000 gallons. Analysis of tap sample from Lake McAlester by E. W. Lohr, Aug. 10, 1931.
489	Muskogee (32,026); municipal; Grand River; coagulation without filtration. Analyzed by E. W. Lohr, July 14, 1931.
490	Oklahoma City (185,389); municipal; North Canadian River impounded in reservoir; aerated, softened, recarbonated, filtered. Analyzed by L. A. Shinn, U.S. Geological Survey, Mar. 20, 1931. The analysis probably represents a hardness greater than the average. Monthly averages of regular determinations for the year 1929–30: Alkalinity 29 to 62, average 39; hardness 88 to 171, average 121.
491	Okmulgee (17,097); municipal; Salt Creek impounded in Lake Okmulgee; aerated, filtered. The pH of the filtered water is reported to average around 7.2. Analyzed by Okmulgee Chemical & Clinical Laboratory, Jan. 16, 1929.

cities of the United States, 1932—Continued

	Analyses (parts per million)												No.
	Total dissolved solids	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulphate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Total hardness as $CaCO_3$ [a]	
A	351	9.6	0.05	86	26	5.0	2.4	322	49	7.0	11	322	471
B	355	16	2.3	79	33	9.8	2.0	396	15	9.0	.37	333	
	185	4.0	.0	17	9.0	[a] 11		10	79	9		79	472
A	424		1.0					413	38	15		[e] 376	473
B	[a] 389	18		84	26	16		279	83	25		317	
													474
A	187	6.6	.11	26	5.1	24	2.2	[dd] 52	73	10	11	86	475
B	230	9.8	.52	49	12	6.8	2.2	132	58	9.9	9.8	172	
	323	12		68	26	3.6		289	36	5.0		277	476
	188	6.0	.06	30	6.6	13	2.5	8.0	105	13	2.3	102	477
	346	2.4	.17	70	19	12	2.8	164	105	16	10	253	478
	251	.2	.0	41	14	18		29	137	9.0		160	479
A	178	1.4	.04	18	8.7	25		[j] 35	86	7.5		81	480
B	232	2.4	[b] 1.1	36	14	15		90	81	7.0		147	
	618	12	.33	104	16	70	3.1	164	96	180	.50	326	481
	351	20	.07	78	37	4.6	1.1	413	7.7	5.8	2.3	347	482
	139	8.8	.01	36	5.9	4.8	2.2	127	11	3.0	2.2	114	483
	521	6.0	.04	89	16	77	2.2	226	41	153	2.0	288	484
	967	12	.09	170	49	51	3.3	228	471	38	.20	626	485
	292	11	.02	59	9.7	31	1.8	223	19	26	21	187	486
	153	1.8	.06	38	6.7	10	3.8	141	15	8.0	1.0	122	487
	69	4.6	.09	8.1	3.5	5.8	2.4	22	26	3.4	1.4	35	488
	192	5.4	.02	44	6.0	14	2.5	124	37	19	.0	135	489
	578	12	.02	27	22	131	3.8	[j] 46	152	180	1.0	158	490
	212	3.0	[b] .80	21	5.8	42		78	12	65		76	491

[a] Calculated.
[b] Iron and aluminum oxides.
[j] Includes equivalent of 16 parts of carbonate (CO_3).
[e] Determined.
[dd] Includes equivalent of 6 parts of carbonate (CO_3).

TABLE 5.—*Public water supplies of the larger*

No.	Description
	OKLAHOMA—continued
492	Ponca City (16,136); municipal; wells 40 feet deep in Arkansas River bottom. Analyzed by Kansas City Testing Laboratory, Inc. Kansas City, Mo., Sept. 30, 1932.
493	Sapulpa (10,533); municipal; Rock Creek impounded in reservoir; filtered. Quality of water is reported to be affected by oil wells Analyzed by W L. Lamar, May 25, 1931.
494	Seminole (11,459); municipal; 7 wells (nos. 1, 4, 5, 6, 7, 8, and 10), 620, 584, 595, 610, 600, 620, and 605 feet deep. The wells are located within a radius of about a quarter of a mile. Analysis of a sample from well 7 by E. W Lohr, Feb. 16, 1931
495	Shawnee (23,283); municipal; 21 wells, known as West Wells, about 48 feet deep; 3 wells at West Highway station about 50 feet deep. Analyzed by L. K. Cecil, International Filter Co., Chicago, Ill., Mar. 13, 1931. A, West Wells; B, wells at West Highway station.
496	Tulsa (141,258); municipal; Spavinaw Lake; aerated, filtered. Analyzed by A. B. Jewell, Tulsa Water Department, Sept. 10, 1930.
497	Wewoka (10,401); municipal; Lake Wewoka; aerated, filtered. The average alkalinity is reported to be about 45, and the average hardness about 85. The pH, based on daily determinations, ranged from 6.6 to 7.4 with an average of 7.0 The analysis probably represents a minimum concentration. Analyzed by E. W. Lohr, Feb 29, 1932.
	OREGON
498	Astoria (10,349); municipal; Bear Creek (mountain stream). Analysis of tap sample by E. W. Lohr, June 17, 1932.
499	Eugene (18,901); municipal; McKenzie River; filtered only during periods of high river stage, when the water is rather turbid. The mineral content of the water is low, and the range in concentration not great. A, Average of analyses of raw water from McKenzie River near Springfield by U.S. Geological Survey in 1911–12 (Water-Supply Paper 363, p. 92, 1914); B, analysis of the filtered water by L. A. Shinn, U.S. Geological Survey, Apr. 1, 1931.
500	Klamath Falls (16,093); California-Oregon Power Co.; 8 wells (nos. 1–8) near together, 90, 90, 190, 93, 75, 147, 370, and 845 feet deep. Analysis of sample from well 8 by W. F. Langelier, University of California, Mar. 3, 1930.
501	Marshfield and North Bend District (12,000 consumers); Oregon-Washington Water Service Co. (controlled by Federal Water Service Corporation, 27 William St., New York, N.Y.). Supplies Marshfield, North Bend, and the suburban area in the vicinity of these two communities. Pony Creek; filtered. Analysis of tap sample by P. Villarruz, California Water Service Co., Stockton, Calif., Apr. 21, 1931.
502	Medford (11,007); municipal; Big Butte Springs. Analyzed by O. F. Stafford, University of Oregon, June 20, 1925.
503	Portland (301,815); municipal; Bull Run River and Lake. A, Analysis of tap sample by E. W. Lazell, Chemical & Physical Laboratories, Portland, July 1, 1930; B, analyses of water from Bull Run River near Bull Run by U.S. Geological Survey, 1911–12 (Water-Supply Paper 363, p. 86, 1914).
504	Salem (26,266); Oregon-Washington Water Service Co. (controlled by Federal Water Service Corporation, 27 William St., New York, N.Y.). Infiltration galleries along Willamette River. Analyzed by P. Villarruz, California Water Service Co., Stockton, Calif., July 25, 1930. The mineral content of the water is fairly low, and the range in concentration not great. An average of analyses of water from the Willamette at Salem for 1911–12 is about the same as the analysis given.
	PENNSYLVANIA
505	Aliquippa (27,116); Woodlawn Water Co. (85 percent of total supply) and municipal (15 percent of total supply); wells.

	Source	Approximate depth (feet)	Percent of total supply	Date of collection (1931)	Analyst
A	22 river wells (Woodlawn Water Co.).	40	78	April	Aliquippa Works of Jones & Laughlin Steel Corporation.
B	Gravel-packed well (Woodlawn Water Co.).	90	7	do	Do.
C	15 wells (municipal)	30	15	May 20	W. L. Lamar.

cities of the United States, 1932—Continued

	Analyses (parts per million)												
	Total dissolved solids	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulphate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Total hardness as $CaCO_3$[a]	No.
----------	1,005	8.5	0.1	143	20	157		306	133	276	0.0	440	492
----------	330	17	.38	27	9.3	69	3.9	[dd] 44	33	134	1.8	106	493
----------	259	10	.03	5.7	1.6	89	1.5	[c] 202	44	5.8	.96	21	494
A-------	[a] 550	26	.91	109	37	42		511	56	28	-------	424	495
B-------	[a] 99	26	.07	12	6.4	7.3		63	6.8	9.7	-------	56	
----------	[a] 98	4.0	.1	30	1.3	4.7		93	7.5	4.5	Trace	80	496
----------	112	5.9	.11	18	4.8	8.9	2.3	26	41	15	1.1	65	497
----------	70	26	.16	5.4	2.7	5.6	1.6	30	4.1	6.8	.10	25	498
A-------	50	17	.06	4.4	1.1	4.1	1.2	24	3.8	1.3	.18	16	499
B-------	44	14	.02	4.6	1.5	2.3	.8	10	13	1.2	.10	18	
----------	[a] 155	46	.0	10	4	29		117	0	8	-------	41	500
----------	78	10	.10	12	1.9	[a] 9.4		24	18	14	-------	38	501
----------	[a] 61	28	[b] 3.2	6.8	2.8	([cc])		21	6.3	3.5	-------	28	502
A-------	25	3.9	[b] .13	2.0	.7	2.9	.9	13	-------	2.4	.3	8	503
B Av---	30	9.0	.03	2.7	.5	3.1	.5	12	3.1	1.3	.31	9	
B Max--	41	13	.05	4.7	1.7	6.4		20	4.6	1.3	Trace	19	
B Min--	21	6.3	.06	1.7	.04	2.9		9.8	1.7	.8	.08	4	
----------	52	16	.05	5.0	2.3	[a] 5.8		32	2.7	4.0	-------	22	504
A-------	505	8.0	[b] 1.4	102	9.8	37		105	238	30	-------	295	505
B-------	1,028	15	[b] 1.5	210	33	50		222	503	45	-------	660	
C-------	605	15	.08	123	20	24	2.9	117	304	21	2.4	390	

[a] Calculated.
[b] Iron and aluminum oxides.
[c] Includes equivalent of 9 parts of carbonate (CO_3).
[cc] Less than 5 parts.
[dd] Includes equivalent of 6 parts of carbonate (CO_3).

TABLE 5.—*Public water supplies of the larger*

No.	Description
	PENNSYLVANIA—continued
506	Allentown (92,563); municipal; Schantz and Crystal Springs, Little Lehigh Creek (filtered). The springs furnish about 70 percent of the supply. There is some variation in the composition of the water throughout the year, but the analysis given may be taken to represent reasonably well the composition of the water delivered to consumers. Analysis of tap sample by H. J. Krum, City Water Bureau, Jan. 28, 1931.
507	Altoona (82,054); municipal; 8 impounding reservoirs. Industrial wastes affect the composition of the water. During 1932 some of the industrial wastes formerly received by the system were eliminated. Analyzed by E. W. Lohr, Oct. 21, 1931. A, Kittanning Point Reservoir; B, Allegheny Reservoir. A partial analysis of a tap sample collected Oct. 22, 1931, from Juniata Reservoir is similar to the analysis given for the Allegheny Reservoir.
508	Ambridge (20,227); municipal; 30 wells 35 to 40 feet deep along Ohio River. There are two groups of wells, one above a creek at the point where it enters Ohio River and the other below it. In general more water is obtained from the upper group, the water from which is harder but lower in iron than that obtained from the lower group. The composition of the water delivered to consumers varies with the seasons and in accordance with the quantities pumped from each group of wells. It is proposed to soften the supply. Analyzed by J. J. Boyle, Ambridge Water Commission, Oct. 6, 1930. A, Upper group; B, lower group.
509	Bethlehem (57,892); municipal; Lehigh River, about 6,300,000 gallons a day (filtered); 3 wells (nos. 1 to 3) 600, 800, and 1,200 feet deep, about 1,000,000 gallons a day. The river and wells furnish different sections of the city, but as the entire distributing system is interconnected consumers may receive river water, well water, or mixed water. Analyzed by E. W. Lohr, Nov. 18, 1931. A, Lehigh River (filtered water); B, wells 1 and 3. The analysis for Lehigh River probably represents a concentration greater than the average. Frequent determinations on the filtered river water for the year 1931–32: Alkalinity 4.0 to 79, average 31; pH 6.1 to 7.3, average 6.7. The pH of the well water averages about 7.5.
510	Butler (23,568); Butler Water Co. (controlled by American Water Works & Electric Co., 50 Broad St., New York, N.Y.). Connoquenessing Creek impounded in Boydstown Reservoir and Lake Oneida, Thorn Run impounded in Thorn Run Reservoir; filtered, adjustment of pH. Analysis of tap sample (90 percent Lake Oneida, 10 percent Thorn Run Reservoir) by E. W. Lohr, Dec. 31, 1931. The Lake Oneida system is the main source and normally furnishes around 90 percent of the supply. If necessary the total supply may be obtained from one system. The composition of the water is affected by irregular drainage from oil wells. Yearly averages of chlorides for the period 1923 to 1929 ranged from 74 for 1927 to 178 for 1925, with an average of 101 for the 7-year period. Regular determinations for 1929: Hardness 31 to 87, average 61; chloride 30 to 138, average 79.
511	Carbondale (20,061); Scranton-Spring Brook Water Service Co. (controlled by Federal Water Service Corporation, 27 William St., New York, N.Y.). Supplies also part of Carbondale and Fell townships, Jermyn, and Mayfield. Total population supplied about 30,000. Brownell Reservoir (about 70 percent), Crystal Lake (about 30 percent). Analysis of sample from Brownell supply by G. R. Taylor, Scranton-Spring Brook Water Service Co., Mar. 14, 1931.
512	Chester (59,164); Chester Water Service Co. (controlled by Federal Water Service Corporation, 27 William St., New York, N.Y.). Supplies also Aston township, Lower Chichester township, Marcus Hook, Nether Providence township, Parkside, Trainer, Upland, and Upper Chichester township. Total population supplied about 80,000. Delaware River; aerated, filtered, final adjustment of pH by addition of lime. Analyzed by E. W. Lohr, Aug. 5, 1931. During the fall of 1930 there was contamination with sea water due to extremely low fresh-water run-off. The peak of this period was reached in November, with average total solids of 1,042 and an average chloride of 465. Monthly averages of regular determinations for the 2-year period 1928–29: Hardness 43 to 96, average 75; chloride 7.9 to 16, average 10; pH (for the 2-year period 1929–30) 7.3 to 8.6, average 7.6.
513	Dunmore (22,627); Scranton-Spring Brook Water Service Co.; Scranton supply. (See Scranton)...
514	Duquesne (21,396); municipal; 19 wells about 100 to 130 feet deep along Monongahela River; lime added for iron removal, filtered without other coagulation. Analyzed by E. C. Trax, McKeesport, Dec. 6, 1927. The raw water is very high in iron. There is some variation in the composition of the water. The alkalinity of the treated water has ranged from 15 to 35 but is usually within the range 17 to 25. The pH is reported to range generally from 8.0 to 8.5.
515	Easton (34,468); Lehigh Water Co. Supplies also part of Wilson. Total population supplied about 42,000. Delaware River above mouth of Lehigh River. Water is taken directly from a filtering crib in the river. A, Tap sample, May 12, 1932; B, tap sample, Nov. 2, 1931; C, average of analyses of composite samples of raw water from Delaware River at Lambertville, N.J., by U.S. Geological Survey 1906–7 (Water-Supply Paper 236, p. 60, 1909). A and B analyzed by J. H. Wilson, Lafayette College.
516	Erie (115,967); municipal; Lake Erie; filtered. The chemical composition of the water is fairly constant. Analyzed by L. A. Shinn, U.S. Geological Survey, Mar. 18, 1931.
517	Harrisburg (80,339); municipal; Susquehanna River; filtered, final adjustment of pH to about 6.9–7.2 by addition of soda ash. Analysis of tap sample by G. N. Book, Bureau of Water and Lighting, Aug. 6, 1931. Regular determinations for the year 1931: Alkalinity (daily tests) 14 to 42, average 24; hardness (weekly tests) 40 to 80, average 58; pH (daily tests) 6.9 to 7.2, average 7.0.

