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THE COMPOSITION OF THE RIVER AND LAKE WATERS OF THE UNITED STATES

BY

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THE COMPOSITION OF THE RIVER AND LAKE WATERS OF THE UNITED STATES.

By Frank Wigglesworth Clarke.

Part I.—INTRODUCTION.

In the summer of 1903 the late Richard B. Dole, chemist of the water-resources branch of the United States Geological Survey, began a systematic investigation of the composition of the river and lake waters of the United States. His plan, which developed gradually, was to have analyses made of the different waters in such a manner as to give the average composition of each one for an entire year. For a few waters, such completeness was impracticable, the analyses covered only part of a year, but even in these waters the data obtained were of much value. As a rule, samples of each water were collected day by day. They were then mixed in sets of ten and analyzed, so that for each river or lake from 34 to 37 analyses were made. For the Mississippi above New Orleans composite analyses were made in sets of seven, giving 52 analyses from which to compute the average. For the Great Lakes, however, only monthly samples were taken, for the reason that their waters vary so little in composition that greater elaboration was not necessary. Some of the larger rivers were treated even more thoroughly; their average composition was determined at more than one point—the Mississippi at six points. For some rivers the analyses cover two years of collection, and for the data, received from a contributor not connected with the Geological Survey, three years.

In 1909 the first fruit of Mr. Dole's investigation appeared as a water-supply paper.[1] This report, in addition to text that described the purpose of the work and the methods of analysis, contained more than 2,000 analyses, representing 59 different waters. So large a mass of data relative to the composition of river and lake waters had never before been published as the work of any single laboratory. Indeed, nothing like it had ever been attempted elsewhere. Of course Mr. Dole could not possibly have done all the work single handed. He was fortunate in having a corps of capable assistants or rather colleagues, whose names appear in connection with the tables of analyses. Credit is given to every man who shared in this labor.

But this is not all. Under Mr. Dole's direction, or in cooperation with him, other similar reports were soon published, as follows: On the waters of California, by Walton Van Winkle and F. M. Eaton; on Illinois by W. D. Collins; on Washington and on Oregon, by Van Winkle, and on Kansas by H. N. Parker with analyses made under the direction of Prof. E. H. S. Bailey.[2] In all these reports the same policy was followed as in the earlier report; tables of analyses were given to show the average annual composition of the water of each river. Furthermore, by correspondence with a number of railroad companies, Mr. Dole obtained many "boiler-water" analyses, which, if not of the greatest elaboration, have proved to be of considerable value. Some of the companies responded most liberally to his appeal, but others seemed to take little or no interest in it. This material is now utilized for the first time.

It was Mr. Dole's intention to bring together all his accumulated data in one exhaustive monograph. The work was actually begun and covered part of the Atlantic slope, but on January 21, 1917, after a brief illness, Mr. Dole died, leaving his task unfinished. His plan was most ambitious and under the conditions that controlled him would have occupied him for many years. Unfortunately, but unavoidably, his official duties were so numerous that he could give only part of his time to this monograph. His last work, completed only a few days before his fatal illness, was to make, in cooperation with A. A. Chambers, a set of analyses of waters from the Yukon, showing the composition of that river for an entire year. These analyses will be found in the last section of this memoir.

The course of Mr. Dole's investigations was followed by the present writer with much interest. He realized their great value to science, and their unique character, and felt that the notable mass of material thus accumulated should be preserved in collected form. Very few of the analyses received from sources outside of the Geological Survey had been published, yet they served to reinforce and increase the value of the many printed tables. The writer therefore volunteered to take up one phase of Mr. Dole's more elaborate plan and to make these thousands of analyses available for scientific use and discussion. The task thus assumed was laborious but well worth the time spent upon it.

Since the death of Mr. Dole a considerable number of additional analyses have been collected, and they are incorporated in the present work. Some of them were made in the laboratories of the United States Geological Survey; others were found in official

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[1] U. S. Geol. Survey Water-Supply Paper 236, 1909.

[2] U. S. Geol. Survey Water-Supply Papers 237, 239, 339, 363, and 273.

reports published by individual States. A few more were received from railroad companies, and some unpublished data were contributed in manuscript, either by the analysts or by the organizations for which they were made. Every analysis is credited to the source from which it was obtained.

The work done by the present writer falls into two principal divisions. First came the classification and arrangement of the analyses, each one being assigned to its proper drainage basin. As regards the larger rivers and their chief tributaries this task was easy, but with the smaller streams and lakes it was often difficult. Part of the trouble was due to defective maps, and part of it to the duplication of names. For instance, two St. Joseph rivers rise near each other in Michigan and flow in opposite directions, one into Lake Michigan, the other into the Maumee. Two Fox rivers in Wisconsin and two Vermilion rivers in Illinois behave in the same way, and for each couple two drainage basins are indicated. There are also two Delaware rivers, two Red rivers, two Colorado rivers, and two Platte rivers, and such descriptive names as Rock River, Cedar River, White River, and Cottonwood Creek occur over and over again. It has also been necessary to reject a good many of the collected analyses because of obvious defects. Some were incomplete, some obscurely stated, and others distinctly bad. This part of the work was largely critical and could not be done hastily. It required a good deal of conscientious study, and errors were not always easy to avoid.

The reduction and tabulation of the analyses was the second and most important division of this work. In order that they should be comparable it was necessary to reduce all analyses to a uniform standard, and that task, although easy, was very laborious. The analyses published in the water-supply papers of the Geological Survey were all stated in ionic form, in parts per million, and with the bicarbonate radicle instead of the normal CO_3. Alumina was not determined, and in most of the analyses potassium was included with the sodium and not separately estimated. These deficiencies were admitted by Dole and excused on the ground that the amount of work to be done made the simplification of the analyses necessary. With these analyses the reduction to percentage form was all that the present writer had to do in the way of recalculation.

The treatment of the miscellaneous analyses as they were received from various sources was a different problem. They were stated in many different ways, some in parts per million or parts per hundred thousand and others in grains per gallon or even grains per imperial gallon. A few were given in terms of ions, but most of them were expressed in terms of salts—that is, as hypothetical combinations. In nearly all these analyses normal carbonates were assumed as present, with no word as to bicarbonates. Because of these differences the reductions to standard form became necessary in order that the analyses might be compared with one another. By that treatment some interesting relations were brought to light which otherwise could hardly have been suspected.

Wherever it seemed to be practicable the tables of analyses have been followed by attempts at interpretation, in order to discover relations between the waters and their lithologic origin. For what may be called primary waters—that is, waters of single streams as distinguished from blends or mixtures—the interpretation is often easy, but all such streams are small, and most of them form the headwaters of larger rivers. The waters of great rivers and their principal affluents are all blended waters and are more difficult to deal with. Even with them it is possible to reach some definite conclusions, based upon a study of the tributaries and of the geologic and climatic characters of the drainage areas. What has been done in the way of interpretation is, however, only a small fraction of what is desirable.

That the present work is very incomplete is plainly evident, and, indeed, even an approach to completeness would be impossible. Only about 650 different waters have been studied, and there must be thousands of others for which no analyses were found. Some of the deficiencies are, of course, insignificant, but many large rivers are unrepresented in our tabulations. Furthermore, the available analyses are very unevenly distributed geographically. Some States and some drainage basins have been covered with comparative thoroughness; others are almost neglected. Vermont, for example, is represented by a single analysis, and the data relative to the waters of Texas are altogether inadequate. These are only two of many examples which might be cited. This paper may be regarded as an outline for future workers to fill in.

STATEMENT OF ANALYSES.

In the usual statement of water analyses an essentially vicious mode of procedure has become so firmly established that it is difficult to set aside. For example, a water is found to contain sodium, potassium, calcium, magnesium, chlorine, and the radicles of sulphuric and carbonic acids; or, in ordinary parlance, three acids and four bases. If these are combined into salts at least 12 such compounds must be assumed, and there is no definite law by which their relative proportions can be calculated. A combination, however, is commonly taken for granted, and each chemist allots the several acids to the several bases according to his individual judgment. The 12 possible salts rarely appear in the final statement; all the chlorine may be assigned to the sodium and all the sulphuric acid to the lime, and the result is a meaningless chaos of assumptions and uncertainties. We can not be sure that the chosen combinations are correct, and we know that in most analyses they are too few.

But are the radicles combined? This is a point at issue. Although no complete theory covering all the phenomena of solution has yet been developed, it is the prevalent opinion, at least among physical chemists, that in dilute solutions the salts are dissociated into their ions, and that with ions only can we legitimately deal. Whether this theory of dissociation shall ultimately stand or fall is a question which need not concern us now; we can use it without danger of error as a basis for the statement of analyses, putting our results in terms of ions which may or may not be actually combined. Upon this foundation all water analyses can be rationally compared, with no unjustifiable assumptions and with all the real data reduced to the simplest uniform terms. We do not, however, get rid of all difficulties, and some of these must be met by pure conventions. For example, Is silica present in colloidal form, or as the silicic ion SiO_3? Are ferric oxide and alumina present as such, or in the ions of their salts? The ion may represent ferrous carbonate, the alumina may be equivalent to alum; but as a rule the quantities found are so trivial that the true conditions can not be determined from the ratios between acidic and basic radicles. The unavoidable errors of analysis are commonly too large to permit a final settlement of these questions; and only in exceptional cases can definite conclusions be drawn.

For convenience, then, we may regard these substances as colloidal oxides and tabulate them in that form. The procedure may not be rigorously exact, but the error in it is usually very small. If we consider an analysis as representing the composition of the anhydrous inorganic matter which is left when a water has been evaporated to dryness, the difficulty as regards iron disappears, for ferrous carbonate is then decomposed and ferric oxide remains. A similar difficulty in respect to the presence of bicarbonates also vanishes at the same time, for the bicarbonates of calcium and magnesium can exist only in solution and not in the anhydrous residues. If in a given water notable quantities of lime, magnesia, and carbonic acid are found, bicarbonic ions must be present, for without them the bases could not continue dissolved; but after evaporation only the normal salts remain. Sodium and potassium bicarbonates are not so readily broken down; but even with them it is better to compare the monocarbonates, so as to secure a uniformity of statement. In fact, some analysts report only normal salts, and others bicarbonates; so that for the comparison of different analyses we are compelled to adopt an adjustment such as that which is here proposed. In other words, we eliminate the variable factors and study the constants alone.

One other large variable remains to be considered—the variation due to dilution. A given solution may be very dilute at one time and much more concentrated at another, and yet the mineral content of the water is possibly the same at both times. For example, average ocean water contains 3.5 per cent of saline matter, while that of the Black Sea carries little more than half as much; and yet the salts which the two waters yield upon evaporation are nearly if not quite identical. In some cases it is desirable to compare waters directly; but most generally it is also convenient to study the composition of the solid residues in percentage terms. In that way essential similarities are brought to light and the data become intelligible.

Before proceeding further, it may be well to consider a single water analysis in order to illustrate the various methods of statement. For this purpose we will take W. P. Headden's analysis of water from Platte River near Greeley, Colo., which he himself states in several forms. In the first column of the subjoined table the results are given in oxides, etc., as in a mineral analysis, and in grains to the imperial gallon. In the second column they are stated in terms of salts, and we have here recalculated Headden's figures into parts per million of the water taken. Finally, in a third column we give, as proposed in the foregoing pages, the composition of the residue in radicles or ions and in percentages of total anhydrous inorganic solids.

Analysis of a water stated in different forms.

	Grains per imperial gallon.		Parts per million.		Per cent.
SiO_2	0.891	$CaSO_4$	457.7	SiO_2	1.26
SO_3	32.601	$MgSO_4$	236.0	SO_4	55.28
CO_2	4.554	K_2SO_4	9.4	CO_3	8.78
Cl	2.681	Na_2SO_4	62.5	Cl	3.79
Na_2O	11.463	NaCl	63.2	Na	12.02
K_2O	.355	Na_2CO_3	156.9	K	.41
CaO	13.117	Na_2SiO_3	21.9	Ca	13.24
MgO	5.530	$(Fe, Al)_2O_3$	2.7	Mg	4.69
$(Fe, Al)_2O_3$	.189	Mn_2O_3	2.7	R_2O_3	.53
Mn_2O_3	.189	Ignition	34.2		100.00
Ignition	2.397	Excess SiO_2	1.3	"Ignition" omitted. Salinity, 1,014 parts per million.	
	73.967		1,048.5		
Less O=Cl	.604				
	73.363				

So far as appearance goes, these statements might represent three different waters; and yet the analytical data are the same. A change in the last column of SiO_2 into the radicle SiO_3 would affect the other figures but slightly. The compactness and simplicity of the ionic form of statement are evident at a glance. Under it, as "salinity," we have given the concentration of the water in terms of parts per million. One million parts of this water contain in solution 1,014 parts of anhydrous, inorganic, solid matter.

There are few rules that are not subject to qualifications, and that is true in the present case. The statement of an analysis in percentages is best for purposes of comparison, but it gives only the relative proportions of the several reported constituents of a water, not their absolute amounts. For this reason it has seemed best to state the analyses which are discussed in this memoir in two forms—first, in parts per million, and second, in percentages. For ordinary fresh waters, such as we find in nearly all our rivers and lakes, 1 part per million is very nearly 1 milligram per liter, but for highly concentrated waters or brines, like that of Great Salt Lake, this is not true. For waters of the latter class the proper form of statement is in milligram per kilogram, which is exactly equivalent to parts per million. With waters of moderate concentration the error in parts per million is so slight as to be negligible, and the samples for analysis may be taken by volume; for strong saline waters they should be taken by weight. For the most concentrated waters the salinity may be stated in percentage terms; that, however, is only a matter of convenience. But in all such cases the specific gravity of the water ought also to be determined.

The desirability of the double form of statement appears most clearly in the study of very dilute waters. In Moosehead Lake, for example, the dissolved solids amount to only 16 parts per million, so that one part is equivalent to more than 6 per cent of the total. The percentage column, therefore, gives an erroneous conception as to the relative importance of the several constituents of the anhydrous residues, which can be corrected by a glance at the other column. The unavoidable errors of analysis are magnified, and a minor constituent, such as chlorine, assumes undue importance. An error of 1 part per million is serious in the analysis of such a water, although it might be insignificant in waters of average concentration. This subject is considered more fully in our general discussion of the tables of analyses as they are given in the second part of this paper.

INTERPRETATION OF ANALYSES.

In the interpretation of any water analysis the first question to ask is as to its accuracy. Every analysis is subject to errors, great or small, and for each individual analysis it is important to decide whether the error is serious or negligible. When an analysis is stated in terms of salts, the errors are obscured, as in the smoothing of a curve, and an accurate estimate of its value is not possible. In such a case the reputation of the analyst is the safest criterion upon which to base a judgment.

When, however, an analysis is stated in terms of the radicles actually determined, a decision as to its value is much simpler. The negative or acid radicles and the positive or basic radicles must be chemically equivalent, at least within the limits of permissible experimental errors. To this rule, which applies to nearly all waters, there are some apparent but not real exceptions. If the basic radicles are much in excess of the acid, it is possible that a part of the alkaline ions may be balanced or held in equilibrium by silica—that is, the usually colloidal silica may represent an alkaline silicate, which, however, is hydrolyzed in solution. Some geyser waters of the Yellowstone National Park have this peculiarity. On the other hand, certain volcanic waters are strongly acid; and then it is necessary to assume the presence of hydrogen ions in order to completely balance the negative radicles. Another source of acidity is found in some mineral springs, in which the iron and aluminum are presumably in equilibrium as sulphates. The iron and aluminum must then be counted, not as colloids but as among the basic radicles. Examples of these exceptional waters are well known and demand no further attention here.

The calculations implied in the preceding paragraph are very simple and may be based either upon the analysis as stated in parts per million or upon its percentages. The quantity for each radicle is divided by its chemical equivalent, and the quotients for each group, acid or basic, are separately added together. The two sums should then be equal, or so nearly equal that the difference can be ascribed to the small, inevitable errors of analysis. For the univalent radicles Na, K, Cl, NO_3, and HCO_3 the chemical equivalent and the atomic weight are the same; for the bivalent radicles Ca, Mg, SO_4, and CO_3 the atomic weights should be halved. This is the usual procedure. H. Stabler, however, has proposed a modification of the method, in which the quantities determined are multiplied by the reciprocals of the equivalents, which he calls the "reaction coefficients" of the radicles. The products so obtained, the "reacting values" of the radicles, are identical with the quotients of the ordinary process and must balance in the same way. A table of Stabler's coefficients may save some labor when large numbers of analyses are to be discussed, but the economy is probably small.

The interpretation of a water analysis, then, is founded upon a study of equilibria. Even the hypothetical combination of the radicles is a crude attempt at such a study—an attempt, however, which, as we have already seen, is based ordinarily upon unverifiable assumptions. I speak now, of course, of such waters as commonly occur in nature. A solution of a single salt, or one in which, as in certain brines, one salt overwhelmingly predominates, is obviously easy to deal with.

Suppose, now, that the analysis of a river water is satisfactory, what does it signify From what source, did the river obtain its dissolved solids? Was it a simple water, drawn from an area of definite geologic character, or a blend of many waters of very different origin? Was it, furthermore, a natural water, or one that had been seriously contaminated by human industries.

In any attempt to answer these questions it must be borne in mind that the composition of a river water varies from time to time and from place to place. The water varies in concentration between times of flood and times of drought, and its composition is changed by the influx of tributaries. It is also modified by seepage from the river banks, and the additions to the salinity of a river from this source may be of considerable magnitude. In an arid region, for example, the occasional heavy showers dissolve large quantities of alkaline salts from the desert soils and wash them into the rivers. In short, no general answer to the questions can be formulated. Each water must be studied on its individual merits and with due regard to many different conditions. Some of these conditions are chemical, some geologic, some climatic, and others cultural. The large rivers, like the Mississippi, the St. Lawrence, and the Columbia, are mixtures of waters from nearly all conceivable sources, and these should be separately investigated. To do this is not always possible, for necessary data are often lacking. The best example of systematic changes in the composition of a water is given by the Rio Grande, as shown by the table of analyses on page 128. Small rivers near their sources are easier to deal with.

Although the minerals that form the rocky crust of Earth are relatively insoluble, they are not absolutely so. The feldspars are especially susceptible to change through aqueous agencies, yielding up their lime and alkalies to percolating waters and forming a residue of clay. Rain water contains carbonic acid in solution, with other minor impurities, and these increase its solvent power, particularly with regard to limestone. The moment that water leaves the atmosphere and enters the porous earth its chemical and solvent activities begin, and they continue, with little or no interruption, until it reaches the sea. The character and extent of the work thus done varies with local conditions, but it is never zero. It is to the solvent power of carbonated waters that the rivers and lakes owe their dissolved solids. Such water comes primarily from rain and secondarily from the decay of organic matter in the soil. Other minor sources need not be considered here.

As water carrying carbonic acid in solution is the primary agent of rock decomposition, it is an almost necessary inference that carbonates should be the principal salts in nearly all fresh waters. That this is true may be seen by a glance at the great number of analyses which are cited in this memoir. The following figures, which give the average composition of the river and lake waters of North America, excluding those of closed basins, may serve to emphasize this conclusion.[3]

Average composition of North American waters.

CO_3	33. 40
SO_4	15. 31
Cl	7. 44
NO_3	1. 15
Ca	19. 36
Mg	4. 87
Na	7. 46
K	1. 77
$(Fe, Al)_2O_3$	. 64
SiO_2	8. 60
	100. 00

This composition is not far from that given by the Mississippi alone, which naturally dominates the entire combination. Carbonates form about 50 per cent of the solid compounds held in solution by the average fresh water. The two chief sources of them are the decomposition of feldspars and the solution of limestones. Other sources are of minor importance, but not negligible. The waters of saline and alkaline lakes, like those of the Great Basin, form a distinct class to be considered separately. (See pp. 183–189.) Their composition depends upon local and often undetermined conditions and is by no means uniform.

Sulphates rank next to carbonates among the solid contents of river waters. Their original source was the oxidation and partial solution of iron pyrites and to a much less extent of other sulphides. Iron pyrites is widely diffused in the igneous rocks and alters easily to limonite. The sulphates thus formed are either disseminated in soils or concentrated into beds of gypsum. In the soils of arid regions alkaline sulphates accumulate, and from all these sources sulphates find their way into the rivers. When neither gypsum nor desert salts are present, an abnormally high proportion of sulphates is indicative of industrial contamination. Androscoggin River, for example, is polluted by pulp and paper mills. The Susquehanna, upper Potomac, and Monongahela receive the drainage of coal mines. Here again iron pyrites is the source of the sulphates, for that mineral is a common impurity in coal. In a purely agricultural region the extensive use of artificial fertilizers, which contain either gypsum or superphosphates, may yield sulphates to adjacent waters. Superphosphates of lime contain an admixture of calcium sulphate. In the same way fertilizers containing potash salts, ammonia, or nitrates may have a local influence upon the composition of both ground and surface waters. Such an influence would be mainly apparent in seepage from the banks of a stream.

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[3] See Clarke, F. W., The data of geochemistry, 4th ed.: U. S. Geol. Survey Bull. 695, p. 115, 1920.

Only a very small part of the chlorine contained in river waters can be traced to the decomposition of igneous rocks. Nearly all of it is primarily of organic origin, or secondarily derived from marine rocks and sediments. Waters near the points at which they join the sea may carry an abnormal quantity of salt, and even for many miles inland cyclic chlorine—that is, chlorine which represents salt thrown into the air by ocean spray and brought down again in rain—can be determined. The sedimentary rocks, especially those of marine origin, commonly contain at least traces of chlorides, and such deposits as those of rock salt are composed almost entirely of them. Where beds of salt exist they affect the springs, which pour their dissolved chlorides into the streams. Salt also accumulates in desert soils and from them is leached into rivers. The rivers of western Kansas, the Rio Grande, and the Colorado are good examples of chloride-bearing waters.

In densely populated regions much chlorine is carried into rivers by sewage. The influence of the Chicago drainage canal upon the Illinois and Mississippi is clearly shown on page 73 of this memoir. It is a striking example of this sort of pollution, which in less degree is exceedingly common. A less objectionable source of salt is found in oil fields. Petroleum is commonly accompanied by strong brines, which are brought to the surface when wells are drilled and allowed to drain away. When in the analysis of a fresh water excessive amounts of sodium and chlorine are found, some sort of pollution is to be inferred. To the saline rivers of the West and to salt directly received from the ocean this rule does not apply. (See, for example, the analyses of water from Cape Fear River on p. 39.)

Nitrates are of minor significance in the study of river and lake waters. They may be formed, together with ammonia, by electrical discharges in the atmosphere, and then brought to the surface of the earth in rain. Relatively large quantities in a water may represent pollution by sewage, or, as has already been shown, the drainage from fertilized fields or even from barnyards. The normal proportion of nitrates in natural waters is always small, except in a very few mineral springs.

The basic radicles that are determined in water analyses were derived originally from the decomposition or solution of rocks. As for the igneous rocks, their average mineral composition is shown, with a fair approximation to the truth, by the following percentages, based upon a study of about 700 rocks, which had previously been investigated microscopically.

Average composition of igneous rocks.

Feldspar	59. 5
Quartz	12. 0
Amphiboles and pyroxenes	16. 8
Micas	3. 8
Accessory minerals	7. 9
	100. 0

The feldspars, it will be seen, are by far the most abundant minerals and therefore of the greatest significance in the present discussion.

The foregoing figures are quite in harmony with those previously given for the average composition of fresh waters. Calcium ranks first among the basic radicles and comes in great part from the decomposition of the lime feldspar, anorthite. A small part may have been derived from hornblende or pyroxene, or from the ubiquitous apatite. Its secondary and perhaps the largest source is from the solution of limestone, and in less degree from gypsum.

Secondary sources such as salt beds and desert salts being left out of account, the alkaline radicles sodium and potassium are derived from the alkaline feldspars albite and orthoclase. Potassium is of minor significance, because much of it is retained by the sediments and does not find its way into the river waters. Some sodium may come from nepheline syenites, and some potassium from leucite rocks, but these sources are too local to have any general significance. In regions where albite is more abundant than anorthite, sodium may be in excess of calcium, but such occurrences are relatively uncommon. They are, however, not unimportant, as will be shown a little later.

Amphiboles, pyroxenes, and olivine are the chief primary sources of the magnesium of the river waters, but its secondary source, the solution of magnesium limestones and dolomites, is perhaps even more important. In southeastern Wisconsin these rocks are abundant, and the proportion of magnesium in the waters is remarkably bigh. That region might well be defined as a hydrochemical province, and its waters, which drain into Lake Michigan, have an appreciable influence upon the lower lakes and the St. Lawrence River. (See pp. 14–15.)

Silica, although its determination is often neglected, is one of the most significant constituents of river and lake waters. In some waters of South America it forms more than 50 per cent of the total dissolved solids, and even in some rivers of the United States it reaches figures that are nearly as high. From 30 to 40 per cent is not uncommon. The silica content of river waters may be derived from the solution of almost any rock-forming silicates, except those contained in shales and slates, which, with sandstone, represent the end products of aqueous decomposition. Its chief source, however, is from the feldspars, and their relative importance is shown by their percentage composition, as given in the following table:

Composition of feldspars.

	Albite.	Orthoclase.	Anorthite.
SiO_2	68. 7	64. 7	43. 2
Al_2O_3	19. 5	18. 4	36. 7
CaO	-----	-----	20. 1
Na_2O	11. 8	-----	-----
K_2O	-----	16. 9	-----
	100. 0	100. 0	100. 0

The plagioclase feldspars—oligoclase, andesine, labradorite, and bytownite—are isomorphous mixtures of albite and anorthite. These mixtures are far more abundant than either of their components taken alone.

The significance of the foregoing figures is apparent at a glance. The alkali feldspars yield sodium and potassium to percolating waters, and anorthite yields calcium. The first two minerals, moreover, contribute much more silica to the waters than the third. If the silica in the anhydrous residue from a water exceeds 30 per cent, the alkalies are probably in excess of lime; if anorthite predominates, lower silica is found, and the proportions of the bases are reversed. These conclusions can be tested by an examination of the analyses of waters from the south Atlantic slope on pages 36–49 and will be seen to be very nearly but not rigorously true. The waters contain other substances than those derived from feldspars, and so the suggested regularities are disturbed. The rocks contained other minerals, and the feldspars themselves were not absolutely pure. The agreement with theory, however, is remarkably close.

From what has been said it is clear that the silica of natural waters is of importance as an aid to diagnosis. It also serves as a cement which binds grains of sand together and so helps to form sandstone. It is, furthermore, of economic significance, for it is commonly determined in the analysis of waters for use in steam boilers, for silica is classed among the objectionable incrustants. In the preparation of this memoir many otherwise good analyses have been rejected because the analyst had ignored silica. Such analyses could not properly be reduced to the standard percentage form for comparison with others. In many boiler-water analyses silica and sesquioxides were weighed together, and in such analyses the reduction to percentages was possible.

A few minor constituents of river and lake waters remain to be mentioned. Manganese has been reported in some analyses, and so also have phosphates, but these are rarely determined. Traces of phosphates may be common, but overlooked, derived partly from the apatite of the igneous rocks and partly from sedimentary deposits. Waters traversing an area containing extensive beds of phosphate rock are likely to contain more than traces. Borates are found in some alkaline lake waters, and zinc has been detected in the basin of Spring River, Kans. The zinc-bearing waters have received the drainage from zinc mines, or else from springs issuing from ore bodies.

The sesquioxides of iron and aluminum are almost invariably present in river waters, but rarely in large amount. When, however, they are found in abnormal quantities, defective filtration of the sample is to be suspected. Very finely divided sediments are easily retained in suspension and appear in the analyses. Such analyses, evidently, are of very doubtful value.

Organic matter, which is commonly present in both surface and ground waters and which is sometimes determined, has been left out of account in the present investigation. It may be derived from the decay of vegetation, or it may represent pollution by sewage. Its chief geologic significance is as a source of carbonic acid in the soil, for then it helps the decomposition of the débris of rocks. It was formerly supposed to be a solvent of silica, but that belief was long since abandoned.

The salinity of a river water is a variable quantity, being highest in times of drought and lowest in times of flood. It is, nevertheless, a useful aid to diagnosis, especially when the average composition of a water has been determined for a sufficiently long period of time. As a general but not invariable rule, the salinity of a water is lowest near its source and tends to increase downstream. In the downward course of a river it receives more saline matter from its tributaries, and so the water becomes more concentrated. If, however, a large tributary of lower salinity joins the main stream, the general rule may be temporarily reversed.

To a certain extent the salinity of a water is determined by its geologic environment—that is, it depends upon the solubility of the rocks from which its solid contents were derived. In a stream issuing from an area of crystalline rocks the salinity is generally low, usually less than 100 parts per million, and the same is true of waters flowing from areas of shale or sandstone. A limestone water, on the other hand, is much higher in salinity, carrying as much as 200 parts per million and often more. In each class of rocks the solubility is in part dependent upon texture—whether a rock is compact or porous; firm and solid like a marble, or of a loose structure like chalk. Waters flowing from areas of silicate rocks are represented by most of the streams of the Atlantic slope; the rivers of Ohio, Illinois, and Iowa belong to the sedimentary class. These examples are only a few among many. The waters of the arid regions are highest in salinity, for they are loaded with desert salts. The Colorado, of Arizona, is typical of this class.

In the complete study of a river water climatic conditions must be considered. Where rainfall is abundant vegetation is abundant and organic matter accumulates in the soil. Its influence as a source of carbonic acid has already been mentioned. In the colder parts of the Temperate Zone alternations of freezing and thawing help to disintegrate the rocks and so to make them more accessible to the percolating waters. When, however, the winters are long and severe, as in the interior of Alaska, the soil is frozen during a large part of the year, and the solvent activity of the waters becomes extremely slight. Under such conditions nearly all the water of a river is mere surface run-off, and its salinity is very low. In a warmer climate the interruptions to the chemical efficiency of the waters are less frequent, and their salinity is increased. In hot and arid regions the conditions are quite different from those in humid regions. There the decay or organic matter is of trifling significance, and the salinity of a water is highest during or after a heavy rain. The contrast between the rivers of humid and arid regions is clearly shown in the table of analyses on page 130, where the waters of the St. Lawrence, the Mississippi, and the Colorado are compared. In general we may say that in humid regions carbonates are the dominant salts carried by the rivers; in arid regions sulphates and chlorides prevail. Local conditions may partly reverse this rule, as, for example, where a water traverses beds of gypsum or rock salt, but these are quite exceptional occurrences.

From what has been said it is clear that the interpretation of a water analysis involves the consideration of several distinct lines of evidence. First, the quality of the analysis, which may be excellent, but of very little meaning, taken separately. It must be compared with other analyses, all belonging to a definite drainage basin. Furthermore, it must represent a normal water—that is, one which is uncontaminated by human agencies. The leading sources of contamination have already been pointed out and ought to be recognized without much difficulty.

With the comparison of analyses from a distinct basin, relations begin to appear that would otherwise be unsuspected. Low salinity indicates that the solid contents of a water come from rocks of relatively low solubility, such as granite, for example, or shale and sandstone in a sedimentary area. High salinity, when compared with the composition of a water, may point either to a derivation from limestone, or else, in an arid region, to soluble salts in the soil. If much magnesium is present, it probably came from magnesian limestone or dolomite, and then a reference to the geologic character of the basin should show whether the supposition is correct.

The analyses of waters in regions which are geologically complex—that is, where plutonic, effusive, and sedimentary rocks are all present—are less easy to interpret. Even then the problem is not altogether hopeless. From what we know as to the possible source of each constituent of the water some definite conclusions may be drawn. In such cases the relations between silica, lime, and alkalies, as shown by analyses of samples taken at different points in the drainage basin, are particularly significant. They at least suggest probabilities, which are sometimes extremely strong.

The study and interpretation of water analyses inevitably leads to attempts at classification. They may be classified according to character, or to composition, or to geologic origin. Under the first heading waters are classed according to the purposes for which the analyses are made. Sanitary analyses, in which only a few determinations are needed, relate to the suitability of waters for human consumption—that is, Are they wholesome or injurious to health? Other analyses, which need not be very complete, are made for definite economic reasons—for example, Are the waters fit for use in steam boilers, or for irrigation, for paper making, or for any one of a great variety of other industrial purposes? Many so-called boiler-water analyses have been utilized in the present investigation, but without reference to their economic significance. They have given much useful information relative to the river and lake waters of the United States.

Under the second heading the classification of waters is purely chemical, although the analyses may be made for utilitarian reasons. The water of a mineral spring is commonly analyzed in order to determine its therapeutic value, and it may be defined as saline, alkaline, chalybeate, or acid, as calcic, or magnesian, or as containing lithia. The nomenclature under such a classification is very varied. A different system, which is much more general, describes a water in terms of its acid radicles, as a carbonate, sulphate, or chloride water. Moses Lake, Wash., is essentially a carbonate water, Arkansas River at Rockyford, Colo., is characterized by sulphates, and Great Salt Lake is a solution of common salt. Between these types there are all sorts of mixtures, and in some waters all three radicles are present in nearly equal proportions. There are no sharp lines between the three subclasses.

A classification of waters according to their origin is something quite different from the other two systems. Its purpose is geologic, and although no complete scheme for it has yet been developed, the analyses as arranged in this memoir give some suggestions as to what may be possible, The dolomitic waters of Wisconsin represent one definite class, and distinctly limestone waters form another. The siliceous waters of the south Atlantic slope seem to form a distinct family to which the waters of other widely separated localities belong. Some of the rivers of Oregon and Washington are of this general character, and so also are Potaro River in British Guiana, the Mahanuddy in India, and certain streams at the headwaters of the Elbe and Danube, in Bohemia and Bavaria.[4] Such waters might be termed granitic or feldspathic, at least until a better name can be found. The blended waters of the larger rivers are more difficult to classify. By far the greater number of these, however, are essentially carbonate waters. The waters that deposit siliceous sinter or calcareous tufa are geologically important, but they are not clearly represented among our rivers. Great Salt Lake, however, has deposited large beds of oolitic sand.

A perfect classification of natural waters is evidently impossible, but the chemical system is the simplest and most general. Even here the analyses shade into one another with all conceivable graduations.

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[4] For analyses of these foreign waters see Clarke, F. W., The data of geochemistry, 4th ed.: U. S. Geol. Survey Bull 695, pp. 91, 99, 101, 104, 1920.

PART II.—TABLES OF ANALYSES.

ST. LAWRENCE BASIN.

The St. Lawrence, one of the largest rivers of North America, forms, together with the Great Lakes, a large part of the boundary between the United States and Canada. The climate of its basin is that of the northern half of the Temperate Zone, with cold winters and warm summers; and the alternations of freezing and thawing help to disintegrate the rocks and so to render them more easily decomposed by percolating waters. The snowfall over much of its area is heavy, and freshets due to the spring thaws carry away much of the water as mere surface run-off which has taken up little saline matter. The average salinity of the water of the basin is therefore not high, and its character as a whole is little affected by local conditions. Between the smaller tributaries of the St. Lawrence there are marked differences in composition, but the Great Lakes serve as colossal mixing bowls in which the various waters are blended into something like homogeneity. Such variations as are at all noteworthy will be considered in their proper connection later. The mean annual rainfall of the St. Lawrence basin is about 31 inches.

Much of the territory drained by the St. Lawrence is either forested or fertile, and the soil is therefore rich in organic matter. The decay of such substances generates abundant carbonic acid, which tends to convert the dissolved inorganic matter into carbonates, mainly of lime and magnesia, and therefore the water of the system is to be classed as a carbonate water. The waters that drain an arid region as distinguished from a humid region are very different in character. The Colorado River of Arizona is in this respect quite unlike the St. Lawrence.

LAKE SUPERIOR.

Lake Superior, the largest body of fresh water on the globe, has a surface area of 31,000 square miles, and a hydrographic or drainage basin of 82,800 square miles. The composition of its water is best shown by the following table of analyses, which were made in the water-resources laboratory of the United States Geological Survey.[5]

Analyses of water from Lake Superior at Sault Ste. Marie, Mich.[a]

[Parts per million.]

Date (1906-7).	Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total dissolved solids.	Mean gage height (feet).[b]
Sept. 22	2	11	0.09	13	3.2	3.9	0.0	59	4.1	0.25	1.0	63	602.95
Oct. 22	1	8.7	.03	13	3.1	3.5	.0	56	3.8	.25	1.2	61	602.84
Nov. 22	2	5.9	.04	13	2.9	2.0	.0	54	1.8	.45	1.4	54	602.66
Dec. 20	Tr.	7.2	.08	13	2.9	3.6	.0	55	1.8	.30	1.3	58	602.45
Jan. 22	Tr.	4.7	.03	13	2.9	2.0	.0	55	1.6	.45	1.2	53	602.22
Mar. 22	3	12	.04	13	3.2	5.1	.0	55	1.7	.35	1.1	68	602.06
Apr. 20	1	12	.11	13	3.1	3.5	.0	56	1.5	.30	1.0	64	601.94
May 23	3	4.8	.09	13	3.0	3.0	.0	52	1.5	.55	1.0	57	602.10
June 22	3	4.6	.04	14	3.2	3.3	.0	59	1.7	1.2	1.2	59	602.55
July 22	2	5.7	.05	12	3.0	2.8	.0	58	1.5	1.2	1.0	5	602.70
Aug. 22	5	5.3	.05	13	3.1	2.9	.0	60	1.6	.50	1.1	66	602.93
Mean	2	7.4	.06	13	3.1	3.2	.0	56	2.1	.5	1.1	60	......

[a] Analyses by R. B. Dole and M. G. Roberts.
[b] Gaging station at Marquette, Mich., 160 miles west.

Several other analyses of waters from Lake Superior have been published, but they differ so much from the normal as to be of doubtful value.[6]

TRIBUTARIES OF LAKE SUPERIOR.

Complete analyses of water from tributaries of Lake Superior are few in number. Those which seem to be available for present purposes are as follows:

Analyses of water from tributaries of Lake Superior.