cities of the United States, 1932—Continued

	Analyses (parts per million)											No.
	Total dissolved solids	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulphate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Total hardness as $CaCO_3$[a]	
----------	277	7.5	[b] 1.1	40	20	[a] 8.5		187	22	15	4	182	506
A-------	190	11	1.4	24	8.0	2.2	2.0	0	[ii] 114	2.2	.25	93	507
B-------	33	5.0	.24	5.4	1.5	1.5	1.1	14	9.9	2.2	.40	20	
A-------	[jj] 602	15	.07	120	31	18		88	314	45	-------	427	508
B-------	[kk] 448	12	.35	81	16	26		93	190	35	-------	268	
A-------	204	7.0	.09	30	15	14	2.7	81	66	16	7.8	136	509
B-------	266	8.4	.02	52	26	3.7	1.9	202	64	7.2	1.2	237	
----------	192	4.8	.02	23	4.5	30	1.8	18	28	70	2.8	76	510
----------	[a] 54	9.1	.05	6.5	2.3	[a] 4.7		8.1	24	3.0	-------	26	511
----------	150	8.9	.02	26	5.4	8.6	2.6	53	47	9.8	2.6	87	512
----------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	513
----------	[a] 366	14	.1	60	13	[a] 33		21	198	35	2.7	203	514
A-------	49	0.7	[b] 1.3	8.7	2.9	2.7	0.9	[a] 29	12	3.2	0.36	34	515
B-------	69	2.0	[b] .8	14	5.1	3.4	1.0	[a] 53	14	4.5	.28	56	
C-------	70	9.0	.07	12	3.3	5.4		46	12	2.9	1.1	44	
----------	147	1.0	.01	34	8.0	5.7	1.1	109	19	14	1.0	118	516
----------	[a] 96	5.4	[b] 1.4	15	4.2	11		[a] 46	24	11	1.0	55	517

[a] Calculated.
[b] Iron and aluminum oxides.
[ii] Includes equivalent of 29 parts of free sulphuric acid (H_2SO_4).
[jj] Includes 3.6 parts of manganese.
[kk] Includes 4.0 parts of manganese.

TABLE 5.—*Public water supplies of the larger*

No.	Description
	PENNSYLVANIA—continued
518	Haverford township (21,362); supplied by Philadelphia Suburban Water Co. (See Upper Darby township.)
519	Hazleton (36,765); Wyoming Valley Water Supply Co.; supplies also West Hazleton. Total population supplied about 44,100. Impounded mountain streams and springs as follows: Hudsondale supply (46 percent), Dreck Creek (28 percent), Wolffs and Barnes Runs (22 percent), Mount Pleasant supply (3.5 percent), and Harleigh Springs (0.5 percent). The mineral content of the different sources of supply is so low and the range in concentration throughout the year so small that a single analysis may be taken to represent the composition of the water. Analysis of tap sample by W. L. Lamar, May 11, 1931.
520	Homestead (20,141); supplied by city of Pittsburgh. (See Pittsburgh municipal)
521	Johnstown (66,993); Johnstown Water Co.; mountain streams impounded. Average analyses of monthly composite samples by C. M. Ogborn, Johnstown Water Co., 1929. Range in concentration of the monthly composite samples: Alkalinity 5 to 10, hardness 11 to 18, chloride 2.0 to 2.5.
522	Kingston (21,600); Scranton-Spring Brook Water Service Co.; Wilkes-Barre supply. (See Wilkes-Barre.)
523	Lancaster (59.949); municipal; Conestoga Creek; aerated at times, filtered. There is considerable variation in the composition of the water throughout the year. The coagulation and filtration reduce the silica and iron; the bicarbonate may be decreased, and the sulphate is increased. Analysis of a fairly representative sample of raw water by E. W. Lohr, Nov. 25, 1931.
524	Lebanon (25,561); municipal; Poplar Run (about two thirds of supply), 5 springs (about one third), auxiliary supply from Hammer Creek. The water is fed to two small reservoirs and is furnished to consumers from reservoir 1. There is some variation in the composition of the water throughout the year. Analysis of tap sample by E. W. Lohr, Feb. 2, 1932.
525	Lower Merion township (35,166); supplied by Philadelphia Suburban Water Co. (See Upper Darby township.)
526	McKeesport (54,632); municipal; Monongahela River; softened at times, filtered, final adjustment of pH by addition of lime or lime and soda ash. Analysis furnished by E. C. Trax, McKeesport Water Department. There is considerable variation in the composition of the raw water throughout the year. A greater part of the time the raw water is acid from industrial wastes, principally drainage from bituminous-coal mines. Daily determinations on the treated water for the year 1931-32: Alkalinity 9 to 25, average 15; hardness 45 to 195, average 107; pH 7.2 to 9.7, average 8.7. Range in hardness of the raw water for different years: 1929, 40 to 280; 1930, 55 to 440; 1931, 40 to 315.
527	McKees Rocks (18,116); Pittsburgh Suburban Water Service Co (controlled by Federal Water Service Corporation, 27 William St., New York, N.Y.). Supplies also Avalon, Bellevue, Ben Avon, Ben Avon Heights, Emsworth, Neville township, Ross township, most of Stowe township, and West View. Total population supplied about 66,000. 46 wells 30 to 35 feet deep, near together; softened with zeolite; pressure filtration. Analyzed by E. W. Lohr, Jan. 28, 1932. A, Softened water; B, raw water. Daily determinations on the treated water for the year 1931: Hardness 70 to 240, average 124; manganese (weekly tests) 0.1 to 1.0, average 0.8; pH 6.3 to 7.5, average 7.3. Daily determinations on the raw water for the year 1931: Hardness 275 to 420, average 311; manganese (average of weekly tests) 1.2; pH 6.3 to 7.5, average 7.4.
528	Monessen (20,268); Tri-Cities Water Co. Supplies also Charleroi, Donora, North Charleroi, and parts of adjacent townships and small boroughs. Total population supplied about 50,000. Monongahela River; hydrated lime 100 percent of the year, alum 10 percent of the year, and iron sulphate 2 percent of the year, filtered, adjustment of pH by addition of lime to produce a phenolphthalein alkalinity of around 5 parts per million in the final effluent. Analysis of a single tap sample by E. C. Trax, McKeesport Water Department, Sept. 10, 1928. There is considerable variation in the composition of the water, and the analysis cannot be taken as representative of the composition of the water delivered to consumers at all times. Industrial wastes affect the quality of the water. The river water is acid most of the time.
529	Nanticoke (26,043); Scranton-Spring Brook Water Service Co.; Wilkes-Barre supply. (See Wilkes-Barre.)
530	New Castle (48,674); New Castle Water Co. (controlled by American Water Works & Electric Co., 50 Broad St., New York, N.Y.). Shenango River; aerated, filtered, adjustment of pH to about 7.6 by addition of lime. Pymatuning Dam is now under construction. This dam will be located on Shenango River about 34 miles north of New Castle and will impound 65,600,000,000 gallons. Analysis of tap sample by Margaret D. Foster, U.S. Geological Survey, Apr. 28, 1922. Regular determinations for the year 1930: Alkalinity (weekly averages) 11 to 68, average 32; hardness 47 to 200, average 119; chloride 1 to 49, average 27; pH 7.2 to 8.4.
531	Norristown (35,853); Norristown Water Co.; Schuylkill River; aerated, filtered, adjustment of pH to about 7.6 by addition of lime. The composition of the water varies throughout the year. Analyzed by E. W. Lohr, Mar. 9, 1932.
532	Philadelphia (1,950,961); municipal. Torresdale plant supplied by Delaware River (55 percent); slow sand filtration. Queen Lane, Belmont, and Upper Roxborough plants supplied by Schuylkill River (45 percent); slow and rapid sand filtration. Lime is added most of the time at the Belmont rapid sand filtration plant to adjust the pH; the average in 1931 was 7.2. The average pH at the Queen Lane rapid sand filtration plant in 1931 was 6.9. Analyzed by U.S. Geological Survey. A, Torresdale, Sept. 29, 1930; B, Belmont, Sept. 29, 1930; C, Torresdale, May 12, 1931; D, Belmont, May 12, 1931. A and B analyzed by L. A. Shinn, C and D by W. L. Lamar. Results of monthly composites for the year 1931: Torresdale plant, alkalinity 13 to 43, average 29; hardness 38 to 80, average 64. Belmont plant, alkalinity 31 to 78, average 48; hardness 115 to 172, average 131.

cities of the United States. 1932—Continued

	Analyses (parts per million)												No.
	Total dissolved solids	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulphate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Total hardness as $CaCO_3$[a]	
----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	518
----------	23	2.6	0.11	2.6	0.7	1.1	0.6	4.0	6.4	1.3	0.78	9	519
----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	520
----------	35	3.2	.20	3.7	1.0	[a] 3.2		9.1	9.3	2.2	-------	13	521
----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	522
----------	184	7.8	.35	45	12	4.9	2.2	176	15	5.8	4.9	162	523
----------	96	16	.15	20	5.7	2.4	1.1	72	12	2.5	2.9	73	524
----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	525
----------	232	3.0	.0	39	7.2	[a] 23		20	134	14	.5	127	526
A-------	373	13	.02	43	6.8	70	4.5	141	133	29	3.2	135	527
B-------	397	13	.48	81	12	26	5.7	146	144	28	4.0	252	
----------	244	5.2	.1	32	7.4	[a] 18		13	117	11	4.9	110	528
----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	529
----------	136	3.8	.17	27	6.1	4.2	1.5	32	65	5.1	1.4	93	530
----------	189	6.4	.01	33	11	7.3	1.8	55	85	5.5	4.2	128	531
A-------	99	2.4	.01	17	6.4	6.6	2.1	54	25	10	4.5	69	532
B-------	266	12	.01	43	15	16	2.6	88	105	17	7.7	169	
C-------	63	4.2	.07	9.8	3.4	3.1	1.2	22	21	4.0	2.0	38	
D-------	194	7.7	.04	30	11	8.5	1.5	37	87	9.0	3.2	120	

[a] Calculated.

TABLE 5.—*Public water supplies of the larger*

No.	Description

PENNSYLVANIA—continued

533 Pittsburgh (669,817):
Municipal. Supplies also Blawnox, Homestead, and part of O'Hara, Reserve, and Shaler townships. Total population supplied about 600,000. Allegheny River; slow sand filtration, adjustment of pH by addition of soda ash during periods of low river alkalinity. There is considerable variation in the composition of the water. Industrial wastes affect the quality of the water. A, Analyses of weekly composite samples by Pittsburgh Water Department, 1929.
South Pittsburgh Water Co. (controlled by American Water Works & Electric Co., 50 Broad St., New York, N.Y.). Supplies wards 28 to 32 and parts of wards 16, 18, 19, and 20 in Pittsburgh, also Baldwin township, Bethel township, Brentwood, Bridgeville, Carnegie, Castle Shannon, Collier township, Crafton, Dormont, Greentree, Heidelberg, Ingram, Jefferson township, Mifflin township, Mount Lebanon township, Mount Oliver, Munhall, Robinson township, Rosslyn Farms, Scott township, Snowden township, South Fayette township, Thornburg, Upper St. Clair township, and West Homestead. Total population supplied about 225,000. Monongahela River; aerated, softened with lime and soda ash, recarbonated, filtered, final adjustment of pH to about 8.0 by addition of lime or soda ash. There is considerable variation in the composition of the water. Industrial wastes entering the river change the character of the river water from alkaline to acid. The hardness of the river water may vary from 35 to 550. The water delivered to consumers is softened to 100 and is adjusted in alkalinity. Analyzed by E. W. Lohr. B, Softened water, Nov. 20, 1931; C, raw water, Nov. 21, 1931.
Pennsylvania Water Co. Supplies part of ward 13 of Pittsburgh and also ward 4 of Braddock, Braddock township, Chalfont, East McKeesport, East Pittsburgh, Forest Hills, Edgewood, North Braddock, North Versailles township, Patton township, Penn township, Pitcairn, Rankin, Swissvale, Trafford, Turtle Creek, Wilkins township, Wilkinsburg, and Wilmerding. Total population supplied about 160,000. Allegheny River; filtered. The pH of the filtered water is reported to be around 6.6. (For analyses see A.)

534 Pottsville (24,300); Pottsville Water Co. Supplies also about 23,200 consumers in the surrounding area. Total population supplied about 47,500. Impounding reservoirs on small surface streams. Analyzed by L. A. Shinn, U.S. Geological Survey, Feb. 5, 1931.