1. Pigeon River, on boundary between Minnesota and Canada. Analysis by W. A. Noyes, Minnesota Geol. Survey Eleventh Ann. Rept., p. 174, 1882.
2. Lake at Sidnaw, Houghton County, Mich.
3. Creek at Pori, Houghton County, Mich.
4. Davis Creek at Rockland, Ontonagon County, Mich.
5. Ontonagon River at Ontonagon, Mich. Analyses 2 to 5 received from Chicago, Milwaukee & St. Paul Ry.
6. Branch of Presque Isle River at Wellington, Gogebic County, Mich. From Davidson, G. M., Western Ry. Club Proc., Feb. 17, 1903, p. 243.
7. Creek at Siemens, Gogebic County, Mich. Analysis received from Chicago & Northwestern Ry.

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[5] U. S. Geol. Survey Water-Supply Paper 236, p. 101, 1909.

[6] See Noyes, W. A., Minnesota Geol. Survey Eleventh Ann. Rept., p. 174, 1882; Jackman, W. F., cited by A. C. Lane in U. S. Geol. Survey Water-Supply Paper 31, p. 27, 1899; Heath, G. L., Michigan Geol. Survey Rept. for 1903, p. 119. Incomplete analyses are also cited in Wisconsin Geol. and Nat. Hist. Survey Bull. 35, pp. 233, 318, 1915.

Analyses of water from tributaries of Lake Superior—Contd.

I. Parts per million.

	1	2	3	4	5	6	7
CO_3	21.4	10.5	45.3	102.9	80.1	22.2	14.1
SO_4	2.3	.1	Tr.	1.3	9.5	2.8	37.6
Cl	3.0	1.1	.8	.8	9.6	5.0	5.4
NO_3	Tr.	------	------	------	------	------	------
Ca	9.2	3.6	20.0	43.3	36.7	11.5	18.5
Mg	2.9	1.2	3.4	11.9	10.0	2.7	3.9
Na	2.7	2.4	5.5	7.7	10.8	3.2	3.5
K	1.3						
SiO_2	7.2	4.6	4.5	3.1	9.6	8.5	5.1
Fe_2O_3	.8					1.5	------
$(Al, Fe)_2O_3$	------					------	4.6
	50.8	23.5	79.5	171.0	166.3	57.4	92.7

II. Percentage composition of dissolved solids.

	1	2	3	4	5	6	7
CO_3	42.00	44.75	57.02	60.19	48.17	38.64	15.22
SO_4	4.69	.51	Tr.	.74	5.69	4.82	40.56
Cl	6.09	4.73	1.03	.48	5.80	8.67	5.83
NO_3	Tr.	------	------	------	------	------	------
Ca	18.08	15.16	25.11	25.32	22.07	20.00	19.96
Mg	5.74	5.04	4.24	6.99	6.02	4.69	4.20
Na	5.13	10.08	6.98	4.48	6.49	5.62	3.77
K	2.55						
SiO_2	14.15	19.73	5.62	1.80	5.76	14.88	5.50
Fe_2O_3	1.57					------	------
$(Al, Fe)_2O_3$	------					2.68	4.96
	100.00	100.00	100.00	100.00	100.00	100.00	100.00

NOTE.—Other analyses of waters in the northern peninsula of Michigan are cited by A. C. Lane in Michigan Geol. Survey Rept. for 1903. They are too incomplete for use here and otherwise unsatisfactory. Other partial analyses are given in Wisconsin Geol. and Nat. Hist. Survey, Bull. 35, pp. 233, 240, 318, 374, 1915.

LAKE MICHIGAN.

Lake Michigan, which comes next in order, has a water surface of 22,450 square miles, and a drainage basin of 60,150 square miles. For the water of the lake itself, there are, first, the standard analyses made in the laboratory of the water-resources branch of the United States Geological Survey, as given in the next table.

Analyses of water from Lake Michigan at St. Ignace, Mich.[a]

[Parts per million.]

Date (1906–7).	Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total dissolved solids.	Mean gage height (feet).[b]
Sept. 20	1	17	0.02	27	7.7	4.9	5.9	109	6.6	0.20	2.6	126	581.08
Oct. 20	1	9.2	.02	26	7.4	4.4	6.6	103	6.5	.30	2.6	115	580.85
Nov. 20	Tr.	9.5	.05	28	8.8	3.4	2.4	117	6.4	.35	2.9	120	580.72
Dec. 20	1	10	.06	25	7.1	4.7	1.6	104	6.2	Tr.	2.6	108	580.62
Jan. 20	1	6.2	.04	26	8.1	3.2	1.6	110	6.2	.4	2.8	110	580.67
Feb. 19	----	12	.03	26	8.4	5.4	3.4	113	7.6	.35	2.8	120	580.64
Mar. 20	----	14	.03	25	7.9	5.0	Tr.	111	7.9	.4	2.6	117	580.67
Apr. 21	----	8.4	.04	26	8.1	4.7	.0	112	9.5	.3	2.4	115	580.83
May 20	----	9.5	.03	27	8.7	5.4	2.6	115	7.8	.25	2.5	121	581.07
June 20	----	8.6	.04	26	8.4	6.6	4.5	116	7.7	.55	3.0	120	581.42
Aug. 20	----	11	.04	28	9.4	4.2	3.5	120	7.4	.4	3.2	123	581.51
Mean	Tr.	10	.04	26	8.2	4.7	2.9	112	7.2	0.3	2.7	118	------

[a] Analyses by R. B. Dole and M. G. Roberts.
[b] Gaging station at Mackinaw, Mich., 5 miles away.

The foregoing analyses of water from Lake Michigan may be taken as standard. In addition the following analyses have been collected from other sources.

Analyses of water from Lake Michigan.

1. At Port Washington, Wis.; city water supply, 1907. From G. M. Davidson.
2. At Milwaukee, Wis., 1877. By G. Bode, Geology of Wisconsin, vol. 2, p. 32, 1877.
3. At Milwaukee, Wis. Average of five commercial analyses by different analysts.
4. At Kenosha, Wis., 1911. By Dearborn Drug & Chemical Co.
5. At Racine, Wis.; city water supply, 1911. By Dearborn Drug & Chemical Co.
6. At Chicago, Ill. Analysis by J. H. Long. Analyses 1 to 6 from Wisconsin Geol. and Nat. Hist. Survey Bull. 35, 1915.
7. Grand Traverse Bay, Mich. By Dearborn Drug & Chemical Co. From U. S. Geol. Survey Water-Supply Paper 31, p. 18, 1899.

I. Parts per million.

	1	2	3	4	5	6	7
CO_3	66.7	72.0	70.9	68.7	66.4	73.4	66.4
SO_4	9.4	6.0	10.7	15.1	12.2	6.8	21.9
Cl	4.7	3.0	4.0	5.3	7.0	2.3	7.3
Ca	30.8	34.0	31.7	32.9	30.8	32.1	32.3
Mg	9.2	10.2	11.1	10.6	10.7	10.9	9.7
Na, K	5.7	1.5	4.6	5.2	5.6	3.1	10.4
SiO_2	5.6	16.0	6.2	5.4	2.1	5.1	4.0
$(Al,Fe)_2O_3$	2.4	?	2.4	1.8	1.2	.3	Tr.
	134.5	142.7	141.6	145.0	136.0	134.0	152.0

II. Percentage composition of dissolved solids.

	1	2	3	4	5	6	7
CO_3	49.59	50.45	50.07	47.38	48.82	54.78	43.75
SO_4	6.99	4.21	7.56	10.41	8.97	5.08	14.41
Cl	3.49	2.11	2.82	3.66	5.15	1.72	4.80
Ca	22.90	23.83	22.39	22.69	22.65	23.96	21.25
Mg	6.80	7.14	7.84	7.31	7.87	8.11	6.38
Na,K	4.29	1.05	3.25	3.59	4.11	2.32	6.78
SiO_2	4.17	11.21	4.38	3.72	1.54	3.81	2.63
$(Al,Fe,)_2O_3$	1.78	?	1.69	1.24	.89	.22	Tr.
	100.00	100.00	100.00	100.00	100.00	100.00	100.00

These individual analyses of water from Lake Michigan agree fairly well with the standard series but vary somewhat in details; the variation is due in part to differences in their quality and in part to local contamination or to the influence of inflowing streams. The analyses by Dole and Roberts are all of water taken near the outlet of the lake and therefore represent more definitely its average composition.

TRIBUTARIES OF LAKE MICHIGAN.

For the waters tributary to Lake Michigan a goodly number of analyses are available for present use. Of the western drainage, which is mainly in Wisconsin, the larger streams are the Menominee, which forms part of the boundary between Wisconsin and Michigan, and the Peshtigo, Oconto, Fox, Sheboygan, and Milwaukee. The first four of these empty into Green Bay; the others flow into the main body of the lake. The sources of the Menominee, which drains an area of about 4,000 square miles, are in Michigan. The analyses given in the following table represent work done in the laboratories of the Chicago, Milwaukee & St. Paul and Chicago & North Western railways and are of the class known as "boiler-water" analyses.

Analyses of water from the Menominee and Oconto basins.

1. Lake near Floodwood, Dickinson County, Mich., 1891.
2. Sturgeon Creek, Randville, Dickinson County, Mich., 1891. Analyses 1 and 2 received from the Chicago, Milwaukee & St. Paul Ry.
3. Long Lake, Florence County, Wis., 1907. From G. M. Davidson.
4. Menominee River at Menominee, Mich., 1891.
5. The same, 1902. Both received from the Chicago, Milwaukee & St. Paul Ry.
6. Cedar River at Spaulding, Mich. A tributary of the Menominee. From the Chicago & North Western Ry.
7. Wausaukee River, Wausaukee, Wis., 1897. From Chicago, Milwaukee & St. Paul Ry.
8. Oconto River at Oconto, Wis., 1892.
9. Creek at Kingston, Oconto County, Wis., 1897. Analyses 8 and 9 received from G. M. Davidson.

Analyses 3, 8, and 9, made for Chicago & North Western Ry. From Weidman, Samuel, and Schultz, A. R., Wisconsin Geol. and Nat. Hist. Survey Bull. 35, 1915.

I. Parts per million.

	1	2	3	4	5	6	7	8	9
CO_3	66.8	96.7	48.9	77.2	63.5	136.4	40.5	52.1	75.3
SO_4	3.2	5.4	2.1	4.3	5.2	18.9	3.0	20.7	1.7
Cl	Tr.	1.2	7.7	1.0	2.4	4.9	1.4	9.8	4.8
Ca	21.5	34.5	18.1	28.2	21.7	57.2	15.2	26.0	31.3
Mg	13.0	17.1	8.8	12.7	10.9	24.9	4.8	10.5	14.3
Na, K	2.9	5.1	5.0	5.2	6.7	3.2	6.9	6.4	3.2
SiO_2	2.6	7.0	8.0	5.6	3.8	4.4	3.6	7.8	9.9
$(Al, Fe)_2O_3$			.5			1.0		.3	.5
	110.0	167.0	99.1	134.2	114.2	250.9	75.4	133.6	141.0

II. Percentage composition of dissolved solids.

	1	2	3	4	5	6	7	8	9
CO_3	60.72	57.90	49.39	57.53	55.57	54.36	53.58	38.89	53.41
SO_4	2.91	3.24	2.13	3.19	4.55	7.53	3.98	15.49	1.21
Cl	Tr.	.72	7.77	.78	2.09	1.95	1.86	7.35	3.40
Ca	19.55	20.66	18.29	21.00	19.05	22.80	20.16	19.46	22.20
Mg	11.82	10.24	8.88	9.46	9.58	9.93	6.50	7.88	10.14
Na, K	2.64	3.05	5.05	3.84	5.87	1.28	9.15	4.79	2.27
SiO_2	2.36	4.19	7.98	4.20	3.29	1.75	4.77	5.83	7.02
$(Al, Fe)_2O_3$			.51			.40		.21	.35
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Fox River,[7] with a drainage area of 6,449 square miles, all within the State of Wisconsin, empties into the south end of Green Bay. Lake Winnebago divides it into two portions, the upper and the lower Fox. Wolf River is its largest tributary. The analyses given below are all except No. 10 taken from Bulletin 35 of the Wisconsin Survey already cited. Those credited to Hall and Juday were originally published in Bulletin 22, The inland lakes of Wisconsin, by E. A. Birge and C. Juday. Some incomplete analyses and some of small streams and mill ponds have not been used here. The following are suitable for present purposes. Analyses 11 to 17 represent water from the valley of Wolf River; no analysis of the water of the river itself has been found.

Analyses of waters of the Fox River valley, Wis.

1. Buffalo Lake, an enlargement of the Fox near its source. Davidson, 1912.
2. Upper Fox River at Princeton, Green Lake County. Davidson, 1901.
3. Green Lake. Mean of four analyses, 1907, by E. B. Hall and C. Juday. Reduced to standard form.
4. Lake Winnebago near North Fond du Lac. Davidson, 1905.
5. Lake Winnebago at Oshkosh. Davidson, 1896.
6. Lower Fox River at Menasha. Analysis made by Dearborn Drug & Chemical Co., 1907.
7. Lower Fox River at Kaukauna. Davidson, 1909. An incomplete analysis of the water at Appleton is also given.
8. Lower Fox River at De Pere. Davidson, 1892.
9. Lower Fox River at Green Bay. Davidson, 1902.
10. The same, 1919. Received from Chicago & North Western Ry.
11. Creek at Wabeno, Forest County. Davidson, 1907.
12. Pond on west branch of Embarrass River at Tagerton, Shawano County. Davidson, 1909.
13. North branch of Embarrass River at Bowler, Shawano County. Davidson 1907. An incomplete analysis of another branch is also given.
14. Creek, outlet of lake at Red Granite Junction, Waushara County. Davidson, 1901.
15. Lake Beasly, Waupaca County. Mean of three analyses.
16. Long Lake, Waupaca County. Mean of two analyses.
17. Rainbow Lake, Waupaca County. Mean of two analyses. Analyses 15, 16, and 17, by Hall and Juday, 1907. Reduced here to standard form.

I. Parts per million.

	1	2	3	4	5	6	7	8	9
CO_3	119.3	118.9	87.0	100.6	88.4	83.8	80.3	99.2	88.8
SO_4	11.2	36.3	16.7	9.8	29.2	7.6	36.4	13.3	11.1
Cl	2.1	5.4	5.8	3.1	6.4	3.5	6.7	1.9	19.5
Ca	40.4	43.1	21.5	34.8	33.4	23.0	32.3	34.9	32.5
Mg	26.6	28.2	25.7	18.3	19.0	15.6	19.1	19.8	19.0
Na	1.3	3.6	3.4	1.7	9.4	14.1	10.1	6.0	12.7
K			3.0						
SiO_2	6.1	23.7	9.4	13.7	3.9	4.4	6.1	7.0	2.5
$(Al, Fe)_2O_3$	1.7	18.6	2.0	.7	1.5	10.0	.8	2.9	.8
	208.7	277.8	174.5	182.7	191.2	162.2	191.8	185.0	186.9

	10	11	12	13	14	15	16	17
CO_3	61.5	81.9	48.0	80.1	82.0	133.0	89.0	89.2
SO_4	70.6	2.5	33.9	2.5	10.8	10.5	10.4	8.8
Cl	8.7	4.9	5.5	8.9	2.8	2.4	2.5	4.2
Ca	39.9	27.3	25.3	18.1	35.0	45.7	31.8	22.2
Mg	18.2	16.6	12.6	21.4	18.7	27.9	17.7	16.0
Na	5.7	4.4	3.5	7.0	7.5	2.4	3.0	2.3
K						2.0	3.1	3.3
SiO_2	4.6	16.9	7.3	15.2	11.4	22.6	18.2	19.4
$(Al, Fe)_2O_3$	2.7	1.7	.6	.5	Trace.	2.2	2.5	2.2
	211.9	156.2	136.7	153.7	168.2	248.7	178.2	147.6

II. Percentage composition of dissolved solids.

	1	2	3	4	5	6	7	8	9
CO_3	57.16	42.82	49.86	55.03	46.23	51.73	41.87	53.62	47.54
SO_4	5.37	13.05	9.57	5.36	15.28	4.69	18.96	7.19	5.93
Cl	1.01	1.94	3.32	1.69	3.35	2.16	3.49	1.03	10.43
Ca	19.36	15.54	12.32	19.06	17.44	14.20	16.87	18.87	17.38
Mg	12.75	10.14	14.73	10.06	9.95	9.63	9.95	10.70	10.16
Na	.62	1.29	1.95	.93	4.92	8.70	5.26	3.24	6.79
K			1.72						
SiO_2	2.92	8.53	5.39	7.49	2.04	2.92	3.18	3.78	1.34
$(Al, Fe)_2O_3$	.81	6.69	1.14	.38	.79	6.17	.42	1.57	.43
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

	10	11	12	13	14	15	16	17
CO_3	29.02	52.45	35.11	52.08	48.81	53.45	49.95	46.88
SO_4	33.32	1.60	24.75	1.62	6.43	4.26	5.83	5.97
Cl	4.11	3.14	4.02	5.78	1.67	.97	1.40	2.85
Ca	18.83	17.51	18.47	11.82	20.83	18.39	17.85	15.04
Mg	8.59	10.61	9.19	13.89	11.07	11.20	9.93	10.84
Na	2.69	2.81	2.55	4.54	4.46	.97	1.68	1.55
K						.80	1.74	2.24
SiO_2	2.17	10.84	5.40	9.94	6.73	9.08	10.22	13.14
$(Al, Fe)_2O_3$	1.27	1.04	.51	.33	Trace.	.88	1.40	1.49
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

To a geochemist these waters of the Fox River Valley are peculiarly interesting. They are abnormally high in their proportion of magnesium, which is shown very clearly in the percentage tables. This peculiarity is due to the fact that magnesian limestones are abundant in the upper regions of the valley—so much so that the geologists of Wisconsin have named certain areas the "magnesian cuesta"

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[7] Not to be confounded with the Fox River of Illinois. Both rivers rise in Wisconsin, and their sources are not far apart.

and the "magnesian escarpment."[8] From these areas the waters derive a large part of their mannesium. Their influence upon the waters of the Great Lakes appears very clearly upon comparison of their composition. In Lake Superior the proportion of magnesium in the anhydrous saline residue is only 5.35 per cent. In Lake Michigan it rises to 7.01 per cent, and then diminishes regularly to the St. Lawrence, which at Ogdensburg carries 5.49 per cent. That is, the magnesian content of the Fox River waters affects the composition of the lower waters of the St. Lawrence basin. The high proportion of chlorine in the lower Fox at De Pere and Green Bay indicates pollution by human agencies. The difference between the two analyses at Green Bay is very striking.

The mean annual rainfall in the Fox River valley for 1897–1906 is reported as 32.58 inches. The run-off is 7.97 inches or 24.5 per cent of the rainfall.

Analyses of waters draining into Lake Michigan south of Green Bay, Wis.

1. Sheboygan River at Sheboygan. Sample taken from the city reservoir. Davidson, 1900.
2. Random Lake, Sheboygan County. From Chicago, Milwaukee & St. Paul Ry., 1901. Two other analyses are given.
3. Elkhart Lake, Sheboygan County. Mean of four analyses by Hall and Juday, 1908. Two analyses less complete by railway chemists are also given and one of Spring Lake.
4. Pauls Lake at St. Cloud, Fond du Lac County. Davidson, 1903.
5. Menomonee River at New Butler, Waukesha County. From Chicago & Northwestern Ry.
6. Menomonee River at Granville, Milwaukee County. Davidson, 1897. Fourteen other analyses of Menomonee River, either incomplete or showing marked pollution, are also given.
7. Milwaukee River above the dam. Analysis by G. Bode, Geology of Wisconsin, vol. 2, p. 32, 1877. Other analyses by Davidson show pollution.
8. Root River at Racine.

All these analyses except Nos. 5 and 7 are taken from Wisconsin Geol. and Nat. Hist. Survey Bull. 35.

I. Parts per million.

	1	2	3	4	5	6	7	8
CO_3	93.5	140.3	86.5	169.1	157.4	204.9	95.0	169.6
SO_4	35.5	11.5	11.6	17.9	27.8	21.5	25.8	56.1
Cl	20.1	5.0	11.6	6.7	10.2	1.9	9.8	7.9
Ca	37.1	41.7	21.1	61.9	49.2	91.2	42.9	74.7
Mg	26.8	34.8	24.3	35.3	40.4	31.7	19.9	38.6
Na	6.0	3.3	4.1	4.2	6.6	3.7	6.3	18.6
K			2.2					
SiO_2	10.6	2.4	11.1	1.7	6.0	16.9	5.3	9.9
$(Al, Fe)_2O_3$	2.9		1.5	1.0	3.1	1.0	2.1	?
	232.5	239.0	174.0	297.8	300.7	372.8	207.1	375.4

II. Percentage composition of dissolved solids.

	1	2	3	4	5	6	7	8
CO_3	40.21	58.69	49.71	56.78	52.35	54.94	45.89	45.17
SO_4	15.28	4.81	6.66	6.01	9.24	5.76	12.46	14.94
Cl	8.64	2.09	6.66	2.25	3.40	.54	4.74	2.14
Ca	15.96	17.45	12.13	20.78	16.37	24.45	20.72	19.89
Mg	11.52	14.57	13.97	11.86	13.41	8.50	9.62	10.27
Na	2.58	1.38	2.37	1.41	2.20	1.00	3.04	4.96
K			1.26					
SiO_2	4.56	1.01	6.38	.57	1.03	4.54	2.56	2.63
$(Al, Fe)_2O_3$	1.25		.86	.34	2.00	.27	.97	?
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Near the south end of Lake Michigan its chief affluent is St. Joseph River,[9] which rises in Indiana and flows westward. The following analyses of its waters are here reduced to ionic form and parts per million.

Analyses of water from the St. Joseph River basin.

1. Rock River at Three Rivers, Mich.
2. Creek at Albion, Ind. Head of Elkhorn River.
3. Elkhart River at Ligonier, Ind.
4. Rock Run at Goshen, Ind. Tributary of Elkhart River. City water.
5. Elkhart River at Elkhart, Ind.
6. St. Joseph River at Elkhart, Ind. Mean of three analyses.
7. Grapevine Creek at Lydick, Ind.

Analysis No. 2 from Baltimore & Ohio R. R.; the others from the Lake Shore & Michigan Southern R. R. (New York Central). Silica and the oxides of iron and aluminum are reported together as "oxides."

I. Parts per million.

	1	2	3	4	5	6	7
CO_3	129.8	98.0	118.4	118.1	132.7	122.4	151.0
SO_4	11.2	56.8	37.9	15.4	41.2	20.6	30.3
Cl	4.5	3.9	2.8	4.5	3.9	1.3	3.4
NO_3	3.5	--------	--------	4.8	--------	2.9	--------
Ca	59.1	62.3	61.8	55.2	71.1	59.5	70.6
Mg	19.3	15.2	19.1	19.0	17.6	18.4	25.5
Na(K)	4.2	4.1	3.2	2.9	8.6	2.0	2.3
Oxides	2.1	10.6	2.4	4.1	3.9	1.9	1.9
	233.7	250.9	245.6	224.0	279.0	229.0	285.0

II. Percentage composition of dissolved solids.

	1	2	3	4	5	6	7
CO_3	55.54	39.08	48.21	52.72	47.56	53.49	52.98
SO_4	4.79	22.63	15.43	6.88	14.76	8.99	10.63
Cl	1.92	1.56	1.14	2.01	1.40	.56	1.19
NO_3	1.50	--------	--------	2.15	--------	1.26	--------
Ca	25.30	24.81	25.16	24.64	25.49	25.98	24.77
Mg	8.26	6.06	7.78	8.48	6.31	8.03	8.95
Na,K	1.79	1.64	1.30	1.29	3.08	.87	.81
Oxides	.90	4.22	.98	1.83	1.40	.82	.67
	100.00	100.00	100.00	100.00	100.00	100.00	100.00

These waters have a strong family resemblance. Their salinity is of the same order, and alkalies and oxides are unusually low. Calcium is practically the same in all, and magnesium varies only as its parent limestone might be expected to vary. Chlorides are low, and sulphates indicate local variations in the drainage basin. All the water are typical carbonate waters, such as originate in areas of sedimentary rocks.

For the eastern drainage of Lake Michigan there are first two series of analyses made in the water-resources laboratory of the United States Geological Survey. These are of Grand River at Grand Rapids, Mich., and Kalamazoo River near Kalamazoo, Mich. Each series represents the composition of the water, as determined by analyses of samples taken daily during an entire year, and their mean therefore indicate its average quality. The complete data are given in the two following tables.[10]

Each analysis was made upon a composite of ten daily samples.

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[8] For details on the geology of the valley see Bulletins 35 and 36 of the Wisconsin Survey.

[9] Another St. Joseph River rises in the same county and flows southward into the Maumee, a tributary of Lake Erie. These two rivers must not be confused.

[10] Published originally in Water-Supply Paper 236, pp. 63, 68, 1909.

Analyses of water from Grand River at Grand Rapids, Mich.[a]

[Parts per million.]

Date (1906-7).		Turbidity.	Total iron (Fe).	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total dissolved solids.	Mean gage height (feet).
From—	To—														
Oct. 1	Oct. 10	10	0.3	10	Tr.	55	19	10	7.2	220	29	0.7	9.6	256	0.1
11	20	8	Tr.	19	Tr.	59	20	13	11	244	23	1.0	7.9	277	−.2
21	30	7	Tr.	22	Tr.	60	21	13	Tr.	269	24	.7	6.7	277	.1
31	Nov. 9	4	----------	16	0.04	62	21	11	4.8	254	29	1.5	7.9	282	.4
Nov. 10	19	3	----------	16	.03	65	22	9.0	13	244	31	1.5	8.2	290	.1
20	29	19	.05	17	.03	63	21	7.4	9.1	234	37	3.0	7.9	286	2.1
Dec. 1	Dec. 11	5	.16	21	.03	67	20	8.7	.0	246	47	5.0	6.7	303	1.6
12	29	7	.2	15	.03	69	22	6.6	.0	246	49	7.0	8.8	311	1.8
Jan. 2	Jan. 10	375	4.9	11	.12	52	16	7.9	.0	198	39	6.0	6.2	240	4.5
11	23	----------	2.1	13	.3	45	13	7.4	4.3	148	34	6.0	6.7	210	6.6
24	Feb. 6	21	1.3	21	.07	45	14	6.3	4.1	158	32	3.1	4.0	198	10.4
Feb. 7	17	28	.5	5.6	.04	41	21	11	14	172	42	----------	6.5	219	6.8
18	27	9	.4	24	.07	64	19	8.7	17	198	42	4.0	5.8	283	5.4
28	Mar. 9	38	1.1	2.8	.05	41	15	8.2	----------	----------	36	1.7	4.8	201	5.0
Mar. 10	19	42	1.8	6.6	.09	42	13	7.9	18	145	30	1.5	4.3	195	6.0
20	29	55	2.6	6.0	.12	42	12	6.0	8.4	146	26	2.0	4.1	191	7.1
30	Apr. 8	34	1.1	11	.08	47	14	9.1	11	162	30	4.0	7.8	219	6.3
Apr. 9	19	7	.5	15	.04	58	18	13	15	202	35	3.5	7.2	269	2.8
20	May 1	36	1.2	15	.10	60	18	11	16	207	35	2.5	7.8	272	2.0
May 2	12	36	1.4	16	.12	50	15	11	12	179	30	2.0	6.0	235	5.7
13	24	9	.4	26	.08	60	19	9.7	7.2	232	35	4.0	9.0	292	1.6
25	June 4	26	.5	9.6	.10	61	19	13	12	231	33	3.0	9.6	280	1.7
June 5	14	5	.6	8.2	.05	61	19	15	7.2	235	35	2.0	7.8	279	1.0
15	24	20	.8	8.0	.14	60	20	14	7.2	238	30	1.0	7.4	269	.4
25	July 4	9	.4	13	.06	60	20	10	.0	257	28	1.7	10	273	.5
July 5	15	15	1.0	15	.05	61	22	13	----------	----------	31	Tr.	9.8	270	.2
16	25	200	4.4	21	.09	59	20	12	14	204	30	1.6	9.4	265	1.2
26	Aug. 6	40	1.6	10	.06	59	20	9.8	7.2	229	32	.2	9.4	259	.6
Aug. 7	16	20	.8	15	.05	60	22	10	11	226	32	.8	8.6	266	.3
17	26	15	1.1	12	.05	58	23	8.8	12	217	31	1.4	9.4	263	.3
27	Sept. 5	20	1.0	24	.05	59	22	15	.0	249	35	1.2	12	286	.3
Sept. 6	15	15	1.2	14	.04	58	22	9.1	7.2	228	30	1.5	9.0	263	.2
16	25	70	2.6	2.4	.06	53	18	9.3	13	182	30	Tr.	8.2	232	.3
26	Oct. 5	12	.5	20	.04	59	21	15	9.6	237	29	2.0	8.6	277	.6
Mean		37	1.1	14	.07	56	19	10	8.5	214	33	2.3	7.7	258	----------

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[a] Analyses Oct. 1, 1906, to Nov. 29, 1906, by R. B. Dole; Jan. 2 to Mar. 29, 1907, by R. B. Dole and M. G. Roberts; Mar. 30 to July 4, 1907, by Chase Palmer and M. G. Roberts; July 5 to Oct. 5, 1907, by R. B. Dole, Chase Palmer, and W. D. Collins.

Analyses of water from Kalamazoo River near Kalamazoo, Mich.[a]

[Parts per million.]

Date (1906-7).		Turbidity.	Total iron (Fe).	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total dissolved solids.
From—	To—													
Sept. 19	Sept. 28	3	0.3	29	0.3	59	20	9.0	6.8	250	16	1.5	3.8	272
29	Oct. 8	4	.3	19	.3	58	20	8.7	9.8	236	22	1.5	3.8	265
Oct. 9	18	5	Tr.	20	Tr.	62	19	8.8	8.4	257	15	2.1	4.3	261
19	28	3	Tr.	20	Tr.	62	19	8.5	5.8	264	14	1.6	3.6	262
29	Nov. 7	5	.1	16	Tr.	64	18	6.1	17	238	28	2.6	3.8	278
Nov. 8	17	9	Tr.	17	Tr.	63	18	6.5	.0	271	25	2.4	3.8	284
18	27	8	.1	19	Tr.	66	19	8.3	.0	250	27	2.8	3.6	262
27	Dec. 7	4	Tr.	21	Tr.	64	19	7.2	Tr.	253	21	2.8	3.4	267
Dec. 8	18	7	.1	15	.06	60	18	5.4	5.3	222	31	0.8	3.0	255
19	28	5	.1	20	.07	68	21	5.8	17	234	31	3.2	3.6	289
29	Jan. 1	6	.3	17	.07	63	19	4.9	.0	252	24	3.2	3.4	262
Jan. 8	17	11	.8	22	.06	56	17	3.3	.0	213	31	3.2	3.4	241
18	28	11	.6	11	.03	52	16	5.5	.0	198	28	3.2	3.0	223
29	Feb. 8	9	.4	11	.05	49	19	7.1	19	202	32	1.9	3.5	228
Feb. 9	18	19	.3	2.8	.06	31	19	8.4	14	160	25	.2	2.9	174
19	28	13	.2	3.4	.06	22	17	7.4	19	121	----------	.0	3.1	140
Mar. 11	Mar. 20	4	.4	23	.06	57	17	6.9	14	220	23	3.6	3.0	252
21	27	9	.8	15	.05	52	14	6.3	4.8	193	22	2.0	2.4	223
31	Apr. 9	9	.3	19	.06	52	14	11	14	173	26	2.0	3.6	235
Apr. 10	21	10	.15	26	.06	----------	16	----------	17	160	24	3.5	4.6	232
22	May 1	8	.3	24	.05	59	17	10	17	218	20	2.5	3.6	265
May 2	11	13	.6	8.8	.05	49	15	6.9	12	163	30	2.5	3.4	214
12	21	2	.1	19	.07	60	18	12	12	234	22	1.8	3.4	263
22	June 1	4	.2	14	.06	58	18	10	12	235	20	1.5	2.8	252
June 2	11	6	.2	12	.03	58	18	11	11	228	20	2.5	3.0	249
12	22	3	.3	15	.05	58	19	13	Tr.	249	19	1.6	3.4	254
23	July 3	3	.6	16	.06	56	20	9.5	4.8	227	17	Tr.	4.2	241
July 4	13	10	Tr.	22	Tr.	37	20	----------	.0	174	22	Tr.	2.6	189
14	23	7	Tr.	11	Tr.	37	19	----------	9.6	135	20	Tr.	2.4	186
24	Aug. 2	4	Tr.	23	Tr.	58	20	----------	12	202	20	.9	2.2	256
Aug. 3	12	3	Tr.	14	Tr.	55	19	10	Tr.	228	20	1.5	4.5	233
13	22	3	Tr.	19	Tr.	38	21	----------	.0	167	19	2.0	3.6	196
23	Sept. 1	2	Tr.	23	Tr.	58	21	12	.0	251	21	1.5	3.4	254
Sept. 2	11	3	Tr.	22	Tr.	58	21	----------	.0	246	20	1.4	3.6	257
12	21	6	Tr.	18	Tr.	57	20	11	9.6	226	19	1.3	3.8	245
Mean		7	.2	17	.05	55	18	8.2	7.8	216	23	1.9	3.4	242

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[a] Analyses Sept. 19 to Dec. 7, 1906, by R. B. Dole; Dec. 8, 1906, to Mar. 27, 1907, by R. B. Dole and M. G. Roberts; Mar. 31 to July 3, 1907, by Chase Palmer and M. G. Roberts; July 13 to Sept. 21, 1907, by R. B. Dole, Chase Palmer, and W. D. Collins.

Four other analyses, made for commercial purposes by the Dearborn Drug & Chemical Co., of eastern tributaries to Lake Michigan are as follows:[11]

Analyses of waters tributary to Lake Michigan.

1. Boardman River, a tributary of Grand Traverse Bay.
2. Grand River at Jackson, Mich.
3. Manistee Lake. Said to be contaminated by drainage from salt works.
4. Muskegon Lake.

	Parts per million.				Percentage composition.			
	1	2	3	4	1	2	3	4
CO_3	73.1	144.4	91.2	85.2	39.62	48.13	38.65	46.05
SO_4	32.1	30.4	Tr.	19.8	17.40	10.13	Tr.	10.70
Cl	10.1	12.8	52.6	10.4	5.47	4.27	22.37	5.57
Ca	43.2	71.8	40.4	41.8	23.41	23.93	17.12	22.60
Mg	11.5	20.9	11.4	13.2	6.24	6.97	4.83	7.14
Na, K	6.6	10.7	35.4	8.6	3.57	3.59	14.91	4.70
SiO_2	7.8	9.0	5.0	5.0	4.23	3.00	2.12	2.70
$(Al, Fe)_2O_3$	.1	Tr.	Tr.	1.0	.06	Tr.	Tr.	.54
	184.5	300.0	236.0	185.0	100.00	100.00	100.00	100.00

LAKE HURON.

For Lake Huron, with a water surface of 23,800 square miles and a drainage basin of 55,500 square miles, we have the following table of analyses made by Dole and Roberts in the water-resources laboratory of the United States Geological Survey.

Analyses of water from Lake Huron at Port Huron, Mich.[a]

[Parts per million.]

Date (1906-7).	Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total dissolved solids.	Mean gage height (feet).[b]
Sept. 21	1	13	0.02	24	6.4	3.5	3.4	97	4.8	0.30	2.5	108	581.12
Oct. 21	2	8.7	.10	24	6.3	3.7	3.6	96	6.2	.25	2.5	105	580.87
Nov. 21	Tr.	8	.05	24	6.7	3.0	.0	100	5.6	.4	2.6	101	580.68
Dec. 21	Tr.	12	.05	23	6.7	3.5	.0	103	6.6	.3	3.1	106	580.65
Jan. 21	----	12	.03	23	7.1	5.8	.0	99	6.7	.4	2.5	108	580.65
Mar. 21	----	14	.03	22	7.2	4.7	1.2	101	6.7	.3	2.5	109	580.68
Apr. 21	----	14	.04	24	7.7	5.1	Tr.	106	6.0	.45	2.6	110	580.90
May 21	----	14	.05	25	7.6	5.9	2.4	102	7.3	.4	2.8	116	581.08
June 21	----	8.5	.04	24	7.5	4.7	5.3	96	6.4	.45	2.8	105	581.39
Mean	Tr.	12	.04	24	7.0	4.4	1.8	100	6.2	.4	2.6	108	------

[a] Analyses by R. B. Dole and M. G. Roberts.
[b] Gaging station at Harbor Beach, Mich., 60 miles above.

TRIBUTARIES OF LAKE HURON.

Only a few analyses of water from tributaries of Lake Huron have been obtained and several of them are too defective to have any present value.[12] Two, however, are available and appear in the next table.

Analyses of waters tributary to Lake Huron.

1 Shiawassee River at Owosso, Mich. Analysis by Dearborn Drug & Chemical Co.

2. Cass River. G. A. Kirchmaier, analyst. These two rivers drain into Saginaw Bay, Lake Huron.

	Parts per million.		Percentage composition.	
	1	2	1	2
CO_3	135.1	91.4	50.97	35.85
SO_4	17.0	24.8	6.41	9.73
Cl	14.0	14.6	5.28	5.72
Ca	48.2	45.2	18.57	17.72
Mg	24.6	15.7	9.28	6.16
Na,K	18.1	9.4	6.86	3.69
SiO_2	7.0	46.9	2.60	18.39
$(Al, Fe)_2O_3$	1.0	7.0	.03	2.74
	265.0	255.0	100.00	100.00

LAKE ERIE.

The water surface of Lake Erie covers 9,960 square miles, and its drainage basin covers 32,660 square miles. The standard series of analyses, made by Dole and Roberts in the water-resources laboratory, is as follows:

Analyses of water from Lake Erie at Buffalo, N. Y.[a]

[Parts per million.]

Date (1906-7).	Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total dissolved solids.	Mean gage height (feet).
Sept. 19	2	11	0.13	33	7.1	7.2	4.1	118	12	0.40	8.0	143	572.27
Oct. 19	2	11	.08	32	6.8	6.3	4.8	116	11	.00	7.9	138	572.25
Nov. 19	17	4.2	.04	31	7.4	5.8	.0	124	12	Tr.	8.2	129	572.32
Dec. 19	24	7.6	.04	31	7.4	6.8	3.6	118	13	Tr.	8.6	136	572.45
Jan. 19	190	2.9	.07	30	7.4	6.4	.0	117	13	.25	9.2	126	572.96
Mar. 19	13	4.5	.10	31	7.5	5.8	2.2	112	14	.25	9.2	132	572.22
Apr. 19	----	8.6	.06	30	8.2	6.9	1.4	108	13	.35	8.4	129	572.62
May 25	----	4.7	.05	31	7.9	6.5	4.0	104	14	.6	8.6	132	572.84
June 19	----	4.6	.03	31	7.9	6.7	5.3	110	13	.45	8.8	131	573.18
July 19	----	3.9	.03	32	7.8	7.1	5.2	110	14	.50	9.2	134	573.33
Aug. 28	----	2.1	.18	31	8.0	5.9	3.4	112	13	.35	8.6	128	573.02
Mean	41	5.9	.07	31	7.6	6.5	3.1	114	13	.3	8.7	133	------

[a] Analyses by R. B. Dole and M. G. Roberts.

The following boiler-water analyses of samples taken at different points on Lake Erie were received from the Lake Shore & Michigan Southern Railroad. (New York Central system). They are here reduced to standard form.

Analyses of water from Lake Erie.

1. At Painesville, Ohio.
2. At Ashtabula, Ohio.
3. At Erie, Pa.
4. At Dunkirk, N. Y.

	Parts per million.				Percentage composition.			
	1	2	3	4	1	2	3	4
CO_3	59.7	57.4	60.7	56.3	44.22	46.22	45.29	47.51
SO_4	19.8	13.3	15.6	9.9	14.67	10.71	11.64	8.36
Cl	7.2	7.2	8.0	6.4	5.33	5.80	5.97	5.40
Ca	34.1	30.8	33.3	28.7	25.26	24.80	24.85	24.22
Mg	8.3	7.8	8.1	7.2	6.15	6.28	6.05	6.08
Na(K)	4.6	4.6	5.2	5.4	3.41	3.70	3.88	4.56
"Oxides" [a]	1.3	3.1	3.1	4.6	.96	2.49	2.32	3.87
	135.0	124.2	134.0	118.5	100.00	100.00	100.00	100.00

[a] Silica plus sesquioxides.

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[11] From Lane, A. C., U. S. Geol. Survey Water-Supply Paper 31, pp. 18, 92, 1899. Reduced to standard form from hypothetical combinations and parts per thousand.

[12] For these analyses see Lane, A. C., U. S. Geol. Survey Water-Supply Paper 31, 1899. The rejected analyses are of Saginaw, Chippewa, and Tittabawassee rivers, and one also of the Shiawassee. All these streams drain into Saginaw Bay.

These analyses differ to some extent from those made by Dole and Roberts. The latter refer to the water of the main body of the lake, which receives its principal accessions from the upper lakes. The single analyses are evidently of water taken close to the shore and are affected by drainage from smaller streams. Their character, therefore, is that of the lake water slightly mixed with other waters derived from sedimentary areas to the south.

TRIBUTARIES OF LAKE ERIE.

At the extreme west end of Lake Erie are several rivers, and of their water the following analyses have been collected.

Analyses of water from tributaries of Lake Erie.

1. Detroit River, the connecting link between the upper and the lower lakes.
2. Huron River at Ann Arbor, Mich. Analyses 1 and 2 by Dearborn Drug & Chemical Co. (An incomplete analysis made by R. W. Pryor in 1911 is given in U. S. Geol. Survey Geol. Atlas, Detroit folio (No. 205), p. 20, 1917.
3. Wolf Creek near Adrian, Mich. Raisin River basin.
4. Raisin River at Grosvenor, Mich.
5. Raisin River at Plainfield, Mich. Analyses 3, 4, and 5 received from Lake Shore & Michigan Southern R. R. (New York Central system). Reduced here to standard form.

I. Parts per million.

	1	2	3	4	5
CO_3	47.9	150.1	146.6	137.7	135.3
SO_4	7.8	69.8	43.2	24.0	28.5
Cl	9.1	9.1	5.7	6.0	8.2
NO_3			12.5		
Ca	24.8	80.4	78.0	64.9	64.3
Mg	6.0	23.8	24.5	20.7	15.5
Na(K)	6.4	16.8	12.2	7.0	19.0
SiO_2	6.0	23.0	6.3	2.7	4.2
$(Al, Fe)_2O_3$	Tr.	Tr.			
	108.0	373.0	322.0	263.0	275.0

Analyses of water from tributaries of Lake Erie—Continued.

II. Percentage composition of anhydrous residue.

	1	2	3	4	5
CO_3	44.35	40.24	45.52	52.37	49.20
SO_4	7.23	18.74	13.42	9.12	10.37
Cl	8.43	2.44	1.77	2.28	2.98
NO_3			3.88		
Ca	22.97	21.53	22.05	24.68	23.39
Mg	5.55	6.38	7.61	7.87	5.64
Na(K)	5.92	4.50	3.79	2.66	6.91
SiO_2	5.55	6.17	1.96	1.02	1.51
$(Al, Fe)_2O_3$	Tr.	Tr.			
	100.00	100.00	100.00	100.00	100.00

Analyses of several other rivers tributary to Lake Erie have been obtained, and of these the Maumee, which drains an agricultural region in Ohio and empties into the lake at Toledo, is the most important. For this river there are, first, the recent series of analyses made in the water-resources laboratory of the Survey. This series is given in the next table.

Analyses of water from Maumee River at Toledo, Ohio.[a]

[Parts per million.]

Date (1906-7).		Turbidity.	Total iron (Fe).	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total dissolved solids.
From—	To—													
Sept. 9	Sept. 18	55	2.0	28	0.10	58	17	44	0.0	178	44	2.2	91	397
19	29	70	2.4	26	.20	57	16	40	.0	190	44	1.8	76	375
30	Oct. 9	53	2.4	19	.10	57	16	37	.0	192	43	1.8	71	350
Oct. 11	20	37	1.4	20	Tr.	67	19	36	.0	221	59	1.9	58	367
21	Nov. 1	22	1.0	24	.04	66	22	40	----	----	68	1.7	79	416
Nov. 2	11	16	1.1	17	.03	73	23	49	5.8	208	71	2.1	106	442
12	23	80	2.2	14	.05	62	21	35	----	----	80	4.0	85	404
24	Dec. 4	230	3.5	16	.16	54	13	14	.0	157	48	19	23	275
Dec. 5	15	290	6.6	23	.4	53	13	14	.0	159	47	13	24	277
16	26	210	3.9	27	.3	57	14	18	5.8	160	51	12	24	296
Jan. 6	Jan. 15	350	8.0	18	.7	42	8.2	10	.0	134	33	11	12	214
16	26	375	11	17	1.1	37	----	10	.0	123	29	9.0	12	331
27	Feb. 7	55	2.1	7.2	1.5	48	12	11	Tr.	151	37	4.5	14	262
Feb. 8	18	20	.9	14	.13	77	18	22	5.5	228	69	8.5	38	372
19	28	12	.6	15	.03	80	22	29	.0	242	74	6.0	58	410
Mar. 1	Mar. 10	37	1.1	11	.04	70	19	25	.0	216	67	6.4	52	356
11	23	900	16	36	.7	44	12	21	6.0	128	40	8.0	26	266
24	Apr. 2	730	15	5.0	.20	42	11	14	.0	131	41	6.4	13	222
Apr. 3	12	98	3.3	6.0	.10	43	12	15	12	102	43	4.8	28	216
13	23	27	1.2	24	.08	72	18	20	11	210	57	6.0	30	344
24	May 3	37	1.3	20	.06	74	20	25	9.6	214	63	3.0	44	373
May 4	14	9	.3	13	.03	64	18	25	9.6	178	59	2.5	46	326
15	23	42	1.0	9.8	.10	60	23	28	8.4	172	58	.3	44	320
25	June 3	20	.6	4.8	.08	----	12	26	Tr.	93	50	.2	42	202
June 4	13	175	4.0	18	.18	----	10	15	8.4	95	34	4.0	19	180
15	24	250	6.3	18	.18	----	11	16	Tr.	120	34	Tr.	16	187
25	July 2	120	2.2	3.8	.16	----	12	16	----	----	30	2.0	14	162
July 5	16	----	1.9	----	.12	35	16	26	Tr.	134	44	Tr.	35	232
17	26	270	6.7	24	.6	42	13	24	.0	181	34	5.5	29	283
27	Aug. 5	63	2.5	19	.7	44	9.0	14	.0	157	22	4.0	12	212
Aug. 6	15	40	1.2	18	.14	56	12	19	Tr.	199	33	2.2	23	267
16	26	40	1.1	12	.11	64	16	21	.0	228	47	1.6	26	309
27	Sept. 7	38	1.5	14	.16	63	17	22	.0	224	50	2.2	26	310
Sept. 8	17	38	.7	22	.08	62	18	29	.0	229	53	1.0	34	339
18	27	125	2.5	18	.6	52	16	23	.0	187	44	1.8	31	289
28	Oct. 7	90	1.6	22	.5	53	14	27	.0	177	42	2.0	41	292
Mean		143	3.4	17	.27	57	16	24	2.5	173	48	4.5	40	298

[a] Analyses September 9, 1906, to March 10, 1907, by R. B. Dole and M. G. Roberts; March 11 to October 7, 1907, by Chase Palmer and M. G. Roberts.

Three more analyses of the Maumee are available, as follows.

Analyses of water from Maumee River.

1. At Toledo, Ohio, 1903. Received from Lake Shore & Michigan Southern R. R. (New York Central system).
2. At Toledo. Analysis by C. F. Chandler. Cited by I. C. Russell in U. S. Geol. Survey Mon. 11, opp. p. 176, 1885.
3. At Delaware Bend, Ohio. Received from Baltimore & Ohio Railroad.

	Parts per million.			Percentage composition.		
	1	2	3	1	2	3
CO_3	102.9	44.4	146.9	29.79	42.39	47.15
SO_4	55.5	14.0	28.0	16.07	13.38	8.98
Cl	54.3	2.5	21.7	15.72	2.39	6.96
Ca	50.2	26.4	61.6	14.53	25.26	19.77
Mg	19.9	4.4	28.8	5.76	4.23	9.24
Na	44.6	1.6	14.0	12.91	1.54	4.49
K		3.1			2.95	
SiO_2	18.0	7.2	10.6	5.22	6.91	3.41
Fe_2O_3		1.0			.95	
	345.4	104.6	311.6	100.00	100.00	100.00

The analysis of the Maumee by Chandler is very different from the others and shows that great changes have taken place in the river during the intervening years. Analysis No. 1 is in fair agreement with the Survey series, and the evidence indicates that the water at Toledo is now far from normal. The high proportion of sodium and chlorine suggests pollution. Analysis No. 3 of a sample taken at a point above Toledo, is more nearly that of a normal river water the sources of which are in an area of sedimentary rocks.

The Maumee is formed by the union of two streams, St. Marys River and the St. Joseph. The latter is sometimes called "St. Joseph of the Maumee" in order to distinguish it from the other river of the same name which flows into Lake Michigan. These duplicated names are very troublesome. Three other tributaries of the Maumee are Swan Creek, Tiffin River, and Auglaize River, and analyses of all five streams appear in the next table.

Analyses of water from tributaries of the Maumee.

1. Tiffin River at Stryker, Ohio.
2. Auglaize River at Buckland, Ohio.
3. St. Marys River at Decatur, Ind. Analysis received from Cleveland, Cincinnati, Chicago & St. Louis Ry.; W. B. London, chemist.
4. St. Marys River at Fort Wayne, Ind.
5. St. Joseph River at Hillsdale, Mich.
6. St. Joseph River at Edgerton, Ohio.
7. Swan Creek at Air Line Junction, near Toledo, Ohio. All analyses except No. 3 received from Lake Shore & Michigan Southern R. R. (New York Central system).

I. Parts per million.

	1	2	3	4	5	6	7
CO_3	131.7	129.7	116.8	125.1	110.9	115.0	79.2
SO_4	36.7	46.5	125.8	110.6	18.2	29.1	38.7
Cl	7.5	21.5	109.8	64.7	7.1	6.4	17.7
NO_3					2.2		3.5
Ca	69.0	52.9	91.3	88.9	53.0	59.9	51.4
Mg	19.2	20.1	29.0	28.8	17.4	17.3	11.3
Na(K)	7.4	36.1	60.6	33.4	5.0	4,2	11.6
SiO_2	4.5	3.6	2.7	7.5	1.5	7.7	12.6
$(Al, Fe)_2O_3$			3.4				
	276.0	310.4	539.4	459.0	215.3	239.6	226.0

Analyses of water from tributaries of the Maumee—Contd.

II. Percentage composition of dissolved solids.

	1	2	3	4	5	6	7
CO_3	47.71	41.79	21.65	27.26	51.51	47.99	35.05
SO_4	13.30	14.98	23.32	24.09	8.45	12.15	17.12
Cl	2.72	6.92	20.36	14.09	3.30	2.67	7.83
NO_3					1.02		1.55
Ca	25.00	17.05	16.92	19.37	24.62	25.00	22.75
Mg	6.96	6.48	5.38	6.28	8.08	7.22	5.00
Na(K)	2.68	11.62	11.23	7.28	2.32	1.75	5.13
SiO_2	1.63	1.16	.51	1.63	.70	3.22	5.57
$(Al, Fe)_2O_3$			.63				
	100.00	100.00	100.00	100.00	100.00	100.00	100.00

The following analyses are of waters tributary to the St. Joseph. The points of collection are all in Indiana. No. 1 was received from the Baltimore & Ohio Railroad; the others from the Lake Shore & Michigan Southern (New York Central System).

Analyses of waters tributary to the St. Joseph.

1. Creek at St. Joe.
2. Cedar Creek at Waterloo.
3. Bixler Lake at Kendallville; mean of three analyses.
4. Spy Run at Fort Wayne.

	Parts per million.				Percentage composition.			
	1	2	3	4	1	2	3	4
CO_3	132.7	174.5	83.4	163.9	36.46	49.35	40.49	41.81
SO_4	95.8	51.3	44.2	94.3	26.32	14.51	21.46	24.06
Cl	4.9	2.4	3.8	4.0	1.34	.68	1.84	1.02
NO_3			3.1				1.51	
Ca	87.6	80.5	50.8	72.9	24.07	22.77	24.66	18.59
Mg	24.5	26.6	13.9	39.2	6.73	7.52	6.74	10.00
Na(K)	3.1	16.1	3.6	14.3	.85	4.55	1.75	3.65
Oxides [a]	15.4	2.2	3.2	3.4	4.23	.62	1.55	.87
	364.0	353.6	206.0	392.0	100.00	100.00	100.00	100.00

[a] Silica and sesquioxides.

In the next table are analyses of waters from several tributaries of Lake Erie in Ohio east of the Maumee. The Huron River of this table is not to be confused with the other river of the same name which flows into Lake Erie from Michigan, below the mouth of the Detroit.

Analyses of water from tributaries of Lake Erie in Ohio.

1. Sandusky River at Tiffin.
2. Huron River at Monroeville. Analyses 1 and 2 received from Baltimore & Ohio R. R.
3. Huron River at Huron.
4. Vermilion River at Vermilion.
5. Black River at Elyria Junction. City water.
6. Rocky River at Berea.
7. Euclid Creek at Nottingham. Analyses 3 to 7 from Lake Shore & Michigan Southern R. R. (New York Central system).

I. Parts per million.

	1	2	3	4	5	6	7
CO_3	195.3	146.8	59.3	67.9	83.7	102.2	30.6
SO_4	113.7	203.3	55.5	69.6	121.6	78.8	135.0
Cl	72.1	9.8	6.1	8.7	17.2	5.6	17.4
Ca	68.1	100.7	44.2	47.4	64.3	60.8	41.7
Mg	65.7	36.6	11.0	13.4	21.0	21.6	14.9
Na	46.7	30.4	4.0	10.8	19.5	8.4	22.9
K							
SiO_2	11.4	6.0	4.9	5.2	3.3	4.6	1.0
Fe_2O_3							
	573.0	533.6	185.0	223.0	330.6	282.0	263.5

Analyses of water from tributaries of Lake Erie in Ohio—Contd.

II. Percentage composition of anhydrous residue.

	1	2	3	4	5	6	7
CO_3	34.09	27.52	32.05	30.45	25.32	36.24	11.62
SO_4	19.85	38.10	30.00	31.21	36.78	27.94	51.24
Cl	12.58	1.84	3.30	3.90	5.20	1.99	6.60
Ca	11.88	18.88	23.89	21.26	19.45	21.56	15.82
Mg	11.46	6.86	5.95	6.01	6.36	7.66	5.65
Na K	8.15	5.69	2.16	4.84	5.89	2.98	8.69
SiO_2 Fe_2O_3	1.99	1.11	2.65	2.33	1.00	1.63	.38
	100.00	100.00	100.00	100.00	100.00	100.00	100.00

These waters and also those in the basin of the Maumee are not easy to interpret, and their generally high proportion of sulphates is suggestive of pollution. They drain an agricultural region in which there are some important manufacturing centers, and from these centers the streams might easily have become impure. A small stream might even become perceptibly affected by drainage from soil on which fertilizers such as plaster or superphosphates had been freely used. It is very doubtful whether these waters are really normal. More evidence is needed to decide the question.

WATERS TRIBUTARY TO LAKE ONTARIO.

Analyses of three waters tributary to Lake Ontario have been received, as follows:

Analyses of three waters tributary to Lake Ontario.

1. Genesee River at Rochester, N. Y. Analysis by C. F. Chandler, cited by I. C. Russell in U. S. Geol. Survey Mon. II, opp. p. 176, 1885.
2. Hemlock Lake, 30 miles south of Rochester.
3. Skaneateles Lake, southwest of Syracuse, N. Y. From tap at city laboratory, Syracuse. Analyses 2 and 3 by Margaret D. Foster, in the water-resources laboratory of the United States Geological Survey.

	Parts per million.			Percentage composition.		
	1	2	3	1	2	3
CO_3	64.6	32.1	55.6	37.94	38.23	48.56
SO_4	43.6	18.0	13.0	25.29	21.43	11.35
Cl	2.4	2.0	1.5	1.41	2.38	1.31
NO_3	------	.38	.96	------	.45	.84
Ca	41.7	20.0	33.0	24.48	23.82	28.82
Mg	9.0	5.2	6.1	5.29	6.19	5.33
Na	4.4	3.0	1.7	2.59	3.57	1.48
K	2.3	1.1	.8	1.35	1.31	.70
Fe_2O_3	1.4	.3	.34	.83	.36	.30
SiO_2	1.4	1.9	1.5	.82	2.26	1.31
	170.8	83.98	114.50	100.00	100.00	100.00

ST. LAWRENCE RIVER AND TRIBUTARIES.

The omission of Lake Ontario from the group of standard analyses is not serious, for the composition of the water of the St. Lawrence at Ogdensburg must be essentially the same. For the river at this point we have the following set of analyses by Dole and Roberts:

Analyses of water from St. Lawrence River at Ogdensburg, N. Y.[a]

[Parts per million.]

Date (1906-7).	Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total dissolved solids.	Mean gage height (feet).
Sept. 18	2	9.6	0.06	32	6.9	6.2	4.2	114	12	Tr.	7.7	135	244.93
Oct. 18	1	8.2	.03	32	6.5	6.7	3.7	115	12	Tr.	7.2	134	244.68
Nov. 18	5	3.7	.05	31	7.3	6.1	4.2	114	12	0.6	7.6	128	244.62
Dec. 24	2	6.6	.04	32	7.1	5.7	Tr.	123	13	.45	7.6	133	244.64
Jan. 18	3	6.6	.04	31	7.4	6.9	3.6	117	13	.25	7.8	135	245.20
Mar. 18	18	5.0	.05	31	7.3	5.4	Tr.	120	13	.25	7.7	128	245.42
Apr. 23	4	7.7	.05	30	7.7	7.3	2.5	116	12	.15	7.3	141	245.32
May 22	1	7.1	.06	30	7.6	6.8	4.0	113	12	.15	7.2	143	245.74
June 18	----	3 9	.05	32	6.9	6.1	0.0	118	12	.8	7.9	130	246.05
July 20	----	5.2	.03	32	7.4	5.8	4.4	112	14	.6	8.6	133	246.12
Aug. 18	----	9.4	.04	32	7.3	6.1	4.8	111	12	.4	8.3	137	245.90
Mean	4.5	6.6	.05	31	7.2	6.3	2.9	116	12	.3	7.7	134	------

[a] Analyses by R. B. Dole and M. G. Roberts.

According to estimates made by engineers of the United States Army, the flow of the St. Lawrence past Ogdensburg is 248,518 cubic feet per second. This, with a salinity of 134 parts per million, corresponds to a transport of dissolved matter of 29,722,000 metric tons annually. The area drained, exclusive of water surface, is 286,900 square miles, and from each square mile 103.6 tons is removed in solution each year.

Two other analyses of the water of the St. Lawrence, from Canadian sources, may properly be cited here. They give the composition of the water near Montreal and are here reduced to standard form and given in percentages of the dissolved constituents.

Analyses of the St. Lawrence near Montreal.

1. At Pointe des Cascades, near Vaudreuil, above Montreal. Analysis by T. Sterry Hunt, Philos. Mag., 4th ser., vol. 13, p. 239, 1857.
2. Opposite Montreal. Analysis by Norman Tate, cited by T. Mellard Reade, in Evolution of earth structure, 1903.

	1	2
CO_3	41.66	44.43
SO_4	5.19	11.17
Cl	1.51	2.41
Ca	20.08	20.67
Mg	4.52	6.44
Na	3.20	4.87
K	.72	------
SiO_2	23.12	10.01
	100.00	100.00
Salinity, parts per million	160	148

The very high silica in the first of these analyses is probably due to the influence of Ottawa River.

For the southern tributaries of the St. Lawrence there are data relative to the Oswegatchie, which rises in the Adirondacks and enters the St. Lawrence at Ogdensburg, and Lake Champlain, of which Richelieu River is the outlet. The analyses of the Oswegatchie by Dole and his colleagues are given in the following table:

Analyses of water from Oswegatchie River at Ogdensburg, N. Y.[a]

[Parts per million.]

Date (1906-7). From—	Date (1906-7). To—	Turbidity.	Total iron (Fe).	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potasium (Na+K).	Carbonate radicle (CO_4).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total dissolved solids.	Mean gage height (feet).
Aug. 28	Sept. 10	8	1.2	12	0.4	11	2.9	----------	0.0	45	6.2	0.0	Tr.	80	4.6
Sept. 11	20	9	.3	14	.28	11	3.2	----------	.0	45	4.8	.0	Tr.	82	4.8
21	30	7	.5	13	.4	12	3.4	----------	.0	49	Tr.	Tr.	Tr.	91	4.6
Oct. 1	Oct. 10	8	5.2	13	Tr.	9.6	4.8	----------	.0	36	7.2	.0	Tr.	81	5.1
11	20	6	.2	13	Tr.	12	3.6	----------	.0	46	6.6	Tr.	Tr.	83	6.0
21	30	8	.5	15	Tr.	14	4.0	6.9	.0	59	7.1	Tr.	Tr.	90	6.6
31	Nov. 9	7	.1	14	.10	15	3.8	6.5	.0	64	7.9	.0	Tr.	94	6.0
Nov. 10	20	9	.5	16	.20	15	4.0	6.1	.0	59	13	.0	Tr.	100	5.5
22	30	10	.6	11	.30	13	3.6	4.9	.0	56	8.6	.0	Tr.	83	6.3
Dec. 1	Dec. 11	6	.1	7.8	.10	15	3.4	5.8	.0	59	8.6	Tr.	Tr.	84	6.1
12	22	5	.7	10	.18	13	4.4	4.9	.0	53	9.0	.9	.7	79	5.7
23	Jan. 1	7	.6	8.5	.21	15	4.8	3.5	.0	59	8.5	.6	.5	83	5.4
Jan. 2	11	17	.6	8.8	.21	13	4.0	3.3	.0	51	7.9	.6	.2	72	7.0
12	21	6	.4	7.5	.16	14	4.2	3.6	.0	52	6.9	1.0	.6	78	6.5
22	Feb. 1	7	.3	8.0	.16	12	3.4	3.5	.0	51	7.7	.6	1.6	72	6.5
Feb. 2	12	18	.3	5.6	.10	13	2.0	4.1	[b]6.8	40	6.4	.0	Tr.	70	5.1
13	22	9	.4	8.6	.18	12	2.8	4.9	.0	46	7.1	1.0	2.2	69	4.7
23	Mar. 6	10	.4	8.4	.14	12	2.8	3.9	.0	44	8.7	1.2	Tr.	70	4.6
Mar. 7	18	7	.3	9.2	.14	10	2.8	5.2	.0	37	9.4	1.9	Tr.	67	4.9
19	29	10	.8	3.0	.05	11	2.8	5.7	----------	----------	6.8	.0	Tr.	64	6.8
Apr. 10	Apr. 19	6	.5	12	.13	14	3.9	6.8	.0	59	7.1	1.9	1.9	78	6.3
20	30	9	.8	12	.15	14	4.1	6.3	.0	60	7.2	1.0	.2	80	5.5
May 1	May 10	23	1.4	----------	.30	14	3.7	6.4	.0	57	7.6	1.4	.6	87	6.8
11	20	8	.7	8.2	.10	14	3.8	7.5	[b]2.4	56	7.1	Tr.	1.0	75	6.3
21	30	3	.4	7.6	.13	13	3.6	6.1	.0	56	7.6	Tr.	.6	74	5.4
31	June 9	8	.5	7.2	.14	14	3.5	4.6	[b]4.1	53	7.1	.8	.2	73	5.3
June 11	20	3	.5	8.2	.12	14	3.9	4.6	.0	61	7.4	.8	.6	78	4.9
21	30	8	1.0	----------	.35	12	3.2	5.6	.0	64	9.1	.5	.2	88	4.8
July 1	July 10	15	.8	6.4	.30	12	3.6	----------	----------	----------	10	Tr.	.6	69	4.9
11	20	10	.8	6.6	.21	12	2.7	6.3	.0	49	9.3	Tr.	Tr.	69	4.7
21	30	10	.8	5.4	.35	12	3.8	5.4	.0	----------	8.2	Tr.	Tr.	62	4.5
31	Aug. 10	5	.9	6.2	.44	11	3.3	4.7	.0	----------	9.4	.3	1.2	60	4.5
Aug. 11	20	5	.9	7.6	.52	11	3.2	----------	.0	----------	10	.2	.6	65	4.4
21	30	7	.9	9.4	.56	10	3.4	----------	.0	----------	12	.2	1.2	75	4.4
31	Sept. 9	3	.8	7.6	.35	10	3.5	6.3	.0	----------	13	.2	Tr.	70	4.5
Mean........		8	.7	9.4	.21	13	3.5	5.3	.0	53	8.2	.4	.4	77	----------

[a] Analyses August 28 to December 11, 1906, by R. B. Dole; December 12, 1906, to March 29, 1907, by R. B. Dole and M. G. Roberts; April 10 to June 30, 1907, by Chase Palmer and M. G. Roberts; July 1 to September 9, 1907, by R. B. Dole, Chase Palmer, and W. D. Collins.

[b] Abnormal; computed as HCO_3 in the average.

In an important paper on the pollution of Lake Champlain[13] M. O. Leighton has given a number of analyses of water from the lake itself and also from some of its tributaries. The latter, however, need not be considered here, for they show, not normal water, but water heavily contaminated by the drainage from pulp mills.

A glance at the map will show that the lake may be divided into two portions. One of these is long and narrow, hardly broader than a river, and extends from Whitehall, at the head of the lake, to a point a little above Ticonderoga. Below this the lake broadens out to a maximum width of about 11 miles. The larger feeders of the lake rise in the Green Mountains, on the east, and the Adirondacks, on the west.

Analyses of water of Lake Champlain.

1. The upper or narrow lake, half a mile south of Chipmans Point.
2. Mean of five concordant analyses of water taken at various points in the broad portion of the lake. These analyses by Leighton are reduced to standard form.
3. Winooski River at Montpelier, Vermont. Analysis by Margaret D. Foster.

	In parts per million.			Percentage composition.		
	1	2	3	1	2	3
CO_3	29.9	30.6	41.4	28.51	45.41	46.29
SO_4	29.2	7.4	7.8	27.83	10.99	8.72
Cl	1.2	1.2	2.0	1.14	1.78	2.23
NO_3	--------	--------	1.4	--------	--------	1.57
Ca	20.0	14.3	26.0	19.07	21.23	29.07
Mg	5.8	2.9	2.8	5.53	4.30	3.14
Na	3.4	6.1	2.5	3.24	9.05	2.79
K	--------	--------	1.3	--------	--------	1.45
Fe_2O_3	--------	--------	.04	--------	--------	.05
$(Al, Fe)_2O_3$	4.2	1.1	--------	4.00	1.60	--------
SiO_2	11.2	3.8	4.2	10.68	5.64	4.69
	104.9	67.4	89.44	100.00	100.00	100.00

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[13] U. S. Geol. Survey Water-Supply Paper 121, 1905.

The differences between the two analyses of water from Lake Champlain are very striking. The upper water is evidently contaminated, and that of the broad lake is much more characteristic. The water of Lake Champlain is an ordinary carbonate water, and so also is that of Winooski River, which rises in the Green Mountains.

Few analyses seem to have been made of waters from the northern tributaries of the St. Lawrence. Two, however, of water from Ottawa River may be useful here, even though that stream is not within the limits of the United States. They are reduced to the usual percentage standard.

Analyses of water from Ottawa River.

1. At Ottawa, Canada. High water, July, 1907. Analysis by F. T. Shutt and A G Spemcer, Royal Soc. Canada Trans., 3d ser., vol. 2, p. 175, 1908. Another incomplete analysis is also given.
2. At St. Ann Lock, Montreal. Analysis by T. Sterry Hunt. Cited by I. C. Russell in U. S. Geol. Survey Mon. 11, opp. p. 176, 1885. Originally published in 1863.

	1	2
CO_3	35.44	36.87
SO_4	8.57	3.17
Cl	1.42	1.24
Ca	16.58	16.23
Mg	4.74	2.63
Na	4.51	3.92
K	1.59	2.27
SiO_2	20.03	33.67
$(Al, Fe)_2O_3$	[a] 7.12	Tr.
	100.00	100.00
Salinity, parts per million	45	61.2

[a] Includes traces of PO_4 and Mn_2O_3.

The very high silica shown in these analyses is characteristic of waters originating in areas of the older crystalline and especially feldspathic rocks.

SUMMARY FOR ST. LAWRENCE BASIN.

In the foregoing pages nine sets of analyses made in the United States Geological Survey may be taken as standards because of their completeness in nearly all essential respects. Single analyses are obviously of much less significance. Even the Survey analyses are confessedly incomplete in certain particulars. Alumina, for example, was not determined, but that omission is not of much consequence. The alkalies were determined as sodium only, but that defect has been corrected in four of the sets now under consideration by supplementary determinations of potassium by Chase Palmer. These determinations were made on portions of the original samples that were used in making the uncorrected analyses. The unused portions were mixed, and in the mixture the potassium was determined once for all.

For the Great Lakes and the St. Lawrence the samples of water for analysis were taken at monthly intervals during the greater part of a year. For the other rivers daily samples were taken, mixed in sets of ten, and then analyzed. Thirty-five analyses therefore represent 350 daily samples, and their average gives the mean composition of the dissolved solids during about a year.

In order to compare these averages and to eliminate the variations due to differences of concentration in the several waters, the next table has been constructed. It gives the percentage composition of the saline matter contained in each water, as reduced to anhydrous form by evaporation and heating to complete dryness. Palmer's potassium determinations have been utilized in four of the averages, and Fe has been corrected to Fe_2O_3, in which form it would finally be deposited. With these amendments the table is as follows:

Percentage composition of dissolved solids in waters of St. Lawrence basin.

1. Lake Superior, 11 analyses.
2. Lake Michigan, 11 analyses.
3. Lake Huron, 9 analyses.
4. Lake Erie, 11 analyses.
5. St. Lawrence River, 11 analyses.
6. Grand River, 34 analyses.
7. Kalamazoo River, 35 analyses.
8. Maumee River, 36 analyses.
9. Oswegatchie River, 35 analyses.

	1	2	3	4	5	6	7	8	9
CO_3	47.42	49.45	47.26	44.70	45.70	44.37	47.32	29.63	39.10
SO_4	3.62	6.15	5.77	9.83	9.15	12.88	9.54	16.25	12.24
Cl	1.89	2.31	2.42	6.58	5.87	3.00	1.41	13.55	.59
NO_3	.86	.26	.38	.23	.23	.89	.79	1.52	.59
Ca	22.42	22.21	22.33	23.45	23.66	21.85	22.82	19.29	19.40
Mg	5.35	7.01	6.52	5.75	5.49	7.42	7.47	5.44	5.23
Na	5.52	4.02	4.10	4.92	4.81	3.20	2.87	6.79	6.57
K						.89	.70	1.62	1.80
SiO_2	12.76	8.54	11.16	4.46	5.03	5.46	7.05	5.78	14.03
Fe_2O_3	.16	.05	.06	.08	.06	.04	.03	.13	.45
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Salinity [a]	60	118	108	133	134	258	242	298	77

[a] Parts per million.

These analyses fall into two natural groups. The first five relate to the main stem of the St. Lawrence basin; the last four to its tributaries. The first group is peculiarly instructive. The salinity of its waters is relatively low but tends to increase downstream. That it is not higher in the lower lakes and the St. Lawrence is probably due to the influence of Canadian tributaries, which originate in great part in areas of old crystalline rocks. Analyses of the Canadian waters are much to be desired.

Lake Superior, at the head of the system, is relatively high in its proportion of silica, and so too are most of its tributaries on the south side. Pigeon River, on the north, resembles it in this respect. Lake Huron receives silica directly from Lake Superior and perhaps from northern waters also. Waters rising in areas of granite or granitoid rocks are almost invariably low in salinity and relatively high in silica. This relation has already been noted and explained. It also appears in the water of the Oswegatchie, which rises among the old rocks of the Adirondacks. The diminution of silica in the lower lakes and the St. Lawrence does not imply a loss, but merely a dilution by waters of different character. The positive amount of silica in parts per million may actually show gains.

The magnesian content of the waters is even more significant. The influence of a magnesian environment upon the waters of Fox River was noted in the section upon Lake Michigan, and its effect upon the lake appears very clearly in the table. It is furthermore shown in the analyses of the two Michigan rivers, which are more than ordinarily magnesian and which doubtless are affected by magnesian rocks along their courses. From Lake Michigan downward the percentage of magnesium in the waters steadily decreases. The high percentage of the carbonic radicle in Lake Michigan is a necessary consequence of the high magnesium. Magnesium carbonate contains about 71 per cent of the carbonic radicle, calcium carbonate about 60. In the table of analyses the two figures, for magnesium and the carbonic radicle, emphasize each other.

For the other constituents of the waters no definite regularities appear. The high chlorine and the sulphates of the Maumee are probably due to some sort of contamination. The water is abnormal. To draw any positive conclusions from the composition of the tributary waters a much more intensive study of them and their minor affluents would be necessary. Each water is a blend of waters from a number of different sources. Even the ground waters would have to be taken into account.

In Water-Supply Paper 454, 1919, data are given for the drainage area, in square miles above the observing stations, and the mean discharge for the year ending September 30, 1917, in cubic feet per second, of nearly sixty rivers in the St. Lawrence basis. Nine of these rivers have been considered in the foregoing pages. Their total annual discharge is as follows:

Drainage area and discharge of nine rivers in St. Lawrence basin.

River.	Drainage area (square miles).	Annual discharge (millions of cubic feet).
Bad River near Odanah, Wis	444	14, 002
Menominee River below Koss, Mich	4, 320	136, 240
Oconto River near Gillett, Wis	778	24, 535
Fox River near Wrightstown, Wis	5, 840	184, 170
Wolf River at New London, Wis	2, 120	66, 856
Sheboygan River near Sheboygan, Wis	286	9, 019
Milwaukee River near Milwaukee, Wis	567	17, 881
Genesee River at Rochester, N. Y	2, 190	69, 064
Oswegatchie River near Heuvelton, N. Y	1, 470	46, 358

NORTH ATLANTIC SLOPE.

For present purposes the waters of the north Atlantic slope may be defined as those which enter the ocean along the coast of the New England States from Maine to western Connecticut. The rocks of this drainage area are predominantly igneous and metamorphic, such as granite, gneiss, and mica schist. There are local bodies of limestone, sandstone, slate, and other sedimentary rocks, but their significance is relatively small. The waters derive their dissolved solids from rocks of igneous origin. In one respect the analyses of these waters are unsatisfactory, for the reason that the waters are too often contaminated by the drainage from factories and in northern New England especially from pulp mills. The effects of such pollution are clearly shown in the analyses.

WATERS OF EASTERN MAINE.

First in order of consideration are the waters of Maine, and these may be divided into an eastern and a western group. A table of hitherto unpublished analyses of water from the Penobscot precedes the general table for the eastern group.

Analyses of water from Penobscot River at Bangor, Maine.[a]

[Parts per million. J. M. Caird, analyst.]