535 Reading (111,171); municipal; 4 impounding reservoirs, Maiden Creek (65 percent), Antietam (18 percent), Bernharts (14 percent), and Egelmans (3 percent); slow sand filtration. It is necessary to treat the water from Maiden Creek with alum several times during the year. Each source supplies a different section of the city. Analyzed by L. A. Shinn, U.S. Geological Survey. A, Maiden Creek, Mar. 25, 1931; B, Antietam, Mar. 17, 1931; C, Bernharts, Mar. 17, 1931. The water from Egelmans is similar to the water from the Antietam supply. Regular determinations on monthly samples for the year 1930:

Source	Alkalinity			Hardness			pH		
	Av.	Max.	Min.	Av.	Max.	Min.	Av.	Max.	Min.
Maiden Creek	74	110	33	91	121	64	7.3	7.6	7.0
Bernharts	54	70	38	64	75	55	7.3	7.6	7.0
Antietam	28	37	19	41	48	34	7.0	7.1	6.8
Egelmans	20	25	13	31	39	28	6.7	7.0	6.6

536 Scranton (143,433); Scranton-Spring Brook Water Service Co. (controlled by Federal Water Service Corporation, 27 William St., New York, N.Y.). Supplies also Dunmore and Blakley, Dickson City, Olyphant, Throop, and Winton boroughs, which have their own supplies but are furnished principally with water from the Scranton system. Total population supplied about 214,000. Reservoirs impounding about 6,000,000,000 gallons, about 9 percent of supply filtered. The system of reservoirs is interconnected. One reservoir may be fed to another or by-passed in accordance with conditions. Dunmore is supplied from Dunmore Reservoir 1. Analyzed by G. R. Taylor, Scranton-Spring Brook Water Service Co. A, Reservoir 7 supply (about 45 percent), May 31, 1931; B, Lake Scranton supply (about 18 percent), Apr. 29, 1930; C, Dunmore Reservoir 1 supply (about 13 percent), February 1930; D, William Bridge Reservoir supply (about 11 percent), March 1930; E, Providence Reservoir filtered supply (about 9 percent), Feb. 9, 1931. Daily determinations on the filtered water for the year 1930–31: Alkalinity 4 to 25, average 15; pH 6.2 to 7.3, average 6.8.

537 Shamokin (20,274); Roaring Creek Water Co.; impounding reservoir on South Branch of Roaring Creek. Analyzed by Pennsylvania Power & Light Co., Hazelton, June 24, 1932.

538 Sharon (25,908); Shenango Valley Water Co.; supplies also Farrell and Wheatland, Pa., and Masury, Ohio. Total population supplied about 43,000. Shenango River; filtered, final adjustment of pH by addition of soda ash. Analyzed by E. W. Lohr, July 28, 1931. The analysis probably represents a concentration higher than the average. Daily determinations for the year 1932: Alkalinity 15 to 110, average 65; hardness 35 to 130, average 90; color 0 to 15, average 8; pH 6.8 to 7.6, average 7.1.

cities of the United States, 1932—Continued

	Analyses (parts per million)												
	Total dissolved solids	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulphate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Total hardness as $CaCO_3$[a]	No.
A Av.	[gg] 150	3.9	0.2	28	4.9	13		7.8	68	13	0.65	90	533
A Max.	[m] 360	4.4	.1	64	12	26		2.4	173	32	.80	209	
A Min.	[ll] 63	5.0	.3	15	1.3	4.7		9.8	26	8	.70	43	
B	371	5.3	.01	28	7.4	73	2.2	24	221	10	2.6	100	
C	352	9.8	7.9	38	12	26	2.2	0	[mm] 231	9.0	.30	144	
	31	5.1	.56	3.6	1.4	3.0	.8	13	6.6	1.2	.20	15	534
A	98	6.6	.04	21	5.7	3.3	2.0	57	22	3.2	14	76	535
B	69	15	.05	8.3	3.2	3.5	1.6	27	16	2.2	3.9	34	
C	78	13	.02	12	6.1	3.3	1.2	55	11	2.4	3.9	55	
A	[a] 39	1.6	.2	6.1	1.0	[a] 5.5		16	14	2.4	-------	19	536
B	[a] 47	4.2	.01	7.9	3.6	(cc)		7.8	24	3.0	-------	35	
C	[a] 34	3.2	.05	4.0	[a] 3.9	(cc)		6.1	18	2.0	-------	[e] 26	
D	44	5.7	.10	4.4	3.2	1.1		6.1	16	2.0	-------	24	
E	[a] 85	4.3	.07	13	8.4	(cc)		13	50	3.0	-------	67	
	32	15	[b] 1.9	2.1	1.3	[a] 2.2		12	4.3	.8	-------	11	537
	179	4.9	.01	36	7.9	8.5	2.4	98	49	7.8	1.0	122	538

[a] Calculated.
[b] Iron and aluminum oxides.
[m] Includes 0.7 part of manganese.
[e] Determined.
[cc] Less than 5 parts.
[gg] Includes 0.1 part of manganese.
[ll] Manganese 0.0.
[mm] Includes equivalent of 57 parts of free sulphuric acid (H_2SO_4).

TABLE 5.—*Public water supplies of the larger*

No.	Description
	PENNSYLVANIA—continuud
539	Shenandoah (21,782); municipal; Davis, Sand, Ulshaeffer, and Spiese Runs, impounded. Analyzed by L. A. Shinn, U.S. Geological Survey, Feb. 24, 1931.
540	Upper Darby township (46,626); Philadelphia Suburban Water Co. Supplies also Aldan, Bryn Athyn, Clifton Heights, Collingdale, Colwyn, Conshohocken, Darby, East Lansdowne, Eddystone, Folcroft, Glenolden, Jenkintown, Lansdowne, Millbourne, Morton, Narbeth, Norwood, Prospect Park, Ridley Park, Rockledge, Rutledge, Sharon Hill, Swarthmore, West Conshohocken, Yeadon, and the following townships: Abington, Cheltenham, Darby, Easttown, East Whiteland, Haverford, Lower Merion, Lower Moreland, Marple, Newtown, Plymouth, Radnor, Ridley, Schuylkill, Springfield (Montgomery County), Springfield (Delaware County), Tinicum, Tredyffrin, Upper Dublin, Upper Merion, Upper Moreland, Whitemarsh, and Willistown. The Philadelphia Suburban Water Co. supplies the suburban territory adjacent to the city of Philadelphia, comprising an area of about 300 square miles. Total population supplied about 315,000. Pickering Creek impounded, 9,450,000 gallons a day; Crum Creek impounded, 7,450,000 gallons a day; Neshaminy Creek, 2,550,000 gallons a day; Pennypack Creek, 850,000 gallons a day; filtered, final adjustment of pH by addition of lime at times. There is a filtration plant at each of the four sources. The system is interconnected. The western portion of the territory receives its supply from Pickering Creek, the southern portion from Crum Creek, and the northern portion from Neshaminy and Pennypack Creeks. Analyzed by E. W. Lohr. A, Pickering Creek at Phoenixville, Aug. 29, 1932; B, Crum Creek at Media, Aug. 29, 1932; C, Neshaminy Creek at Neshaminy, Aug. 30, 1932; D, Pennypack Creek at Bethayres, Aug. 30, 1932. Regular determinations for the year 1931: Pickering Creek, alkalinity 20 to 35, average 27; Crum Creek, alkalinity 18 to 30, average 24; Neshaminy Creek, alkalinity 18 to 41, average 26; Pennypack Creek, alkalinity 25 to 36, average 30.
541	Washington (24,545); Citizens Water Co. (controlled by Community Water Service Co., 100 William St., New York, N.Y.); reservoir 3, reservoir 4, Chartiers Creek (pumped to the reservoirs); filtered. It is proposed to soften the supply. Analysis of tap sample by E. C. Trax, McKeesport Water Department, Jan. 17, 1927. Regular determinations on the filtered water for the year 1931: Alkalinity 40 to 130, average 96; hardness 98 to 191, average 162; chloride 21 to 60, average 48; iron 0.0 to 0.38, average 0.04.
542	Wilkes-Barre (86,626); Scranton-Spring Brook Water Service Co. (controlled by Federal Water Service Corporation, 27 William St., New York, N.Y.). Supplies also Ashley, Avoca, Courtdale, Dupont, Duryea, Edwardsville, Exeter, Fairview, Forty Fort, Hanover township, Hughestown, Jenkins township, Kingston, part of Kingston township, Laflin, Larksville, Laurel Run, Luzerne, Lackawanna township, Moosic, Nanticoke, Newport township, Old Forge, Pittston, Pittston township, Plains township, Plymouth, Plymouth township, Pringle, about 3,000 people in Scranton, Sugar Notch, Swoyersville, Taylor, Warrior Run, West Pittston, West Wyoming, Wilkes-Barre township, Wyoming, and Yatesville. Total population supplied about 370,000. 13 separate sources embracing 36 reservoirs having a total storage capacity of about 11,000,000,000 gallons, furnished from springs and mountain streams. The Huntsville supply alone is filtered. Analyzed by Scranton-Spring Brook Water Service Co. A, Huntsville Reservoir, June 3, 1930; B, Pikes Creek Reservoir, Feb. 4, 1932; C, Mill Creek, Apr. 4, 1932. Regular determinations for the mixed water: Alkalinity 7 to 17, hardness 13 to 31. The pH is reported to range from 6.2 to 7.0.
543	Wilkinsburg (29,639); supplied by Pennsylvania Water Co. (See Pittsburgh)
544	Williamsport (45,729); Williamsport Water Co. (controlled by Community Water Service Co., 100 William St., New York, N.Y.); Mosquito Creek supplied to 21,000,000-gallon reservoir (57 percent), Hagerman Run supplied to 6,600,000 gallon reservoir (14 percent), 8 wells averaging 28 feet deep and 30 feet in diameter (29 percent). Analysis of sample from Mosquito Creek by W. L. Lamar, May 8, 1931. Partial analyses of samples collected Mar. 23 and May 8, 1931, from the two surface supplies are similar to the analysis given. Partial analyses of samples collected on the same dates from the well supply indicate that the water from the wells is harder than the water from the surface supplies.
545	York (55,254); York Water Co.; Codorus Creek impounded; filtered, aerated, adjustment of pH to 6.9–7.1 by addition of soda ash. Analyzed by L. A. Shinn, U.S. Geological Survey, Mar. 10, 1931.
	RHODE ISLAND
	[Descriptive material relating to the supplies and the analytical results in the descriptive text below were furnished by C. L. Pool, chief engineer and chemist, Rhode Island Public Health Commission]
546	Bristol town (11,953); Bristol & Warren Water Works (controlled by Community Water Service Co., 100 William St., New York, N.Y.). Supplies also Barrington and Warren towns. Total population supplied about 25,000. Impounding reservoirs on Kickemuit and Palmer Rivers; filtered, final adjustment of pH to about 7.6 by additional of hydrated lime. Analysis of composite sample by Margaret D. Foster, U.S. Geological Survey, May 28 to June 12, 1925. Monthly determinations for the year 1930–31: Alkalinity 9 to 28, average 16; hardness 20 to 71, average 41; pH 7.2 to 8.2, average 7.6. For the year 1930 an average color of 42 in the raw water was reduced to 10 in the filtered water.
547	Central Falls (25,898); municipal; Pawtucket supply. (See Pawtucket)
548	Cranston (42,911). Providence supplies about 41,600 consumers in Cranston. (See Providence). Pawtuxet Valley Water Co. supplies about 1,311 consumers in Cranston. (See West Warwick town.)

cities of the United States, 1932—Continued

	Analyses (parts per million)												No.
	Total dissolved solids	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulphate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Total hardness as $CaCO_3$[a]	
----------	35	4.1	0.06	3.8	1.5	1.8	0.9	6.0	11	1.5	0.20	16	539
A-------	97	12	.01	18	4.2	5.0	2.0	43	26	6.2	.86	62	540
B-------	88	5.6	.05	15	5.1	4.2	2.4	40	24	6.8	2.9	58	
C-------	119	4.5	.02	19	5.5	12	2.8	57	30	15	.40	70	
D-------	114	9.0	.01	15	5.1	13	2.8	42	29	15	4.8	58	
----------	272	5.4	.2	56	7.0	[a] 10		129	37	32	1.3	169	541
A-------	[a] 36	3.5	.16	5.9	1.3	2.9		11	14	2.4	.0	20	542
B-------	41	1.7	.16	5.4	1.2	1.8		11	10	2.6	.25	18	
C-------	30	2.1	.04	4.7	1.0	2.2		6.7	12	1.5	.11	16	
----------	------	------	------	------	------	------	------	------	------	------	------	------	543
----------	23	4.7	.04	3.5	1.0	1.7	.6	12	4.8	.9	.26	13	544
----------	62	3.6	.01	8.4	2.4	6.6	1.8	29	14	4.0	7.5	31	545
----------	73	.9	.10	12	2.0	5.9	.6	15	24	8.2	.15	38	546
----------	------	------	------	------	------	------	------	------	------	------	------	------	547
----------	------	------	------	------	------	------	------	------	------	------	------	------	548

[a] Calculated.