Date.	Silica (SiO_2).	Iron (Fe).	Aluminum (Al).	Calcium (Ca).	Magnesium (Mg).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Chlorine (Cl).	Nitrate radicle (NO_3).	Total solids at 100° C.	Mineral residue after ignition.
1911.												
March	1.8	0.10	0.42	7.1	1.0	0.0	23	8.5	1.4	0.19	90	28
April	2.2	.18	.64	4.6	2.1	.0	14	6.3	1.9	.19	72	27
May	2.1	.07	.38	2.8	.6	.0	10	9.0	1.4	.12	49	19
June	1.8	.18	.18	3.6	.4	.0	13	14	1.6	.09	55	16
July	1.5	.14	.48	4.4	1.8	.0	18	8.3	1.6	.12	57	24
August	1.6	.14	.26	4.7	2.4	.0	16	6.4	1.8	.09	71	24
September	1.7	.10	.69	4.9	2.0	.0	15	6.4	1.8	.09	78	31
October	1.7	.14	.46	4.9	1.9	.0	15	6.8	1.7	.09	72	30
November	2.0	.10	.69	4.9	.8	.0	15	7.2	1.4	.12	75	23
December	2.4	.10	1.1	4.0	1.3	.0	12	7.2	1.2	.11	59	17
1912.												
January	1.8	.10	.58	3.8	2.0	.0	14	7.5	1.1	.12	71	23
February	2.2	.10	.22	5.0	2.0	.0	17	14	1.2	.15	71	17
Average for 3 years, March, 1909 to February, 1912	2.1	.21	.53	3.8	1.4	.0	15	6.2	1.5	.12	62	23
Percentage of anhydrous residue[b]	8.43	[c] 1.08	[d] 4.02	15.26	5.62	29.74	----------	24.92	6.03	.48	----------	----------

[a] Compiled from data in report of Bangor Water Board for 1911-12, Bangor, 1912. Typographic errors corrected in accordance with personal communication from J. M. Caird.

[b] The alkalies were not determined, but by assuming an average of 1.1 parts per million R. B. Dole computed the amount of them equivalent to the excess of acids over bases, which corresponds to 4.42 per cent of alkalies in the anhydrous residue.

[c] Fe_2O_3.

[d] Al_2O_3.

Analyses of water from eastern Maine.

1. St. John River near International Highway Bridge, 1921.
2. St. Croix River near Baileyville, 1921.
3. Penobscot River near Oldtown, 1921. Analyses 1 to 3 made by Margaret D. Foster, in the water-resources laboratory of the United States Geological Survey.
4. Penobscot River at Bangor. The average of the analyses by J. M. Caird, as shown in the preceding table.
5. Cold Stream Pond, Penobscot County (Penobscot basin).
6. Phillips Lake, Hancock County (Penobscot basin). Analyses 5 and 6 by F. C. Robinson.

I. Parts per million.

	1	2	3	4	5	6
CO_3	21.14	3.59	5.41	7.4	4.4	5.4
SO_4	4.3	3.2	5.6	6.2	2.1	2.3
Cl	.7	.9	1.0	1.5	2.0	2.6
NO_3	Tr.	Tr.	Tr.	.12	Tr.	Tr.
Ca	13.0	3.0	4.2	3.8	1.8	2.1
Mg	1.4	.6	1.0	1.4	.2	.3
Na	1.2	.8	1.3	1.1	1.9	2.6
K	.8	.4	.8		.6	.5
Al_2O_3	------	------	------	1.0	.2	.5
Fe_2O_3	.1	.1	.2	.27		
SiO_2	2.8	1.8	3.0	2.1	1.2	2.0
	45.44	14.39	22.51	24.89	14.4	18.3

II. Percentage composition of dissolved solids.

	1	2	3	4	5	6
CO_3	46.52	24.95	24.03	29.74	30.55	29.52
SO_4	9.48	22.24	24.87	24.92	14.58	12.49
Cl	1.54	6.26	4.44	6.03	13.89	14.22
NO_3	Tr.	Tr.	Tr.	.48	Tr.	Tr.
Ca	28.60	20.85	18.66	15.26	12.50	11.49
Mg	3.08	4.17	4.44	5.62	1.39	1.64
Na	2.64	5.56	5.80	4.42	13.19	14.22
K	1.76	2.78	3.55		4.17	2.74
Al_2O_3	------	------	------	4.02	1.39	2.74
Fe_2O_3	.22	.69	.89	1.08		
SiO_2	6.16	12.50	13.32	8.43	8.34	10.94
	100.00	100.00	100.00	100.00	100.00	100.00

The water of St. John River, taken at a point far above its mouth, shows little evidence of pollution. The St. Croix and Penobscot, on the other hand, have the high proportion of sulphates that indicates contamination, partly by pulp mills. The apparently high proportion of chlorine in analyses 4 and 5 may be cyclic—that is, brought down as salt in rainfall. Both waters were taken at points not very far from the coast, and considered in parts per million the figures for chlorine are not extravagant. The salinity of these waters is very low.

WATERS OF WESTERN MAINE.

The largest rivers of western Maine are the Kennebec, the Androscoggin, and the Saco. For the Androscoggin there is a table of analyses covering an entire year. That table is next in order, followed by a general table containing five other analyses of water in this area.

Analyses of water from Androscoggin River at Brunswick, Maine.[a]

[Parts per million.]

Date (1905-6).	Silica (SiO$_2$).	Fe$_2$O$_3$+Al$_2$O$_3$.	Calcium (Ca).	Magnesium (Mg).	Sodium (Na).	Potassium (K).	Sulphate radicle (SO$_4$).	Chlorine (Cl).	Total dissolved solids.
Apr. 25	6.6	2.1	3.6	1.4	1.7	0.7	6.4	3.0	27
May 2	6.0	1.8	4.6	.8	2.0	.9	9.2	3.3	30
9	5.5	1.0	3.7	.6	2.0	.7	9.5	1.0	25
16	5.4	1.4	4.3	1.3	1.9	.6	8.2	.6	26
23	5.3	1.4	4.4	1.3	1.9	.8	8.6	.9	26
30	5.8	2.9	5.8	.9	2.2	1.0	9.6	.9	31
June 6	7.3	3.1	6.2	1.0	2.4	1.3	11	.8	35
13	7.5	2.0	6.3	1.5	2.4	.9	11	1.2	35
20	6.5	1.8	6.0	1.5	2.0	.8	11	.6	32
27	7.8	3.3	6.9	1.2	2.4	.9	9.7	.4	35
July 4	7.5	2.6	5.6	1.2	2.5	.9	9.4	.9	33
11	9.5	1.7	5.8	1.7	2.1	.8	11	2.6	37
18	8.1	3.2	7.2	1.7	2.5	.8	14	.9	41
25	10	4.1	6.1	1.5	2.7	1.2	12	3.0	43
Aug. 1	9.8	3.3	6.3	2.0	2.4	.9	13	3.9	44
8	6.7	2.2	5.5	1.4	2.8	.7	9.6	3.5	34
15	7.0	2.2	6.9	2.1	2.6	.8	14	3.7	41
22	7.6	2.1	6.9	2.0	2.1	1.1	13	3.9	40
29	6.8	4.0	7.9	1.6	2.8	1.0	12	3.9	43
Sept. 5	9.0	3.0	8.4	2.2	2.8	1.4	16	3.5	49
12	7.4	1.8	5.9	1.1	2.2	.9	8.8	3.5	33
19	9.9	4.9	7.7	1.7	3.4	.6	13	3.9	48
26	6.2	2.7	8.8	.6	1.3	.7	14	3.0	40
Oct. 3	9.6	2.7	8.4	.7	3.2	.8	14	3.0	48
10	9.3	3.1	14	.9	3.8	.9	8.9	1.2	51
17	13	4.1	13	.6	3.4	.9	14	3.9	56
24	8.3	4.9	11	1.5	3.0	.9	13	3.5	49
31	9.4	3.9	7.5	.7	1.7	.7	13	3.0	39
Nov. 7	13	4.6	9.3	.6	1.9	1.6	14	3.5	52
15	14	4.6	7.0	.7	3.2	1.2	8.8	3.3	47
21	14	3.6	7.8	.8	3.7	1.2	16	3.5	52
28	14	4.7	7.7	.7	3.4	1.1	12	3.5	52
Dec. 5	12	5.9	7.9	.3	3.0	1.2	9.1	1.2	45
12	7.5	4.1	8.4	.5	2.6	.9	11	1.0	40
19	10	3.2	11	.7	2.4	.8	6.4	1.2	49
26	9.5	4.5	10	.6	3.3	1.5	16	3.5	53
Jan. 6	9.9	2.0	6.0	1.6	2.3	1.3	15	1.2	47
9	11	5.5	9.3	.5	2.4	1.5	9.7	.9	47
16	11	2.9	11	1.0	1.7	1.4	15	1.0	52
23	10	4.2	8.5	.6	2.8	1.3	10	1.2	43
30	8.0	1.8	6.0	.5	3.0	1.3	8.8	.5	34
Feb. 6	9.5	4.6	6.8	.5	2.7	1.4	11	.9	42
13	11	2.5	7.2	1.7	2.6	1.3	17	1.2	50
20	11	4.0	12	.8	2.2	1.2	15	.4	52
27	14	4.3	7.9	.9	2.2	1.2	14	.8	49
Mar. 6	------	2.6	5.6	.8	2.5	1.2	9.4	3.0	53
13	12	2.8	8.8	1.2	2.5	1.4	16	3.5	52
20	14	4.9	10	1.2	3.6	1.5	16	3.5	56
27	11	4.9	11	.9	2.3	1.3	13	3.3	52
Apr. 3	6.0	3.4	5.6	.6	1.9	1.0	6.1	2.8	31
10	4.9	2.0	3.6	.8	2.0	.7	8.9	3.6	27
17	4.0	1.0	3.4	.6	1.7	.8	8.7	3.0	24
Mean	9.0	3.2	7.4	1.1	2.5	1.0	12	2.3	42

[a] Analyses by F. C. Robinson.

Analyses of waters in western Maine.

1. Moosehead Lake, at head of Kennebec River. Analysis by F. C. Robinson.
2. Kennebec River at Waterville. Analysis by Margaret D. Foster.
3. Rangeley Lake, at head of Androscoggin River. Analysis by Robinson.
4. Androscoggin River at Gorham, N. H. Analysis by Miss Foster.
5. Androscoggin River at Brunswick. Average of the analyses given in the previous table. CO$_3$ not determined but calculated to satisfy excess of bases. Analyses by Robinson.
6. Saco River at Cornish. Analysis by Miss Foster.

I. Parts per million.

	1	2	3	4	5	6
CO$_3$	5.4	6.4	5.9	4.43	9.8	4.08
SO$_4$	2.1	7.8	2.2	9.3	12.0	6.4
Cl	2.0	.3	2.1	.9	2.3	.8
NO$_3$	Tr.	Tr.	Tr.	Tr.	------	Tr.
Ca	2.2	4.2	2.4	3.6	7.4	3.0
Mg	.3	1.4	.3	1.4	1.1	.9
Na	1.8	1.4	1.9	1.3	2.5	1.8
K	.6	.7	.7	.5	1.0	.7
Fe$_2$O$_3$	.2	.3	.3	.37	3.2	.42
SiO$_2$	1.4	3.3	2.2	4.0	9.0	5.9
	16.0	25.8	18.0	25.8	48.3	24.0

Analyses of waters in western Maine—Continued.

II. Percentage composition of dissolved solids.

	1	2	3	4	5	6
CO$_3$	33.75	24.80	32.78	17.17	20.29	17.01
SO$_4$	13.13	30.23	12.22	36.05	24.85	26.67
Cl	12.50	1.16	11.67	3.48	4.76	3.33
NO$_3$	Tr.	Tr.	Tr.	Tr.	Tr.	Tr.
Ca	13.75	16.28	13.33	13.95	15.33	12.48
Mg	1.87	5.43	1.67	5.43	2.27	3.75
Na	11.25	5.43	10.55	5.04	5.17	7.50
K	3.75	2.72	3.89	1.94	2.07	2.92
Fe$_2$O$_3$	1.25	1.16	1.67	1.44	6.63	1.75
SiO$_2$	8.75	12.79	12.22	15.50	18.63	24.59
	100.00	100.00	100.00	100.00	100.00	100.00

The two lake waters in this table are of exceedingly low salinity. Consequently a small error in parts per million becomes a large one relatively in the percentage column. One part per million in the analysis of water from Moosehead Lake is equivalent to 6 per cent of the total amount. In order to avoid such uncertainties much larger quantities of water than are commonly used should be taken for analysis.

The three river waters in the table show serious industrial contamination. At Berlin, N. H., a few miles above Gorham, there are large paper and pulp mills. At Rumford Falls, lower downstream, there are more paper and pulp mills and also chemical works. These two points alone cause much pollution, and they are only part of a large list. Their effects appear in the very high proportion of sulphates shown in the analysis.

MERRIMACK BASIN.

The headwaters of Merrimack River are in the White Mountains of New Hampshire, its principal source, the Pemigewasset, rising in the Franconia Notch. After a course of about 170 miles, it enters the ocean near Newburyport, Mass. Its drainage area is about 5,000 square miles. The analyses in the next table, with one exception, relate to the Merrimack and its subordinate waters. A single analysis of water from Cocheco River is included here as a matter of convenience.

Analyses of waters in the Merrimack basin.

1. Pemigewasset River at North Woodstock, N. H. Analysis by Margaret D. Foster.
2. Lake Winnepesaukee at Wolfboro, N. H. Analysis by Miss Foster.
3. Merrimack River above Concord, N. H. Analysis by H. E. Barnard, made for the United States Geological Survey.
4. Penacook Lake at Penacook, N. H. Analysis received from Boston & Maine R. R. J. J. Callahan, analyst.
5. Nashua River at Clinton, Mass. (Wachusett Reservoir). Analysis by Miss Foster.
6. Nashua River at Nashua, N. H. Received from Boston & Maine R. R.
7. Cocheco River at Dover, N. H. From Boston & Maine R. R.

Analyses of waters in the Merrimack basin—Continued.

I. Parts per million.

	1	2	3	4	5	6	7
CO_3	4.57	4.92	47.9	7.4	3.44	13.9	5.0
SO_4	16.0	4.0	21.7	3.9	6.0	23.1	4.5
Cl	2.2	1.6	14.9	2.4	2.1	16.7	2.8
NO_3	Tr.	Tr.			.22		
Ca	6.8	2.7	29.1	3.3	3.0	10.6	1.6
Mg	1.8	.7	7.1	.9	.7	1.2	.7
Na	1.9	2.4	10.5	3.7	2.2	18.1	4.7
K	1.0	.6	Tr.		1.0		
Al_2O_3			2.3				
Fe_2O_3	3.9	.03	5.7	2.0	.03	9.9	3.6
SiO_2	8.5	1.2	30.8		3.7		
	43.16	18.15	170.0	23.6	22.39	93.5	22.9

II. Percentage composition of dissolved solids.

	1	2	3	4	5	6	7
CO_3	10.59	27.11	28.15	31.42	15.37	14.87	21.67
SO_4	37.07	22.04	12.78	16.66	26.80	24.71	19.68
Cl	5.10	8.82	8.78	10.11	9.38	17.86	12.38
NO_3	Tr.	Tr.			.98		
Ca	15.76	14.87	17.14	13.91	13.41	11.37	6.87
Mg	4.17	3.86	4.18	3.73	3.13	1.26	3.20
Na	4.40	13.23	6.16	15.48	9.81	19.33	20.53
K	2.32	3.30	Tr.		4.46		
Al_2O_3			1.34				
Fe_2O_3	.90	.17	3.33	8.69	.13	10.60	15.67
SiO_2	19.69	6.60	18.14		16.53		
	100.00	100.00	100.00	100.00	100.00	100.00	100.00

With two exceptions the salinity of these waters is extremely low. Analysis No. 3 shows an abnormally high salinity, which is unexplained. No. 6, Nashua River at Nashua, is clearly affected by industrial contamination. Along a large part of its course there are factories of various kinds, which render its waters abnormal. The very high proportion of suphates in the Wachusett Reservoir is difficult to explain. Nashua River above Clinton flows through farming country, and the sulphates may perhaps be derived from fertilizers. In parts per million the proportion of the sulphate radicle is not excessive, but it is apparently magnified in terms of percentage.

CONNECTICUT BASIN.

Connecticut River, the largest river in New England, issues from the Connecticut Lakes, in extreme northern New Hampshire, and after a course of 375 miles enters Long Island Sound at Saybrook, Conn. Its drainage area is 11,083 square miles. The following analyses represent the composition of its dissolved solids.

Analyses of waters in the Connecticut basin.

1. Connecticut River at Pittsburg, N. H.
2. Connecticut River at Orford, N. H.
3. Connecticut River at Sunderland, Mass. Analyses Nos. 1 to 3 by Margaret D. Foster.
4. Roaring Brook at South Deerfield, Mass.
5. Pond at Unionville, Conn.
6. Brook at Vernon, Conn.
7. River View Pond, Saybrook, Conn. Analyses 4 to 7 received from New York, New Haven & Hartford R.R.

Analyses of waters in the Connecticut basin—Continued.

I. Parts per million.

	1	2	3	4	5	6	7
CO_3	3.74	19.2	18.2	21.6	17.7	10.1	23.9
SO_4	5.8	7.2	7.3	25.8	12.4	7.1	7.4
Cl	.1	1.0	1.6	3.2	4.3	5.3	7.2
NO_3	.28	Tr.	Tr.				
Ca	3.3	13.0	12.0	18.6	12.2	4.4	5.9
Mg	1.0	1.2	1.5	2.2	2.2	3.2	7.9
Na	.8	1.8	2.0	5.3	3.9	3.4	4.6
K	.4	.9	1.2				
Fe_2O_3	.17	.2	.16				
SiO_2	2.3	5.2	4.5				
Oxides [a]				10.3	4.4	10.4	2.4
	17.89	49.7	48.46	87.0	57.1	43.9	59.3

[a] Silica plus sesquioxides.

II. Percentage composition of dissolved solids.

	1	2	3	4	5	6	7
CO_3	20.90	38.63	37.56	24.79	30.96	23.00	40.35
SO_4	32.42	14.49	15.07	29.68	21.71	16.21	12.44
Cl	.59	2.02	3.30	3.70	7.43	12.04	12.10
NO_3	1.56	Tr.	Tr.				
Ca	18.43	26.16	24.76	21.33	21.34	10.02	9.93
Mg	5.59	2.41	3.09	2.58	3.92	7.20	13.30
Na	4.47	3.62	4.13	6.14	6.88	7.80	7.84
K	2.24	1.81	2.48				
Fe_2O_3	.95	.40	.33				
SiO_2	12.85	10.46	9.28				
Oxides [a]				11.78	7.76	23.73	4.04
	100.00	100.00	100.00	100.00	100.00	100.00	100.00

[a] Silica plus sesquioxides.

WATERS OF WESTERN CONNECTICUT.

West of the Connecticut River basin there are several large streams and ponds for which analyses have been made. The available data are as follows:

Analyses of waters in western Connecticut.

1. Pond at East Wallingford (Quinnipiac basin).
2. Lake Saltonstall near New Haven.
3. Norwalk River near Branchville. Analyses 1 to 3 received from New York, New Haven & Hartford R. R.
4. Housatonic River at Falls Village. Analysis by Margaret D. Foster.

	Parts per million.				Percentage composition.			
	1	2	3	4	1	2	3	4
CO_3	10.1	8.7	22.7	57.1	20.81	10.96	32.41	47.59
SO_4	16.8	39.0	14.1	13.0	34.67	49.17	20.19	10.84
Cl	4.3	6.4	7.6	3.4	8.79	8.11	10.83	2.84
NO_3				.32				.27
Ca	8.1	11.5	9.4	28.0	16.71	14.45	13.50	23.34
Mg	3.4	4.0	3.6	10.0	6.97	5.04	5.10	8.33
Na	2.8	7.0	11.4	4.1	5.69	8.82	16.26	3.42
K				1.3				1.08
Fe_2O_3				.26				.21
SiO_2				2.5				2.08
Oxides [a]	3.1	2.7	1.2		6.36	3.45	1.71	
	48.6	79.3	70.0	119.98	100.00	100.00	100.00	100.00

[a] Silica plus sesquioxides.

The high chlorine in several of these Connecticut waters is evidently due to the proximity of Long Island Sound.

MIDDLE ATLANTIC SLOPE.

The rivers of the middle Atlantic slope, from the Hudson to the Potomac, are of mixed character as regards the composition of their waters. They are fed partly by streams rising in areas of crystalline rocks and partly by tributaries from sedimentary formations. They form, therefore, an intermediate class between the rivers of New England and those south of the Potomac, as will appear when the streams of the latter region are studied. The group of rivers to be considered now are the Hudson, Raritan, Delaware, Susquehanna, and Potomac, with some of their tributaries. For the smaller rivers in this area few data are available, and they are more or less unsatisfactory.[14]

HUDSON RIVER.

The Hudson, which drains an area of 13,366 square miles, rises among the old crystalline rocks of the Adirondacks, and on its way southward it receives many tributaries, of which the Mohawk, entering it from the west, is the largest. The Mohawk Valley is in a region of varied sedimentary formations, but the streams entering the Hudson from the east are of the New England type. For the Hudson itself the analyses by Dole and his colleagues appear in the next table.

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[14] Partial analyses of water from 22 streams in New Jersey are given in New Jersey Geol. Survey, Report on water supply, 1894. Alkalies were reported in only two samples, and carbonic acid not at all.

Analyses of water from Hudson River at Hudson, N. Y.[a]

[Parts per million.]

Date (1906-7).		Turbidity.	Total iron (Fe).	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total dissolved solids.
From—	To—													
Sept. 17	Sept. 27	10	0.6	19	0.2	24	4.4	7.9	0.0	87	16	Tr.	3.8	131
28	Oct. 7	9	.4	15	.2	24	4.2	7.9	.0	80	17	0.5	5.3	129
Oct. 8	17	6	.2	9.0	.1	26	3.8	10	.0	80	20	.9	5.6	131
18	28	7	.3	13	.05	26	3.8	11	.0	82	20	.7	5.3	135
29	Nov. 7	8	----------	13	.18	25	4.8	9.9	.0	79	21	.9	4.1	125
Nov. 8	17	8	----------	15	.16	22	4.4	10	.0	77	21	.9	4.1	123
18	27	18	.8	13	.2	20	4.2	7.9	.0	71	15	1.0	3.0	112
28	Dec. 8	9	.3	8.6	.15	18	3.8	6.3	.0	63	12	.5	2.6	96
Dec. 9	18	8	.6	8.0	.08	20	4.2	7.3	.0	72	16	1.6	4.3	99
19	28	8	.5	11	.06	24	5.0	7.6	.0	83	18	1.5	4.4	114
29	Jan. 8	39	1.4	7.4	.1	18	4.0	6.3	.0	60	14	1.8	2.9	88
Jan. 9	18	31	1.1	12	.16	15	3.4	4.6	.0	52	12	1.2	3.4	82
19	27	13	.6	5.6	.09	18	4.0	5.0	.0	57	15	1.1	3.6	86
31	Feb. 9	6	.4	9.6	.12	21	4.6	5.0	.0	67	16	1.6	4.1	103
Feb. 10	20	18	.4	4.2	.1	19	4.8	6.6	.0	70	17	.0	4.3	99
21	Mar. 2	9	.8	9.6	.13	24	5.0	5.7	.0	77	19	2.0	5.0	118
Mar. 3	12	6	.4	27	.13	25	4.8	5.8	.0	76	21	2.1	5.0	129
13	22	20	1.1	13	.13	20	4.0	4.9	.0	63	16	2.1	4.2	98
23	Apr. 1	34	2.1	5.6	.13	16	2.2	5.0	[b] 7.9	43	9.7	.3	1.2	63
Apr. 2	12	15	.5	15	.09	16	1.2	9.8	.0	61	13	1.3	2.9	94
13	22	13	.7	9.2	.12	16	1.4	6.9	.0	56	10	1.0	3.0	82
23	May 2	30	1.4	13	.16	16	1.4	9.4	.0	56	12	.9	2.4	87
May 3	12	12	.6	12	.13	----------	1.0	5.0	.0	48	12	.8	2.4	77
13	22	7	.5	9.0	.15	16	1.2	7.6	.0	62	11	.8	2.4	84
23	June 1	6	.5	10	.15	18	1.4	6.3	.0	----------	13	.6	3.4	96
June 2	11	7	.5	5.4	.11	18	1.8	----------	.0	63	----------	.5	3.4	92
12	21	6	.4	4.8	.11	20	2.0	6.9	.0	----------	14	.5	3.4	93
22	July 1	29	1.0	6.6	.09	22	4.0	9.5	[b] 12	56	14	Tr.	6.2	103
July 2	11	20	.8	9.2	.12	----------	5.4	9.8	[b] 12	60	19	.0	5.8	117
12	21	4	.8	16	.40	22	4.6	11	.0	83	17	Tr	3.8	122
22	31	9	.8	11	.11	26	4.6	12	.0	92	20	Tr.	3.4	127
Aug. 1	Aug. 10	7	.7	10	.21	26	5.0	9.4	.0	88	20	Tr.	5.0	127
11	21	8	.8	----------	.14	26	5.4	9.3	[b] 4.8	84	19	.0	5.4	125
22	Sept. 1	7	.7	8.0	.23	26	5.4	9.8	.0	95	21	.0	5.4	131
Sept 2	11	9	.9	8.8	.42	26	5.8	8.8	.0	87	22	Tr.	5.8	133
12	22	11	.7	13	.10	26	5.4	9.4	.0	85	23	Tr.	4.2	132
Mean		13	.7	11	.15	21	3.8	7.9	.0	73	16	.8	4.0	108

[a] Analyses Sept. 17 to Dec. 8, 1906, by R. B. Dole; Dec. 9, 1906, to Apr. 1, 1907, by R. B. Dole and M. G. Roberts; Apr. 2 to July 1, 1907, by Chase Palmer and M. G. Roberts; July 2 to Sept. 22, 1907, by R. B. Dole, Chase Palmer, and W. D. Collins

[b] Abnormal; computed as HCO_3 in the average

In addition to the analyses given in the foregoing table the following are available:

Analyses of Hudson Valley waters.

1. Mohawk River at Utica. Cited by I. C. Russell in U. S. Geol. Survey Mon. II, opp. p. 176, 1885.
2. Hudson River at Albany.
3. Croton River, 1872. Analyses 2 and 3 from Am. Public Health Assoc., Rept., vol. 1, pp. 542, 561, 1875. All reduced to standard form and parts per million, with organic matter rejected. Analyses 1 to 3 by C. F. Chandler.
4. Croton River, water from the Croton aqueduct, 135th Street gatehouse, New York City.
5. Water from the Catskill aqueduct, New York City. Mainly from Esopus Creek, with a small admixture from other streams. Analyses 4 and 5 by Margaret D. Foster, in the water-resources laboratory of the U. S. Geological Survey.

	1	2	3	4	5
CO_3	56.9	36.2	24.2	20.30	5.41
SO_4	18.7	12.5	2.5	11.00	7.7
Cl	2.3	4.5	2.9	2.60	1.0
NO_3	----------	----------	----------	.88	.49
Ca	31.8	22.6	10.0	12.00	4.5
Mg	6.9	4.2	3.8	4.40	1.2
Na	3.6	2.4	2.1	1.70	1.1
K	.9	.6	1.6	1.20	.6
SiO_2	6.7	8.0	3.8	9.60	2.6
Fe_2O_3	----------	----------	----------	.06	.06
$(Al, Fe)_2O_3$	1.3	1.2	1.0	----------	----------
	129.1	92.2	51.9	63.74	24.66

Reduced to percentages of the anhydrous residue the figures for the Hudson Valley waters assume the following form:

Hudson Valley analyses in percentages.

1. Mohawk River; Chandler.
2. Hudson River at Albany; Chandler.
3. Hudson River at Hudson; Survey series, mean of 36 composites of 10 daily samples each. Alkalies given as corrected by Palmer's determination of potassium. For parts per million see the complete table, ante.
4. Croton River; Chandler.
5. Water from Croton aqueduct; Foster.
6. Water from Catskill aqueduct (Esopus Creek); Foster.

	1	2	3	4	5	6
CO_3	44.03	39.26	35.45	46.71	31.84	21.94
SO_4	14.50	13.62	15.84	4.83	17.25	31.22
Cl	1.78	4.86	3.96	5.66	4.08	4.06
NO_3	-------	-------	.79	-------	1.38	1.99
Ca	24.65	24.51	20.79	19.25	18.82	18.25
Mg	5.35	4.53	3.76	7.27	6.90	4.87
Na	2.79	2.63	6.53	3.98	2.67	4.46
K	.70	.63	1.78	3.04	1.88	2.43
SiO_2	5.19	8.66	10.90	7.34	15.09	10.54
Al_2O_3	1.01	1.30	-------	1.92	-------	-------
Fe_2O_3			.20		.09	.24
	100.00	100.00	100.00	100.00	100.00	100.00
Salinity, parts per million	129.1	92.1	108	51.9	63.7	24.7

The difference between the two analyses of Croton water is unexplained. Miss Foster's analysis was made in 1921, Chandler's in 1872. The change in character between these dates is very great.

These analyses are not quite comparable. The Mohawk, as has already been mentioned, comes from a region of sedimentary rocks, in which gypsum is not uncommon. From that source probably the relatively high proportion of sulphates is derived. The Croton, on the other hand, rises in an area of pre-Cambrian gneiss and is very different in character from the Mohawk. As for the Hudson itself, its water shows the influence of the Mohawk, and also the higher silica from its northern sources. Analyses of its waters north of Glens Falls are much to be desired. The difference in salinity between the Survey series and Chandler's analysis is of very little significance. The Survey figure is an average for an entire year; the other represents a single sample taken at a time of high water, and therefore of low concentration. The individual analyses of the Survey series vary in salinity from 77 to 135 parts per million.

RARITAN RIVER.

The Raritan, one of the minor rivers of the Atlantic slope, rises in northern New Jersey and has its entire course within that State. The only available analyses of its water are given in the following table:

Analyses of water from Raritan River at Bound Brook, N. J.[a]

[Parts per million.]

Date (1906-7). From—	To—	Turbidity.	Total iron (Fe).	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total dissolved solids.	Mean gage height (feet).
Sept. 10	Sept. 19	9	0.1	22	Tr.	14	5.0	10	0.0	65	10	0.8	4.6	102	1.4
20	29	155	2.0	15	0.5	13	4.6	9.9	.0	57	12	1.9	4.6	93	1.6
30	Oct. 9	42	4.3	14	.20	12	4.4	7.4	.0	59	12	1.8	4.2	92	1.8
Oct. 10	19	8	.2	15	.10	14	4.8	7.9	.0	58	13	1.8	5.3	89	1.4
20	29	32	1.4	23	.20	13	5.2	9.5	.0	56	10	1.7	6.0	97	1.9
30	Nov. 8	13	.6	18	.09	12	5.0	7.4	.0	57	10	1.6	5.3	98	1.6
Nov. 9	18	9	.5	14	.14	12	5.6	7.6	.0	59	12	.3	5.0	85	1.6
19	29	12	.15	12	.08	11	5.2	7.9	.0	52	14	.6	4.9	80	2.0
30	Dec. 9	6	.2	18	.09	13	5.4	7.6	.0	62	9.9	2.0	4.7	93	1.4
Dec. 10	19	26	.9	20	.16	12	4.8	6.6	.0	50	13	1.9	4.6	88	2.1
21	30	28	1.0	14	.18	10	4.4	6.1	.0	39	11	3.0	4.6	79	2.0
31	Jan. 9	37	1.4	14	.30	9.6	4.2	-------	.0	-------	12	2.1	4.6	73	2.8
Jan. 10	19	47	1.6	11	.17	9.2	2.8	-------	.0	34	13	-------	5.3	69	3.1
30	Feb. 9	5	.4	17	.10	9.6	3.8	7.2	.0	45	10	3.8	4.8	75	1.8
Feb. 10	19	4	.2	19	.08	11	5.2	9.4	.0	52	8.6	4.0	5.9	83	1.6
20	Mar. 2	5	.2	22	.09	12	5.0	7.7	.0	52	11	2.4	5.3	89	1.4
Mar. 3	12	11	.8	22	.10	10	4.8	9.0	.0	45	13	3.0	4.8	82	2.1
13	22	80	3.3	21	.20	7.2	2.6	6.0	.0	30	11	2.1	4.1	69	4.9
23	Apr. 1	7	.4	12	.09	8.2	4.0	6.3	.0	38	10	2.8	3.8	64	2.2
Apr. 2	11	10	.4	17	.09	11	2.4	11	.0	43	11	3.0	3.7	76	1.9
12	21	5	.2	20	.11	10	3.0	12	.0	44	11	2.9	3.8	81	1.8
22	May 2	40	.8	17	.21	10	3.4	9.8	.0	45	11	2.8	3.8	81	1.8
May 3	12	20	.7	26	.18	10	3.6	9.0	.0	44	12	2.7	3.6	90	2.2
13	22	45	1.6	24	.13	11	3.8	-------	.0	46	11	2.7	3.5	86	2.2
23	June 2	8	.3	11	.06	11	3.6	7.6	.0	52	8.9	2.3	3.6	74	1.8
June 3	12	18	.6	8.2	.08	9.6	3.0	11	.0	47	10	2.3	3.8	67	1.7
13	21	5	.2	10	.08	13	4.4	8.4	.0	59	10	2.2	4.2	81	1.3
23	July 2	18	.3	8.0	.03	13	5.2	11	.0	67	11	1.7	4.6	88	1.3
July 3	12	130	4.7	20	.11	17	2.4	12	.0	57	14	.7	4.6	96	1.3
13	23	272	7.0	9.6	.18	14	3.8	11	.0	50	15	.7	4.8	81	1.4
24	Aug. 2	25	1.4	13	.05	17	1.8	12	.0	56	17	.4	5.4	92	1.1
Aug. 3	12	8	.8	10	.05	18	-------	-------	.0	43	18	.3	4.8	88	1.1
13	23	7	.6	8.4	.07	18	-------	-------	.0	66	18	.4	5.8	93	1.0
24	Sept. 3	45	1.2	15	.16	17	1.2	12	.0	62	16	.9	5.4	97	1.4
Sept. 5	12	120	2.6	19	.7	16	1.6	14	.0	56	18	1.0	5.4	104	1.5
Mean		37	1.2	16	.15	12	3.9	9.1	.0	51	12	1.9	4.7	85	-------

[a] Analyses Sept. 9 to Oct. 29, 1906, and from Nov. 9 to Nov. 29, 1906, by R. B. Dole; Oct. 30 to Nov. 8, 1906, and from Nov. 30, 1906, to Apr. 1, 1907, by R. B. Dole and M. G. Roberts; Apr. 2 to July 2, 1907, by Chase Palmer and M. G. Roberts; July 3 to Sept. 12, 1907, by R. B. Dole, Chase Palmer, and W. D. Collins.

DELAWARE RIVER.

The Delaware drains an area of about 12,000 square miles in New York, New Jersey, and Pennsylvania. Its largest tributary is the Lehigh, and the Survey analyses for both rivers appear in the two following tables.

Analyses of water from Delaware River at Lambertville, N. J.[a]

[Parts per million.]

Date (1906-7).		Turbidity.	Total iron (Fe).	Silica (SiO₂).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO₃).	Bicarbonate radicle (HCO₃).	Sulphate radicle (SO₄).	Nitrate radicle (NO₃).	Chlorine (Cl).	Total dissolved solids.	Mean gage height (feet).
From—	To—														
Sept. 8	Sept. 17	2	--------	22	0.20	14	4.4	5.7	0.0	59	9.9	0.5	2.6	94	2.80
18	26	13	0.1	12	Tr.	16	5.2	6.9	.0	63	13	.5	3.1	87	2.64
28	Oct. 7	85	.3	13	.20	15	3.8	5.7	.0	61	17	.5	2.8	94	3.17
Oct. 8	17	5	.1	13	Tr.	16	3.2	5.5	.0	52	15	.6	3.2	85	3.16
18	29	18	.8	16	Tr.	12	1.6	5.2	.0	38	12	.5	2.8	75	4.67
30	Nov. 9	6	.1	7.2	Tr.	10	1.8	5.7	.0	37	10	.8	2.6	58	4.74
Nov. 10	19	5	.1	8.0	.06	10	2.4	5.4	.0	36	14	.7	2.6	61	4.39
20	29	9	.2	6.0	Tr.	7.8	1.0	4.9	.0	28	9.2	.8	1.8	46	5.64
30	Dec. 9	3	Tr.	8.0	Tr.	9.4	2.2	--------	.0	35	11	.8	1.9	55	4.62
Dec. 10	19	5	.2	6.4	.12	9.2	3.4	3.6	.0	--------	9.2	1.6	2.6	51	4.92
20	30	6	.2	7.6	.11	10	3.6	3.6	.0	37	11	2.0	2.9	58	4.80
31	Jan. 9	43	2.1	7.6	.14	9.0	3.0	3.9	.0	--------	--------	1.4	2.4	50	7.12
Jan. 10	19	8	.4	5.8	.11	9.0	3.2	3.0	.0	--------	9.6	1.6	2.4	47	5.98
20	30	8	.3	6.6	.09	9.5	3.4	3.8	.0	--------	11	1.8	2.4	51	5.39
31	Feb. 9	3	.2	7.2	.14	10	4.0	3.3	.0	35	11	1.6	2.9	57	4.66
Feb. 10	19	6	.2	6.0	.04	12	4.2	5.8	.0	--------	13	1.9	2.6	65	--------
20	Mar. 1	12	.1	--------	.06	12	4.0	6.6	--------	--------	11	.5	2.6	76	--------
Mar. 2	11	7	.3	12	.06	13	4.6	--------	[b]4.3	41	14	2.1	2.9	77	3.75
12	22	39	1.9	3.0	.05	8.4	2.6	5.7	.0	35	11	1.1	2.6	49	7.19
Apr. 2	Apr. 12	2	.3	7.4	.09	8.9	2.9	3.8	.0	--------	9.9	1.5	2.6	50	5.20
13	22	1	.2	7.2	.09	9.4	1.9	4.4	.0	32	9.6	1.0	2.2	52	4.89
May 4	May 13	7	.3	8.6	.05	9.7	3.5	5.0	.0	41	9.2	.6	2.2	59	4.94
14	23	4	.5	11	.07	10	3.0	6.3	.0	41	9.7	1.0	2.6	66	4.34
24	June 2	4	.4	7.4	.11	10	3.7	5.7	.0	43	9.7	.7	2.5	62	4.21
June 4	13	4	.5	5.6	.10	9.1	3.3	--------	.0	30	10	.7	2.6	52	4.79
14	23	4	.3	3.4	.11	11	3.8	3.8	.0	43	10	.6	3.2	58	3.88
25	July 4	9	.4	4.8	.09	12	4.0	5.4	.0	44	12	1.4	3.0	66	4.10
July 5	14	90	1.6	--------	.05	14	5.0	--------	--------	--------	16	Tr.	3.0	101	3.73
15	24	65	1.8	14	.13	16	--------	8.8	.0	--------	15	1.5	3.0	85	3.52
25	Aug. 3	15	1.0	7.2	.04	16	--------	6.9	.0	52	16	1.1	4.0	83	2.57
Aug. 4	13	10	.9	11	.04	17	--------	6.6	.0	61	18	1.1	4.0	94	2.29
15	25	30	1.2	4.8	.04	19	--------	7.9	.0	66	18	1.7	5.4	94	2.32
26	Sept. 4	12	.7	11	.06	19	--------	--------	.0	72	19	1.6	4.8	109	2.83
Sept. 5	12	12	.6	13	.03	17	--------	9.1	.0	66	17	1.5	3.6	101	4.02
Mean	--------	16	.6	9.0	.07	12	3.3	5.4	.0	46	12	1.1	2.9	70	--------

[a] Analyses Sept. 8 to Dec. 9, 1906, by R. B. Dole; Dec. 10, 1906, to Mar. 22, 1907, by R. B. Dole and M. G. Roberts; Apr. 2 to July 4, 1907, by Chase Palmer and M. G. Roberts; July 5 to Sept. 12, 1907, by R. B. Dole, Chase Palmer, and W. D. Collins.