TABLE 5.—*Public water supplies of the larger*

No.	Description
	RHODE ISLAND—*continued*
549	East Providence town (27,000 consumers): Municipal; supplies about 17,000 consumers in the town of East Providence. Tenmile River; filtered, adjustment of pH to about 6.9 by addition of soda ash. Analyzed by E. W. Lohr, Sept. 9, 1931. Monthly determinations for the year 1930–31: Alkalinity 11 to 27, average 17; hardness 23 to 43, average 34; color 0 to 27, average 13; pH 6.8 to 7.2, average 6.9. Pawtucket supplies about 10,000 consumers in the Watchemoket district of East Providence. (See Pawtucket.)
550	Newport (27,612); Newport Water Corporation. Supplies also part of Middletown town. Total population supplied about 28,600. Eastons North and Eastons South Ponds, auxiliary supply from Nelsons, Gardner, St. Marys, and Sissons Ponds; aerated, filtered, final adjustment of pH to about 8.3 by addition of lime. Analysis of composite sample by Margaret D. Foster, U.S. Geological Survey, Dec. 20, 1924, to Jan. 20, 1925. Monthly determinations for the year 1930–31: Alkalinity 8 to 23, average 15; hardness 22 to 61, average 42; color 7 to 16, average 12.
551	Pawtucket (77,149); municipal. Supplies also Central Falls, part of Cumberland town (Ashton, Berkley, Lonsdale, and Valley Falls), part of East Providence town (Watchemoket district), and a small part of North Providence town. Total population supplied about 130,000. Abbott Run impounded in Diamond Hill and Arnolds Mill Reservoirs. Analyzed by Margaret D. Foster, U.S. Geological Survey, Jan. 8, 1924. Monthly determinations for the year 1930–31: Alkalinity 4 to 13, average 9; hardness 16 to 38, average 24; color 10 to 58, average 23; pH 6.8 to 7.1, average 6.9.
552	Providence (252,981); municipal. Supplies also most of Cranston and part of Johnston, North Providence, and Warwick towns. Total population supplied about 314,000. Scituate Reservoir, filtered. Addition of ferric iron coagulant followed by aeration, adjustment of pH by addition of lime, filtration, and aeration. Analyzed by E. L. Bean, Providence Water Works, August 1932.
553	Warwick town (15,800 consumers): Providence supplies about 12,000 consumers in Warwick. (See Providence.) East Greenwich Water Supply Co. (controlled by New England Water, Light & Power Associates, 833 Hospital Trust Building, Providence) supplies about 3,800 consumers. 1 dug well along Hunts River, auxiliary supply from Hunts River (pressure filtration). The system is interconnected with those of the Warwick & Coventry Water Co. and Pawtuxet Valley Water Co. for use in emergency only. A, Average of analyses of unfiltered water from the well supply by Rhode Island Public Health Commission, 1932; B, analysis of filtered water from the Hunts River supply by Margaret D. Foster, U.S. Geological Survey, Feb. 26, 1924. Regular determinations for the well supply for 1932: Color 0 to 10, average 1; pH 5.4 to 6.8, average 6.2.
554	Westerly town (10,997); municipal; pumping station 1 supplied by 85 driven wells about 29 to 66 feet deep, pumping station 2 supplied by 48 driven wells about 41 to 66 feet deep. The water is pumped directly to the mains. The pH, based on four determinations, for the year 1930 ranged from 6.2 to 6.6. A, Analysis of sample from pumping station 1 by Margaret D. Foster, U.S. Geological Survey, Mar. 19, 1924; B, analysis of sample from pumping station 2 by E. W. Lohr, Jan. 14, 1932.
555	West Warwick town (17,696); Warwick & Coventry Water Co. and Pawtuxet Valley Water Co. (both controlled by New England Water, Light & Power Associates, 833 Hospital Trust Building, Providence). Supplies also part of Coventry town (Anthony, Arkwright, Harris, Phenix, Quidnick, and Washington), part of Cranston (Fiskeville and Oaklawn), and part of Scituate town (Hope). Total population supplied about 30,000. Carrs Pond, Upper and Lower Reservoirs. The system is interconnected, and consumers receive water from both sources. Analyzed by Margaret D. Foster, U.S. Geological Survey. A, Carrs Pond, May 14, 1924; B, reservoir supply, Dec. 10, 1924. Partial analyses of samples collected Aug. 11, 1931, from both sources of supply agree with the analyses given. Regular determinations on samples collected at different sampling stations for the year 1930–31: Alkalinity 2 to 11; hardness 8 to 23; color 8 to 65; pH 6.4 to 6.9.
556	Woonsocket (49,376); municipal. Supplies also part of Bellingham and Blackstone towns, Mass., and part of North Smithfield town (Union Village and Waterford), R.I. Total population supplied about 56,000. Crook Fall Brook impounded in North Smithfield Reservoir. Analyzed by Margaret D. Foster, U.S. Geological Survey, Jan. 7, 1924. Monthly determinations for the year 1930–31: Alkalinity 1 to 8, average 4; hardness 10 to 40, average 18; color 15 to 72, average 39; pH 6.2 to 6.9, average 6.5.
	SOUTH CAROLINA
	[Descriptive material was furnished by A. E. Legare, sanitary engineer, South Carolina Board of Health]
557	Anderson (14,383); Southern Public Utilities Co. Baileys Creek, Rocky River; filtered. Baileys Creek furnishes about 75 percent of the total supply. The composition of the water varies throughout the year. Analysis of a tap sample by L. A. Shinn, U.S. Geological Survey, Nov. 25, 1930.
558	Charleston (62,265); municipal; impounding reservoir on Goose Creek; filtered, aerated, final adjustment of pH by addition of caustic soda. Analyzed by Parker Laboratory, Dec. 16, 1929. Daily determinations for the year 1931: Alkalinity 19 to 34, average 25; hardness 16 to 29, average 22; color 10 to 30, average 21; pH 8.1 to 9.2, average 9.0. For the same period the color of the raw water based on weekly determinations ranged from 70 to 160.

cities of the United States, 1932—Continued

	Analyses (parts per million)												No.
	Total dissolved solids	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulphate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Total hardness as $CaCO_3$[a]	
----------	93	5.7	0.05	8.5	2.0	17	1.9	27	30	9.5	2.9	29	549
----------	79	1.4	.06	9.2	4.1	8.9	1.0	8.5	29	15	1.8	40	550
----------	42	5.0	.10	6.0	1.6	2.8	.6	11	13	3.7	.67	22	551
----------	[aa]54	11	.05	12	.5	([cc])		17	12	4.4	.53	32	552
A-------	-------	-------	-------	-------	-------	-------	-------	11	-------	7	-------	[e]19	553
B-------	42	7.9	.04	2.4	1.2	6.5	.7	10	12	3.7	1.1	11	
A-------	56	13	.02	5.4	2.2	5.7	1.0	23	7.2	5.5	4.0	23	554
B-------	73	16	.71	7.4	2.6	7.7	1.5	23	9.1	8.6	8.4	29	
A-------	20	3.0	.49	1.6	.7	2.1	.4	3.7	5.8	2.6	.0	6	555
B-------	33	6.0	.37	3.3	1.2	3.4	.8	9.8	6.9	3.7	.38	13	
----------	36	5.2	.23	3.3	1.2	2.0	1.0	4.4	9.5	2.9	.71	13	556
----------	47	16	.02	3.8	2.0	3.1	1.3	18	7.3	3.0	.50	18	557
----------	67	2.6	.06	4.0	.7	19	.3	21	16	15	.0	13	558

[a] Calculated.
[e] Determined.
[aa] Less than 0.01 part of manganese.
[cc] Less than 5 parts.

TABLE 5.—*Public water supplies of the larger*

No.	Description
	SOUTH CAROLINA—continued
559	Columbia (51,581); municipal; Congaree River; filtered, final adjustment of pH by addition of lime. The intake is a quarter of a mile below junction of Broad and Saluda Rivers. Analysis of tap sample by E. W. Lohr, June 9, 1932. Monthly averages of daily determinations for the year 1932: Alkalinity 11 to 24, average 18; pH 7.0 to 8.3, average 7.6.
560	Florence (14,774); municipal; 3 wells (nos. 6, 7, and 8), 475, 550, and 500 feet deep. Analyzed by E. W. Lohr, June 4, 1932.
561	Greenville (29,154); municipal; South Saluda River impounded in Table Rock Lake. The impounding reservoir is so large and the mineral content of the water so low that a single analysis may be safely assumed to represent the composition of the water throughout the year. Analyzed by L. A. Shinn, U.S. Geological Survey, Mar. 25, 1931.
562	Greenwood (11,020); municipal; Rocky Creek (50 percent) and 6 wells (50 percent). The creek water is filtered. Analyzed by E. W. Lohr, June 2, 1932. A, Rocky Creek (filtered); B, 300-foot well.
563	Spartanburg (28,723); municipal; impounding reservoir on South Pacolet River; filtered. Analyzed by L. A. Shinn, U.S. Geological Survey, Nov. 11, 1930.
564	Sumter (11,780); municipal; 13 wells 45 to 67 feet deep connected to a common suction line and supplied direct to mains, 2 wells about 430 feet deep pumped to a receiving basin, 2 wells 418 and 711 feet deep supplied to a steel tank. All wells are in the same well field. Analysis of tap sample by E. W. Lohr, Aug. 4, 1932.
	SOUTH DAKOTA
	[Descriptions of all the supplies and several analyses were furnished by W. W. Towne, director, Division of Sanitary Engineering, South Dakota Board of Health]
565	Aberdeen (16,465); municipal; 6 wells 1,300 feet deep, fed to reservoirs. Analyzed by International Filter Co., Chicago, Ill., Jan. 23, 1931. Several other analyses made at an earlier date indicate that the analysis given represents reasonably well the composition of the water regularly delivered to consumers.
566	Huron (10,946); municipal; James River; aerated, filtered. There is considerable variation in the composition of the water throughout the year and from year to year. The alkalinity is reported to range from about 60 to 450 and hardness from about 200 to 850. A, Analysis of tap sample by C. B. Stone, South Dakota State Chemical Laboratory, Dec. 8, 1925; B, analysis of tap sample by E. W. Lohr, May 11, 1932.
567	Mitchell (10,942); municipal; Lake Mitchell impounding Firesteel Creek; coagulated and softened with sodium aluminate and lime, filtered. Analysis of tap sample by E. W. Lohr, Aug. 9, 1932. There is considerable variation in the composition of the raw water throughout the year. The hardness of the raw water is reported to range from about 170 to 430. Monthly averages of determinations on the treated water for the period January to August 1932: Hardness 137 to 310.
568	Rapid City (10,404); municipal; 2 springs. Analyzed by Charles Bentley, South Dakota School of Mines, May 20, 1921.
569	Sioux Falls (33,362); municipal; 9 dug wells 27 to 45 feet deep, 18 to 50 feet in diameter; aerated, filtered without coagulation. Analysis of sample from the clear-water reservoir by K. C. Beeson, State Chemical Laboratory, Jan. 7, 1930. Several analyses of the raw and treated water indicate that the analysis represents reasonably well the composition of the water regularly delivered to consumers.
570	Watertown (10,214); municipal; Lake Kampeska; aerated, filtered. Analysis of tap sample by G. G. Frary, State Chemical Laboratory, December 1925
	TENNESSEE
	[Descriptive material for some of the places and assistance in obtaining information were furnished by A. E. Clark, associate sanitary engineer, Tennessee Department of Public Health]
571	Bristol (12,005); municipal; Henry Preston Spring; softened with lime, filtered. Analyzed by E. W. Lohr, Jan. 19, 1932. The raw water has a hardness of over 200 and is softened by lime to about 80. Monthly averages of regular determinations on the treated water for the year 1930: Alkalinity 58 to 94, average 86.
572	Chattanooga (119,798); City Water Co. (controlled by American Water Works & Electric Co., 50 Broad St., New York, N.Y.). Tennessee River; filtered. There is some variation in the composition of the water. A, Sample of the filtered water analyzed by Margaret D. Foster, U.S. Geological Survey, May 22, 1922; B, average of analyses of composites of daily samples of raw water from Tennessee River near Knoxville by U.S. Geological Survey, 1906–7 (Water-Supply Paper 236, p. 105, 1909).
573	Jackson (22,172); municipal; 6 wells (nos. 1–2, 4, 6–8) about 150 feet deep. Analysis of tap sample by E. W. Lohr, May 1, 1932. Wells 1 and 6 were not in operation when the sample was collected.
574	Johnson City (25,080); municipal; springs supplied to reservoir. Analysis of tap sample by L. A. Shinn, U.S. Geological Survey, Jan. 26, 1931.
575	Kingsport (11,914); municipal; impounding reservoir on Bays Mountain; South Fork of Holston River; aerated, filtered. The water from both sources is filtered through the same plant. The supply is mainly from the reservoir. Part of the time water from the two sources is used and part of the time the river water alone. Analyzed by E. W. Lohr. A, Reservoir supply, Mar. 21, 1932; B, river supply, Mar. 28, 1932.

cities of the United States, 1932—Continued

	Analyses (parts per million)												
	Total dissolved solids	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulphate (SO)	Chloride (Cl)	Nitrate (NO_3)	Total hardness as $CaCO_3$[a]	No.
....	58	13	0.14	8.1	1.8	4.5	1.6	24	13	3.6	0.40	28	559
....	75	22	1.0	4.5	2.2	10	3.6	24	9.8	13	.10	20	560
....	19	6.4	.06	1.9	.6	.7	.5	7.0	1.8	1.0	.10	7	561
A.......	95	31	.08	9.5	2.5	6.5	1.6	22	27	2.9	.10	34	562
B.......	141	39	.01	20	2.6	9.1	2.0	54	33	2.6	.66	61	
....	53	16	.18	6.7	1.6	2.3	1.4	25	6.2	1.6	.10	23	563
....	38	11	.40	3.1	1.1	3.0	1.9	13	6.0	3.4	.90	12	564
....	[a]1,969	12	2.0	218	62	319		168	1,199	74	....	799	565
A.......	1,033	11	[b] 1.8	88	47	197		350	393	104	....	413	566
B.......	486	4.2	.06	53	21	74	8.8	177	181	42	.20	219	
....	408	32	.01	56	1.4	48	13	([nn])	192	16	.10	146	567
....	[a] 214	12	1.1	43	21	3.8		202	31	2.0	....	194	568
....	515	26	.1	106	35	6.0		326	159	6.3	....	408	569
....	310	4.0	[b] 1.8	55	29	13		264	52	5.0	....	256	570
....	94	15	.01	16	11	.9	1.2	[dd] 90	5.3	1.0	5.2	85	571
A.......	76	7.3	Trace	17	3.3	[a] 4.1		57	11	4.4	.56	56	572
B.......	122	25	.54	22	4.3	8.2		86	6.4	9.6	.8	73	
....	129	16	.17	14	5.5	14	2.5	26	31	20	11	58	573
....	67	11	.01	13	7.4	1.0	.9	70	5.0	.2	.80	63	574
A.......	42	3.9	.01	9.7	.6	1.0	.9	9.0	20	1.2	.10	27	575
B.......	109	5.7	.01	25	5.2	2.4	1.4	68	29	1.6	2.6	84	

[a] Calculated.
[b] Iron and aluminum oxides.
[dd] Includes equivalent of 6 parts of carbonate (CO_3).
[nn] Carbonate (CO_3) 12, hydroxide (OH) 11.

TABLE 5.—*Public water supplies of the larger*

No.	Description
	TENNESSEE—continued
576	Knoxville (105,802); municipal; Tennessee River; filtered, adjustment of pH by application of hydrated lime. Analysis of tap sample by E. W. Lohr, Jan. 28, 1932. Daily determinations for the year 1931: Alkalinity 34 to 74, average 56; hardness 68 to 172, average 98; pH 6.6 to 8.2, average 7.3.
577	Memphis (253,143); municipal; Parkway and Sheahan plants supplied by wells around 500 and 1,400 feet deep; aerated over trays filled with coke, filtered without coagulation. Analysis of tap sample from the Parkway plant by Margaret D. Foster, U.S. Geological Survey, July 26, 1928 (Water-Supply Paper 638, p. 34, 1932).
578	Nashville (153,866); municipal; Cumberland River; filtered. The coagulation and filtration reduce the silica and iron, the bicarbonate may be slightly reduced, and the sulphate is increased. Average of analyses of composite samples of raw water from Cumberland River near Nashville by U.S. Geological Survey, 1906-7 (Water-Supply Paper 236, p. 57, 1909). There is some variation in the composition of the water throughout the year. Range in concentration of the composite samples of river water: Alkalinity 60 to 97, hardness 65 to 101, chloride 1.0 to 4.8.
	TEXAS
	[Descriptive material and some analyses were furnished by V. M. Ehlers, chief sanitary engineer, Texas Department of Health]
579	Abilene (23,175); municipal; Lake Abilene, auxiliary supply from Lake Kirby and from wells, softened with lime, coagulated, regulation of pH to around 10.0. Although Lake Kirby is used only in midsummer, nevertheless this source furnishes about 25 percent of the total yearly supply, as it is used at a time of maximum consumption. The water from this source is treated at a separate plant known as the Kirby plant. The composition of the water from Lake Kirby is reported to be about the same as that from Lake Abilene. The water from the wells is pumped into Lake Abilene. The wells are used only a few weeks during the year. The mineral content of the well water is reported to be considerably higher than that of the lake water. Analysis of tap sample from Lake Abilene by E. W. Lohr, Feb. 5, 1932. Determinations for the year 1931: Alkalinity 26 to 74, hardness 36 to 108.
580	Amarillo (43,132); municipal; group of 10 wells about 200 feet deep, group of 5 wells about 275 feet deep. Analyzed by Jack Wyatt, city chemist, Mar. 15, 1932. A, 200-foot well group (Ward site); B, 275-foot well group (McDonald site).
581	Austin (53,120); municipal; Colorado River in Texas; softened with lime and soda ash, filtered. A, Analysis of tap sample of the softened water by E. W. Lohr, Sept. 24, 1932; B, average of analyses of composites of daily samples of the raw water by U.S. Geological Survey, 1905-6 (Water-Supply Paper 236, p. 56). There is considerable variation in the composition of the raw water throughout the year. Regular determinations on samples collected at 2-hour intervals for the year 1931: Softened water, alkalinity 26 to 70, average 51; hardness 44 to 104, average 81; pH (based on daily tests) 9.0 to 9.5. Raw water, alkalinity 72 to 214, average 170; hardness 65 to 230, average 184. The turbidity of the raw water is reported to range from 20 to 18,000.
582	Beaumont (57,732); municipal; Neches River; filtered, adjustment of pH by addition of lime. Analysis of composite sample by E. W. Lohr, May 1 to Aug. 20, 1932. Regular determinations for the year 1931: Alkalinity 10 to 36, average 22; hardness 33 to 52, average 41; pH 6.4 to 7.4, average 7.0.
583	Brownsville (22,021); municipal; Rio Grande; filtered. The composition of the water varies throughout the year. A, Analysis of tap sample by E. W. Lohr, Jan. 12, 1932; B, average of analyses of raw water from the Rio Grande at Laredo by U.S. Geological Survey, 1905-6 (Water-Supply Paper 236, p. 96, 1909).
584	Corpus Christi (27,741); municipal; Nueces River; aerated, filtered. The composition of the water varies throughout the year. Analysis of a sample of the raw water furnished by the Water Department.
585	Dallas (260,475); municipal; Garza and Bachman Lakes (aerated, softened, filtered), 6 wells 2,140 to 2,772 feet deep, reserve system consisting of White Rock Lake and small filtration plant. The wells supply a section of the city known as Oak Cliff and furnish about 25 percent of the total supply. The pH of the filtered water is reported to range from 8.4 to 9.0. There is some variation in the composition of the water. Analyzed by L. C. Billings, Dallas Water Department, February 1932. A, Sample of filtered water from surface supply; B, sample of water from Oak Cliff well 35, 2,500 feet deep; C, sample of water from Oak Cliff well 38, 2,140 feet deep.
586	El Paso (102,421); municipal; 11 wells (nos. 1 to 11) 860, 700, 860, 882, 834, 490, 525, 715, 795, 660, and 735 feet deep. Each well can furnish 1,000,000 to 2,000,000 gallons a day. The average daily consumption for the year 1931 was 8,000,000 gallons. Analyses of samples collected in 1930 and 1931 from each of the wells show a considerable range between extremes in hardness and total dissolved solids, but omitting the extremes the hardness ranged from 139 to 179 and the total dissolved solids from 428 to 659. Analyzed by R. M. Maese, El Paso Testing Laboratories. A, Well 11 (about average), Sept. 3, 1931; B, well 6 (maximum total solids and hardness), Aug. 8, 1930; C, well 7 (minimum total solids), Aug. 8, 1930; D, well 9 (minimum hardness), Aug. 24, 1932.

cities of the United States, 1932—Continued

	Analyses (parts per million)												No.
	Total dissolved solids	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulphate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Total hardness as $CaCO_3$[a]	
----------	156	7.6	0.02	32	5.5	9.0	1.1	74	27	23	2.0	103	576
----------	87	16	.08	8.6	4.2	15	1.2	80	4.4	1.8	.07	39	577
Av------	119	20	.42	26	3.6	9.6		92	14	2.1	1.2	80	578
----------	92	8.6	.01	8.9	8.8	8.4	4.2	[oo] 57	22	6.8	.40	58	579
A-------	514	30	Trace	68	33	74		465	63	20	-------	305	580
B-------	324	23	Trace	35	25	36		270	63	12	-------	190	
A-------	159	14	.02	13	8.8	24	3.4	[u] 48	43	25	4.7	69	581
B-------	321	18	[b] 3.1	52	17	44	5.1	195	42	59	-------	200	
----------	113	12	.06	13	3.5	17	2.0	36	20	25	.10	47	582
A-------	682	9.8	.16	77	24	116	3.9	134	211	154	1.5	291	583
B-------	791	29	[b] 3.6	104	23	112	6.6	178	228	164	-------	354	
----------	[a] 380	25	-------	67	4.0	65		224	34	75	-------	184	584
A-------	135	3.0	[b] 2.0	21	4.0	16		53	44	14	-------	69	585
B-------	1,008	19	[b] 7.0	20	2.0	344		501	233	115	-------	58	
C-------	1,119	15	[b] 13	14	3.0	367		451	382	88	-------	47	
A-------	480	8.7	[b] 3.8	55	7.0	88		203	69	84	-------	166	586
B-------	732	12	[b] 4.5	116	10	97		237	196	100	-------	331	
C-------	385	9.1	[b] 4.3	55	7.9	51		155	72	58	-------	170	
D-------	608	21	[b] 5.5	29	5.5	161		194	63	157	-------	95	

[a] Calculated.
[b] Iron and aluminum oxides.
[u] Includes equivalent of 18 parts of carbonate (CO_3).
[oo] Includes equivalent of 19 parts of carbonate (CO_3).

TABLE 5.—*Public water supplies of the larger*

No.	Description
	TEXAS—continued
587	Fort Worth (163,447); municipal; Lake Worth impounding West Fork of Trinity River; aerated, filtered, slight alkalinity to phenolphthalein maintained in effluent. Analysis of about an average sample by W. S. Mahlie, City Water Department, May 25, 1932. The composition of the water varies throughout the year. The alkalinity for the year 1930–31 based on determinations made 3 times daily ranged from 38 to 145 with an average of 117. The pH is reported to range from 8.0 to 8.3.
588	Galveston (52,938) municipal; 7 wells at Alta Loma (nos. 1–7) 840, 855, 866, 828, 888, 888, and 843 feet deep. The water from the wells is fed to a common supply line. Analysis of tap sample by Felix Paquin, Galveston Laboratories, Oct. 7, 1930. The different wells furnish water of practically the same composition. Analyses of tap samples collected in 1928 and 1929 and analyses of samples from the individual wells collected in 1916 are about the same as the analysis given.
589	Houston (292,352); municipal; 39 wells 200 to 1,700 feet deep at the following pumping plants: Central (30 percent), Scott St. (21 percent), South End (17 percent), Heights (15 percent), Magnolia Park (5 percent), West End (5 percent), East End (4 percent), and North Side (3 percent). The plants furnish different sections of the city. The system is partly interconnected. All the wells are not in service at one time. The wells furnish waters of different composition, and the quality of water delivered from a pumping plant is dependent upon the wells in service. Analyzed by E. W. Lohr, May 9, 1932. A, Central plant (4 wells in service); B, South End plant (sample collected from reservoir); C, Magnolia Park plant (1 well in service); D, West End plant (2 wells in service); E, East End plant (1 well). Partial analyses of samples from the Scott St. plant (wells 3 and 4 in service) and Heights plant (wells 4 and 5 in service) are similar to analysis A for the Central plant, and a partial analysis of a sample from the North Side plant is reasonably similar to analysis E for the East End plant. All samples were collected May 9, 1932.
590	Laredo (32,618); Central Power & Light Co., Rio Grande; aerated, filtered. The composition of the water varies throughout the year. A, Analysis of sample of the filtered water by E. J. Umbenhauer, Central Power & Light Co., Jan. 5, 1931; B, average of analyses of the raw water by U.S. Geological Survey, 1905–6 (Water-Supply Paper 236, p. 96, 1909).
591	Lubbock (20,520); municipal; 6 wells 97, 147, 98, 141, 140, and 145 feet deep. Analysis of sample from the 140-foot well by E. W. Lohr, July 2, 1931.
592	Port Arthur (50,902); municipal; Neches River; filtered, adjustment of pH by addition of lime or soda ash. Analyzed by W. L. Lamar, Apr. 11, 1931. Regular determinations for the year 1930: Alkalinity 22 to 45, average 30; hardness 49 to 56, average 53; pH 7.4 to 8.2, average 7.9.
593	San Angelo (25,308); West Texas Utilities Co.; South Concho River; aerated, filtered. Analyzed by R. H. Lash, Fort Worth Laboratories, Fort Worth, April 1931. There is considerable variation in the composition of the water throughout the year. Monthly averages of daily determinations for the year 1931: Alkalinity 154 to 210, average 185. The hardness is reported to range from about 120 to 400.
594	San Antonio (231,542); municipal; Market St. station supplied by 14 wells 900 feet deep, Brackenridge Park station supplied by 10 wells 825 feet deep, Mission Park station supplied by 8 wells 1,300 feet deep (used only during peak load in summer). The Market St. station furnishes regularly about 60 percent of the total supply. This proportion is slightly decreased when the Mission Park station is used. Analysis of sample from Market St. station by L. A. Shinn, U.S. Geological Survey, Apr. 18, 1931. Partial analyses of samples collected at the same time from other stations are similar to the analysis given, although the sulphate and chloride are higher for the Mission Park station.
595	Texarkana (16,602 (total population of Texarkana, Tex., and Texarkana, Ark., 27,366)). Texarkana Water Corporation (controlled by American Water Works & Electric Co., 50 Broad St., New York, N.Y.). Arkansas station supplied by 24 wells 30 to 40 feet deep, Bringle station supplied by 14 wells about 30 feet deep and by Clear Creek impounded. The chemical character of the ground water and the impounded surface water at this station is about the same. At the Arkansas station the water is aerated and treated with lime; the pH is adjusted to maintain an alkalinity to phenolphthalein. At the Bringle station the ground water is aerated and the surface water is coagulated with alum, all the water is treated with lime and filtered, and the pH is adjusted to maintain an alkalinity to phenolphthalein. The two stations furnish about equal quantities of water. During the winter the Arkansas station furnishes the larger proportion of water; in summer this proportion is reversed. Analyzed by L. A. Shinn, U.S. Geological Survey, Mar. 12, 1931. A, Arkansas station; B, Bringle station.
596	Tyler (17,113); municipal; Indian Creek impounded in Lake Bellwood; filtered, adjustment of pH. Analysis of tap sample by E. W. Lohr, May 18, 1932.
597	Waco (52,848); municipal; Bosque River impounded in Lake Waco; filtered. Analyzed by R. H. Adams, Baylor University, Apr. 22, 1930. The alkalinity is determined daily and ranges between 80 and 185, with an average around 140. The pH is reported to range from 7.2 to 7.6.
598	Wichita Falls (43,690); municipal; Lake Wichita (artificial), emergency supply from Lake Kemp; filtered. Analysis furnished by the water department, dated July 1925. The quality of the water is affected by hard irrigation water and by highly mineralized water from oil wells. There is considerable variation in the composition of the water. Regular determinations for the year 1932: Alkalinity 45 to 55, average 50; hardness 205 to 376, average 269.

cities of the United States, 1932—Continued

	Analyses (parts per million)												
	Total dissolved solids	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulphate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Total hardness as $CaCO_3$[a]	No.
----------	262	4.8	0.1	51	9.0	26		157	35	39	0.1	164	587
----------	[a] 825	24	[b] 1.0	18	5.5	299		363	Trace	299	-------	68	588
A-------	362	20	.17	22	5.8	108	1.9	301	7.8	48	.0	79	589
B-------	303	22	.39	27	7.2	76	1.9	256	14	32	.10	97	
C-------	281	23	.16	34	7.5	59	2.1	239	16	26	.20	116	
D-------	[a] 314	-------	-------	[r] 45	-------	[a] 53		260	[r] 12	50	.20	[s] 182	
E-------	[a] 397	-------	-------	[r] 2	-------	[a] 175		[j] 402	[r] 1	38	.0	[s] 4	
A-------	[a] 696	15	Trace	39	23	123		168	180	183	-------	317	590
B-------	791	29	[b] 3.6	104	23	112	6.6	178	228	164	-------	354	
----------	641	59	.03	50	58	79	10	328	143	81	2.8	363	591
----------	158	11	.05	14	3.5	31	1.6	35	42	30	.0	49	592
----------	[a] 396	7.2	[b] 4.2	51	18	70		229	58	75	-------	201	593
----------	238	9.8	.02	62	16	8.4	1.0	244	14	10	3.6	221	594
A-------	171	39	.05	17	3.9	19	2.0	50	5.8	32	15	58	595
B-------	102	1.7	.02	23	3.0	5.2	1.6	52	23	8.0	3.2	70	
----------	71	9.7	.13	11	2.0	5.7	2.0	27	13	9.8	.20	36	596
----------	288	2.6	[b] .2	45	5.3	31		166	15	25	-------	134	597
----------	[a] 908	26	[b] 2.8	89	23	192		94	239	290	-------	317	598

[a] Calculated.
[b] Iron and aluminum oxides.
[j] Includes equivalent of 16 parts of carbonate (CO_3).
[r] By turbidity.
[s] Determined.