[b] Abnormal; computed as HCO_3 in the average.

Analyses of water from Lehigh River at South Bethlehem, Pa.[a]

[Parts per million.]

Date (1906-7).		Turbidity.	Total iron (Fe).	Silica (SiO₂).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO₃).	Bicarbonate radicle (HCO₃).	Sulphate radicle (SO₄).	Nitrate radicle (NO₃).	Chlorine (Cl).	Total dissolved solids.	Mean gage height (feet)[b]
From—	To—														
Sept. 11	Sept. 20	8	1.5	11	0.10	22	8.0	6.8	0.0	58	43	2.0	7.0	128	4.2
21	30	7	.6	13	.5	23	8.8	9.1	.0	65	44	1.9	8.2	145	4.2
Oct. 1	Oct. 10	12	.5	11	.10	17	7.0	7.9	.0	48	42	3.0	5.5	119	4.4
11	21	8	.9	11	.10	17	6.6	7.7	.0	49	38	3.2	6.0	113	4.5
22	31	13	1.7	9.0	.20	12	4.8	6.9	.0	30	26	1.9	3.8	79	5.1
Nov. 1	Nov. 11	12	1.4	5.4	.06	12	4.6	5.8	.0	28	29	2.8	4.7	78	4.9
12	21	16	1.6	6.4	.08	12	4.8	6.1	.0	25	32	2.8	5.3	84	4.9
23	Dec. 3	10	.8	10	.07	12	4.8	8.5	.0	34	29	3.0	6.2	88	4.9
Dec. 4	13	13	1.4	5.6	.06	13	5.6	5.2	.0	28	31	3.0	4.6	78	--------
14	23	11	1.0	6.4	.07	11	4.8	4.1	.0	28	26	3.8	5.0	72	4.9
24	Jan. 2	50	3.2	7.0	.12	10	--------	5.0	.0	28	25	4.0	5.4	68	--------
Jan. 3	13	17	1.9	8.0	.10	8.8	3.4	3.9	.0	22	20	4.0	3.8	60	5.4
14	25	13	1.8	9.6	.10	10	3.8	4.9	.0	27	21	4.0	3.7	68	5.2
26	Feb. 4	11	1.1	7.2	.11	11	4.8	--------	.0	29	27	3.0	4.8	72	--------
Feb. 6	15	9	1.0	9.2	.09	13	5.4	5.0	.0	40	28	3.0	4.6	84	--------
16	25	6	.8	6.2	.06	15	5.0	5.0	.0	44	25	2.1	3.6	83	--------
26	Mar 7	11	1.0	8.4	.04	16	5.4	8.5	.0	49	30	6.9	4.2	100	--------
Mar. 8	17	55	2.8	7.2	.10	13	--------	4.5	.0	37	23	2.9	3.4	82	--------
18	27	19	1.2	4.0	.09	7.6	1.6	5.8	.0	17	15	1.9	2.2	48	6.0
28	Apr. 7	12	1.0	6.0	.09	11	2.2	4.6	.0	28	20	2.6	2.6	70	4.4
Apr. 8	17	1	.9	4.6	.07	12	4.6	6.1	[c]9.6	17	23	.9	3.8	72	4.6
18	27	4	1.6	17	.10	13	5.0	--------	.0	34	26	1.0	3.6	92	4.7
28	May 7	2	1.0	12	.08	14	4.8	8.2	.0	36	25	1.0	3.8	86	4.5
May 8	17	18	1.0	7.6	.09	13	6.7	11	[c]16.	13	30	.0	4.4	98	4.5
18	27	1	.6	15	.05	14	4.8	8.7	.0	45	25	.5	3.8	95	4.5
28	June 6	--------	1.4	5.6	.06	12	4.5	7.6	.0	23	31	1.3	3.8	77	4.7
June 7	15	1	.7	10	.07	11	4.2	5.7	.0	32	23	1.5	3.6	76	4.7
17	26	2	.5	8.8	.05	13	4.2	7.6	.0	37	29	Tr.	4.4	85	4.5
27	July 6	3	.4	3.0	.05	14	5.0	6.9	[d]11	11	34	.2	4.2	83	4.6
July 7	17	4	.6	7.8	.04	14	6.0	7.2	.0	27	37	2.1	4.2	94	4.5
18	27	42	1.8	--------	.21	20	7.6	15	[c]4.8	57	37	1.8	5.8	174	4.3
28	Aug. 6	30	.9	--------	.03	15	7.0	11	[c]2.4	35	39	.0	5.8	123	4.2
Aug. 7	17	5	.6	10	.04	21	9.6	--------	.0	56	38	1.8	7.0	127	4.3
18	27	4	.6	12	.13	24	10	12	.0	78	37	3.0	7.8	139	4.3
28	Sept. 6	6	.8	15	.06	24	11	12	.0	78	37	2.2	8.4	147	4.2
Sept. 7	16	--------	1.8	--------	.06	--------	--------	--------	--------	--------	44	--------	6.0	--------	4.5
17	26	40	2.4	--------	.30	18	6.6	14	.0	66	31	.8	5.4	146	4.6
Mean	--------	14	1.2	8.8	.10	14	5.7	7.5	.0	40	30	2.2	4.9	95	--------

[a] Analyses Sept. 11 to Oct. 31, 1906, by R. B. Dole; Nov. 1, 1906 to Apr. 7, 1907, by R. B. Dole and M. G. Roberts; Apr. 8 to June 26, 1907, by Chase Palmer and M. G. Roberts; June 27, 1907, to Sept. 26, 1907, by R. B. Dole, Chase Palmer, and W. D. Collins.

[b] Gaging station at Mauch Chunk, Pa., 30 miles above.

[c] Abnormal; computed as HCO_3 in the average.

The following analyses of water from the Lehigh and some of its tributaries were made by R. J. Wysor in the years 1913–14. They are reduced here to standard form.

Analyses of water from Lehigh River basin.

1. Lehigh River at South Bethlehem, Pa. Mean of 12 analyses.
2. Little Lehigh River. Mean of two analyses.
3. Jordan Creek. Mean of two analyses.
4. Monocacy Creek. Mean of two analyses.
5. Saucon Creek. Mean of two analyses.

I. Parts per million.

	1	2	3	4	5
CO_3	20.2	50.2	24.1	50.2	43.8
SO_4	26.0	16.0	19.0	20.0	3.0
Cl	8.3	12.0	8.6	3.6	4.2
Ca	15.0	28.0	20.0	30.0	22.0
Mg	5.1	13.0	8.8	12.0	10.0
Na(K)	7.6	23.0	5.2	12.0	12.0
SiO_2	5.5	7.1	6.5	8.0	8.5
Fe_2O_3	3.1	1.5	1.6	1.8	2.8
	90.8	150.8	93.8	137.6	106.3

II. Percentage composition of dissolved solids.

	1	2	3	4	5
CO_3	22.25	33.29	25.69	36.48	41.21
SO_4	28.63	10.61	20.26	14.53	2.82
Cl	9.14	7.96	9.00	2.62	3.95
Ca	16.52	18.57	21.32	21.81	20.70
Mg	5.62	8.62	9.38	8.72	9.40
Na(K)	8.37	15.25	5.54	8.72	11.29
SiO_2	6.06	4.71	6.93	5.81	8.00
Fe_2O_3	3.41	.99	1.71	1.31	2.63
	100.00	100.00	100.00	100.00	100.00

Two additional analyses of water from the Delaware are available for comparison with the standard series, as follows:

Analyses of water from Delaware River.

1. At Port Jervis, N. Y. Analysis received from the Erie R. R., 1902.
2. Analysis by H. Wurtz, Am. Jour. Sci., 2d ser., vol 22, p. 125, 1856. Point of collection not stated, but probably at Trenton, N. J.

[Parts per million.]

	1	2
CO_3	6.8	25.5
SO_4	2.9	2.2
Cl	3.2	1.2
PO_4	----	1.5
Ca	2.1	10.8
Mg	1.4	4.3
Na	3.5	.7
K		1.8
SiO_2	6.0	8.40
Al_2O_3	2.1	.5
Fe_2O_3		----
	28.0	56.9

For Schuylkill River, which joins the Delaware at Philadelphia, there is one available analysis, made by Margaret D. Foster in the water-resources laboratory of the United States Geological Survey.

Analysis of water from Schuylkill River at Norristown, Pa.

	Parts per million.	Percentage composition.
CO_3	27.7	14.58
SO_4	87.0	45.79
Cl	11.0	5.79
NO_3	.8	.42
Ca	24.0	12.64
Mg	12.0	6.32
Na, K	19.0	10.00
Fe_2O_3	.5	.26
SiO_2	8.0	4.20
	190.0	100.00

The high sulphates in this water are due to drainage from coal mines.

Now, including the Raritan with the Delaware, we have the following table of analyses as reduced to percentages.

Analyses of water from the Raritan and Delaware.

1. Raritan River. Mean of 35 composites of 10 daily samples.
2. Delaware River at Port Jervis. Erie R. R. analysis.
3. Lehigh River at South Bethlehem. Mean of 37 composites of 10 daily samples.
4. Delaware River at Lambertville. Mean of 34 composites of 10 daily samples.
5. Delaware River at Trenton (?). H. Wurtz, analyst.

[Percentage composition of dissolved solids.]

	1	2	3	4	5
CO_3	29.48	24.28	21.01	32.95	44.70
SO_4	14.08	10.36	32.02	17.49	3.93
Cl	5.52	11.43	5.25	4.23	2.12
NO_3	2.23	----	2.38	1.60	----
PO_4	----	----	----	----	2.61
Ca	14.08	7.50	14.87	17.49	18.89
Mg	4.58	5.00	6.04	4.81	7.63
Na	9.27	12.50	8.03	6.70	1.26
K	1.76			1.46	3.12
SiO_2	18.77	21.43	9.41	13.12	14.92
Al_2O_3	----	7.50	----	----	.82
Fe_2O_3	.23		.99	.15	
	100.00	100.00	100.00	100.00	100.00
Salinity, parts per million	85	28	95	70	56.9

In columns 1 and 4 the alkalies are corrected by Palmer's determinations of potassium.

These analyses are hardly comparable. The Raritan clearly reflects its origin among the silicate rocks and sandstones of northern New Jersey. The Survey analyses of the Delaware (column 4), which drains part of the same territory, show the same high silica. They also show the influence of the Lehigh, which is contaminated by the drainage from coal mines. The sulphates in the Lehigh originate in this way and are in excess of the carbonates. Analysis No. 2 is somewhat misleading. The salinity is low, which is to be expected in a water taken near the sources of a stream; but that condition tends to distort the proportions of the several radicles. For silica that proportion is only 6 parts per million, and that of chlorine is 3.9. A small error in either of these figures would be magnified in the percentage column, which is most accurate for high salinities and less exact for low. As for the analysis by Wurtz, it is out of all relation to the others, and yet Wurtz was a good analyst. His determination of calcium phosphate, as it was given in the original unreduced analysis, is of very doubtful value. Phosphates have been found in other river waters, although they are rarely looked for; but never in so large an amount.

SUSQUEHANNA RIVER.

The Susquehanna is a river whose source lies mainly in a region of sedimentary rocks, in which the coal measures are conspicuous. Its basin covers an area of 27,400 square miles. Three sets of analyses of water taken at three different points, were made in the water-resources laboratory of the Survey, as follows:

Analyses of water from Susquehanna River at West Pittston, Pa.[a]

[Parts per million.]

Date (1906-7).		Turbidity.	Total iron (Fe).	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total dissolved solids.	Mean gage height (feet).[b]
From—	To—														
Oct. 28	Nov. 7	5	0.3	12	0.04	15	2.4	4.1	0.0	61	8.2	0.3	3.1	79	5.11
Nov. 8	16	3	1.0	10	.03	16	3.0	4.7	.0	62	8.1	.4	3.0	77	4.24
28	Dec. 7	8	.4	8.4	.03	15	2.8	4.4	.0	56	8.5	1.0	2.0	72	5.33
Dec. 8	17	37	1.4	10	.13	16	2.0	6.5	.0	58	12	3.0	4.1	79	8.11
19	28	12	.9	8.4	.14	16	1.6	6.5	.0	58	11	2.0	4.1	76	6.80
29	Jan. 7	150	5.1	10	.21	12	1.4	6.6	.0	47	10	3.0	3.6	68	11.50
Jan. 8	18	27	1.5	10	.19	13	1.6	5.0	.0	38	15	3.6	3.6	70	10.10
19	29	21	1.5	8.0	.16	14	1.6	5.5	.0	46	13	3.0	3.4	69	10.10
30	Feb. 10	2	.6	8.8	.14	19	2.4	5.4	.0	54	18	6.0	4.6	89	8.20
Feb 11	20	2	.3	16	.10	20	2.6	6.6	.0	72	13	4.0	4.6	95	5.60
21	Mar. 3	2	.4	8.2	.12	22	3.2	7.4	[c]2.9	81	12	2.2	5.0	100	4.10
Mar. 4	13	2	.7	9.0	.10	----------	3.2	----------	.0	83	12	3.2	5.9	103	3.40
14	23	65	2.6	12	.13	12	2.6	6.8	7.2	25	10	2.6	2.2	69	10.90
24	Apr. 2	33	1.8	5.4	.13	10	2.0	----------	.0	26	11	1.6	1.4	50	11.80
Apr. 3	14	8	.9	12	.21	16	2.2	6.8	.0	56	9.2	2.0	3.6	82	6.40
15	24	----------	.4	14	.19	21	3.4	6.3	.0	----------	17	2.0	4.2	98	6.10
25	May 4	43	1.5	15	.22	24	3.9	5.8	.0	----------	18	1.5	4.8	102	10.40
May 5	14	1	.5	18	.15	26	6.0	9.0	.0	96	18	1.7	4.2	134	7.50
15	24	2	.3	9.2	.29	12	4.2	9.0	[c]4.8	36	18	.0	5.0	80	5.60
25	June 3	2	.3	6.4	.15	----------	4.2	9.1	[c]4.8	35	19	Tr.	5.0	82	4.70
June 4	13	3	.4	12	.27	14	4.2	8.2	[c]4.8	43	20	Tr.	5.0	91	4.80
14	23	1	.2	10	.17	12	4.2	7.1	[c]12	27	17	Tr.	5.0	80	3.60
24	July 3	2	.3	3.4	.06	14	4.6	11	.0	54	20	Tr.	7.0	86	3.60
July 4	13	Tr.	----------	23	.05	26	5.8	11	.0	98	21	.8	6.6	148	4.00
14	24	Tr.	----------	14	.06	27	6.2	3.8	.0	----------	17	1.0	4.6	117	4.00
25	Aug 4	Tr.	----------	7.8	.06	26	4.4	3.5	.0	82	14	.8	4.6	108	3.30
Aug. 5	15	Tr.	----------	9.0	.05	24	4.8	4.6	.0	85	11	.8	4.6	106	2.70
16	25	Tr.	----------	5.4	.05	25	6.6	3.3	.0	85	11	.4	4.6	100	2.40
27	Sept. 6	8	----------	14	.11	26	2.9	9.1	.0	95	12	.3	5.4	120	2.30
Sept. 7	16	18	----------	8.4	.15	20	4.0	3.5	.0	66	13	.3	4.6	91	5.00
17	26	Tr.	----------	8.0	.06	17	3.0	5.5	.0	61	14	1.0	2.2	85	4.10
27	Oct. 9	5	.3	13	.06	20	1.8	----------	.0	67	12	Tr.	3.6	97	4.90
Oct. 10	22	3	.7	4.0	.06	17	2.9	1.9	.0	55	9.7	.5	2.4	71	6.30
Mean		14	1.0	10	.12	18	3.4	6.3	.0	63	14	1.5	4.2	90	----------

[a] Analyses Oct. 28, 1906, to Apr. 2, 1907, by R. B. Dole and M. G. Roberts; Apr. 3 to July 3, 1907, by Chase Palmer and M. G. Roberts; July 4 to Oct. 22, 1907, by R. B. Dole, Chase Palmer, and W. D. Collins.

[b] Gaging station at Wilkes-Barre, Pa., 10 miles above.

[c] Abnormal; computed as HCO_3, in the average.

Analyses of water from Susquehanna River at Williamsport, Pa.[a]

[Parts per million.]

Date (1906-7).		Turbidity.	Total iron (Fe).	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total dissolved solids.	Mean gage height (feet).
From—	To—														
Sept. 21	Sept. 30	8	0.1	7.6	0.10	17.0	4.6	9.9	0.0	40	41	0.5	5.4	110	0.93
Oct. 1	Oct. 10	7	.3	5.2	.10	17	6.2	8.0	.0	38	42	.9	2.0	123	1.14
11	21	13	.3	9.0	Tr.	14	3.0	7.6	.0	33	34	.6	4.6	97	1.86
22	31	9	.1	13	Tr.	8.4	1.8	6.0	.0	30	17	.4	2.6	68	3.15
Nov. 1	Nov. 10	5	.4	5.4	.13	10	2.2	7.7	.0	24	23	.5	3.4	63	2.03
11	21	6	.4	5.4	.16	11	3.0	----------	.0	27	21	.5	3.5	66	1.86
22	Dec. 2	8	.6	5.2	.11	8.0	1.8	----------	.0	20	17	.6	2.6	52	3.06
Dec. 3	12	14	1.3	5.6	.14	8.4	2.0	6.9	.0	17	18	.6	2.9	55	3.22
13	22	12	1.0	6.2	.15	7.8	2.4	4.9	.0	14	19	1.3	3.4	50	3.63
23	Jan. 1	11	.8	6.2	.11	8.4	2.4	5.4	.0	18	20	1.5	3.4	55	2.99
Jan. 2	11	19	2.1	6.2	.12	6.2	1.8	4.6	.0	15	16	1.9	2.9	45	6.78
22	Feb. 1	7	.6	5.8	.11	8.8	2.4	3.8	.0	15	18	1.4	2.4	49	4.96
Feb. 2	11	1	.2	4.0	.06	11	3.2	3.9	.0	18	27	1.8	4.1	62	2.79
12	21	4	.5	6.2	.09	13	3.6	5.7	.0	20	32	1.6	4.7	73	2.27
22	Mar. 3	2	.3	5.8	.10	14	3.8	5.5	.0	22	34	1.6	5.0	79	1.80
Mar. 4	13	3	.4	5.2	.19	14	4.0	6.0	.0	22	32	1.6	5.8	78	2.09
14	23	95	7.2	13	.25	9.6	1.8	5.5	----------	----------	18	.9	1.7	55	10.89
24	Apr. 3	13	1.0	14	.12	10	2.2	8.4	----------	----------	13	.4	7.7	69	7.20
Apr. 4	13	12	.6	8.0	.13	8.2	2.2	8.2	----------	----------	19	Tr.	3.4	52	3.37
14	23	1	.5	9.4	.17	9.0	2.1	8.8	----------	----------	20	1.2	3.4	62	2.64
24	May 3	4	1.0	16	.15	6.6	1.6	7.4	----------	----------	14	1.0	2.4	54	5.02
May 4	13	1	.9	7.4	.14	6.6	1.5	4.9	----------	----------	14	Tr.	2.4	41	4.67
14	23	3	.6	18	.12	7.5	1.7	7.7	----------	----------	16	Tr.	2.4	64	3.32
24	June 2	Tr.	.2	4.6	.12	9.6	2.2	----------	----------	----------	21	Tr.	2.4	55	2.22
June 3	12	9	1.4	3.6	.11	7.1	1.7	----------	.0	19	15	Tr.	2.2	44	4.60
13	23	1	.5	9.8	.12	9.0	2.2	7.4	----------	----------	20	Tr.	2.4	62	2.65
24	July 3	78	2.2	12	.12	11	2.0	----------	[b] 4.8	16	19	Tr.	3.6	73	3.72
July 4	13	8	----------	8.0	.06	8.7	3.4	2.6	.0	23	18	.6	2.2	57	2.98
14	23	4	----------	6.8	.11	13	4.5	2.2	.0	29	26	.2	3.4	72	1.61
24	Aug. 2	Tr.	----------	2.8	.15	17	4.9	2.5	.0	26	37	Tr.	4.2	81	1.04
Aug. 3	12	Tr.	----------	3.8	.12	17	5.4	2.8	.0	32	37	.2	4.8	93	.67
13	22	3	----------	5.6	.13	19	7.1	5.3	.0	40	45	.2	6.0	111	.50
23	Sept. 1	Tr.	----------	5.4	.16	22	7.9	6.0	.0	55	39	1.0	6.6	117	.36
Sept. 2	11	Tr	----------	8.6	.14	23	7.9	6.6	.0	55	42	.9	6.2	128	.58
12	21	2	----------	5.8	.05	22	6.4	5.8	.0	38	51	.0	7.8	122	1.19
22	Oct. 2	4	.3	11	.08	24	5.4	7.7	.0	44	----------	1.1	7.2	120	1.20
Oct. 3	11	8	.6	5.6	.06	17	3.6	----------	.0	----------	38	.5	6.2	90	2.03
Mean........		10	.9	7.6	.11	12	3.4	6.0	.0	28	26	.7	4.0	74	----------

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[a] Analyses Sept. 21 to Oct. 31, 1906, by R. B. Dole; Nov. 1, 1906, to Mar. 13, 1907, by R. B. Dole and M. G. Roberts; Mar. 14 to Apr. 3, 1907, by M. G. Roberts; Apr. 4 to July 3, 1907, by Chase Palmer and M. G. Roberts; July 4 to Oct. 11, 1907, by R. B. Dole, Chase Palmer, and W. D. Collins.

[b] Abnormal; computed as HCO_3 in the average.

Analyses of water from Susquehanna River at Danville, Pa.[a]

[Parts per million.]

Date (1906-7).		Turbidity.	Total iron (Fe).	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total dissolved solids.	Mean gage height (feet).
From—	To—														
Sept. 10	Sept. 20	3	----------	15.0	0.30	----------	----------	7.2	0.0	48	39	0.2	4.2	124	2.50
21	30	4	Tr.	14	Tr.	22.0	6.2	11	.0	55	53	.8	4.9	141	2.40
Oct. 1	Oct. 10	22	0.4	8.2	Tr.	----------	5.0	8.7	.0	48	35	.4	4.3	105	2.79
11	20	5	.1	6.4	Tr.	18	5.2	8.2	.0	47	28	1.5	5.0	98	2.90
21	31	29	2.3	7.0	.05	18	5.6	8.0	.0	67	17	1.3	4.8	98	5.01
Nov. 1	Nov. 10	8	.3	6.0	.06	13	2.6	6.6	.0	45	15	.0	3.1	73	4.71
11	20	9	.3	6.0	.05	16	3.4	7.2	.0	56	22	Tr.	4.7	88	3.95
21	30	19	1.8	3.8	.18	12	2.8	6.5	.0	41	13	.3	2.2	64	6.12
Dec. 1	Dec. 10	13	.6	7.6	.09	17	4.0	8.4	.0	51	24	2.6	5.8	92	5.25
11	21	19	1.0	9.6	.10	15	3.6	8.2	.0	50	20	2.6	5.3	86	5.75
23	Jan. 1	22	.8	14	.10	19	5.4	9.4	.0	52	25	5.6	8.6	112	4.83
Jan. 2	11	53	2.1	6.4	.19	9.4	3.0	4.7	.0	28	13	2.0	2.3	55	10.52
12	21	41	1.5	15	.26	15	4.0	16	[b] 14	40	22	3.0	5.8	121	7.14
22	31	8	.9	23	.10	30	----------	9.8	.0	76	42	11	16	178	6.10
Feb. 1	Feb. 11	12	.7	8.0	.06	27	6.0	10	.0	68	39	7.2	12	140	3.94
13	22	15	.7	5.2	.06	32	7.2	12	[b] 4.8	67	40	7.2	13	152	3.28
23	Mar. 4	6	.3	11	.06	25	6.4	8.0	.0	61	41	3.6	6.5	134	----------
Mar. 5	14	30	1.0	9.0	.05	26	6.4	12	.0	66	42	7.0	9.8	142	4.38
15	24	55	3.0	15	.15	6.4	1.4	4.9	.0	24	10	1.9	2.4	56	9.70
25	Apr. 3	19	1.4	6.4	.12	11	2.2	5.4	.0	34	14	2.0	3.4	62	9.24
Apr. 4	13	10	.5	6.0	.08	20	2.8	9.8	[b] 3.4	43	22	5.3	10	104	5.26
14	23	11	.6	12	.08	19	2.2	11	[b] Tr.	44	22	5.2	9.4	99	5.18
24	May 3	42	1.9	12	.13	12	1.0	8.2	.0	43	14	3.1	5.3	76	7.82
May 4	13	18	.8	12	.10	18	1.4	8.0	.0	48	18	3.0	7.0	95	6.37
14	23	8	.5	9.6	.06	19	1.6	13	.0	58	20	6.1	9.6	108	4.95
24	June 2	40	1.0	13	.18	22	1.6	12	.0	65	21	5.1	9.4	120	4.10
June 3	12	3	.3	7.2	.03	19	1.2	8.8	.0	48	21	6.2	11	100	4.36
13	22	3	.2	6.2	.05	25	4.0	13	.0	65	30	6.2	14	138	3.41
23	July 2	40	.4	4.0	.03	23	5.6	5.7	.0	----------	32	3.7	12	126	3.19
July 3	12	8	.8	6.0	.06	21	4.8	7.9	.0	51	31	2.8	10	116	3.86
13	23	8	.5	4.2	.06	23	5.6	5.2	.0	55	32	1.8	10	121	3.63
24	Aug. 2	1	.3	4.8	.06	22	5.0	9.9	[b] 6.0	41	37	1.8	11	122	3.08
Aug. 3	12	Tr.	.2	4.0	.05	28	6.8	9.0	.0	60	47	3.0	11	143	2.59
13	22	Tr.	.2	4.0	.05	32	9.8	7.7	.0	62	63	3.0	13	170	2.24
23	Sept. 1	Tr:	.1	2.8	.04	34	10	11	[b] 6.0	50	71	2.9	13	177	2.12
Sept. 2	11	7	.4	----------	.12	35	11	9.0	.0	79	71	2.9	11	----------	2.52
Mean........		16	.8	8.7	.09	21	4.6	8.9	.0	54	31	3.4	8.1	112	----------

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[a] Analyses Sept. 10 to Nov. 30, 1906, by R. B. Dole; Dec. 1, 1906, to Apr. 3, 1907, by R. B. Dole and M. G. Roberts; Apr. 4 to July 2, 1907, by Chase Palmer and M. G. Roberts; July 3 to Sept. 11, 1907, by R. B. Dole, Chase Palmer, and W. D. Collins.

[b] Abnormal; computed as HCO_3 in the average.

The following analyses are of water from the Susquehanna at a point above the others, and of one of its northern tributaries.

Analyses of waters of the Susquehanna basin.

1. Chenango River at Binghamton, N. Y. Analysis received from Erie R. R.
2. Susquehanna River at Sayre, Pa. Analysis by Kennicott Co. of Chicago.

[Parts per million.]

	1	2
CO_3	23.6	40.0
SO_4	12.0	11.0
Cl	14.0	9.0
Ca	16.0	22.0
Mg	1.2	3.9
Na(K)	13.0	8.4
SiO_2	18.0	10.0
$(Al, Fe)_2O_3$		2.0
	97.8	106.3

In the following table the analyses of Susquehanna waters are reduced to percentages of the anhydrous solids.

Percentage analyses of Susquehanna waters.

1. Chenango River at Binghamton.
2. Susquehanna River at Sayre.
3. Susquehanna River at West Pittston. Mean of 33 composite samples of 10 days each.
4. Susquehanna River at Williamsport. Mean of 37 composite samples of 10 days each.
5. Susquehanna River at Danville. Mean of 36 composite samples of 10 days each.

	1	2	3	4	5
CO_3	24.13	37.63	34.33	18.73	23.54
SO_4	12.26	10.35	15.55	35.28	27.53
Cl	14.32	8.47	4.67	5.43	7.19
NO_3			1.67	.95	3.02
Ca	16.36	20.69	20.00	16.28	18.64
Mg	1.23	3.67	3.77	4.61	4.08
Na	13.30	7.90	7.00	8.14	6.84
K					1.33
SiO_2	18.40	9.41	11.12	10.31	7.72
$(Al, Fe)_2O_3$		1.88	[a] 1.89	[a] .27	[a] .11
	100.00	100.00	100.00	100.00	100.00
Salinity, parts per million	97.8	106.3	90.	73.7	112.

[a] Fe_2O_3.

In analysis No. 5 the alkalies are corrected by Palmer's determination of potassium.

These analyses show clearly that the water of the Susquehanna is now far from normal. The very high figure for sulphates in the last three analyses is due to contamination from the drainage of coal mines. In analyses 1 and 2 it is much lower, and No. 2 approaches nearly what may be called a normal river water. The low salinity, however, suggests that a large part of the water emerges from shales and sandstones, and that limestones are of less influence than is usual in sedimentary areas. The proportion of silica also leads to the same conclusion.

MINOR TRIBUTARIES OF CHESAPEAKE BAY.

Between the Susquehanna and the Potomac numerous streams enter Chesapeake Bay, and for three of them analyses by Penniman and Browne are available.[15] Reduced to standard form they appear in the following table.

Analyses of three Maryland waters.

1. Big Elk Creek at Elkton.
2. Gunpowder River; water from reservoir at Loch Raven. Average of daily samples during May, 1912.
3. Patapsco River, Baltimore County. Average as in No. 2.

	Parts per million.			Percentage composition.		
	1	2	3	1	2	3
CO_3	14.4	45.5	2.6	27.38	35.80	3.74
SO_4	1.8	4.9	5.9	3.43	3.86	8.49
Cl	4.4	3.3	3.7	8.33	2.60	5.33
NO_3	3.7	3.3	3.1	7.04	2.60	4.46
Ca	5.2	18.3	14.0	9.89	14.39	20.14
Mg	2.0	3.9	3.4	3.81	3.07	4.89
Na	6.6	13.0	6.5	12.55	10.23	9.35
Al_2O_3	1.1	3.4	2.6	2.09	2.67	3.74
Fe_2O_3	.4	.1	.1	.76	.08	.15
SiO_2	13.0	31.4	27.6	24.72	24.70	39.71
	52.6	127.1	69.5	100.00	100.00	100.00

These waters, as shown by the high proportion of silica and sodium, derived their saline matter from igneous and crystalline metamorphic rocks. The nitrates in them are in excess of the usual or normal amounts. Is this peculiarity due to pollution or to small experimental errors that have been magnified in the percentage column?

POTOMAC RIVER.[16]

The headwaters of the Potomac in Maryland and West Virginia are seriously contaminated by drainage from coal mines, sawmills, pulp mills, tanneries, and other industrial enterprises. Eight analyses, however, are worth citation, as follows. All are reduced to standard form, with the carbonates normal.

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[15] Maryland Geol. Survey, vol. 10, pp. 539, 540, 1918.

[16] U. S. Geol. Survey Water-Supply Paper 192, 1901, is devoted to a general description, by several authors, of Potomac River. It contains many sanitary analyses of the waters and some "mineral" analyses, but the latter are unsatisfactory. The figures indicate that the samples analyzed had been imperfectly filtered and retained much sediment.

Analyses of water from the upper Potomac basin.

1. North Branch of the Potomac, Garrett County, Md. Mean of two analyses.
2. North Branch of the Potomac at Keyser, W. Va. Much polluted.
3. Savage River, Garrett County, Md. Mean of 2 analyses.
4. New Creek at Keyser, W. Va.
5. Wills Creek at Ellerslie, Md. Much polluted.
6. Wills Creek near Cumberland, Md.
7. Evitts Creek at Evitts, Md.
8. Evitts Creek near Cumberland, Md. Analyses 1, 3, and 7 by Penniman and Browne, Maryland Geol. Survey, vol. 10, pp. 539, 541, 1918. Nos. 2, 4, 5, 6, and 8, from Baltimore & Ohio R. R.

I. Parts per million.

	1	2	3	4	5	6	7	8
CO_3	8.36	16.2	17.24	55.4	21.5	21.0	31.7	74.2
SO_4	10.1	25.4	9.55	12.1	14.2	9.2	3.7	11.5
Cl	1.1	6.0	1.95	9.9	2.9	4.9	1.4	3.0
NO_3			.35					
Ca	4.7	14.2	9.25	33.8	15.2	12.8	17.3	41.3
Mg	1.65	2.9	2.45	4.9	3.0	3.0	2.2	7.8
Na	3.75	6.4	3.90	6.5	1.9	3.2	3.2	1.9
K								
Al_2O_3	1.23		.94				.8	
Fe_2O_3	.02	13.0	.14	3.9	8.0	3.4	.1	12.0
SiO_2	5.7		9.25				5.4	
	36.61	84.1	55.02	126.5	66.7	57.5	65.8	151.7

Analyses of water from the upper Potomac basin—Continued.

II. Percentage composition of dissolved solids.

	1	2	3	4	5	6	7	8
CO_3	22.84	19.26	31.34	43.79	32.20	36.57	48.17	48.93
SO_4	27.59	30.13	17.36	9.54	21.30	15.97	5.62	7.56
Cl	3.01	7.15	3.54	7.86	4.35	8.49	2.13	1.99
NO_3			.64					
Ca	12.84	16.92	16.81	26.73	22.79	22.25	26.29	27.23
Mg	4.50	3.43	4.45	3.86	4.53	5.27	3.34	5.12
Na	10.24	7.66	7.09	5.11	2.81	5.50	4.86	1.28
K								
Al_2O_3	3.36		1.71				1.22	
Fe_2O_3	.05	15.45	.25	3.11	12.02	5.95	.15	7.89
SiO_2	15.57		16.81				8.22	
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

From Cumberland to Chesapeake Bay the Potomac forms the southern boundary of Maryland. For its water at Cumberland there is, first, the series of analyses by Dole and his colleagues, covering an entire year, as follows:

Analyses of water from Potomac River at Cumberland, Md.[a]

[Parts per million.]