TABLE 5.—*Public water supplies of the larger*

No.	Description
	UTAH
	[Descriptions and analyses for four places were furnished by C. O. Pickel, sanitary engineer, Utah Board of Health]
599	Logan (9,979); municipal; Devitt Springs fed to small reservoirs. Analysis of tap sample by M. E. Christensen, assistant State chemist, Nov. 18, 1931.
600	Murray (5,172); municipal: McGee Spring supplying a small reservoir in Union, 21 wells 44 to 290 feet deep supplying a small reservoir on Vine St. Valves are placed so that water from the wells may be supplied to the reservoir in Union and conversely so that water from the Union Reservoir may be turned into the system served by the wells. Analyzed by Herman Harms, State chemist, Nov. 12, 1931.
601	Ogden (40,272); municipal; 51 wells 100 to 520 feet deep (about 95 percent of supply), auxiliary supply from Wheeler Canyon Creek, Coldwater Canyon Creek, and Warmwater Canyon Creek. The water is fed to 2 distribution reservoirs and is supplied to the city from these reservoirs. Analysis of tap sample by M. E. Christensen, assistant State chemist, Nov. 19, 1931.
602	Provo (14,766); municipal; springs in Provo Canyon. The water is supplied to a small reservoir. Analysis of tap sample by M. E. Christensen, assistant State chemist, July 13, 1928.
603	Salt Lake City (140,267); municipal; Cottonwood Creek 37 percent, Parleys Creek impounded in Mountain Dell Reservoir 21 percent, City Creek 21 percent, Little Cottonwood Creek 5 percent, Mill Creek 4 percent, Emigration Springs 4 percent, 95 wells, 70 to 440 feet deep, 8 percent. There are 7 groups of wells, all belonging to the same artesian basin. The water from each group of wells is fed to a collecting basin and then discharged into a central supply line. All the water from the streams is fed through gravity-flow conduits to distributing reservoirs. The water from the streams, with the exception of City Creek, is mixed to some extent before entering the system. The water from City Creek comes to the consumers unmixed and furnishes the North Bench and the north industrial sections of the city. The composition of the water from the streams varies throughout the year, and several partial analyses show a considerable range in the mineral content of the water from the different wells. A, Cottonwood Creek, Apr 1, 1932; B, Cottonwood Creek, June 21, 1932; C, Parleys Creek, Apr. 1, 1932; D, Parleys Creek, June 22, 1932; E, City Creek, July 13, 1928; F, Little Cottonwood Creek, Apr. 1, 1932; G, Emigration Springs, June 22, 1932; H, composite sample from all wells, May 18, 1932. A to D and F to H analyzed by E. W. Lohr E analyzed by M. E. Christensen, assistant State chemist.
	VERMONT
	[Descriptive material relating to the supplies was furnished by C. P. Moat, chemist, Vermont Department of Public Health, who also furnished the analytical results in the descriptive text below]
604	Barre (11,307); municipal; brooks and springs. Analyzed by E. W. Lohr, Oct. 7, 1931. 4 samples of the Orange supply and 5 samples of the Bolster supply collected during 1930 show the range in composition indicated below.

	Source	Approximate percentage of total supply	Total hardness	Color
A	Orange system (Orange Brook impounded)	60	50 to 80	20 to 50
B	Bolster system (brooks and springs)	35	100 to 163	5 to 25
	McFarland and Boyce system (2 springs)	3		
	Hersey system (25 small springs)	2		

No.	Description
605	Burlington (24,789); municipal; Lake Champlain; filtered. Analyzed by E. W. Lohr, Aug. 20, 1931. The composition of the water is practically uniform throughout the year. 4 samples collected during 1930 show a range in hardness from 57 to 62 with an average of 60.
606	Montpelier (7,837); municipal; Berlin Pond. Analyzed by E. W. Lohr, Aug. 21, 1931. The mineral content of the water is fairly uniform throughout the year. 4 samples collected during the year 1930–31 show the following range in composition of the water: Hardness 73 to 87, average 80; color 9 to 20; average 13.
607	Rutland (17,315); municipal; Mendon Brook. Analyzed by E. W. Lohr, Aug. 19, 1931. The mineral content of the water is fairly uniform throughout the year. 6 samples collected during 1930 show the following range in composition of the water. Hardness 36 to 51, average 42; color 7 to 20, average 10.
608	St. Albans (8,020); municipal; 2 impounding reservoirs, emergency supply from Silver Lake. Analyzed by E. W. Lohr, Oct. 13, 1931. The mineral content of the water is fairly uniform throughout the year. 7 samples collected during 1930 show the following range in composition of the water: Hardness 35 to 50, average 43; color 10 to 25, average 18.

cities of the United States, 1932—Continued

	Analyses (parts per million)												No.
	Total dissolved solids	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulphate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Total hardness as $CaCO_3$[a]	
----------	183	1.2	[b]0.8	41	15	4.5		188	7.5	7.0	0	164	599
----------	214	14	[b]1.4	39	14	10		153	30	14	-------	155	600
----------	181	6.2	[b]1.1	40	9.2	8.9		155	10	14	Trace	138	601
----------	174	4.7	Trace	37	12	5.2		152	16	8.0	0	142	602
A-------	-------	-------	-------	[r]30	17	[a]17		[dd]126	70	4.2	.20	145	603
B-------	94	9.0	.14	19	6.4	2.5	.7	75	16	1.9	.30	74	
C-------	-------	-------	-------	87	18	[a]3.6		236	71	22	.64	291	
D-------	252	16	.07	68	8.6	9.8	1.4	228	23	11	.41	205	
E-------	240	4.5	.0	53	16	9.1		221	14	14	-------	198	
F-------	-------	-------	-------	43	8.7	([cc])		80	59	2.5	.20	143	
G-------	599	17	.02	122	34	19	2.1	325	185	21	1.4	444	
H-------	310	17	.02	58	20	18	2.6	197	62	25	3.2	227	
A-------	96	7.9	.02	26	2.1	1.8	1.4	86	6.5	.2	.57	74	604
B-------	152	6.0	.01	48	4.8	1.9	.9	157	9.1	.8	.50	140	
----------	71	4.0	.02	16	3.8	2.4	1.2	50	15	1.8	.50	56	605
----------	96	6.6	.23	28	3.4	1.4	.8	93	5.6	.8	.50	84	606
----------	56	8.1	.02	12	4.1	1.5	.7	50	5.0	1.1	.60	47	607
----------	69	7.0	.18	15	2.9	2.1	1.2	54	9.1	1.0	.50	49	608

[a] Calculated.
[b] Iron and aluminum oxides.
[r] By turbidity.
[cc] Less than 5 parts.
[dd] Includes equivalent of 6 parts of carbonate (CO_3).

TABLE 5.—*Public water supplies of the larger*

No.	Description
	VIRGINIA
	[Descriptions of the supplies were furnished by Richard Messer, chief engineer, Virginia Department of Health]
609	Alexandria (24,149); Alexandria Water Co. (controlled by American Water Works & Electric Co., 50 Broad St., New York, N.Y.); canal fed by Barcroft Impounding Reservoir and Cameron Run; filtered, final adjustment of pH to around 8.3-8.5 by addition of lime. Analyzed by H. S. Haller, U.S. Geological Survey, Feb. 28, 1931.
610	Charlottesville (15,245); municipal; Moormans River; aerated, filtered, aerated. The mineral content of the water is low and the range in concentration not great, so that the single analysis may be considered reasonably representative of water delivered to consumers throughout the year. Analysis of tap sample by E. W. Lohr, June 2, 1932.
611	Danville (22,247); municipal; Dan River; aerated, filtered, final adjustment of pH to about 8.0 by addition of lime. The coagulation and filtration reduce the silica and iron; the bicarbonate may be decreased, and the sulphate is increased. Average of analyses of 10-day composites of daily samples of raw water from the Dan River at South Boston by U.S. Geological Survey, 1929-30 (Virginia Comm. Conservation and Development, Div. Water Resources and Power, Bull. 3, p. 129, 1932). Range in concentration of the composite samples of river water: Alkalinity 16 to 30, hardness 15 to 29, chloride 1.6 to 3.0. The average alkalinity of the filtered water for the year 1929-30 was 18.
612	Hopewell (11,327); Old Dominion Water Corporation; Appomattox and James Rivers; filtered, final adjustment of pH by addition of lime. The intake is in Appomattox River near the junction with James River. During flood tide water from James River reaches the intake, and during ebb tide water is mostly from Appomattox River. For the year 1929-30 the average alkalinity of the filtered water was 30. (See Petersburg for analyses of Appomattox River; see Richmond for analysis of James River.)
613	Lynchburg (40,661); municipal; impounding reservoir on Pedlar River, reserve supply from James River; aeration, pressure filtration. A, Analysis of sample of filtered water from Pedlar River by Pittsburgh Equitable Meter Co., Pittsburgh, Pa., Sept. 25, 1928; B, average of analyses of 10-day composites of daily samples of raw water from James River at Salt Creek, 1930-31 (Virginia Comm. Conservation and Development, Div. Water Resources and Power, Bull. 3, p. 101, 1932). Regular determinations for the year 1930-31: Alkalinity (monthly averages) 9 to 20, average 13; pH 6.0 to 6.7, average 6.4.
614	Newport News (34,417); municipal. Supplies also Hampton and Phoebus. Total population supplied 44,000. Lee Hall Reservoir, reserve supply from impounding reservoir on Skiffs Creek and from Harwoods Mill Reservoir; filtered, final adjustment of pH to about 7.6 by addition of soda ash. To utilize the two reserve supplies it is necessary to pump the water to the Lee Hall Reservoir. Analysis of tap sample by Maud Mason Obst, Newport News Water Works Commission, May 21, 1932. Average of regular determinations for the year 1929-30: Alkalinity 70, pH 7.0.
615	Norfolk (129,710); municipal; Moores Bridges plant supplied by Lakes Wright, Little Creek, Smith, Lawson, and North Landing; Lake Prince plant supplied by Lake Prince Impounding Reservoir; filtered, final adjustment of pH by addition of lime. The two systems impound 6,500,000,000 gallons. Analysis of sample representing the combined supply by R. W. Fitzgerald, Norfolk City Water Department, Nov. 1, 1929. Average of regular determinations for the year 1929-30: Moores Bridges plant, alkalinity 37, pH 8.3; Lake Prince plant, alkalinity 31, pH 8.3.
616	Petersburg (28,564); municipal; principally from power canal fed by Appomattox River; filtered. The coagulation and filtration reduce the silica and iron; the bicarbonate may be decreased, and the sulphate is increased. Average of analyses of 10-day composites of daily samples by U. S. Geological Survey, 1929-30 (Virginia Comm. Conservation and Development, Div. Water Resources and Power, Bull. 3, p. 109, 1932). Range in concentration of the 10-day composite samples of river water: Alkalinity 18 to 40, hardness 20 to 35, chloride 1.8 to 40. The average alkalinity of the filtered water for the year 1929-30 was 20.
617	Portsmouth (45,704); municipal. Supplies also Suffolk and some additional consumers in Norfolk and Nansemond Counties. Total population supplied about 65,000. Lake Kilby supplemented when necessary by Lake Cahoon; filtered. Analyzed by Margaret D. Foster, U.S. Geological Survey, May 3, 1922. Daily determinations for the year 1932: Alkalinity 2.0 to 8.0, average 3.8.
618	Richmond (182,929); municipal; James River; filtered, aerated; final adjustment of pH by addition of lime. The coagulation and filtration reduce the silica and iron; the bicarbonate may be decreased, and the sulphate is increased. Analyses of 10-day composite samples of raw water from James River at Cartersville by U.S. Geological Survey, 1929-30 (Virginia Comm. Conservation and Development, Div. Water Resources and Power, Bull. 3, p. 107, 1932). A, Average, 1929-30; B, sample of maximum hardness, Sept. 21-30, 1929; C, sample of minimum hardness, Apr. 21-30, 1929.

cities of the United States, 1932—Continued

	Analyses (parts per million)												No.
	Total dissolved solids	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulphate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Total hardness as $CaCO_3$[a]	
----------	60	12	0.03	7.9	2.1	3.4	2.1	17	16	4.9	0.49	28	609
----------	27	10	.01	2.9	1.5	2.1	.7	16	2.3	1.0	.20	13	610
Av------	52	15	.27	5.0	2.3	4.0	1.2	27	4.3	2.4	.44	22	611
----------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	612
A-------	[a] 41	7.1	[b] .9	2.5	.4	7.7	.9	8.3	15	1.9	.6	8	613
B-------	185	8.1	.09	35	7.8	12	1.6	125	33	7.8	.22	120	
----------	147	1.2	[b] 1.4	32	2.3	12		80	26	16	------	89	614
----------	98	4.5	.18	18	2.0	13		43	19	15	.06	53	615
Av------	63	19	.35	6.2	2.7	4.5	1.2	34	4.4	2.7	.26	26	616
----------	43	3.2	.22	3.6	1.2	3.9	.7	2.4	12	5.1	Trace	14	617
A-------	85	12	.25	16	3.9	3.7	1.3	60	9.7	2.5	.18	56	618
B-------	128	14	.33	22	6.3	6.6	1.8	86	15	4.5	.10	81	
C-------	65	10	.03	11	2.9	3.3	.9	46	6.0	2.0	.20	39	

[a] Calculated.
[b] Iron and aluminum oxides.

TABLE 5.—*Public water supplies of the larger*

No.	Description
	VIRGINIA—continued
619	Roanoke (69,206); Roanoke Water Works Co. (controlled by Consumers Water Co. of Maine, Portland, Maine). Supplies also Vinton. Total population supplied about 73,000. Crystal Spring, 5,000,000 gallons daily; Falling Creek impounded, 2,000,000 gallons daily capacity (aeration in summer, pressure filtration); Muse and House Springs, 1,500,000 gallons daily; River Spring, 500,000 gallons daily; Smith Spring, 300,000 gallons daily. A new source known as Carvins Cove is under development. This source alone will make available about 10,000,000 gallons daily for Roanoke and its environs. A, Fire hydrant halfway between Albemarle and Walnut Aves. on Third St. SE., Aug. 27, 1917; B, fire hydrant at junction of Campbell and Norfolk Aves., Aug., 27, 1917; C, Carvins Cove, July 8, 1932. A and B analyzed by J. A. Gibboney, Roanoke; C analyzed by E. W. Lohr. Determinations based on 11 samples collected from each of the following sources during the year 1931: Crystal Spring, alkalinity 122 to 125; hardness 138 to 177, average 145; pH 7.6 to 7.9, average 7.8. Falling Creek (filtered), alkalinity 8 to 17, average 12; hardness 23 to 28, average 24; pH 6.5 to 7.0, average 6.8. Muse Spring, alkalinity 105 to 113, average 108; hardness 120 to 130, average 125; pH 7.2 to 7.7, average 7.5. River Spring, alkalinity 109 to 112; hardness 134 to 164, average 154; pH 7.6 to 7.7. Smith Spring, alkalinity 159 to 161; hardness 216 to 223, average 220; pH 7.3 to 7.6, average 7.4. Carvins Cove, alkalinity 16 to 25, average 21; hardness 20 to 39, average 28.
620	Staunton (11,990); municipal, impounding reservoir on North River (tributary of Shenandoah River); adjustment of pH to about 9.6–10.0 by addition of lime. Analysis of tap sample by E. W. Lohr, July 28, 1932.
621	Suffolk (10,271); supplied by Portsmouth. (See Portsmouth)
622	Winchester (10,855); municipal; Old Town and Rouss Springs, emergency supply from Shawnee Spring. Analyzed by H. S. Haller, U.S. Geological Survey, Feb. 19, 1931. A, Old Town Spring; B, Rouss and Shawnee Springs.
	WASHINGTON
623	Aberdeen (21,723); municipal; domestic system supplied by Wishkah River, impounded; industrial system supplied by Wynoochee River. The industrial system furnishes water to industrial plants using large quantities of water. Analyzed by Laucks Laboratories, Inc., Seattle, Wash. A, Wishkah River, Mar. 28, 1928; B, Wynoochee River, June 2, 1928. The analyses are reported to represent about average conditions.
624	Bellingham (30,823); municipal; Lake Whatcom, Lake Padden. The water is distributed to consumers from both lakes. Analyzed by E. W. Lohr, U.S. Geological Survey, Nov. 28, 1932. A, Lake Whatcom; B, Lake Padden.
625	Bremerton (10,170); municipal; Gorst, Anderson, and Charleston Creeks. Consumers receive the mixed water. There is some variation in the composition of the delivered water. Analyzed by R. E. Canfield, Puget Sound Navy Yard, Sept. 15, 1932. A, Tap sample; B, Gorst Creek; C, Anderson Creek; D, Charleston Creek.
626	Everett (30,567); municipal; Sultan River. Analyzed by E. W. Lohr, Aug. 19, 1932. The mineral content of the water is so low and the range in concentration so small that the analysis given may be considered representative of the composition of the water regularly delivered to consumers.
627	Hoquiam (12,766); municipal; Little Hoquiam River, East Fork of Hoquiam River, Davis Creek. Analysis of tap sample from Davis Creek by E. W. Lohr, June 1, 1932. Partial analyses of samples taken Sept. 10 and Oct. 1, 1927, indicate that all the sources furnish water of about the same composition.
628	Longview (10,652); Washington Gas & Electric Co.; 3 wells (nos. 1, 5, and 6) 248, 232, and 252 feet deep; aerated, filtered without coagulation. Well 5 furnishes about 70 percent of the total supply. Analyzed by E. W. Lazell, 537 Railway Exchange Building, Portland, Oreg., June 19, 1923. Samples taken twice a year for the period 1924 to 1929 show the following range in concentration of the filtered water: Alkalinity 170 to 189, average 177; hardness 160 to 180, average 170; pH average 7.0 with practically no variation.
629	Olympia (11,733); municipal; 28 wells averaging 130 feet deep, 9 wells 144 to 296 feet deep, springs, creek fed by springs, all in Moxlie Creek Basin. Analyzed by T. G. Thompson, University of Washington, Oct. 5, 1928. A, Well 1-J, 162 feet; B, well 2-J, 144 feet deep.
630	Seattle (365,583); municipal; Cedar River and Cedar Lake. The mineral content of the water is low at all times; the composition of the water is reasonably uniform throughout the year, although there is some variation. The pH of the water is reported to be usually 7.0 or 7.1. A, Single analysis by Seattle Department of Health and Sanitation, Jan. 1, 1933; B, average of a series of analyses of water from Cedar River at Ravensdale by U.S. Geological Survey, 1910–11 (Water-Supply Paper 339, p. 44, 1914).
631	Spokane (115,514); municipal; 5 wells (nos. 1 to 5), 40.6, 41.4, 43.7, 50.4, and 51.0 feet deep. The wells furnish water of about the same composition. Analyzed by Quintard Johnson, Water Department, November 1931.
632	Tacoma (106,817); municipal; Green River (about 90 percent), South Tacoma wells (about 10 percent). The well water is used in emergency and to supplement the surface water during the sprinkling season in summer. The composition of the river water is reasonably uniform throughout the year. It is reported that all the South Tacoma wells furnish water of about the same chemical quality. A, Single analysis of water from Green River by E. W. Lohr, Oct. 27, 1931; B, average of analyses of water from Green River at Hot Springs by U.S. Geological Survey, 1910–11 (Water-Supply Paper 339, p. 46, 1914); C, analysis of water from South Tacoma well 1-A by E. W. Lohr, Oct. 27, 1931.

cities of the United States, 1932—Continued

	Analyses (parts per million)												
	Total dissolved solids	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulphate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Total hardness as $CaCO_3$[a]	No.
A	[a] 139	11	[b] 1.6	24	16	3.9		145	4.8	6.0	-------	126	619
B	[a] 41	16	[b] 2.4	2.8	2.3	2.6		17	2.4	4.0	-------	16	
C	30	6.3	.44	6.5	1.7	1.6	1.0	22	5.4	.9	0.68	23	
----------	44	9.4	.34	9.1	1.2	1.4	1.0	[f] 35	2.8	1.2	.10	28	620
----------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	621
A	279	11	.04	75	19	2.1	2.0	300	13	2.6	2.3	265	622
B	308	14	.04	84	19	12	7.1	315	34	6.1	11	288	
A	[a] 44	6.0	[b] 2.0	7.1	3.0	1.9		30	4.8	4.0	-------	30	623
B	[a] 63	6.0	[b] 2.0	11	3.6	4.7		48	2.4	10	-------	42	
A	52	6.7	.16	4.8	1.6	6.0	.7	17	8.8	5.8	.60	19	624
B	32	2.9	.19	4.5	1.4	3.3	.7	19	3.9	3.0	.20	17	
A	[a] 68	21	.1	7.8	2.8	4.2		50	1.8	4.0	.44	31	625
B	[a] 67	19	.1	9.4	2.8	4.0		49	1.7	5.0	.44	35	
C	[a] 54	15	.0	7.1	2.0	2.9		39	1.7	4.5	.44	26	
D	94	23	1.0	14	3.8	5.5		68	2.4	5.0	.44	51	
----------	23	5.8	.07	4.1	.7	1.4	.6	15	3.2	.9	.10	13	626
----------	52	18	.22	5.1	2.5	4.6	.4	30	1.6	5.2	.10	23	627
----------	256	56	.0	52	10	8.2		208	3.6	13	-------	171	628
A	151	45	[b] 1.0	15	9.3	[a] 10		97	12	3.9	-------	76	629
B	166	51	[b] 1.6	15	9.7	[a] 8.7		101	7.4	4.1	-------	77	
A	46	6.4	[b] .90	5.8	1.5	[a] 2.2		26	2.0	1.5	.0	21	630
B	49	13	.02	6.7	1.4	3.6		28	5.7	1.2	.20	23	
----------	[a] 168	13	Trace	31	11	7		174	17	2.4	-------	123	631
A	39	14	.05	5.0	1.2	2.7	.6	21	3.2	1.6	.20	17	632
B	55	17	.04	6.0	1.3	5.6		28	5.9	1.3	.13	20	
C	76	25	.29	7.9	4.4	4.1	1.4	38	4.9	4.0	5.3	38	

[a] Calculated.
[b] Iron and aluminum oxides.
[f] Includes equivalent of 13 parts of carbonate (CO_3).

TABLE 5.—*Public water supplies of the larger*

No.	Description
	WASHINGTON—continued
633	Vancouver (15,766); Oregon-Washington Water Service Co. (controlled by Federal Water Service Corporation, 27 William St., New York, N.Y.). Springs (50 percent), 3 wells 157 to 165 feet deep (50 percent). Analyzed by P. Villarruz, California Water Service Co., Stockton, Calif., Apr. 21, 1931. A, Springs; B, well 165 feet deep at station 1; C, well 157 feet deep at station 2.
634	Walla Walla (15,976); municipal; Mill Creek. The pH is reported to be around 7.4. Analyzed by E. W. Lohr, Nov. 25, 1931.
635	Wenatchee (11,627); municipal; Columbia River; filtered. The composition of the water is fairly uniform throughout the year, although there is some variation. A, Analysis of tap sample by E. W. Lohr, Nov. 16, 1931; B, average of analyses of composites of daily samples of raw water from Columbia River at Pasco by U.S. Geological Survey, 1910–11 (Water-Supply Paper 339, p. 85, 1914).
636	Yakima (22,101); municipal; infiltration from Naches River. Analysis furnished by Water Department.
	WEST VIRGINIA
	[Descriptions of the supplies and the analytical results in the descriptive text below were furnished by E. S. Tisdale, director, Division of Sanitary Engineering, West Virginia Department of Health, who also arranged for the collection of samples from 6 supplies]
637	Bluefield (19,339); West Virginia Water Service Co. (controlled by Federal Water Service Corporation, 27 William St., New York, N.Y.); Ada Spring (about 90 percent), Horton Impounding Reservoir (about 10 percent), emergency supply from Bailey and Beaver Pond Springs; filtered. Analysis of tap sample by W. L. Lamar, May 2, 1931.
638	Charleston (60,408); West Virginia Water Service Co. (controlled by Federal Water Service Corporation, 27 William St., New York, N.Y.). Supplies also South Charleston. Total population supplied about 66,300. Elk River about 1 mile above mouth (pool formed by Government navigation dam in Kanawha River), emergency intake in Kanawha River; filtered, adjustment of pH. Analysis of tap sample by E. W. Lohr, June 7, 1932. The composition of the water varies throughout the year. Daily reports of tests for the year 1931: Alkalinity 12 to 40, average 22; hardness 14 to 60, average 34; pH 8.0 to 9.6, average 9.0.
639	Clarksburg (28,866); municipal. Supplies also Nutter Fort. Total population supplied about 31,000. West Fork River (4 dams in river to increase storage capacity); filtered. Analysis of tap sample by W. L. Lamar, July 8, 1932. Regular determinations for the year 1931: Alkalinity 11 to 48, average 23; hardness 28 to 392, average 84.
640	Fairmont (23,159); municipal. Supplies also Barracksville and Rivesville. Total population supplied about 26,000. Tygarts Valley River above junction with West Fork River to form Monongahela River (lock in Monongahela River causes pool in river at intake); filtered. Analyzed by W. L. Lamar, July 19, 1932. Daily determinations for the year 1931: Alkalinity 9 to 42, average 19; hardness 18 to 155, average 39; pH 6.9 to 8.5, average 7.7.
641	Huntington (75,572); Huntington Water Corporation (controlled by American Water Works & Electric Co., 50 Broad St., New York, N.Y.); Ohio River (pool formed by Government navigation dam) above mouth of Guyandotte River; filtered. Analyzed by F. R. Perrin, South Pittsburgh Water Co., Pittsburgh, Pa., June 10, 1931. There is considerable variation in the composition of the water throughout the year. Daily determinations for the year 1931; Alkalinity 6 to 25, average 14.
642	Martinsburg (14,857); municipal; Old Kilmer Springs (4 springs) supplied to reservoirs. Analyzed by L. A. Shinn, U.S. Geological Survey, Nov. 22, 1930.
643	Morgantown (16,186); Morgantown Water Co. (controlled by American Water Works & Electric Co., 50 Broad St., New York, N.Y.). Supplies also area surrounding Morgantown. Total population supplied about 20,000. Monongahela River (pool formed by Government navigation dam), about 50 percent of supply, filtered. Tibbs Run impounded in Tibbs Run Reservoir, about 50 percent of supply. During 1932 the proportion of the river water used ranged from 1 percent for April to 89 percent for August. The greatest use of the river water is at a time when the hardness is around a maximum. Analyzed by E. W. Lohr. A, Monongahela River (filtered), July 28, 1932; B, Tibbs Run Reservoir, Oct. 21, 1932. Daily determinations on the filtered river water for the year 1932: Alkalinity 9 to 15, average 10; hardness 50 to 210, average 125.
644	Moundsville (14,411); Moundsville Water Co. (controlled by Community Water Service Co., 100 William St., New York, N.Y.); wells along Ohio River 68 feet deep; final adjustment of pH to around 7.5–7.7 by addition of lime. Analysis of tap sample by E. W. Lohr, Sept. 20, 1932.
645	Parkersburg (29,623); municipal; 18 wells averaging 50 feet deep; aerated, settled. Analyzed in laboratory of Morris Knowles, Inc., Pittsburgh, Pa., Aug. 30, 1929.
646	Wheeling (61,659); municipal. Supplies also Benwood and McMechen. Total population supplied about 69,000. Ohio River above lock 12; filtered. Analyzed by W. L. Lamar, July 19, 1932. Daily determinations for the year 1931: Alkalinity 8 to 32, average 13; hardness 61 to 229, average 125; pH 6.8 to 7.6, average 7.2. Average hardness for 1926, 90; for 1927, 88; for 1928, 95; for 1929, 90; for 1930, 150 (drought).