Date (1906-7).		Turbidity.	Total iron (Fe).	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potasium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total dissolved solids.	Mean gage height (feet).
From—	To—														
Sept. 11	Sept. 20	10	1.4	9.0	Tr.	39	7.4	8.5	0.0	46	96	1.7	12	204	3.1
21	30	6	.1	12	Tr.	45	8.6	12	.0	51	117	.5	16	234	2.6
Oct. 1	Oct. 11	18	2.1	6.0	0.20	33	5.6	4.9	.0	51	59	.5	9.0	157	2.4
12	21	21	1.7	8.0	.10	30	4.8	9.3	.0	43	62	.8	11	150	2.7
22	31	8	.9	6.4	.20	19	3.2	7.4	.0	37	34	.3	5.0	97	3.5
Nov. 1	Nov. 10	8	1.2	7.4	.05	27	4.4	8.0	.0	45	53	.0	9.5	134	3.5
12	21	14	1.1	5.0	.14	29	4.6	8.5	.0	42	63	Tr.	9.8	144	3.6
22	Dec. 2	8	.9	7.0	30	20	3.8	--------	.0	22	36	1.0	6.7	98	3.4
Dec. 3	12	29	1.6	10	.20	20	3.4	--------	.0	30	34	1.0	7.2	100	4.1
13	22	27	1.7	13	.20	13	2.6	6.6	.0	39	24	.9	4.1	80	5.7
23	Jan. 1	34	2.1	5.2	.16	17	3.8	4.9	.0	36	42	1.5	3.8	84	4.3
Jan. 2	11	22	2.1	5.2	.20	15	3.4	4.4	.0	32	37	1.4	2.8	79	5.0
12	21	80	6.6	5.8	.15	12	2.6	4.7	.0	19	26	2.0	3.8	63	7.4
22	31	28	2.8	14	.06	23	5.8	19	[b] 12	22	76	1.4	4.4	159	5.1
Feb. 1	Feb. 10	26	1.9	14	.09	23	5.4	4.4	.0	25	64	1.8	3.4	128	3.7
11	20	26	1.9	6.8	.08	23	5.2	4.3	.0	29	63	1.8	3.4	122	3.6
21	Mar. 2	33	1.6	5.8	.08	22	4.8	3.2	.0	28	55	1.2	3.8	111	3.9
Mar. 3	12	37	2.1	5.8	.10	17	3.2	3.3	.0	28	38	1.9	2.9	84	4.8
13	23	280	9.1	16	.30	14	2.8	4.3	.0	20	39	2.0	1.4	89	8.0
24	Apr. 4	21	1.9	4.8	.06	30	7.4	4.4	.0	11	97	1.4	3.8	155	5.0
Apr. 5	14	7	3.2	7.2	.09	31	4.2	10	.0	22	93	0.9	5.3	168	4.0
15	24	35	4.4	6.2	.12	18	3.8	9.9	.0	23	45	1.0	4.8	100	3.9
25	May 4	21	5.8	11	.15	17	3.0	8.0	.0	26	36	.9	3.4	90	4.0
May 5	14	13	2.6	16	.10	17	3.2	7.7	.0	30	39	.8	2.9	101	4.8
15	24	11	3.0	6.2	.12	20	4.0	17	.0	43	45	.7	8.2	118	4.4
25	June 3	21	2.5	6.6	.14	17	3.0	26	.0	53	40	.6	14	134	4.2
June 4	14	20	4.6	8.4	.14	17	3.0	7.4	.0	25	41	1.1	2.4	91	4.2
15	24	10	1.4	7.0	.10	20	4.4	7.9	.0	25	51	1.0	4.1	107	3.9
25	July 5	3	.3	7.0	.06	32	6.8	10	[b] 7.2	28	82	Tr.	6.0	166	3.8
July 6	15	3	2.6	8.8	.08	38	--------	--------	[b] 2.4	29	99	.6	6.2	186	3.9
16	25	35	7.9	5.0	.22	21	4.0	--------	[b] 9.6	9.0	41	.0	3.8	98	3.8
27	Aug. 5	15	3.5	4.2	.06	24	4.6	5.7	[b] 8.4	13	50	Tr.	5.4	113	3.2
Aug. 6	15	25	9.6	6.8	.11	--------	--------	12	.0	41	54	.2	7.4	132	2.6
16	25	40	8.8	7.4	.06	41	7.8	14	.0	48	91	1.0	12	197	2.3
26	Sept. 4	8	2.1	--------	.60	32	6.4	--------	.0	72	57	.6	8.4	194	2.3
Sept. 5	14	18	1.8	12	.09	42	--------	20	.0	61	95	.4	13	215	2.5
Mean		28	3.0	8.2	.14	24	4.6	9.0	.0	36	58	.9	6.4	130	--------

[a] Analyses Sept. 11 to Nov. 21, 1906, by R. B. Dole; Nov. 22, 1906 to Apr. 4, 1907, by R. B. Dole and M. G. Roberts; Apr. 5 to July 5, 1907, by Chase Palmer, and M. G. Roberts; July 6 to Sept. 14, 1907, by R. B. Dole, Chase Palmer, and W. D. Collins.

[b] Abnormal; computed as HCO_3 in the average.

A similar table of analyses of water from the Potomac at Great Falls, 16 miles above Washington, made in the water-resources laboratory of the United States Geological Survey, is as follows. The samples were taken at the filtration plant of Washington. An earlier set of 12 analyses by R. Outwater is replaced by this.

Analyses of water from Potomac River near Washington, D. C.

[Parts per million. Analyses by Margaret D. Foster.]

Date (1921).	Total dissolved solids.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium (Na).	Potassium (K).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Chloride radicle (Cl).	Nitrate radicle (NO_3).
Jan. 1-10	84	8.6	0.15	17	3.9	[a]3.3	-----	48	17	2.3	6.0
11-20	83	7.5	.08	18	4.1	[a]3.8	-----	55	15	2.6	4.3
21-31	89	9.4	.08	18	4.2	2.4	1.4	56	15	2.6	3.1
Feb. 1-10	88	9.5	.08	18	4.2	2.8	1.2	55	16	2.7	3.1
11-19	86	9.6	.07	18	4.1	2.5	1.4	54	15	2.8	3.3
20-28	85	8.2	.08	18	4.1	2.2	1.3	51	16	2.8	2.8
Mar. 1-10	83	7.7	.06	18	4.1	2.3	1.4	52	15	2.8	2.8
11-20	77	8.1	.06	15	3.6	2.1	1.0	39	17	2.6	3.2
21-31	79	6.4	.05	17	3.8	2.2	1.2	47	16	2.5	3.0
Apr. 1-10	84	6.7	.05	19	4.2	2.4	1.2	57	15	2.8	2.5
11-20	90	5.8	.05	21	4.8	2.9	1.7	65	15	2.8	2.5
21-30	96	5.2	.04	23	5.5	3.0	1.5	72	18	2.9	2.2
May 1-10	94	5.5	.04	22	5.0	2.4	1.9	68	18	3.1	2.5
11-20	76	7.1	.04	16	3.8	2.1	1.6	47	14	2.3	2.9
21-31	75	9.2	.09	15	3.7	2.1	1.3	43	14	2.3	3.3
June 1-10	87	8.6	.09	19	4.1	2.7	1.4	53	18	2.6	3.3
11-20	95	7.8	.03	21	4.9	2.4	1.3	64	16	3.0	2.9
21-30	105	4.2	.03	26	5.7	2.3	1.2	85	15	3.2	2.1
July 1-10	117	4.4	.02	28	6.2	2.3	.9	88	22	3.5	2.5
11-20	122	7.7	.07	27	6.3	3.4	1.4	77	27	3.3	3.1
21-31	118	5.8	.07	26	6.0	3.2	1.4	74	26	3.5	3.3
Aug. 1-10	120	5.0	.08	26	6.1	3.6	.9	83	21	3.2	2.5
11-20	111	7.0	.08	23	5.7	3.5	1.2	69	23	3.1	2.8
21-31	113	6.4	.06	24	6.2	3.5	1.0	74	21	3.3	2.5
Sept. 1-10	125	4.9	.06	28	7.1	3.7	1.4	93	22	4.1	1.0
11-20	121	4.4	.12	28	7.5	3.8	1.0	98	20	4.3	1.4
21-31	126	5.3	.12	30	7.0	3.5	1.9	98	22	4.3	1.9
Oct. 1-10	117	6.9	.12	27	6.3	3.4	1.7	80	25	3.8	2.9
11-20	124	6.3	.12	29	6.6	3.4	1.8	92	21	4.0	3.2
21-31	134	4.3	.08	32	7.5	3.9	2.0	104	24	4.5	1.9
Nov. 1-10	140	3.8	.10	34	8.1	3.6	2.2	110	26	5.0	1.4
11-20	145	5.5	.07	34	8.1	4.3	1.6	109	28	5.5	1.9
21-30	132	4.6	.06	31	6.8	3.9	1.6	95	29	5.3	1.9
Dec. 1-10	112	6.2	.07	25	6.0	2.9	1.8	74	24	4.2	2.3
11-20	90	7.2	.08	18	4.5	2.8	.8	43	24	2.9	4.6
21-31	89	7.3	.08	18	4.8	2.8	.7	51	20	2.7	4.8
Average	-----	6.6	.07	23.0	5.4	2.9	1.4	70	20	3.3	3.8

[a] Includes potassium.

For the water of the main trunk of the Potomac there are the following additional data.

Analyses of water from the Potomac.

1. At Cumberland, Md.
2. At Brunswick, Md. Both analyses received from Baltimore & Ohio Railroad.

	Parts per million.		Percentage composition.	
	1	2	1	2
CO_3	40.7	50.6	24.11	25.72
SO_4	60.2	54.6	35.67	34.53
Cl	6.9	5.0	4.12	3.15
Ca	33.8	31.8	20.03	20.15
Mg	8.8	10.8	5.24	6.83
Na	8.7	3.2	5.16	2.04
K				
SiO_2	9.6	12.0	5.67	7.58
(Al, Fe) $_2O_3$				
	168.7	158.0	100.00	100.00

The largest tributary of the Potomac is the Shenandoah, which has its principal source near Staunton, Va., and enters the Potomac at Harpers Ferry. Its basin is in a sedimentary area, with much limestone, and that condition is reflected in the composition of its waters. Two analyses from the headwaters of the Shenandoah have been received from the Baltimore & Ohio Railroad, and with these, for convenience, an analysis of a small stream near Washington is tabulated. The figures are as follows:

Analyses of waters from the Shenandoah basin, etc.

1. Lewis Creek at Staunton, Va.
2. North River at Bluffs, Va. Not to be confused with another North River which enters the James near Lexington.
3. Pimmit Run near East Falls Church, Va. Analysis by C. H. Kidwell, of the U. S. Geological Survey. Reduced here to normal carbonates.

	Parts per million.			Percentage composition.		
	1	2	3	1	2	3
CO_3	127.4	163.4	12.3	54.06	57.00	22.01
SO_4	9.4	5.3	3.4	4.00	1.85	6.08
Cl	5.9	6.4	3.8	2.50	2.25	6.79
NO_3	-------	-------	.5	-------	-------	.89
Ca	71.9	69.1	3.4	30.52	24.12	6.08
Mg	10.2	25.2	3.1	4.32	8.80	5.55
Na(K)	3.8	4.2	4.0	1.63	1.45	7.16
SiO_2	7.0	13.0	25.0	2.97	4.53	44.72
(Al, Fe) $_2O_3$			-------			-------
Fe_2O_3	-------	-------	.4	-------	-------	.72
	235.6	286.6	55.9	100.00	100.00	100.00

Analyses 1 and 2 are of typical limestone waters, with high salinity, and calcium carbonate largely in excess of all other saline matter. Analysis 3 is less definite in character, but the water is evidently derived from silicate rocks. Its salinity, 55.9 parts per million, is typically low.

For the Shenandoah itself, the analyses by Dole and his colleagues appear in the following table:

Analyses of water from Shenandoah River at Millville, W. Va.[a]

[Parts per million.]

Date (1906-7).		Turbidity.	Total iron (Fe).	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potasium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total dissolved solids.	Mean gage height (feet).
From—	To—														
Sept. 12	Sept. 21	17	0.3	16	Tr.	35	11	5.0	0.0	156	3.6	2.1	2.6	149	1.4
22	Oct. 1	12	.2	12	0.10	35	12	6.2	.0	160	3.4	2.0	3.2	150	1.3
Oct. 2	11	42	.8	19	.05	33	9.4	5.8	.0	142	5.1	2.6	3.0	146	2.2
12	21	80	2.1	20	.20	28	8.0	6.0	.0	118	6.1	2.1	2.4	131	3.9
22	31	90	2.6	20	.20	28	7.4	5.8	.0	116	4.6	3.4	2.4	131	4.6
Nov. 1	Nov. 10	9	Tr.	19	Tr.	38	6.8	5.7	Tr.	163	6.1	3.0	2.4	162	2.2
11	20	9	.1	16	.05	42	7.6	4.9	6.0	161	5.8	3.0	2.4	172	1.8
21	30	37	1.4	14	.20	29	7.2	5.2	Tr.	122	6.5	3.0	2.6	126	2.9
Dec. 1	Dec. 10	7	.1	16	.05	37	9.8	5.5	6.0	147	7.1	3.2	2.6	155	1.7
11	20	25	.3	19	.06	36	11	5.7	.0	155	5.9	3.2	2.6	157	2.4
21	30	27	.5	13	.16	30	8.0	3.2	Tr.	120	5.4	3.5	2.2	124	2.7
31	Jan 10	28	1.0	12	.14	30	7.4	4.3	.0	120	5.9	3.0	2.6	126	2.9
Jan. 11	20	27	.9	14	.10	32	7.6	4.1	.0	129	6.6	3.0	2.8	136	3.1
21	30	28	1.1	11	.12	31	7.0	3.3	.0	120	4.8	3.0	2.4	123	3.2
31	Feb. 9	10	.4	10	.08	----------	10	4.1	.0	144	5.8	3.2	3.0	151	2.2
Feb. 10	19	9	.5	14	.06	36	9.4	4.9	5.8	137	8.1	3.6	3.4	148	2.5
20	28	11	.4	17	.07	36	9.0	5.4	.0	145	7.1	4.2	3.0	150	2.2
Mar. 2	Mar. 11	----------	3.7	16	.13	34	8.4	4.9	.0	142	6.9	4.3	2.9	146	2.5
12	21	75	1.5	10	.16	31	7.4	4.7	.0	127	5.3	4.1	2.9	126	3.3
22	31	19	.5	16	.05	30	7.8	4.7	2.4	122	6.1	3.7	2.3	132	2.4
Apr. 1	Apr. 10	11	1.1	20	.07	35	9.6	9.1	.0	----------	6.6	3.7	2.2	154	----------
11	20	75	2.1	26	.13	28	6.4	5.8	4.8	107	5.9	3.4	3.8	138	----------
21	30	4	.2	20	.07	31	7.6	6.0	4.8	110	5.6	2.0	4.2	138	----------
May 1	May 11	5	.3	18	.06	32	8.0	6.9	3.6	116	5.9	2.6	3.8	137	----------
12	21	3	.3	16	.05	28	7.8	8.5	.0	122	6.1	1.7	3.0	134	----------
22	31	9	.4	12	.06	31	7.6	----------	.0	123	4.9	2.3	3.0	134	----------
June 1	June 10	150	4.0	14	.06	24	5.4	6.3	.0	102	5.8	2.0	3.0	112	----------
11	20	85	1.9	11	.08	14	5.4	5.4	.0	71	5.3	Tr.	1.8	78	----------
21	30	2	.3	14	.08	32	9.2	6.6	2.4	127	4.9	1.8	3.6	139	----------
July 1	July 10	15	.5	14	.05	26	5.6	13	4.8	108	7.9	1.3	2.6	122	1.8
11	20	7	.2	11	.04	36	----------	11	4.8	142	8.1	1.5	3.0	149	1.5
21	31	5	.2	11	.03	37	9.8	12	.0	159	8.7	2.0	4.2	158	1.4
Aug. 1	Aug. 10	38	.6	8.6	.03	35	----------	8.8	.0	149	8.4	1.0	3.8	145	1.1
11	20	4	.3	8.6	.03	37	----------	9.0	.0	152	8.1	2.1	3.4	152	1.3
21	30	20	.4	13	.05	38	7.8	12	2.4	149	7.9	2.4	3.8	158	1.4
31	Sept. 9	80	1.6	15	.06	37	7.4	13	.0	149	7.9	2.1	6.6	160	1.3
Mean		31	.9	15	08	32	8.2	6.7	1.3	132	6.2	2.6	3.0	140	----------

[a] Analyses Sept. 12 to Dec. 10, 1906, by R. B. Dole; Dec. 11, 1906, to Mar. 31, 1907, by R. B. Dole and M. G. Roberts; Apr. 1 to June 30, 1907, by Chase Palmer and M. G. Roberts; July 1 to Sept. 6, 1907, by R. B. Dole, Chase Palmer, and W. D. Collins.

For the northern tributaries of the Potomac there are seven analyses by Penniman and Browne.[16] In two of these, representing the waters of Antietam Creek and Monocacy River, excessive amounts of NO_3 are reported, and the acid and basic radicles fail to balance. It seems probable that the apparent error is due to a misplaced decimal point. On applying the necessary correction, 14.3 to 1.43 in one case, 12.6 to 1.26 in the other, the analyses become rational. The corrected analyses appear in the following table. All the localities named are in Maryland.

Analyses of water from northern tributaries of the Potomac.

1. Conococheague Creek at Williamsport.
2. Catoctin Creek at Catoctin.
3. Little Antietam Creek at Fiddlesburg, near Hagerstown.
4. Antietam Creek at Keedysville.
5. Fishing Creek. Water from Frederick city public supply. Drawn from a tap on a farm 4 miles south of reservoir, before mixing with the Tuscarora Creek supply.
6. Tuscarora Creek near Frederick.
7. Monocacy River near Frederick.

I. Parts per million.

	1	2	3	4	5	6	7
CO_3	52.8	34.2	96.0	99.6	7.2	6.0	52.2
SO_4	9.3	18.1	10.1	11.8	.2	1.8	7.2
Cl	5.0	8.4	4.2	5.7	1.6	1.9	4.0
NO_3	1.8	2.2	9.0	1.4	--------	--------	1.3
Ca	23.3	13.2	47.2	50.2	2.1	1.4	29.2
Mg	9.4	5.6	15.4	10.9	.1	.9	3.8
Na	6.2	6.9	6.4	7.7	3.0	3.2	6.0
Al_2O_3	.4	.8	1.1	2.8	1.9	1.1	.4
Fe_2O_3	.1	--------	.1	.1	.2	.1	--------
SiO_2	5.0	14.4	10.8	31.4	4.0	3.6	11.6
	113.3	103.8	200.3	221.6	20.3	20.0	115.7

II. Percentage composition of dissolved solids.

	1	2	3	4	5	6	7
CO_3	46.60	32.95	47.93	44.94	35.47	30.00	45.11
SO_4	8.21	17.44	5.04	5.33	.98	9.00	6.23
Cl	4.41	8.10	2.09	2.57	7.88	9.50	3.46
NO_3	1.59	2.12	4.49	.63	--------	--------	1.12
Ca	20.56	12.71	23.57	22.66	10.34	7.00	25.23
Mg	8.30	5.39	7.69	4.92	.49	4.50	3.29
Na	5.47	6.65	3.20	3.47	14.79	16.00	5.18
Al_2O_3	.35	.77	.55	1.26	9.36	5.50	.35
Fe_2O_3	.09	--------	.05	.05	.98	.50	--------
SiO_2	4.42	13.87	5.39	14.17	19.71	18.00	10.03
	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Now, the basin of the Potomac being considered as a unit, the following table will show the progressive changes in the character of its water from Cumberland to Great Falls, 16 miles above Washington. All the analyses are reduced to the standard percentage form.

Summary of analyses of Potomac water.

1. Potomac River at Cumberland. Mean of 36 composite analyses.
2. Potomac River at Brunswick.
3. Shenandoah River at Millville. Mean of 36 composite analyses.
4. Potomac River above Great Falls. Mean of 36 composite analyses. In analyses 1 and 3 the alkalies are corrected by Palmer's determination of potassium.

	1	2	3	4
CO_3	13.69	25.72	47.22	34.10
SO_4	44.85	34.53	4.43	19.82
Cl	4.95	3.15	2.14	3.27
NO_3	.70	----------	1.86	3.77
Ca	18.56	20.15	22.85	22.79
Mg	3.56	6.83	5.86	5.35
Na	6.11	2.04	3.86	2.88
K	1.08		1.00	1.39
SiO_2	6.35		10.71	6.54
Al_2O_3	----------	7.58	----------	----------
Fe_2O_3	.15		.07	.09
	100.00	100.00	100.00	100.00
Salinity, parts per million	130	158	140	100.9

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[16] Maryland Geol. Survey, vol. 10, pp. 540–542, 1918.

In this table column No. 1 shows the effect of contamination from the drainage of coal mines, pulp mills, etc. In No. 2 the influence of less contaminated or uncontaminated affluents appears. No. 3 represents a water from a limestone region, in which, however, as shown by the relatively high silica, accretions from silicate rocks east of the Shenandoah Valley are indicated. No. 4 gives the quality of the water as modified by the Shenandoah and also by other tributaries. In short, the water has become an average or normal water, much like that of other large streams which derive their dissolved solids from a variety of different sources.

SUMMARY FOR MIDDLE ATLANTIC SLOPE.

In order to compare the analyses of waters from this area the following table has been constructed. Each of the rivers has been taken at the lowest point at which samples for analysis were collected. Tributary streams are omitted.

Comparative analyses for the middle Atlantic slope.

1. Hudson River at Hudson, N. Y.
2. Raritan River at Bound Brook, N. J.
3. Delaware River at Lambertville, N. J.
4. Susquehanna River at Danville, Pa.
5. Potomac River at Great Falls, Md.

[Percentage composition of dissolved solids.]

	1	2	3	4	5
CO_3	35. 45	29. 48	32. 95	23. 54	34. 10
SO_4	15. 84	14. 08	17. 49	27. 53	19. 82
Cl	3. 96	5. 52	4. 23	7. 19	3. 27
NO_3	. 79	2. 23	1. 60	3. 02	3. 77
Ca	20. 79	14. 08	17. 49	18. 64	22. 79
Mg	3. 76	4. 58	4. 81	4. 08	5. 35
Na	6. 53	9. 27	6. 70	6. 84	2. 88
K	1. 78	1. 76	1. 46	1. 33	1. 39
SiO_2	10. 90	18. 77	13. 12	7. 72	6. 54
Al_2O_3					
Fe_2O_3	. 20	. 23	. 15	. 11	. 09
	100. 00	100. 00	100. 00	100. 00	100. 00
Salinity, parts per million	108	85	70	112	100. 9

Although these rivers are blends of different waters, the analyses tell something of their geologic origin. In the Hudson the high silica and alkalies came from crystalline rocks at its northern and eastern sources, and the sulphates came in great measure from the sedimentary formations in the valley of the Mohawk. The Raritan and Delaware derived their silica and alkalies mainly from the crystalline rocks and sandstones of northern New Jersey, but the Delaware also shows the influence of the contaminated Lehigh. In the Susquehanna the contamination due to coal-mine drainage is very evident. It is unfortunate that no analyses are available giving the composition of the Susquehanna at some points below Harrisburg and nearer its mouth. The Potomac shows a more complete blending of its component waters than appears in the analyses of the other streams. All five of these streams show a lower salinity than is usually found in rivers emerging from entirely sedimentary areas.

SOUTH ATLANTIC SLOPE AND EASTERN GULF OF MEXICO.

For the purpose of this memoir the south Atlantic slope is regarded as extending from the basin of James River in Virginia to that of Pearl River in Mississippi. This region is a well-defined hydrochemical province, in which the large streams are chemically similar and much alike in geologic origin. The peninsula of Florida, which belongs here geographically, is, however, quite distinct in the character of its waters and must be considered a separate province, to be studied later.

JAMES RIVER.

James River, which drains an area of about 9,700 square miles in southern Virginia, owes its chemical character in great part to the crystalline rocks of the eastern Appalachians. It is slightly modified, however, by contributions from the limestone region of Rockbridge and adjacent counties. For the James itself we have the analyses made by Dole and his associates in the United States Geological Survey, which appear in the next table.

Analyses of water from James River at Richmond, Va.[a]

[Parts per million.]

Date (1906-7).		Tur-bidity.	Total iron (Fe).	Silica (SiO₂).	Iron (Fe).	Calcium (Ca).	Magne-sium (Mg).	Sodium and po-tassium (Na+K).	Car-bonate radicle (CO₃).	Bicar-bonate radicle (HCO₃).	Sulphate radicle (SO₄).	Nitrate radicle (NO₃).	Chlorine (Cl).	Total dissolved solids.	Mean gage height (feet).
From—	To—														
Sept. 10	Sept. 19	38	2.5	25	0.6	17	4.0	6.8	0.0	72	4.3	Tr.	2.4	100	0.7
20	29	43	2.8	30	1.0	17	4.2	6.3	.0	76	5.1	0.4	2.2	119	.6
30	Oct. 8	400	21	54	1.3	17	3.2	4.7	.0	69	12	.4	Tr.	146	2.8
Oct. 10	19	70	3.5	15	.5	15	2.6	5.8	.0	58	5.1	.9	1.9	83	1.1
20	29	270	7.1	21	.8	12	2.0	6.7	.0	----------	3.9	.9	1.4	93	7.2
30	Nov. 8	14	1.1	31	.3	15	3.6	6.9	.0	68	5.6	.7	2.9	98	1.0
Nov. 9	18	12	0.5	25	.2	16	4.0	6.6	.0	71	10	.5	2.2	97	.6
19	28	260	8.6	14	.9	11	1.4	4.6	.0	46	5.8	.4	1.4	71	2.1
29	Dec. 8	14	0.8	18	.3	13	2.4	3.9	.0	58	4.6	.2	.2	76	.7
Dec. 9	18	11	0.9	17	.25	14	4.2	3.0	.0	60	5.1	.1	2.2	79	.6
19	29	47	3.0	11	.4	13	3.0	1.8	.0	54	5.9	.2	2.2	71	1.3
30	Jan. 8	55	5.8	16	.8	11	2.8	----------	.0	46	4.9	.7	1.9	71	1.5
Jan. 9	19	9	1.3	15	.23	13	3.2	----------	.0	56	4.6	.4	1.9	73	1.1
20	29	21	2.3	12	.26	12	2.8	----------	0	50	4.3	.5	1.8	63	1.2
30	Feb. 8	6	0.8	14	.35	13	3.2	----------	.0	53	5.1	Tr.	2.4	70	1.0
Feb. 9	18	24	1.2	11	.6	13	3.4	3.6	.0	55	5.1	Tr.	3.0	69	1.0
19	Mar. 1	17	0.6	13	.18	13	2.0	4.7	.0	51	8.8	.9	1.7	70	1.0
Mar. 3	12	55	1.8	17	.67	12	2.3	6.1	.0	49	7.7	.7	1.0	76	1.4
12	22	55	1.8	13	.23	12	2.5	6.1	.0	51	5.8	.6	1.0	69	1.8
23	Apr. 2	38	1.9	16	.19	14	2.5	6.8	.0	59	12	.3	1.4	83	.9
Apr. 3	12	190	8.6	24	.7	13	1.8	11	.0	60	8.4	.0	2.6	97	3.5
13	22	42	2.1	26	.16	13	1.6	10	.0	59	5.6	.0	1.8	91	1.6
23	May 3	80	2.7	----------	.7	16	3.2	14	[b] 17	55	7.4	Tr.	3.4	174	1.3
May 4	13	220	10	22	1.8	11	1.4	6.6	.0	52	6.6	.0	2.2	88	1.8
14	23	70	2.6	24	.35	12	1.8	9.4	[b] 2.4	54	6.9	Tr.	1.8	91	1.2
24	June 2	110	5.6	20	.3	13	1.9	8.8	.0	62	7.2	Tr.	2.2	88	1.5
June 3	12	230	14	6.4	.5	9.6	0.6	6.9	[b] 2.4	33	7.7	.0	2.4	58	3.8
13	22	235	11	11	.3	12	0.4	7.2	[b] 11	27	6.1	.0	2.2	69	3.6
23	July 2	110	5.4	19	.24	15	0.6	9.8	[b] 12	46	6.2	Tr.	2.4	93	1.2
July 3	12	48	1.2	11	.04	16	4.0	8.0	.0	62	7.6	.3	3.8	82	.6
13	22	20	0.6	17	.06	18	4.6	5.7	.0	71	8.4	.2	3.6	94	.6
23	Aug. 1	100	1.4	14	.28	18	4.8	6.1	.0	67	11	Tr.	4.6	97	.4
Aug. 2	11	45	1.0	16	.05	18	4.8	7.2	.0	71	9.9	.4	3.6	98	.2
12	21	120	1.6	18	1.5	17	5.2	6.9	.0	----------	10	.7	3.6	100	.5
22	Sept. 1	28	1.2	12	.19	19	5.5	5.0	[b] 3.6	67	10	.3	3.6	97	.3
Sept. 2	9	150	1.5	16	.79	19	5.1	6.0	.0	----------	11	Tr.	3.2	100	.2
Mean		90	3.9	18	.5	14	3.0	6.7	.0	60	7.1	.3	2.3	89	----------

[a] Analyses Sept. 10 to Nov. 28, 1906, by R. B. Dole; Nov. 29, 1906, to Apr. 2, 1907, by R. B. Dole and M. G. Roberts; Apr. 3 to July 2, 1907, by Chase Palmer and M. G. Roberts; July 12 to Sept. 9, 1907, by R. B. Dole, Chase Palmer, and W. D. Collins.

[b] Abnormal; computed as HCO_3 in the average.

Only a few analyses of waters tributary to the James have been obtained. North River, not to be confused with the North River of the Shenandoah system, drains a large part of Rockbridge County, Va., and flows into the James south of Lexington. Several waters of this small basin have been analyzed by A. F. White,[17] and of his analyses four are suitable for use here. Unfortunately determinations of carbonic acid were not made, and it has been necessary to compute the amount needed to satisfy the bases—a procedure which is not ideally exact, but one which helps to show the essential character of the waters.

These are typical limestone waters and very much alike. The differences between them are small and probably are due in part to varying local conditions, such, for example, as dissimilar composition of the minor tributaries that form the larger streams.

The data are as follows:

Analyses of waters in North River basin.

1. South River above Irish Creek.
2. Old Buena Vista Creek.
3. Mill Creek.
4. North River at South River station, Lexington.

	Parts per million.				Percentage composition of residue.			
	1	2	3	4	1	2	3	4
CO_3	56.0	105.2	109.2	40.1	50.36	54.43	56.37	47.97
SO_4	4.2	6.1	9.2	4.6	3.78	3.15	4.75	5.50
Cl	6.1	8.4	3.5	5.1	5.48	4.35	1.81	6.10
Ca	22.5	46.2	45.9	20.6	24.73	23.90	23.69	24.64
Mg	7.8	17.3	17.9	5.6	7.01	8.95	9.24	6.70
Na	1.4	1.2	1.5	1.3	1.26	.62	.77	1.55
K	1.6	1.5	1.5	.9	1.44	.77	.77	1.08
SiO_2	5.5	7.3	4.5	5.1	4.95	3.77	2.31	6.10
$(Al, Fe)_2O_3$	1.1	.1	.5	.3	.99	.06	.29	.36
	111.2	193.3	193.7	83.6	100.00	100.00	100.00	100.00

RIVERS FROM THE DAN TO THE SAVANNAH.

For the Dan, Roanoke, Neuse, Cape Fear, Peedee, Saluda, Wateree, and Savannah we have only the tables of analyses made in the water-resources laboratory of the United States Geological Survey. These tables are as follows:

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[17] Thesis, Washington and Lee University, 1906.

Analyses of water from Dan River at South Boston, Va.[a]

[Parts per million.]

Date (1096-7).		Turbidity.	Suspended matter.	Coefficient of fineness.	Total iron (Fe).	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total dissolved solids.	Mean gage height (feet).
From—	To—																
Sept. 3	Sept. 13	210	126	0.60	8.9	26	1.4	6.0	2.8	4.2	0.0	41	1.3	Tr.	2.4	75	3.2
Oct. 1	Oct. 11	260	175	.67	9.8	31	2.1	5.2	1.8	7.6	.0	34	2.5	0.8	2.6	82	4.2
12	21	43	42	.98	2.4	50	.7	6.0	2.2	8.5	.0	39	2.6	Tr.	3.1	100	4.3
22	31	31	25	.81	1.4	23	.6	5.2	2.0	7.6	.0	36	2.3	Tr.	2.4	61	4.8
Nov. 1	Nov. 11	17	23	1.94	1.0	17	.07	5.2	1.6	5.2	.0	34	2.8	.6	3.4	52	2.5
12	21	230	181	.79	8.4	21	1.3	4.8	1.2	5.4	.0	30	3.3	1.6	2.7	67	2.7
22	Dec. 1	28	131	.47	2.0	16	.3	5.6	1.4	6.3	.0	32	4.3	.6	2.6	54	2.3
Dec. 2	12	21	76	3.62	3.5	18	.28	5.4	1.8	4.9	.0	35	1.6	.5	3.0	50	2.3
13	23	220	664	3.00	16	26	2.2	4.4	1.6	6.8	.0	33	4.3	1.1	3.4	78	2.6
24	31	350	742	2.12	24	23	1.8	4.6	1.8	6.0	.0	29	4.3	1.6	2.9	69	3.5
Jan. 3	Jan. 13	55	525	9.54	10	16	.35	4.8	1.8	6.2	.0	31	2.8	1.6	3.4	54	4.5
20	29	110	815	7.41	9.5	21	1.0	5.6	2.0	6.5	.0	40	3.1	Tr.	4.1	75	2.7
30	Feb. 9	90	215	2.39	6.5	23	1.0	6.2	2.0	6.2	.0	40	3.5	.2	3.6	77	2.8
Feb. 10	19	175	324	1.85	11	23	2.2	5.4	1.0	6.5	.0	25	4.1	2.1	2.9	75	3.1
20	Mar. 2	110	209	1.90	8.0	25	2.2	6.0	1.2	6.6	.0	24	5.8	1.8	2.5	84	2.9
Mar. 3	12	380	677	1.78	9.0	24	2.4	5.8	.6	7.7	.0	26	4.0	1.9	3.1	86	5.1
13	24	47	231	4.9	5.3	18	.33	7.8	.8	6.8	.0	28	5.3	2.4	4.1	66	4.6
25	Apr. 3	27	45	1.67	1.4	16	.08	6.8	.8	9.5	[b] 16	3.0	5.1	.0	5.3	64	2.6
Apr. 4	13	225	150	.67	10	28	1.0	6.0	1.1	9.4	.0	40	3.6	3.0	3.1	88	4.9
14	23	38	44	1.16	2.3	18	.24	5.6	1.6	6.3	.0	29	2.5	1.8	3.4	55	2.7
24	May 2	98	110	1.12	6.5	31	1.1	5.6	1.0	8.2	.0	30	2.8	1.8	4.2	86	4.2
Mean		132	264	2.35	7.5	24	1.1	5.6	1.5	6.8	.0	33	3.4	1.1	3.2	71	--------

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[a] Analyses Sept. 3 to Oct. 31, 1906, by R. B. Dole; Nov. 1, 1906, to Apr. 3, 1907, by R. B. Dole and M. G. Roberts; Apr. 4 to May 2, 1907, by Chase Palmer and M. G. Roberts.

[b] Abnormal; computed as HCO_3 in the average.

Analyses of water from Roanoke River at Randolph, Va.[a]

[Parts per million.]

Date (1906-7).		Turbidity.	Total iron (Fe).	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total dissolved solids.
From—	To—													
Sept. 7	Sept. 16	500	14	25	2.5	10	4.4	6.5	0.0	57	3.6	0.5	2.4	102
17	26	300	14	24	1.5	8.8	2.8	6.9	.0	55	3.8	.3	2.6	90
27	Oct. 4	270	15	16	1.2	9.0	3.2	6.3	.0	48	4.0	Tr.	1.9	74
Oct. 10	25	290	14	23	2.1	8.4	2.6	----------	.0	45	3.0	.7	1.9	84
26	Nov. 5	38	2.6	19	.4	11	4.4	6.6	.0	59	4.3	.5	2.2	76
Nov. 6	17	21	1.2	22	.3	11	4.4	7.4	.0	61	4.9	.6	2.5	80
18	27	350	15	23	1.3	8.8	3.8	7.2	.0	50	5.7	.9	1.9	82
Dec. 1	Dec. 15	17	1.4	29	.4	11	4.6	2.8	.0	61	4.4	.5	2.9	87
16	27	----------	7.7	20	1.0	9.2	3.8	3.9	.0	50	4.3	.4	2.6	75
28	Jan. 6	----------	7.3	19	1.6	8.8	3.6	5.4	.0	56	4.1	.9	2.3	72
Jan. 7	16	26	1.9	23	.6	9.4	3.8	2.5	.0	52	4.6	.6	2.4	69
17	26	23	2.1	25	.6	10	4.0	4.5	.0	54	4.6	.4	2.9	81
27	Feb. 5	26	2.3	18	.5	9.6	3.6	3.2	.0	51	4.1	.3	2.6	68
Feb. 6	Mar. 2	60	3.9	13	.5	9.4	2.8	4.4	.0	46	4.8	.3	2.2	62
Mar. 3	12	----------	7.7	25	1.0	8.8	3.2	7.2	.0	44	4.8	1.0	1.3	87
13	25	29	1.6	17	.19	8.4	2.6	7.1	[b] 8.2	34	4.3	.0	1.7	65
26	Apr. 4	65	2.1	13	.32	9.8	3.0	7.6	.0	51	4.8	.2	2.0	64
Apr. 5	14	171	6.5	24	1.0	9.6	3.2	7.6	.0	50	4.9	1.0	1.4	83
19	29	290	18	28	1.0	10	3.4	7.2	.0	55	5.1	1.0	2.2	91
30	May 12	400	16	22	1.0	9.6	3.2	8.5	.0	58	4.1	.5	2.6	85
Mean		169	7.7	21	.95	9.5	3.5	5.9	.0	53	4.4	.5	2.2	79

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[a] Analyses Sept. 7 to Nov. 27, 1906, by R. B. Dole; Dec. 1, 1906, to Apr. 4, 1907, by R. B. Dole and M. G. Roberts; Apr. 5 to May 12, 1907, by Chase Palmer and M. G. Roberts.

[b] Abnormal; computed as HCO_3 in the average.

Analyses of water from Neuse River at Raleigh, N. C.[a]

[Parts per million.]