cities of the United States, 1932—Continued

	Analyses (parts per million)												
	Total dissolved solids	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulphate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Total hardness as $CaCO_3$[a]	No.
A	115	53	0.01	14	6.8	[a]0.8		66	6.1	3.0		63	633
B	140	47	.02	22	4.7	[a]8.6		103	4.2	3.0		74	
C	125	53	.02	16	5.1	[a]5.2		75	6.3	3.0		61	
	69	34	.11	6.6	2.7	2.4	1.8	38	2.2	.4	0.10	28	634
A	75	5.3	.01	19	4.5	2.1	.9	65	13	.8	.20	66	635
B	83	7.7	.04	18	4.5	6.0		73	11	.7	.14	63	
	[a]71	17	[b]1.7	8.8	.4	12		50	3.7	3.0	Trace	24	636
	118	13	.05	33	4.2	1.5	.8	113	6.3	1.4	3.0	100	637
	51	3.2	.04	10	1.7	3.7	1.2	26	11	6.5	.30	32	638
	118	5.2	.12	23	3.4	5.6	1.1	31	47	7.0	4.7	71	639
	62	4.0	.03	6.5	1.8	9.1	1.3	16	29	1.8	1.8	24	640
			[b].8	29	3.1			27		17		85	641
	272	7.8	.08	76	16	2.0	2.5	282	13	4.0	22	256	642
A	205	3.5	.03	38	6.8	12	2.3	14	124	5.2	1.4	123	643
B	21	2.4	1.0	1.7	.9	1.6	.9	0	[pp]5.6	6.2	.0	8	
	330	15	.22	74	9.0	15	1.7	134	115	16	8.4	222	644
	230	18	Trace	48	7.9	[a]7.3		83	58	28	.25	152	645
	188	6.0	.06	30	6.6	13	2.5	8.0	105	13	2.3	102	646

[a] Calculated.
[b] Iron and aluminum oxides.
[pp] Includes equivalent of 4.8 parts of free sulphuric acid (H_2SO_4).

TABLE 5.—*Public water supplies of the larger*

No.	Description
	WISCONSIN
	[Descriptive material and assistance in obtaining needed information were furnished by L. F. Warrick, State sanitary engineer, Wisconsin Board of Health]
647	Appleton (25,267); municipal; Fox River; aerated, filtered. Analysis of tap sample by E. W. Lohr, June 17, 1932. There is some variation in the composition of the water throughout the year. Regular determinations for the year 1931-32: Alkalinity 110 to 142, average 120; pH 7.0 to 7.4.
648	Beloit (23,611); Wisconsin Power & Light Co.; East Side pumping station with 13 wells averaging 130 feet deep, Electric Plant pumping station with 4 wells averaging 120 feet deep, East Side well 969 feet deep, West Side well 1,230 feet deep. Analyzed by E. W. Lohr, June 14, 1932. A, East Side pumping station; B, West Side well. Partial analyses of samples collected at the same time from the Electric Plant pumping station and from the East Side well indicate that the analyses given are representative of the composition of the water at Beloit.
649	Eau Claire (26,287); municipal; 8 wells 40 to 100 feet deep in a well field adjacent to Chippewa River. The wells discharge into a low-service reservoir. Analysis of tap sample by E. W. Lohr, July 25, 1932. Partial analyses of samples collected in June and July 1932 from each of the wells show, with the exception of well 6, the following range in composition of the waters from the different wells: Alkalinity 52 to 102 hardness 57 to 102, iron 0.0 to 5.0, manganese 0.5 to 3.3. The partial analysis from well 6 (65 feet deep) gave alkalinity 94, hardness 96, iron 6.1, manganese 10. Water from this well was not included in the tap sample for which the analysis is given.
650	Fond du Lac (26,449); municipal; 8 wells 480 to 900 feet deep supplied to a reservoir. Analysis of sample from the reservoir by E. W. Lohr, June 27, 1932.
651	Green Bay (37,415); municipal; wells 837 to 966 feet deep. Analysis of sample from 930-foot well by Margaret D. Foster, U.S. Geological Survey, Mar. 30, 1922. Partial analyses of samples collected Nov. 24, 1930, from an 865-foot well and a 966-foot well resemble in a general way the analysis made in 1922. The results obtained in 1922 are about an average of those for the two samples collected in 1930.
652	Janesville (21,628); municipal; 2 wells about 1,100 feet deep, 1 well 25 feet deep and 30 feet in diameter. The shallow well furnishes approximately 75 percent of the total supply. Analyzed by Dearborn Chemical Co., Chicago, Ill., Dec. 12, 1928. Partial analyses of samples collected Dec. 1, 1930, indicate that both the shallow and deep wells furnish water of about the same composition.
653	Kenosha (50,262); municipal; Lake Michigan; filtered. The chemical composition of the water is fairly constant and is practically the same as that of the supply for Racine. (For analysis see Racine.)
654	LaCrosse (39,614); municipal; 6 groups of wells (4 wells to the group) 115 to 120 feet deep. Analyzed by H. S. Haller, U.S. Geological Survey, Feb. 24, 1931. A, Group 1; B, group 3. Partial analyses of samples collected at the same time from the other groups of wells are similar to the analyses given.
655	Madison (57,899); municipal; group of 11 wells 499 to 737 feet deep and 4 unit wells 737 to 840 feet deep. Analyzed by E. W. Lohr, Aug. 17, 1931. A, Sample from group wells 1, 4 to 6, 8 to 11, 505 to 737 feet deep; B, group well 10, 723 feet deep; C, unit well 3, 753 feet deep.
656	Manitowoc (22,963); municipal; 2 wells (nos. 0 and 2) 35 and 55 feet deep, 3 wells (nos. 1, 3, and 4) 51 to 65 feet deep. Wells 0 and 2 furnish about 85 percent of the total supply. Analyzed by L. A. Shinn, U.S. Geological Survey, Feb. 6, 1931. A, Wells 0 and 2; B, wells 1, 3, and 4.
657	Milwaukee (578,249); municipal; supplies also Fox Point, Shorewood, West Allis, West Milwaukee, Whitefish Bay, and a number of consumers in the nearby towns. Total population supplied about 652,000. Lake Michigan. The composition of the water is fairly uniform throughout the year. Average of analyses by N. A. Thomas, Milwaukee Water Department, 1932.
658	Oshkosh (40,108); municipal; Lake Winnebago; filtered. Analyzed by R. A. Maddock, 1921
659	Racine (67,542); municipal; Lake Michigan; filtered. Analysis of a monthly composite sample of raw water by H. S. Haller, U.S. Geological Survey, Jan. 1-31, 1931. Monthly averages of daily determinations on the filtered water for the year 1930: Alkalinity 105 to 122, pH 7.5 to 7.6.
660	Sheboygan (39,251); municipal; Lake Michigan; filtered. The chemical composition of the water is fairly constant and is practically the same as that of the supply for Racine. (For analysis see Racine.)
661	Superior (36,113); Superior Water, Light & Power Co.; wells 14 to 40 feet deep; slow sand filtration. Analysis furnished by Superior, Water, Light & Power Co., September 1921. A partial analysis made in June, 1930, resembles the analysis given.
662	Waukesha (17,176); municipal; wells. Analyzed by E. W. Lohr

	Station	Number of wells	Depth (feet)	Percent of supply	Date of collection
A	No. 2	1	1,783	50	Jan. 23, 1933
B	No. 9	1	1,630	45	May 14, 1932
C	No. 1	3	1,500	5	Do.

cities of the United States, 1932—Continued

	Analyses (parts per million)												
	Total dissolved solids	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulphate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Total hardness as $CaCO_3$[a]	No.
----------	206	3.7	-------	36	18	4.0	1.4	144	46	4.6	0.20	164	647
A-------	364	18	0.02	72	33	5.1	1.9	297	47	7.2	22	315	648
B-------	291	12	.02	59	34	2.4	1.9	336	11	1.4	1.4	287	
----------	[m] 120	24	1.3	21	9.2	2.4	1.1	106	3.5	2.0	.84	90	649
----------	459	23	.19	67	34	33	3.7	240	114	46	.30	307	650
----------	287	14	.08	46	20	31	4.0	218	55	16	Trace	197	651
----------	[a] 352	6.4	[b] 1.2	70	34	18		380	6.1	21	4.4	314	652
----------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	---------	653
A-------	280	21	.06	64	25	2.4	2.8	288	25	2.1	.10	262	654
B-------	292	22	.12	62	30	2.2	1.7	321	19	2.2	.84	278	
A-------	339	16	.02	64	43	7.0	1.9	355	35	8.8	.4	336	655
B-------	631	17	.02	112	69	18	1.9	478	126	42	1.0	563	
C-------	306	23	.01	58	39	4.3	1.7	362	8.7	1.0	.30	305	
A-------	173	9.4	.01	39	13	5.3	.8	155	25	4.0	.80	151	656
B-------	461	19	.04	88	37	11	2.1	292	133	13	4.9	372	
Av------	139	7.8	.05	34	10	4.9		138	16	6.6	.09	126	657
----------	[a] 186	-------	[b] 3.6	32	17	16		148	31	7.2	-------	149	658
----------	161	12	.04	34	11	4.2	2.2	139	21	3.6	.90	130	659
----------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	---------	660
----------	61	1.2	.14	14	3.7	2.9		62	2.8	1.1	.22	50	661
A-------	[qq] 346	8.8	.21	63	25	9.8	3.8	265	75	5.8	.0	[rr] 283	662
B-------	[ss] 323	11	.34	65	29	6.7	3.7	332	36	4.1	.10	[rr] 296	
C-------	[tt] 539	18	.02	95	47	26	4.6	386	117	24	20	[rr] 432	

[a] Calculated.
[b] Iron and aluminum oxides.
[m] Includes 0.7 part of manganese.
[qq] Includes 20 parts of strontium.
[rr] Includes $CaCO_3$ equivalent to strontium.
[ss] Includes 13 parts of strontium.
[tt] Includes 2 parts of strontium.

TABLE 5.—*Public water supplies of the large*

No.	Description
	WISCONSIN—continued
663	Wausau (23,758); municipal; Central station, 13 wells 60 to 135 feet deep and 1 well 36 feet deep and 30 feet in diameter (aerated, filtered); West St. station, 1 well 73 feet deep. The Central station furnishes about 85 percent of the total supply. Analyzed by L. A. Shinn, U.S. Geological Survey. A, Central station (filtered water), Feb. 24, 1931; B, West St. station (raw water), Feb. 6, 1931.
664	Wauwatosa (21,194); municipal; 5 wells 1,692, 1,703, 1,804, 1,714, and 1,660 feet deep. The 1,660-foot well includes also connections with a plugged well 1,357 feet deep. Analyzed in Stephl Laboratories, Milwaukee, Aug. 14, 1930.

	Source	Depth (feet)	Year drilled	Percent of total supply
A	Well of average concentration	1,703	1924	22
B	Well of maximum concentration	1,804	1927	17
C	Well of minimum concentration	1,660	1930	34

No.	Description
665	West Allis (34,671) municipal; Milwaukee supply. (See Milwaukee)
	WYOMING
	[Descriptive material was furnished by W. H. Hassed, State health officer]
666	Casper (16,619); municipal; infiltration gallery on North Platte River, a small portion of the supply is also obtained from Elkhorn Creek. The composition of the water varies throughout the year. Analysis of a sample from North Platte River by E. A. Swedenborg, U.S. Geological Survey, Feb. 9, 1928.
667	Cheyenne (17,361); municipal; Crystal and Granite Springs, North Crow, South Crow, and Upper North Crow Lakes; aerated, filtered. Analysis of tap sample by E. W. Lohr, Nov. 30, 1931.
668	Laramie (8,609); municipal and Union Pacific Railroad Co.; City, Pope, and Soldier Springs. Analyzed by W. M. Barr, Union Pacific System, Omaha, Nebr., July 10, 1930.
669	Rock Springs (8,440); Green River Water Works Co. (controlled by Union Pacific Railroad Co., Omaha, Nebr.). Supplies also town of Green River. Total population supplied about 11,000. Green River; coagulated when muddy, filtered. Analyzed by W. M. Barr, Union Pacific System, Omaha, Nebr. A, Sample collected Sept. 11, 1926; B, sample collected Feb. 1, 1931. The analyses probably represent extremes in mineral content.
670	Sheridan (8,536); municipal; Big Goose Creek. Analysis of tap sample by E. W. Lohr, June 14, 1932.

cities of the United States, 1932—Continued

	Analyses (parts per million)												
	Total dissolved solids	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulphate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Total hardness as $CaCO_3$ [a]	No.
A-------	197	9.6	0.01	47	7.1	4.7	1.3	99	61	4.0	4.8	147	663
B-------	121	12	.02	15	5.9	5.5	1.0	20	12	8.0	43	62	
A-------	[a] 754	6	.12	194	27	9.2		254	379	14	-------	596	664
B-------	[a] 837	-------	.10	248	19	8.3		236	426	13	-------	698	
C-------	[a] 422	-------	.05	77	38	11		276	137	17	-------	348	
---------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	---------	665
---------	375	-------	-------	64	18	[a] 20		145	132	15	-------	234	666
---------	107	11	.15	24	4.1	4.6	2.1	96	7.9	1.6	.10	77	667
---------	[a] 228	6.0	[b] 2.0	53	18	7.5		239	14	5.0	5.0	206	668
A-------	[a] 334	22	[b] 6.0	46	15	40		146	120	12	.58	176	669
B-- ----	[a] 533	12	[b] 1.5	68	25	74		198	238	17	Trace	272	
---------	28	6.9	.09	4.0	1.0	1.5	.7	16	2.8	.2	.10	14	670

[a] Calculated. [b] Iron and aluminum oxides.