Date (1906-7). From—	Date (1906-7). To—	Turbidity.	Suspended matter.	Coefficient of fineness.	Total iron (Fe).	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total dissolved solids.
Oct. 1	Oct. 10	14	13	0.93	0.9	25	0.4	5.2	1.8	7.1	0.0	--------	2.6	0.0	3.8	68
11	20	14	11	.78	.5	27	.4	5.6	1.2	7.2	.0	39	1.0	Tr.	3.8	66
21	30	24	18	.75	.8	25	.4	6.0	1.2	7.9	.0	44	1.2	.0	4.6	68
Nov. 1	Nov. 10	10	5.8	.58	.8	20	.4	7.2	1.8	8.2	.0	39	3.0	.2	5.0	69
11	20	11	7.6	.69	.9	21	.3	5.4	1.6	7.7	.0	37	2.8	.2	4.6	63
21	30	9	5.8	.64	.5	21	.3	6.0	2.0	8.2	.0	40	2.8	Tr.	5.2	65
Dec. 1	Dec. 10	11	3.8	.34	.4	22	.3	5.6	1.8	8.0	.0	41	2.8	.0	4.8	65
11	20	26	16	.61	1.4	22	.65	6.4	1.6	8.0	.0	37	2.1	Tr.	5.8	68
21	30	45	29	.64	2.1	22	1.8	6.0	2.4	6.5	.0	32	2.3	Tr.	6.5	74
31	Jan. 9	17	9.0	.53	1.3	21	.9	5.6	1.6	6.8	.0	35	1.8	Tr.	6.5	68
Jan. 10	19	11	6.8	.62	1.0	22	.8	6.8	2.8	7.9	.0	39	3.5	Tr.	5.9	66
20	29	8	3.4	.42	.9	21	.6	6.4	2.6	7.8	.0	40	2.8	Tr.	5.9	65
30	Feb. 8	15	10	.67	1.3	20	.8	6.2	2.6	6.3	.0	37	2.8	Tr.	--------	67
Feb. 9	18	29	18	.62	1.5	22	1.4	5.8	1.8	6.0	.0	36	3.1	Tr.	--------	72
19	28	--------	72	--------	3.9	22	1.7	5.6	1.4	6.0	.0	23	4.9	.7	4.7	79
Mar. 1	Mar. 10	33	12	.36	2.1	22	2.0	5.0	1.2	7.6	.0	25	3.3	.5	4.1	76
12	21	--------	77	--------	2.8	26	2.6	4.8	1.2	6.9	.0	23	4.6	.6	3.5	85
22	31	18	20	1.11	1.0	22	.6	6.0	1.8	6.8	[b] 2.4	28	2.0	.0	3.8	63
Apr. 1	Apr. 10	48	45	.94	1.8	16	1.3	5.8	1.6	8.2	.0	33	4.1	.5	5.0	62
11	21	27	19	.70	1.3	39	1.2	6.8	1.8	8.8	.0	40	3.6	.5	5.4	93
22	May 2	81	73	.90	2.7	23	2.0	6.4	1.7	8.8	.0	32	4.8	1.0	4.2	77
May 3	12	82	67	.82	2.4	28	2.1	6.0	1.4	9.3	.0	32	3.5	7	4.6	82
13	22	28	39	1.40	1.3	30	.95	6.2	1.8	11	[b] 4.8	29	2.8	Tr.	4.2	78
23	June 1	53	57	1.08	1.8	22	.9	6.4	1.8	--------	.0	35	3.3	.9	3.8	66
June 3	12	100	96	.96	1.8	32	1.7	5.4	.8	10	.0	34	4.4	.0	3.6	90
13	22	325	247	.76	7.4	24	2.0	5.6	.8	8.2	.0	28	4.3	1.2	3.0	79
23	July 2	325	280	.86	13	39	3.7	8.2	2.0	12	.0	50	3.6	Tr.	4.6	--------
July 3	12	48	50	1.04	1.6	24	.9	6.6	--------	9.1	.0	37	3.5	.0	3.6	71
13	23	160	333	2.08	1.9	24	1.8	4.8	--------	8.5	.0	35	3.3	Tr.	3.0	74
24	Aug. 1	120	82	.68	1.6	24	1.5	6.4	3.0	6.3	.0	37	3.9	.8	3.2	75
Aug. 3	12	540	428	.79	7.0	43	5.2	3.8	1.9	5.4	.0	18	7.6	.6	3.8	--------
13	22	70	26	.37	2.6	32	2.2	5.8	--------	5.7	.0	30	3.8	.5	3.2	89
23	Sept. 1	40	37	.92	2.6	26	.66	6.8	--------	--------	.0	38	4.6	.6	4.2	75
Sept. 2	11	170	113	.66	14	33	3.1	4.8	--------	7.6	.0	32	3.3	.6	--------	--------
12	21	30	28	.93	3.5	28	.8	6.4	3.4	9.4	.0	44	3.6	.5	4.2	81
22	Oct. 1	120	76	.63	7.0	29	2.0	5.4	2.4	7.9	.0	34	3.9	.5	3.8	84
Mean		78	68	.79	2.8	26	1.4	5.9	1.8	7.9	.0	35	3.4	.3	4.4	73

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[a] Analyses Oct. 1 to 3 Dec. 10, 1906, by R. B. Dole; Dec. 11, 1906, to Mar. 31, 1907, by R. B. Dole and M. G. Roberts; Apr. 1 to July 2, 1907, by Chase Palmer and M. G. Roberts; July 3 to Oct. 1, 1907, by R. B. Dole, Chase Palmer, and W. D. Collins.

[b] Abnormal; computed as HCO_3 in the average.

Analyses of water from Cape Fear River at Wilmington, N. C.[a]

[Parts per million.]

Date (1906-7). From—	Date (1906-7). To—	Turbidity.	Total iron (Fe).	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total dissolved solids.	Mean gage height (feet).[b]
Oct. 2	Oct. 8	11	1.2	10	0.6	5.4	1.0	6.3	0.0	22	2.6	0.0	6.0	64	5.4
10	23	[c] 16	[c] .9	[c] 10	[c] .7	[c] 7.2	[c] 7.6	[c] 67	[c] .0	[c] 20	[c] 12	[c] .0	[c] 130	[c] 247	[c] 4.9
25	Nov. 5	11	.5	8.8	.5	4.8	1.0	6.6	.0	20	2.6	.0	6.2	65	4.8
Nov. 6	17	12	.6	10	.6	4.6	1.0	6.9	.0	22	2.3	.0	6.5	63	3.6
18	27	9	.5	10	.5	4.4	.8	5.7	.0	22	2.3	.0	6.0	59	4.0
28	Dec. 7	11	.4	11	.4	5.0	1.0	5.8	.0	22	2.8	.0	6.2	52	2.9
Dec. 8	17	14	.4	12	.5	5.6	1.2	7.6	.0	29	3.3	.2	6.1	61	4.7
18	30	19	.9	10	.4	4.6	1.6	6.5	.0	20	2.5	Tr.	--------	53	7.6
31	Jan. 9	11	.8	10	.54	5.0	1.0	6.9	.0	--------	3.1	.0	6.5	56	5.8
Jan. 10	20	17	.9	8.2	.37	5.0	.6	5.3	.0	22	2.3	Tr.	5.8	44	4.3
21	Feb. 1	11	.6	10	.4	4.8	1.0	6.8	.0	22	2.8	.0	4.6	52	4.1
Feb. 2	13	19	1.0	9.8	.53	4.8	1.0	5.6	.0	27	2.3	1.8	6.1	55	8.9
14	27	21	1.4	8.6	.61	3.8	.6	4.8	.0	18	2.5	Tr.	6.0	45	10.6
28	Mar. 14	29	1.5	7.6	.81	3.8	.6	4.9	.0	21	2.8	.3	5.0	47	13.7
Mar. 15	26	29	2.3	18	1.8	4.0	.8	6.4	.0	23	2.6	.0	4.6	65	11.3
27	Apr. 6	27	1.6	11	1.0	4.4	.8	--------	.0	22	2.8	.4	5.8	50	6.4
Apr. 8	18	42	2.3	--------	2.1	4.2	.6	--------	--------	--------	2.5	1.0	--------	--------	10.1
19	30	32	1.9	15	1.7	4.4	1.0	6.9	.0	22	2.6	.75	4.6	62	12.5
May 1	May 11	31	1.6	14	1.1	4.4	1.4	6.8	.0	24	1.6	.5	6.1	60	10.9
13	24	28	1.2	8.0	.35	4.2	1.0	7.7	.0	20	2.0	.5	6.0	52	6.0
25	June 6	25	1.0	7.0	.28	4.6	.8	7.9	.0	22	1.6	.5	6.6	50	10.4
June 8	21	28	1.4	9.2	.75	4.2	1.0	9.0	.0	24	1.6	.5	6.2	58	10.9
24	July 4	32	1.8	7.2	.65	4.8	1.2	6.1	.0	26	2.0	.3	7.0	62	9.6
July 6	17	--------	1.2	2.6	.13	6.6	.6	11	.0	34	4.0	.0	4.8	48	5.4
19	Aug. 1	--------	1.4	7.6	.88	5.4	1.8	6.6	.0	26	5.4	Tr	5.4	57	4.4
Aug. 2	12	--------	1.5	6.2	.61	6.4	.6	9.1	.0	29	6.9	Tr.	4.8	56	4.0
13	24	20	1.4	11	1.1	5.5	2.0	12	.0	41	5.8	Tr.	5.4	66	6.6
26	Sept. 5	20	1.4	8.8	.77	6.5	.8	5.7	.0	24	5.1	Tr.	5.0	61	5.8
Sept. 6	18	75	4.0	14	1.8	5.6	1.8	8.5	.0	28	5.3	.5	6.6	68	6.4
30	Oct. 9	15	1.4	11	.79	8.3	1.8	12	.0	39	5.6	Tr.	7.0	75	3.7
Mean		73	1.3	9.9	.78	5.0	1.5	7.2	.0	25	3.2	.2	5.8	57	--------

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[a] Analyses Oct. 2 to Nov. 27, 1906, by R. B. Dole; Nov. 28, 1906, to Apr. 6, 1907, by R. B. Dole and M. G. Roberts; Apr. 8 to July 4, 1907, by Chase Palmer and M. G. Roberts; July 6 to Oct. 9, 1907, by R. B. Dole, Chase Palmer, and W. D. Collins.

[b] Gaging station near Fayetteville N. C., 75 miles above.

[c] Abnormal; omitted from the average.

Analyses of water from Peedee River near Peedee, N. C.[a]

[Parts per million.]

Date (1906-7).		Turbidity.	Total iron (Fe).	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total dissolved solids.	Mean gage height (feet).[b]
From—	To—														
Oct. 26	Nov. 5	40	----------	39	Tr.	9.1	1.6	----------	0.0	34	----------	0.4	3.5	87	3.0
Nov. 6	16	90	----------	30	0.9	5.7	Tr.	----------	.0	20	----------	.6	2.0	62	2.8
17	29	140	----------	32	.9	4.7	Tr.	----------	.0	16	----------	.3	7.5	82	3.9
30	Dec. 11	135	----------	30	.8	5.5	Tr.	----------	.0	20	----------	.5	7.0	78	2.8
Dec. 12	21	140	----------	26	.8	6.4	1.2	----------	.0	22	----------	.6	7.5	74	3.1
27	Jan. 8	145	----------	30	.40	5.2	Tr.	----------	.0	17	----------	.6	4.0	72	3.8
Jan. 9	21	15	----------	25	.20	7.4	1.6	----------	.0	27	----------	.4	1.7	63	2.8
22	Feb. 3	25	----------	18	.30	8.4	1.6	----------	.0	32	----------	.9	3.0	58	2.6
Feb. 6	19	15	----------	13	.20	9.2	1.6	----------	.0	32	----------	.4	4.5	58	2.7
20	Mar. 15	40	----------	14	.10	12	0.8	----------	.0	41	----------	.4	1.5	64	3.2
Mar. 16	30	25	----------	18	.10	10	1.2	----------	.0	34	----------	.7	3.5	59	2.8
31	Apr. 15	20	----------	26	.30	7.6	Tr.	----------	.0	24	----------	.4	2.0	45	3.1
Apr. 16	25	120	----------	15	.20	7.0	1.2	----------	.0	24	----------	.2	2.0	45	3.1
26	May 1	160	----------	18	.40	5.5	1.2	----------	.0	20	----------	.3	3.0	40	3.4
May 2	11	100	----------	20	[c] 1.4	6.5	2.9	7.2	.0	44	4.0	.5	3.0	76	2.9
12	21	60	----------	27	.40	6.7	3.3	7.8	.0	42	3.6	.2	3.5	78	2.5
22	June 3	255	----------	21	.8	5.1	2.1	11	.0	39	3.6	.4	4.5	74	2.8
June 18	28	365	----------	26	[c] 2.8	4.1	3.7	7.2	.0	39	2.3	.5	3.0	86	3.0
29	July 10	375	----------	37	Tr.	5.1	1.3	14	.0	48	4.4	1.4	1.4	91	3.2
Aug. 19	Aug. 31	270	6.3	34	Tr.	5.8	0.8	13	.0	45	3.9	.9	1.6	86	2.4
Sept. 1	Sept. 13	240	10	23	.03	6.8	1.7	9.4	.0	44	3.9	.5	1.1	64	2.3
14	28	295	8.8	35	.03	4.9	1.3	5.4	.0	26	4.7	.7	.7	70	2.8
Oct. 2	Oct. 15	45	2.4	26	Tr.	6.6	.8	6.5	.0	29	3.9	.3	1.2	62	2.4
16	19	35	----------	30	Tr.	9.3	1.7	7.2	.0	43	5.6	1.1	1.1	78	2.2
Mean--------		131	----------	26	.31	6.9	1.3	8.9	.0	32	4.0	.6	3.1	69	----------

[a] Analyses Oct. 26, 1906, to May 1, 1907, by Jas. R. Evans; May 2 to June 28, 1907, by W. D. Collins; June 29 to Oct. 19, by R. B. Dole, Chase Palmer, and W. D. Collins.

[b] Gaging station at Cheraw, S. C., 20 miles below.

[c] Abnormal; computed as HCO_3 in the average.

Analyses of water from Saluda River near Columbia, S. C.[a]

[Parts per million.]

Date (1906-7).		Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).[b]	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).[c]	Nitrate radicle (NO_3).	Chlorine (Cl).	Total dissolved solids.	Mean gage height (feet).[d]
From—	To—													
Oct. 27	Nov. 5	70	23	1.0	6.3	0.8	----------	0.0	27	----------	0.3	4.0	63	1.4
Nov. 6	16	95	26	.8	4.2	Tr.	----------	.0	----------	----------	.5	4.0	55	1.5
17	28	40	23	.6	9.1	1.2	----------	.0	34	----------	.5	1.0	68	1.7
29	Dec. 8	35	20	.30	10	1.6	----------	.0	39	----------	.7	2.0	70	4.2
Dec. 9	19	85	20	.5	3.9	Tr.	----------	.0	----------	----------	.8	2.2	48	5.2
Jan. 4	Jan. 15	25	32	.20	11	2.0	----------	.0	44	----------	.5	2.5	80	5.6
16	25	45	19	.40	12	2.4	----------	.0	44	----------	.5	2.5	66	3.6
26	Feb. 4	60	17	.20	8.4	1.2	----------	.0	29	----------	.3	5.0	60	3.8
Feb. 5	14	70	27	.30	7.2	.8	----------	.0	24	----------	.3	4.0	67	4.5
15	24	55	15	.20	9.6	Tr.	----------	.0	29	----------	.1	3.5	50	3.2
25	Mar. 14	65	18	.20	10	1.2	----------	.0	34	----------	.5	4.5	62	3.6
Mar. 15	24	45	21	.10	9.6	1.6	----------	.0	34	----------	.4	3.0	64	2.1
25	Apr. 3	18	19	.10	10	1.2	----------	.0	34	----------	.4	4.5	60	2.0
Apr. 4	13	15	20	----------	10	1.6	----------	.0	34	----------	.4	5.0	71	2.7
14	23	250	20	.5	7.5	2.8	----------	.0	32	----------	.3	4.5	57	2.6
24	May 3	185	22	.30	6.0	2.4	----------	.0	24	----------	.4	4.0	55	5.2
Mean--------		72	21	.38	8.4	1.3	[b] 6.0	.0	33	[c] 5.0	.43	3.5	62	----------

[a] Analyses by J. R. Evans.

[b] Fluctuates between 1 and 10 parts; average value about 6 parts.

[c] Fluctuates between trace and 10 parts; average value about 5 parts.

[d] Gaging station at Chappells, S. C., 50 miles above.

[e] Approximate.

Analyses of water from Wateree River near Camden, S. C.[a]

[Parts per million.]

Date (1906-7).		Turbidity.	Total iron (Fe).	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_3).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total dissolved solids.	Mean gage height (feet).
From—	To—														
Oct. 21	Oct. 30	70	--------	25	--------	6.8	4.8	--------	0.0	33	--------	0.9	2.5	65	14.8
Nov. 1	Nov. 10	55	--------	24	0.5	5.5	.8	--------	.0	22	--------	Tr.	4.0	58	8.3
11	20	45	--------	28	.9	4.7	Tr.	--------	.0	--------	--------	.3	2.0	60	7.7
21	Dec. 1	75	--------	31	.7	6.0	1.2	--------	.0	22	--------	.4	3.0	70	10.8
Dec. 2	13	60	--------	28	.8	5.5	1.6	--------	.0	22	--------	.5	2.8	65	8.1
14	24	85	--------	31	.9	6.2	1.6	--------	.0	24	--------	.6	2.5	69	8.8
25	Jan. 3	125	--------	43	.20	--------	.8	--------	.0	37	--------	.5	4.0	95	10.4
Jan. 4	14	75	--------	20	.40	4.2	Tr.	--------	.0	--------	--------	.8	4.0	56	8.9
16	25	10	--------	16	.10	--------	1.2	--------	.0	39	--------	.1	3.0	62	6.8
26	Feb. 4	35	--------	30	.30	8.0	2.0	--------	.0	32	--------	.9	3.5	73	6.3
Feb. 5	15	35	--------	15	.30	8.8	2.0	--------	.0	30	--------	.1	3.3	51	9.3
16	26	60	--------	17	.10	9.6	1.6	--------	.0	32	--------	.4	4.0	60	7.7
27	Mar. 8	80	--------	18	.20	8.4	Tr.	--------	.0	27	--------	.3	4.0	60	10.3
Mar. 10	19	65	--------	16	.10	--------	1.2	--------	.0	46	--------	.8	1.2	69	8.3
20	29	105	--------	16	.20	9.2	.8	--------	.0	29	--------	.6	2.0	48	6.6
30	Apr. 8	35	--------	19	.20	10	1.2	--------	.0	34	--------	.5	3.5	68	6.1
Apr. 9	18	15	--------	23	.20	7.2	2.8	--------	.0	29	--------	.2	3.0	58	6.3
19	28	80	--------	29	.30	5.0	1.6	--------	.0	22	--------	.1	4.5	61	10.6
29	May 9	75	--------	21	.20	5.5	.8	5.0	.0	22	Tr.	.2	4.0	48	8.5
May 10	19	140	--------	26	[b] 2.8	6.1	4.0	6.0	.0	47	2.0	.4	3.0	91	6.8
20	30	325	--------	41	[b] 3.2	7.3	2.8	--------	.0	43	4.3	.3	2.0	118	6.2
31	June 9	500	--------	19	[b] 3.2	4.5	1.3	10	.0	35	5.6	.5	3.0	115	14.5
June 10	19	600	--------	25	[b] 3.0	4.9	2.4	6.1	.0	37	6.6	.3	2.0	90	10.4
20	29	500	--------	31	[b] 4.0	4.9	3.1	3.5	.0	35	1.8	.5	2.0	108	8.4
30	July 9	730	--------	34	[b] 4.0	6.3	2.3	6.3	.0	37	5.9	.2	3.0	106	9.3
July 10	19	566	--------	31	[b] 2.0	6.5	2.6	7.5	.0	41	5.4	.2	2.5	112	8.3
20	29	960	9.6	19	.03	5.3	1.8	11	.0	40	4.3	.7	1.9	60	7.2
30	Aug. 9	960	11	22	.40	5.8	1.4	11	.0	40	4.6	.7	1.7	68	6.6
Aug. 10	20	475	21	20	.07	5.6	1.4	8.7	.0	39	4.4	.5	1.4	63	7.3
24	Sept. 3	525	18	23	.06	5.0	1.4	11	.0	38	4.1	.6	2.2	64	6.9
Sept. 4	14	400	15	17	.04	5.5	2.3	8.8	.0	39	4.4	.3	2.2	60	5.3
15	24	350	10	--------	.04	8.0	4.4	12	--------	--------	5.4	Tr.	1.4	--------	4.8
25	Oct. 4	550	24	31	Tr.	3.1	1.4	7.6	.0	26	4.6	.5	2.2	74	10.7
Oct. 15	25	45	2.2	33	.03	6.1	1.4	12	.0	43	4.3	Tr.	2.2	77	4.0
Mean		259	--------	25	.28	6.3	1.8	8.4	.0	34	4.2	.4	2.8	73	--------

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[a] Analyses Oct. 21, 1906, to May 9, 1907, by Jas. R. Evans; May 10 to July 19, 1907, by W. D. Collins; July 20 to Oct. 25, 1907, by R. B. Dole, Chase Palmer, and W. D. Collins.

[b] Omitted from average.

Goose Creek is a small stream of the Coastal Plain, and its water near Charleston, S. C., has been impounded for practical uses. An analysis of the water, in its natural state, by F. L. Parker, and reduced to standard form, is as follows:

Analysis of water from Goose Creek.

1. Parts per million.
2. Percentage composition of anhydrous residue.

	1	2
CO_3	1.8	2.61
SO_4	4.8	6.96
Cl	26.0	37.68
Ca	5.6	8.12
Mg	1.4	2.03
Na(K)	25.0	36.23
SiO_2	2.8	4.06
Fe_2O_3	1.1	1.59
Al_2O_3	5	.72
	69.0	100.00

The composition of this water is evidently affected by the proximity of sea water and by the fact that Goose Creek drains a flat agricultural area that has probably retained cyclic salt derived from rainfall. It is not a normal river water.

Analyses of water from Savannah River near Augusta, Ga.[a]

[Parts per million.]

Date (1906-7).		Turbidity.	Total iron (Fe).	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_4).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total dissolved solids.	Mean gage height (feet).
From—	To—														
Oct. 25	Nov. 3	45	----------	21	----------	5.4	1.2	----------	0.0	27	----------	0.1	3.0	56	9.6
Nov. 4	13	40	----------	28	0.20	6.2	Tr.	----------	.0	24	----------	3.0	3.0	77	9.0
14	23	35	----------	32	.30	4.4	Tr.	----------	.0	17	----------	.7	1.5	59	10.4
24	Dec. 3	40	----------	32	.20	4.9	Tr.	----------	.0	20	----------	.8	1.5	64	9.2
Dec. 4	13	55	----------	34	.30	6.4	3.2	----------	.0	22	----------	.6	1.8	74	9.6
14	23	65	----------	31	.30	6.2	2.8	----------	.0	22	----------	.5	2.0	72	10.8
24	Jan. 2	85	----------	36	.40	3.9	Tr.	----------	.0	15	----------	.3	3.0	78	11.0
Jan. 3	12	60	----------	24	.70	3.9	1.6	----------	.0	17	----------	.8	2.5	54	11.2
13	22	16	----------	17	.40	6.0	4.8	----------	.0	27	----------	.8	3.0	60	9.3
23	Feb. 2	60	----------	30	.40	8.2	2.8	----------	.0	34	----------	.4	3.5	70	9.3
Feb. 3	12	150	----------	23	.7	5.4	.8	----------	.0	20	----------	.9	3.0	53	14.2
13	22	20	----------	13	1.2	7.6	1.2	----------	.0	24	----------	.6	3.0	52	9.2
Mar. 13	Mar. 22	22	----------	12	.9	5.6	Tr.	----------	.0	20	----------	.6	2.8	42	9.4
23	Apr. 1	15	----------	20	.9	8.4	Tr.	----------	.0	27	----------	.5	3.0	55	8.4
Apr. 2	11	45	----------	23	1.2	8.4	Tr.	----------	.0	27	----------	.3	2.5	59	8.5
12	21	210	----------	26	1.4	7.6	Tr.	----------	.0	24	----------	.3	1.5	52	8.4
Apr. 22	May 1	340	----------	20	1.6	5.5	Tr.	----------	.0	19	----------	.4	3.0	42	11.6
May 2	11	265	----------	17	1.8	7.2	1.6	----------	.0	24	----------	.2	3.0	45	9.5
12	22	45	3.2	37	.22	5.9	.4	13	.0	50	5.5	.8	1.7	90	8.3
23	June 1	130	5.2	31	.20	5.2	.4	13	[b]9.6	27	5.7	.7	1.8	78	8.3
June 2	11	175	14	21	.54	4.9	.4	11	[b]7.2	17	6.1	.7	1.4	61	9.8
12	21	300	9.6	17	.08	5.1	.2	12	[b]Tr.	35	5.6	1.1	1.4	51	8.2
22	July 3	425	14	15	.06	5.1	.4	11	[b]Tr.	37	5.8	1.6	1.6	54	8.8
July 4	13	315	9.4	25	.20	5.0	.7	12	[b]7.2	24	5.5	.2	1.4	67	7.7
14	23	425	18	30	.26	5.0	----------	12	[b]14	9.8	7.3	.9	1.2	76	8.4
24	Aug. 3	400	14	14	.04	4.7	.4	13	[b]9.6	22	7.4	.0	Tr.	53	7.6
Aug. 4	13	575	46	15	Tr.	5.1	.6	11	.0	32	6.8	3.0	1.8	53	7.4
14	23	475	28	16	.04	5.1	.5	10	[b]3.6	30	6.7	.3	1.7	56	9.5
24	Sept. 2	160	7.9	22	Tr.	5.0	.5	13	.0	40	6.0	1.0	2.0	63	6.5
Sept. 3	12	270	11	18	.04	5.0	.4	11	.0	34	5.3	1.0	2.2	58	6.8
13	22	200	9.3	19	.00	6.0	.5	12	.0	40	5.8	.7	2.2	64	6.1
23	Oct. 2	300	21	14	.04	6.0	.3	9.2	.0	33	4.9	.0	1.6	49	10.9
Oct. 3	12	65	5.6	16	Tr.	4.6	.4	9.6	.0	32	4.7	.7	1.9	53	6.3
13	22	2	2.4	21	.00	5.3	.5	11	[b]2.4	32	6.0	.0	1.8	61	5.3
Mean		172	----------	23	.44	5.7	.8	12	.0	30	6.0	.6	2.1	60	----------

[a] Analyses Oct. 25, 1906, to May 11, 1907, by J. R. Evans; May 12 to Oct. 22, 1907, by R. B. Dole, Chase Palmer, and W. D. Collins.

[b] Abnormal; computed as HCO_3 in the average.

OGEECHEE RIVER.

The Ogeechee, whose basin lies between those of the Savannah and Altamaha, appears to be quite different chemically from the other rivers of the south Atlantic slope. For this river only one analysis, by H. C. White, is available, as follows:

Analysis of water from Ogeechee River at Ogeechee, Ga.

1. Parts per million.
2. Percentage composition of anhydrous residue.

	1	2
CO_3	12.3	48.42
SO_4	1.4	5.51
Cl	1.2	4.73
Ca	6.6	25.99
Mg	1.4	5.51
Na(K)	.8	3.15
SiO_2	1.7	6.69
$(Al, Fe)_2O_3$	?	?
	25.4	100.00

NOTE.—Organic matter, 54 parts per million, was also determined, but need not be taken into account here.

This analysis is that of an ordinary carbonate water, low in silica and alkalies. As will be seen in the final summing up for the southern Atlantic rivers, they are generally characterized by high silica and alkalies and are therefore of a very different type chemically from the Ogeechee.

ALTAMAHA RIVER BASIN.

The Altamaha is formed by the union of two rivers, the Oconee and Ocmulgee, and for these we have the next two tables of analyses, which were made in the water-resources laboratory of the Geological Survey.

Analyses of water from Oconee River near Dublin, Ga.[a]

[Parts per million.]

Date (1906-7).		Turbidity.	Total iron (Fe).	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total dissolved solids.	Mean gage height (feet).
From—	To—														
Oct. 18	Oct. 27	55	----------	29	0.6	9.0	1.2	----------	0.0	33	----------	0.4	4.0	76	1.4
28	Nov. 6	75	----------	32	2.0	11	.8	----------	.0	39	----------	.4	4.0	83	.6
Nov. 7	17	85	----------	31	.9	8.8	1.2	----------	.0	32	----------	.7	2.0	68	.8
18	27	85	----------	24	.40	8.8	1.2	----------	.0	32	----------	.1	4.0	70	1.9
28	Dec. 7	80	----------	26	.5	9.6	1.6	----------	.0	34	----------	.7	4.5	78	.9
Dec. 8	17	155	----------	31	.7	12	----------	----------	.0	49	----------	.9	4.8	89	1.7
19	Jan. 3	160	----------	28	1.2	8.3	.8	----------	.0	27	----------	.8	5.0	83	3.1
Jan. 4	15	105	----------	20	.5	5.7	Tr.	----------	.0	20	----------	.4	4.0	61	3.4
16	26	38	----------	30	.9	14	4.4	----------	.0	51	----------	1.1	4.2	94	1.4
27	Feb. 6	80	----------	26	.8	12	----------	----------	.0	56	----------	1.2	3.0	85	4.3
Feb. 7	18	40	----------	22	1.0	5.6	1.2	----------	.0	20	----------	.5	5.0	60	7.5
Mar. 2	Mar. 11	240	----------	34	1.1	7.6	Tr.	----------	.0	27	----------	.6	2.5	69	6.9
12	21	110	----------	16	.6	9.6	1.2	----------	.0	32	----------	.4	2.0	50	3.2
22	31	35	----------	24	1.6	12	1.6	----------	.0	41	----------	.3	4.0	73	1.6
Apr. 1	Apr. 10	75	----------	20	1.3	9.6	1.6	----------	.0	32	----------	.2	6.5	64	1.6
11	24	185	----------	20	2.4	10	2.4	----------	.0	----------	----------	.4	5.0	66	3.3
25	May 4	95	----------	16	1.8	7.0	1.6	----------	.0	24	----------	.3	2.5	48	5.4
May 5	14	200	----------	18	2.5	10	1.6	----------	.0	34	----------	.2	4.5	61	4.0
15	24	100	6.1	18	.42	7.8	2.2	8.4	.0	44	5.4	4.0	2.2	70	1.9
25	June 3	350	15	21	Tr.	7.7	2.0	11	.0	43	6.2	1.5	2.6	68	1.4
June 4	13	375	16	22	Tr.	6.6	2.2	7.9	.0	45	5.6	1.0	1.9	69	.9
14	23	400	16	11	Tr.	6.3	2.1	8.1	.0	38	6.0	Tr.	1.4	51	1.0
24	July 3	230	12	10	Tr.	6.6	3.2	8.3	.0	34	8.1	.6	1.8	54	2.4
July 4	14	350	15	15	Tr.	6.6	1.6	9.4	.0	37	4.9	3.2	2.4	57	1.6
15	24	400	9.6	13	Tr.	7.1	1.9	6.2	[b] 4.8	27	7.5	.6	3.1	62	.8
25	Aug. 2	650	28	17	Tr.	6.3	1.9	8.1	.0	34	6.3	2.3	3.4	62	2.7
Aug. 4	13	400	19	14	.02	5.9	1.2	7.9	.0	32	6.1	2.0	2.9	55	.9
15	24	425	34	21	Tr.	7.2	.9	10	.0	40	5.4	4.2	3.1	74	2.0
26	Sept. 7	290	16	18	Tr.	6.9	1.1	7.9	.0	40	5.0	.7	2.4	62	.7
Sept. 8	17	400	24	18	Tr.	6.4	1.1	12	.0	41	5.5	1.0	2.6	63	1.0
28	Oct. 7	350	15	16	.02	11	1.7	8.3	.0	54	7.4	1.7	4.9	84	3.9
Oct. 8	17	40	3.5	15	.6	8.5	1.9	9.2	.0	50	7.5	Tr.	2.8	----------	.4
Mean		208	----------	21	.68	8.5	1.6	8.8	.0	37	6.2	1.0	3.4	68	----------

[a] Analyses Oct. 18, 1906, to May 14, 1907, by J. R. Evans; May 15 to Oct. 17, 1907, by R. B. Dole, Chase Palmer, and W. D. Collins.
[b] Abnormal; computed as HCO_3 in the average.

Analyses of water from Ocmulgee River near Macon, Ga.[a]

[Parts per million, unless otherwise stated.]

Date (0906-7).		Turbidity.	Total iron (Fe).	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total dissolved solids.	Mean gage height (feet).
From—	To—														
Oct. 19	Oct. 28	35	----------	12	0.6	5.6	1.6	----------	0.0	20	----------	0.1	4.0	50	3.7
29	Nov. 7	49	----------	32	.5	5.2	.8	----------	.0	22	----------	.5	3.0	66	2.9
Nov. 8	17	50	----------	30	.20	8.3	Tr.	----------	.0	27	----------	.5	1.5	77	3.0
18	27	65	----------	30	.30	7.5	1.2	----------	.0	22	----------	.2	1.8	72	4.0
28	Dec. 7	60	----------	26	.9	8.1	1.6	----------	.0	25	----------	.6	1.5	77	2.8
Dec. 8	17	75	----------	29	.7	9.6	1.2	----------	.0	32	----------	.8	1.7	75	3.3
21	Jan. 4	30	----------	26	.9	4.4	Tr.	----------	.0	15	----------	.1	4.0	56	5.4
Jan. 5	16	60	----------	18	.8	3.6	Tr.	----------	.0	12	----------	.5	3.5	88	4.3
17	26	40	----------	21	.8	3.6	Tr.	----------	.0	12	----------	.4	2.0	46	3.3
27	Feb. 5	240	----------	34	1.8	4.6	2.4	----------	.0	----------	----------	.5	2.5	64	7.2
Feb. 6	15	75	----------	32	.8	7.6	Tr.	----------	.0	24	----------	.4	2.0	58	7.8
16	25	40	----------	33	.7	8.0	1.6	----------	.0	27	----------	.3	1.5	57	4.0
26	Mar. 7	210	----------	38	1.4	6.8	Tr.	----------	.0	22	----------	1.2	3.5	71	8.9
Mar. 8	17	55	----------	15	.8	6.0	0.8	----------	.0	20	----------	.6	3.0	47	5.0
18	27	35	----------	14	1.0	9.6	Tr.	----------	.0	29	----------	.5	3.5	52	3.4
28	Apr. 6	25	----------	27	1.2	11	Tr.	----------	.0	34	----------	.7	3.5	70	3.1
Apr. 7	16	30	----------	23	2.1	9.2	Tr.	----------	.0	29	----------	.8	4.0	64	3.4
17	26	560	----------	21	1.7	5.5	1.2	----------	.0	24	----------	1.6	2.5	48	7.7
27	May 6	450	----------	24	1.4	4.5	.8	----------	.0	15	----------	1.8	3.0	50	5.3
May 7	16	204	----------	31	1.1	6.7	----------	10	.0	40	3.3	1.0	5.0	96	4.5
17	26	45	----------	25	2.0	5.7	2.9	8.1	.0	43	2.0	.3	4.0	85	3.0
27	June 5	310	----------	26	1.2	4.9	2.8	11	.0	----------	5.9	.4	2.5	91	3.1
June 6	15	226	----------	23	1.2	5.7	2.6	4.4	.0	37	4.9	.4	3.0	78	2.8
16	26	410	----------	25	2.4	4.1	2.4	6.9	.0	31	4.8	1.1	4.0	86	2.5
27	July 11	670	----------	23	2.0	6.5	1.5	6.3	.0	31	5.2	.7	3.5	84	4.3
July 12	21	416	----------	32	1.6	8.1	2.2	7.5	.0	41	6.8	1.0	4.0	94	2.2
Aug. 3	Aug. 12	1,100	21	7.5	Tr.	5.0	1.5	6.8	.8	24	4.7	1.1	1.4	35	2.7
13	22	580	35	21	Tr.	5.8	1.8	11	.8	40	4.3	1.2	1.8	64	3.3
24	Sept. 9	550	16	16	Tr.	5.8	1.8	6.6	.0	32	4.7	1.3	2.6	53	1.7
Sept. 10	19	270	10	41	Tr.	6.4	2.3	7.4	.0	38	5.8	.9	1.0	87	1.1
20	30	400	8.9	29	Tr.	5.1	1.8	11	.0	34	6.4	1.0	2.3	70	3.7
Oct. 1	Oct. 10	180	2.6	42	Tr.	5.7	1.8	11	.0	37	----------	.7	3.0	85	1.6
12	21	35	1.1	28	Tr.	4.7	1.4	8.1	.0	30	5.5	.6	3.2	70	.9
Mean		230	----------	26	.9	6.3	1.2	8.3	.0	28	4.9	.7	2.8	69	----------

[a] Analyses Oct. 19, 1906, to May 6, 1907, by J. R. Evans; May 7 to July 21, 1907, by W. D. Collins; Aug. 3 to Oct. 21, by R. B. Dole, Chase Palmer, and W. D. Collins.

APALACHICOLA RIVER BASIN.

Apalachicola River, in Georgia and Florida, is formed by the union of the Flint and the Chattahoochee; and for these we have the following tables:

Analyses of water from Flint River near Albany, Ga.[a]

[Parts per million.]

Date (1906-7). From—	Date (1906-7). To—	Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).[b]	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).[c]	Nitrate radicle (NO_3).	Chlorine (Cl).	Total dissolved solids.	Mean gage height (feet).[d]
Oct. 23	Nov. 1	120	47	....	6.8	3.6	....	0.0	29	....	1.8	3.0	84	4.3
Nov. 2	11	45	19	0.8	11	4.8	....	.0	51	....	.4	3.0	80	1.8
12	21	17	25	.20	11	Tr.	....	.0	32	....	.9	2.5	74	2.3
22	Dec. 1	20	27	.30	12	1.2	....	.0	34	....	.6	2.0	77	3.0
Dec. 2	11	25	33	.20	12	1.2	....	.0	37	....	.7	2.2	90	1.9
12	21	35	34	.5	14	1.6	....	.0	49	....	.5	2.5	93	2.1
22	31	40	20	.9	6.0	.8	....	.0	29	....	.8	3.0	68	3.8
Jan. 1	Jan. 11	35	18	.8	6.2	1.2	....	.0	22	....	.5	3.0	62	5.4
12	22	20	22	.10	8.1	.8	....	.0	34	....	.8	4.0	63	2.8
23	Feb 2	12	16	.8	7.0	.8	....	.0	24	....	1.1	5.5	52	3.0
Feb. 2	11	120	36	.9	5.6	.8	....	.0	22	....	.4	2.0	66	7.9
12	21	60	22	1.1	6.8	.8	....	.0	22	....	.7	4.0	70	5.8
22	Mar. 3	65	14	1.2	8.4	1.2	....	.0	27	....	.1	2.5	47	3.8
Mar. 4	13	85	18	1.4	8.8	1.2	....	.0	29	....	.4	3.0	54	5.8
14	23	40	12	.7	6.4	.8	....	.0	22	....	.3	1.5	39	4.1
24	Apr. 2	30	24	1.4	10	1.2	....	.0	37	....	.7	3.0	72	2.1
Apr. 3	12	60	19	.8	10	.8	....	.0	34	....	.3	2.5	59	3.8
13	22	160	23	.9	9.5	2.5	....	.0	34	....	.3	2.0	60	3.6
23	May 2	460	27	1.3	9.0	1.6	....	.0	34	....	.2	3.5	66	9.4
May 3	12	560	33	2.1	7.0	1.2	....	.0	24	....	.1	2.0	60	7.2
Mean		100	24	.86	8.8	1.4	[b] 7.0	.0	31	[c] 6.0	.6	2.8	67	....

[a] Analyses by J. R. Evans.
[b] Fluctuates between 2 and 10 parts. Average value about 7 parts.
[c] Fluctuates between trace and 8 parts. Average value about 6 parts.
[d] Approximate.

Analyses of water from Chattahoochee River at West Point, Ga.[a]

[Parts per million.]

Date (1906-7). From—	Date (1906-7). To—	Turbidity.	Total iron (Fe).	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total dissolved solids.	Mean gage height (feet).
Oct. 20	Oct. 29	85	....	16	1.0	6.6	1.2	....	0.0	24	....	0.0	2.0	50	4.2
30	Nov. 8	45	....	30	.6	3.6	.8	....	.0	19	....	.4	2.5	60	3.4
Nov. 9	18	65	....	20	.20	5.7	Tr.	....	.0	22	....	.4	1.5	54	3.5
19	29	70	....	26	.7	6.8	1.6	....	.0	27	....	.6	3.0	71	4.1
30	Dec. 9	60	....	30	.8	6.0	2.8	....	.0	24	....	.7	2.8	77	3.3
Dec. 10	19	55	....	32	.5	6.4	2.4	....	.0	29	....	.4	3.0	81	4.1
21	Jan. 1	130	....	32	.9	3.9	Tr.	....	.0	15	....	.7	1.5	60	4.8
Jan. 2	11	85	....	24	.7	2.3	.8	....	.0	....	....	.8	2.5	55	5.3
12	21	25	....	17	.10	4.7	.8	....	.0	17	....	.8	3.5	59	3.7
22	31	15	....	24	.30	7.4	1.6	....	.0	29	....	.5	3.5	59	3.5
Feb. 1	Feb. 10	220	....	33	1.2	3.6	1.6	....	.0	....	....	.4	1.8	53	7.2
11	26	55	....	18	.9	4.8	Tr.	....	.0	15	....	.3	....	56	3.8
27	Mar. 8	260	....	25	1.3	4.4	Tr.	....	.0	15	....	.3	1.5	53	7.7
Mar. 9	18	290	....	24	.9	5.6	Tr.	....	.0	20	....	.4	2.5	53	3.8
19	28	30	....	11	1.0	6.4	Tr.	....	.0	22	....	.2	2.5	40	3.6
29	Apr. 7	285	....	28	1.4	6.8	Tr.	....	.0	22	....	.4	3.0	59	3.5
Apr. 8	17	190	....	27	1.1	2.0	Tr.	....	.0	9.8	....	1.6	1.5	40	3.7
18	27	185	....	18	1.0	2.5	Tr.	....	.0	9.8	....	1.3	2.0	33	5.9
28	May 7	185	....	16	1.3	3.5	.8	....	.0	12	....	1.1	1.5	34	4.6
May 8	18	350	16	22	.03	4.9	1.1	8.8	[b] 8.4	13	4.8	.9	....	57	5.1
19	28	115	7.9	23	.03	5.2	1.9	9.2	[b] 8.4	21	5.0	.9	1.3	65	3.6
29	June 7	260	10	14	.03	3.0	.6	10	.0	26	4.0	1.2	1.7	47	3.7
June 8	17	130	2.4	16	.03	3.2	1.1	7.2	[b] 3.6	21	3.5	.0	1.0	45	3.1
18	27	120	5.8	11	.00	5.1	1.2	6.7	.0	16	7.6	.7	1.7	42	2.8
28	July 7	340	13	12	.00	4.9	.7	7.0	[b] Tr.	27	4.0	1.1	2.0	45	3.2
July 9	18	450	35	9.0	.00	4.3	.9	7.6	.0	28	3.0	1.0	1.2	36	3.0
19	28	325	12	13	.00	4.0	1.1	8.1	.0	24	3.8	1.1	1.2	40	2.6
29	Aug. 7	375	21	12	.03	6.0	1.3	9.4	.0	37	6.6	1.2	4.8	63	2.7
Aug. 8	17	400	10	14	Tr.	3.2	1.0	7.9	.0	24	4.0	1.1	1.8	47	2.6
18	27	375	6.6	15	Tr.	4.2	.6	6.3	.0	28	4.2	1.1	2.0	48	2.6
28	Sept. 6	225	3.7	17	Tr.	4.9	.5	6.5	.0	27	4.8	1.0	1.8	60	2.0
Sept. 17	26	155	5.2	12	Tr.	5.1	.8	6.6	.0	27	4.3	.7	1.3	46	2.6
27	Oct. 8	185	12	18	Tr.	4.9	.4	9.0	.0	29	4.1	1.0	1.8	54	2.5
Oct. 9	18	140	4.4	8.9	Tr.	5.7	1.0	5.8	.0	27	3.5	.6	1.7	42	2.1
Mean		185	....	20	.47	4.8	.8	7.7	.0	23	4.5	.7	2.1	52	....

[a] Analyses Oct. 20, 1906, to May 7, 1907, by James R. Evans; May 8 to Oct. 18, 1907, by R. B. Dole, Chase Palmer, and W. D. Collins.
[b] Abnormal; computed as HCO_3 in the average.

MOBILE RIVER BASIN.

Mobile River, in Alabama, is formed by the union of Alabama and Tombigbee rivers. Cahaba River is a tributary of the Alabama, and the Oostenaula also drains through the Coosa into the Alabama. For the Alabama, Cahaba, Oostenaula, and Tombigbee the following tables of analyses have been made:

Analyses of water from Alabama River at Selma, Ala.[a]

[Parts per million.]

Date (1906-7).		Turbidity.	Total iron (Fe).	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total dissolved solids.	Mean gage height (feet).
From—	To—														
Nov. 5	Nov. 17	65	----------	19	0.7	12	1.6	----------	0.0	46	----------	0.3	0.2	79	3.8
18	27	180	----------	40	.6	12	.8	----------	.0	41	----------	.5	2.0	91	17.1
28	Dec. 7	155	----------	34	.8	11	1.2	----------	.0	39	----------	.6	1.8	82	11.0
Dec. 8	17	180	----------	31	.5	9.6	1.6	----------	.0	32	----------	.3	2.0	78	7.0
18	Jan. 1	80	----------	20	.5	11	Tr.	----------	.0	31	----------	.4	----------	78	10.7
Jan. 2	13	50	----------	21	.20	8.3	4.4	----------	.0	44	----------	.3	3.5	83	19.5
14	23	35	----------	20	.40	16	2.8	----------	.0	44	----------	.8	3.2	73	7.7
24	Feb. 2	65	----------	26	.30	8.4	1.6	----------	.0	37	----------	.1	4.5	67	7.5
Feb. 3	12	100	----------	26	.5	8.2	2.4	----------	.0	32	----------	.8	2.8	66	27.9
13	24	25	----------	10	.5	14	1.2	----------	.0	44	----------	.4	3.0	58	9.4
25	Mar. 6	260	----------	22	.10	15	2.0	----------	.0	46	----------	.3	1.0	79	23.0
Mar. 7	16	160	----------	28	.10	10	1.2	----------	.0	34	----------	.5	3.0	70	20.8
17	26	95	----------	20	.20	15	1.2	----------	.0	49	----------	.3	1.5	70	9.3
27	Apr. 5	40	----------	20	.20	16	1.6	----------	.0	51	----------	.4	2.5	72	6.3
Apr. 6	15	95	----------	22	.40	15	5.2	----------	.0	58	----------	.1	1.5	80	7.4
16	25	195	----------	22	.5	12	5.2	----------	.0	51	----------	.2	3.0	76	13.3
26	May 5	220	----------	30	.40	10	3.6	----------	.0	41	----------	.1	2.0	74	16.1
May 6	15	90	----------	19	.40	12	2.8	----------	.0	----------	----------	.1	2.5	63	16.5
16	25	312	----------	13	1.2	13	2.3	3.2	.0	43	10	1.3	1.2	94	23.9
26	June 3	165	----------	15	1.0	11	2.6	----------	.0	48	13	.4	1.8	90	12.7
June 6	15	195	----------	25	1.3	13	2.8	5.6	.0	46	9.4	1.6	1.7	98	9.9
16	25	90	----------	17	.5	15	4.8	6.7	.0	----------	14	1.2	2.4	90	6.0
26	July 6	205	----------	11	.35	18	2.3	6.7	.0	61	8.7	.9	2.1	86	7.2
July 7	16	210	----------	22	1.1	15	4.5	5.5	.0	55	----------	1.6	2.1	104	4.0
17	26	125	----------	16	.48	17	5.8	----------	.0	67	10	1.6	3.0	105	4.4
28	Aug. 6	325	----------	17	1.1	15	5.3	8.9	[b] Tr.	50	13	1.2	1.8	99	5.4
Aug. 7	16	230	----------	25	1.0	15	----------	9.5	.0	----------	12	1.6	2.7	101	3.8
17	26	160	----------	23	1.2	13	----------	7.8	.0	60	9.4	1.1	2.0	110	2.7
27	Sept. 6	100	----------	21	1.0	16	4.8	5.7	.0	59	8.7	.4	2.5	105	1.4
Sept. 8	17	80	2.2	21	Tr.	15	4.0	8.1	.0	68	4.8	1.0	2.2	88	2.1
18	27	90	2.2	17	.03	14	4.1	7.4	.0	66	5.0	1.0	2.4	82	2.0
28	Oct. 7	180	2.8	11	Tr.	12	3.0	6.7	.0	56	3.7	1.1	2.4	64	4.7
Oct. 8	17	90	1	12	.03	12	2.9	9.0	.0	57	4.4	.9	2.3	68	1.5
Mean		141	----------	21	.53	13	2.9	7.0	.0	48	9.0	.7	2.3	82	----------

[a] Analyses Nov. 5, 1903, to May 15, 1907, by J. R. Evans; May 16 to Sept. 6, 1907, by Walton Van Winkle; Sept. 8 to Oct. 17, 1907, by R. B. Dole, Chase Palmer, and W. D. Collins.

[b] Abnormal; computed as HCO_3 in the average.

Analyses of water from Cahaba River near Birmingham, Ala.[a]

[Parts per million.]

Date (1906-7).		Turbidity.	Total iron (Fe).	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total dissolved solids.	Mean gage height (feet).[b]
From—	To—														
Nov. 1	Nov. 11	50	----------	20	0.20	14	1.6	----------	0.0	46	----------	0.9	3.0	78	2.2
12	21	20	----------	20	.30	14	2.4	----------	.0	46	----------	.8	1.5	72	4.5
22	Dec. 1	55	----------	21	.40	12	3.6	----------	.0	49	----------	.9	1.8	70	4.2
Dec. 3	13	75	----------	23	.5	12	----------	----------	.0	51	----------	.7	1.5	74	3.6
24	Jan. 2	100	----------	20	.40	8.8	.8	----------	.0	29	----------	.8	2.5	73	8.8
Jan. 8	19	15	----------	14	.20	9.9	1.2	----------	.0	34	----------	.9	3.4	66	4.8
20	31	15	----------	16	.6	13	----------	----------	.0	49	----------	.4	2.7	72	5.2
Feb. 1	Feb. 11	35	----------	23	.40	6.4	1.2	----------	.0	24	----------	.6	1.8	44	14.3
12	23	5	----------	8.6	.20	13	Tr.	----------	.0	41	----------	.2	1.5	53	4.2
24	Mar. 5	18	----------	12	.20	11	1.2	----------	.0	34	----------	.5	1.5	49	11.6
Mar. 6	15	25	----------	13	.30	12	1.6	----------	.0	41	----------	.3	2.5	59	5.6
16	25	10	----------	10	.30	14	1.2	----------	.0	46	----------	.4	2.0	59	3.7
26	Apr. 4	10	----------	16	.30	15	2.8	----------	.0	54	----------	.3	1.5	75	2.9
Apr. 5	14	25	----------	23	.30	18	1.6	----------	.0	58	----------	.3	3.0	92	4.0
15	24	90	----------	14	1.4	10	.8	----------	.0	37	----------	.2	2.5	52	11.1
25	May 2	265	----------	19	1.9	9.0	1.2	----------	.0	32	----------	.1	1.0	50	8.4
May 5	14	100	----------	14	1.2	7.1	3.0	8.8	.0	44	3.6	.7	2.0	62	9.0
15	24	35	----------	15	.40	8.5	3.6	6.0	.0	41	4.9	.6	2.5	68	12.2
25	June 3	130	----------	13	.8	8.9	2.9	7.4	.0	42	6.5	.3	2.5	66	8.0
June 4	13	10	----------	22	.40	8.3	3.6	5.7	.0	53	4.6	.3	3.0	78	4.1
14	24	20	----------	18	.6	11	4.0	6.3	.0	60	6.9	.6	3.0	87	3.3
25	July 8	20	----------	21	.5	15	3.6	6.0	.0	76	9.5	.8	2.0	99	2.7
July 9	19	15	----------	19	.30	16	3.8	11	.0	74	10	.2	3.0	96	2.4
20	31	8	Tr.	19	Tr.	22	4.7	10	.0	84	11	1.0	2.4	107	2.7
Aug. 1	Aug. 11	7	Tr.	11	Tr.	----------	4.1	8.7	.0	55	9.5	1.2	3.0	88	2.1
12	21	5	Tr.	12	Tr.	20	4.0	12	.0	78	10	.8	2.2	99	2.2
22	Sept. 5	5	Tr.	15	Tr.	23	2.9	12	[c] 4.8	80	9.9	1.2	3.8	108	1.6
Sept. 29	Oct. 9	35	1.0	----------	.8	14	2.7	11	Tr.	70	12	.8	.6	127	2.1
Oct. 10	22	8	.5	13	.22	16	3.0	10	Tr.	60	12	.5	1.4	80	1.6
23	Nov. 1	6	Tr.	10	Tr.	----------	3.0	12	.0	57	13	.3	2.4	86	1.4
Mean		40	----------	16	.44	13	2.5	9.1	.0	52	8.8	.6	2.2	76	----------

[a] Analyses Nov. 1, 1906, to May 2, 1907, by J. R. Evans; May 14 to July 19, 1907, by W. D. Collins; July 31 to Dec. 1, 1907, by R. B. Dole, Chase Palmer, and W. D. Collins.

[b] Gaging station near Centerville, Ala., 75 miles above.

[c] Abnormal; computed as HCO_3 in the average.

There is also a single analysis of water from Cahaba River by R. S. Hodges.[18] The sample analyzed was taken near Leeds, Ala. Restated herewith bicarbonates reduced to normal carbonates, the figures are as follows:

Analysis of water from Cahaba River.

1. Parts per million.
2. Percentage composition of dissolved solids.

	1	2
CO_3	80.0	41.91
SO_4	1.7	.90
Cl	3.5	1.85
Ca	40.7	21.33
Mg	8.0	4.22
Na	3.8	2.00
K	3.6	1.89
SiO_2	46.1	24.22
$(Al, Fe)_2O_3$	3.2	1.68
	190.6	100.00

This analysis differs materially from the average given in the Survey table. The salinity is more than twice as high, and the percentages of the several constituents are notably different.

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[18] Alabama Geol. Survey, Underground water resources, 1907.

Analyses of water from Oostanaula River near Rome, Ga.[a]

[Parts per million.]

Date (1906-7). From—	To—	Turbidity.	Total iron (Fe).	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total dissolved solids.	Mean gage height (feet).
Oct. 21	Oct. 30	25	----------	9.6	Tr.	12	----------	----------	0.0	39	----------	0.1	2.0	63	6.1
31	Nov. 9	40	----------	23	0.30	12	----------	----------	.0	46	----------	.6	3.0	81	2.8
Nov. 10	19	140	----------	34	.40	9.9	----------	----------	.0	39	----------	.3	----------	79	3.3
20	Dec. 1	124	----------	34	.6	11	1.2	----------	.0	37	----------	.4	1.5	85	14.4
Dec. 2	11	95	----------	29	.40	9.6	----------	----------	.0	34	----------	.6	1.5	70	3.6
12	21	105	----------	27	.9	8.2	1.2	----------	.0	32	----------	.8	1.8	66	6.3
22	31	70	----------	25	.7	11	1.6	----------	.0	44	----------	.4	2.0	82	6.6
Jan. 1	Jan. 10	65	----------	22	.8	9.6	1.2	----------	.0	37	----------	.6	1.5	62	8.0
11	20	25	----------	14	.20	11	1.2	----------	.0	37	----------	1.0	1.8	67	3.0
21	31	30	----------	21	.8	13	1.2	----------	.0	44	----------	.2	1.5	75	3.2
Feb. 1	Feb. 10	40	----------	18	.6	11	3.2	----------	.0	41	----------	.7	2.0	66	9.0
11	20	4	----------	13	.7	11	0.8	----------	.0	37	----------	.3	2.0	54	3.6
21	Mar. 4	165	----------	33	1.3	14	2.0	----------	.0	44	----------	.4	3.0	83	9.7
Mar. 5	14	45	----------	16	.9	7.6	Tr.	----------	.0	24	----------	.4	2.0	47	6.1
15	24	25	----------	18	1.2	15	1.2	----------	.0	51	----------	.8	1.0	76	4.0
25	Apr. 3	12	----------	19	1.2	11	----------	----------	.0	34	----------	.6	2.5	62	3.1
Apr. 4	13	65	----------	17	1.4	14	3.2	----------	.0	----------	----------	.4	2.0	70	3.4
14	23	60	----------	8.8	1.4	15	4.0	----------	.0	59	----------	.2	2.0	68	3.6
24	May 2	260	----------	7.8	1.6	13	----------	----------	.0	51	----------	.0	3.0	61	4.7
May 3	13	220	----------	18	.7	15	3.3	8.8	.0	72	2.6	.8	1.0	100	4.2
14	23	150	----------	18	1.0	11	3.1	11	.0	72	4.3	.0	1.5	92	5.4
24	June 5	340	----------	29	1.6	12	3.2	11	.0	71	4.3	.6	1.5	120	5.0
June 6	15	200	----------	25	.6	----------	3.3	6.0	.0	74	4.8	.0	2.5	99	3.8
16	26	180	----------	28	.40	14	4.1	8.2	.0	78	3.6	.6	2.0	101	2.4
27	July 7	415	----------	26	1.2	12	3.7	6.6	.0	68	3.8	.7	2.0	106	2.9
July 8	17	370	----------	39	.8	13	3.9	12	.0	78	5.5	.4	2.0	122	2.4
Aug. 7	Aug. 16	260	----------	31	Tr.	9.6	4.6	13	.0	73	5.1	1.0	1.0	105	1.9
17	26	260	----------	23	Tr.	13	2.9	9.4	.0	67	4.8	1.0	0.6	87	2.0
Sept. 27	Oct. 6	125	----------	47	Tr.	7.3	3.2	7.6	.0	51	3.6	.5	1.7	109	2.6
Oct. 7	17	45	1.2	44	Tr.	14	5.0	7.9	.0	74	3.8	----------	1.2	118	1.5
18	28	10	Tr.	17	Tr.	11	2.9	9.1	.0	70	3.3	----------	1.8	81	1.0
Mean		128	----------	24	.7	12	2.6	9.2	.0	53	4.1	.4	1.8	82	----------

[a] Analyses Oct. 21, 1906, to May 2, 1907, by Jas. R. Evans; May 2 to July 17, 1907, by W. D. Collins; Aug. 7 to Oct. 28, 1907, by R. B. Dole, Chase Palmer, and W. D. Collins.

Analyses of water from Tombigbee River near Epes, Ala.[a]

[Parts per million.]

Date (1906-7).		Turbidity.	Total iron (Fe).	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total dissolved solids.	Mean gage height (feet).
From—	To—														
Oct. 24	Nov. 2	95		37	0.40	12	2.8		0.0	49		0.4	3.5	95	3.7
Nov. 3	12	85		34	.20	11	2.8		.0	46		.3	3.0	85	1.9
13	22	90		23	.9	17	2.4		.0	71		.3	2.5	104	4.1
23	Dec. 2	90		36	.30		Tr.		.0			.1	2.0	71	9.8
Dec. 3	12	85		32	.40		Tr.		.0			.4	1.5	68	5.3
13	22	95		27	.20		Tr.		.0			.6	1.8	57	10.7
23	Jan. 1	135		40	.40	22	2.4		.0	76		.5	5.0	129	11.2
Jan. 2	14	55		20	.40	16			.0	73		.4	4.0	100	12.5
15	24	30		19	.8	18	2.0		.0	61		.3	4.5	93	7.0
25	Feb. 3	145		33	.20	21	1.6		.0	61		.3	3.5	102	10.5
Feb. 4	13	130		22	.6	12	1.2		.0	41		.8	2.2	75	31.1
14	24	8		9.6	.10	12	Tr.		.0	39		.5	3.8	51	7.8
25	Mar. 9	380		31	.40	22	2.4		.0	68		.2	3.0	118	28.0
Mar. 11	20	85		19	.40	14	3.2		.0	51		.4	2.5	73	20.6
21	30	55		21	.40	18	5.2		.0	66		.6	3.5	88	8.4
31	Apr. 13	140		26	.30	17	2.8		.0	56		.3	3.5	92	5.8
Apr 14	23	320		28	.8	20	2.4		.0	68		.4	3.5	97	9.4
24	May. 3	450		33	.9	22	2.4		.0	73		.2	4.0	104	12.3
May 4	13	120		21	1.0	20	1.6		.0	61		.1	3.5	88	31.2
14	24	180	7.0	15	1.0	20	1.9	8.5	.0	79	6.2	.0	1.8	94	33.8
25	June 3	300	10		1.6	21	2.6	12	.0	93	5.9	Tr.	1.8		21.6
June 4	20	220	7.9	23	1.0	22	1.9	8.2	.0	72	6.4	Tr.	1.8	104	12.1
22	July 2	260	8.8	30	.52			11	.0	90	6.6	Tr.	2.4	127	4.3
July 3	12	200	8.8	39	1.0		2.0	11	.0	94	7.1	Tr.	2.6	129	3.5
13	22	45	2.4	27	1.0	23	1.8	12	.0	83	6.7	Tr.	3.2	119	2.9
23	Aug. 1	35	2.4	25	1.2	19	1.6	10	.0		5.9	Tr.	1.8	96	2.4
Aug. 2	11	60	3.7	20	1.0	18	1.5	11	.0		7.9	.2	4.2	95	1.7
12	21	100	3.3	23	.32	21	.9	11	.0	75	5.7	1.7	2.6	102	1.6
22	31	90	3.5	29	1.0	22	.8	11	.0	82	6.1	1.5	2.4	115	2.0
Sept. 14	Sept. 24	20	1.5	16	.52	21	.9	8.8	.0	73	4.8	1.4	3.4	94	.7
25	Oct. 4	50	1.5	23	.33	18	1.5	12	.0	71	5.2	1.3	3.0	98	1.4
Oct. 5	14	20	1.3	10	.24	16	1.0	7.9	.0	50	6.7	5.0	2.6	71	.9
15	24	10	1.1	18	.98	13	1.2	7.6	.0	46	6.5	1.2	3.0	73	1.0
Mean		126		25	.63	18	1.8	10	.0	67	6.3	.6	3.0	94	

[a] Analyses Oct. 24, 1906, to May 13, 1907, by J. R. Evans; May 14 to Oct. 14, 1907, by R. B. Dole, Chase Palmer, and W. D. Collins.

PEARL RIVER.

Pearl River in Mississippi is represented by the next table of analyses.

Analyses of water from Pearl River near Jackson, Miss.[a]

[Parts per million.]

Date (1906-7).		Turbidity.	Total iron (Fe).	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total dissolved solids.	Mean gage height (feet).
From—	To—														
Oct. 16	Oct. 26	45		13		5.2	0.8		0.0	20		0.4	5.0	48	17.8
27	Nov. 8	75		27	0.20	5.5	.8		.0	22		.9	4.0	69	3.0
Nov. 9	20	30		21	.7	9.6	1.2		.0	32		.4	1.8	67	2.0
21	Dec. 3	35		23	.8	10	1.6		.0	34		.7	2.0	72	3.3
Dec. 4	15	40		19	.7	12	1.2		.0	41		.9	2.2	65	3.4
26	Jan. 5	105		28	.30	6.5	Tr.		.0	22		.5	6.0	62	7.8
Jan. 6	15	55		32	.9	4.7	.4		.0	20		1.0	4.2	77	9.6
16	26	25		19	.6		1.6		.0	54		.7	6.0	76	5.0
28	Feb. 6	60		19	.5	4.4	1.2		.0			.9	4.0	52	7.9
Feb. 7	16	30		15	.40	4.4	1.2		.0	15		.3	3.5	43	18.5
17	26	90		20	.10	4.4	Tr.		.0			.1	3.5	46	8.9
Mar. 1	Mar. 16	85		14	.20	4.4	Tr.		.0	12		.2	4.0	36	23.0
17	26	60		13	.10	10	1.6		.0	34		.5	1.8	50	9.5
27	Apr. 5	30		20	.40	8.8	.8		.0	29		.8	4.5	61	4.3
Apr. 6	18	160		16	.5	8.4	Tr.		.0	27		.6	2.5	60	3.7
19	29	35		31	2.8	4.0			.0			.7	2.5	52	7.9
30	May 9	170		23	1.7	5.0	Tr.		.0	17		.9	3.0	46	12.4
May 10	23	60	2.8	10	.05	5.1	1.2	7.9	.0	28	5.5	1.0	2.5	50	21.0
24	June 2	60	6.6	11	.10	6.2	1.6	6.7	.0	28	6.7	1.1	2.6	45	12.7
June 3	13	45	4.4	26	.07	7.9	1.4	8.3	.0	44	6.6	1.0	3.1	79	5.4
14	23	50	9.6	24	.04	8.1	1.6	11	.0	44	7.4	1.2	3.4	74	3.6
24	July 3	50	11	20	Tr.	9.7	1.6	13	.0	56	6.2	.5	3.2	76	2.7
July 4	13	100	7.0	13	.03	7.0	1.9	14	.0	30	11		5.5	75	3.4
14	23	45	7.9	15	.03	8.6	1.7	9.6	.0	45	6.9	.9	3.2	65	2.6
24	Aug. 3	15	3.5	13	.03	9.7	1.6	8.8	.0	40	6.8	Tr.	2.9	54	1.9
Aug. 4	14	30	3.5	11	.03	8.3	1.7	7.6	.0	40	6.2	.7	2.6	52	1.9
15	24	45	2.4	11	.04	7.7	1.4	8.3	.0	32	6.1	2.2	5.0	59	2.1
25	Sept. 3	45	5.2	12	.04	6.3	.9	7.9	.0	29	4.9	.8	2.6	53	2.5
Sept. 4	14	40	3.2	13	.04	7.4	1.0	9.2	.0	38	4.8	.0	2.6	56	1.9
15	26	50	6.1	9.7	.03	6.9	1.5	4.7	.0	30	4.7	.7	2.4	41	1.5
27	Oct. 7	10	2.8	14	.03	8.0	2.1	8.3	.0	41	6.0	Tr.	3.6	63	1.0
Oct. 8	19	30	2.3	8.9	.03	6.9	1.3	8.3	.0	37	5.6	.2	2.9	52	1.3
Mean		56		18	.37	7.1	1.1	8.9	.0	32	6.4	.7	3.4	59	

[a] Analyses Oct. 16, 1906, to May 8, 1907, by James R. Evans; May 10 to Oct. 19, 1907, by R. B. Dole, Chase Palmer, and W. D. Collins.

SUMMARY FOR SOUTH ATLANTIC SLOPE.

In the foregoing pages there are 18 tables of analyses made in the water resources laboratory of the United States Geological Survey. The averages, recalculated into the percentage composition of the dissolved solids are given in the next table, in which, with two exceptions, the alkalies have been corrected by Palmer's determinations of potassium.

Reduced analyses of waters of the south Atlantic slope.

1. James River. Mean of 36 composite samples.
2. Dan River. Mean of 21 composites.
3. Roanoke River. Mean of 20 composites.
4. Neuse River. Mean of 36 composites.
5. Cape Fear River. Mean of 30 composites. Water probably modified by tidal contamination.
6. Peedee River. Mean of 24 composites.
7. Saluda River. Mean of 16 composites.
8. Wateree River. Mean of 34 composites.
9. Savannah River. Mean of 34 composites.
10. Ocmulgee River. Mean of 33 composites.
11. Oconee River. Mean of 32 composites.
12. Flint River. Mean of 20 composites.
13. Chattahoochee River. Mean of 34 composites.
14. Oostanaula River. Mean of 31 composites.
15. Cahaba River. Mean of 30 composites.
16. Alabama River. Mean of 33 composites.
17. Tombigbee River. Mean of 33 composites.
18. Pearl River. Mean of 32 composites. In this table each composite sample analyzed was a mixture of 10 or more samples taken daily between the dates given in the original tables.

	1	2	3	4	5	6	7	8	9
CO_3	36. 02	25. 43	34. 99	24. 93	26. 57	23. 33	26. 01	25. 15	22. 49
SO_4	8. 67	5. 34	5. 90	4. 90	6. 91	5. 95	8. 01	6. 33	9. 12
Cl	2. 81	5. 03	2. 95	6. 34	12. 52	4. 60	5. 61	4. 22	3. 19
NO_3	. 37	1. 73	. 67	. 43	. 43	. 89	. 69	. 60	. 91
Ca	17. 10	8. 79	12. 74	8. 50	10. 80	10. 25	13. 46	9. 49	8. 67
Mg	3. 66	2. 35	4. 69	2. 59	3. 24	1. 93	2. 08	2. 71	1. 22
Na	7. 20	9. 10	6. 70	10. 09	14. 04	10. 99	9. 62	10. 84	14. 42
K	1. 34	2. 04	1. 47	1. 87	1. 95	2. 82		2. 41	4. 12
SiO_2	21. 98	37. 68	28. 15	37. 47	21. 38	38. 65	33. 65	37. 65	34. 95
Fe_2O_3	. 85	2. 51	1. 74	2. 88	2. 16	. 59	. 87	. 60	. 91
	100. 00	100. 00	100. 00	100. 00	100. 00	100. 00	100. 00	100. 00	100. 00
Salinity [a]	89	71	79	73	57	69	62	73	60

	10	11	12	13	14	15	16	17	18
CO_3	21. 06	26. 00	22. 73	21. 32	32. 06	32. 53	27. 86	33. 34	25. 29
SO_4	7. 48	8. 86	8. 95	8. 49	5. 04	11. 18	10. 63	6. 37	10. 31
Cl	4. 28	4. 86	4. 17	3. 96	2. 21	2. 79	2. 72	3. 03	5. 48
NO_3	1. 07	1. 43	. 90	1. 32	. 50	. 76	. 83	. 61	1. 12
Ca	9. 62	12. 14	13. 12	9. 06	14. 74	16. 52	15. 35	18. 18	11. 43
Mg	1. 83	2. 29	2. 09	1. 51	3. 19	3. 17	3. 42	1. 82	1. 77
Na	10. 23	10. 14	10. 44	12. 08	9. 60	8. 78	11. 33	8. 18	11. 59
K	2. 90	2. 85		3. 40	1. 96	3. 18	2. 12	2. 32	3. 22
SiO_2	39. 70	30. 00	35. 77	37. 73	29. 48	20. 33	24. 79	25. 25	28. 99
Fe_2O_3	1. 83	1. 43	1. 83	1. 13	1. 22	. 76	. 95	. 90	. 80
	100. 00	100. 00	100. 00	100. 00	100. 00	100. 00	100. 00	100. 00	100. 00
Salinity [a]	69	68	67	52	82	76	82	94	59

[a] Parts per million.

A glance at this table is enough to show the general similarity in composition of these 18 rivers. They are all low in salinity and relatively high in their percentages of silica and alkalies. Calcium is low in all, and in some of the analyses it is exceeded by sodium. Some rivers in Oregon and Washington show these peculiarities, and so do others at the headwaters of the Elbe in Bohemia and the Danube in Bavaria.[19] The similarity is so great that the analyses of these foreign waters might be placed side by side with those of the south Atlantic slope as members of the same general family.

Of course the rivers now under consideration are not identical in composition. There are naturally variations due to local conditions. The James, for example, shows the influence of the limestone area at the head of the Valley of Virginia, and in a sense it may be regarded as intermediate in type between the

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[19] For analyses of these foreign waters see U. S. Geol. Survey Bull. 695, pp. 99, 101, 1920.

Potomac and the more southern rivers. Cape Fear River, with its abnormal percentage of chlorine, shows the effect of proximity to salt water, for the samples analyzed were taken near Wilmington, a seaport. In spite of these local differences, however, the analyses in the foregoing table tell a definite story and are easy to interpret.

The rivers of this region, at least those represented in the table of analyses, rise in the southern Appalachians and, after a long course on the Piedmont Plateau, descend to the Coastal Plain. They owe their chemical peculiarities to the rocks at their sources, which are essentially sodic in character. The granites of Georgia, of which many analyses have been made, are mostly soda granites, and the rivers derive their silica and alkalies from the decomposition of sodic feldspars by carbonated waters. Streams emerging from areas characterized by the presence of potash feldspars are much poorer in alkaline compounds, for the reason that potash salts are largely retained by the sediments, while the sodium compounds remain in solution. The potash thus held back reappears in the slates and shales, which are essentially consolidated muds and in which potassium is usually if not always in excess of sodium. The rivers of the south Atlantic slope reflect the character of the rocks from which they flow. Their low salinity is due to the relatively slight solubility of the feldspars. Limestones are more soluble, and therefore limestone waters are generally much higher in salinity.

Ogeechee River falls outside the class of the other streams as given in the last table. Its course is in the Coastal Plain, and its dissolved solids are derived from sedimentary rocks.

SOUTHERN FLORIDA.

Few analyses of the waters of Florida have been made, and they all show the effect of proximity to the ocean. The streams flow through a country of only slight elevation, with many swamps and morasses. The underlying rocks are all calcareous and of geologically recent origin. The following analyses are available for present purposes:

Analyses of waters in southern Florida.

1. Kissimee River.
2. Lake Okechobee. Analyses 1 and 2 by W. T. Read for R. B. Dole.
3. Small stream at Deerfield.
4. Small lake at Likely.
5. Clear Lake at West Palm Beach. Analyses 3 to 5, by the American Water Softener Co., are of waters close to the eastern coast of Florida.
6. Turkey Creek at Turkey Creek station.
7. Small stream at Ellenton. Analyses 6 and 7, of waters in the region of Tampa Bay, were received from the Seaboard Air Line. In all seven analyses bicarbonates are here reduced to normal carbonates, and organic matter is rejected.

I. Parts per million.

	1	2	3	4	5	6	7
CO_3	6.4	55.9	60.2	4.0	15.3	1.5	182.0
SO_4	4.3	7.3	4.0	4.0	1.3	8.2	22.0
Cl	10.0	28.0	35.0	46.0	30.0	6.1	47.0
NO_3	.2	.1	------	------	------	------	------
Ca	4.5	31.0	72.1	2.0	9.7	3.4	72.0
Mg	2.7	7.0	7.0	3.6	2.4	.6	39.0
Na	7.2	16.0	7.0	26.0	16.0	4.0	23.0
K	1.4	2.0					
SiO_2	1.0	8.2	2.7	2.7	5.5	6.9	------
Fe_2O_3	.1	.1				------	------
$(Al, Fe)_2O_3$	------	------	------	------	------	2.1	3.6
	37.8	155.6	188.0	88.3	80.2	32.8	388.6

II. Percentage composition of dissolved solids.

	1	2	3	4	5	6	7
CO_3	16.93	35.96	32.02	4.53	19.08	4.57	46.83
SO_4	11.37	4.69	2.13	4.53	1.62	25.00	5.66
Cl	26.46	18.00	18.62	52.09	37.41	18.59	12.10
NO_3	.52	.06	------	------	------	------	------
Ca	11.91	19.93	38.35	2.26	12.10	10.36	18.53
Mg	7.14	4.50	3.72	4.08	2.98	1.86	10.03
Na	19.05	10.28	3.72	29.45	19.95	12.19	5.92
K	3.71	1.28					
SiO_2	2.65	5.27	1.44	3.06	6.86	21.03	------
Fe_2O_3	.26	.03				------	------
$(Al, Fe)_2O_3$	------	------	------	------	------	6.40	.93
	100.00	100.00	100.00	100.00	100.00	100.00	100.00

These analyses, in general terms, represent limestone waters, contaminated more or less by sea water and also by cyclic salt derived from rainfall. It is also possible that the porous coralline rocks and coquina may contain disseminated salt, and so too may the swamps through which the streams flow. Any one of these sources of chlorides would account for their presence in the waters.

MISSISSIPPI BASIN.

MISSISSIPPI RIVER.

For the main stem of the Mississippi there are six tables of analyses made in the water-resources laboratory of the United States Geological Survey. Tables 2, 3, 4 are from Water-Supply Paper 239; the others are from Water-Supply Paper 236. They are as follows:

1. Analyses of water from Mississippi River at Minneapolis, Minn.[a]

[Parts per million.]

Date (1906-7).		Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K)	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total dissolved solids.	Mean gage height (feet).[b]
From—	To—													
Sept. 10	Sept. 19	25	33	0.10	----------	13	15	0.0	204	8.2	0.8	0.9	225	1.7
20	30	10	30	.10	40	15	14	.0	182	20	.9	2.5	209	2.5
Oct. 1	Oct. 10	15	19	.10	38	----------	15	.0	----------	14	5.2	3.8	194	3.0
11	21	10	22	.05	41	16	10	.0	196	25	.4	2.5	191	2.0
22	31	10	21	Tr.	42	15	9.2	.0	189	27	.3	2.0	203	2.2
Nov. 1	Nov. 10	15	13	Tr.	38	16	11	.0	----------	18	Tr.	1.0	187	2.8
11	21	10	12	.05	43	16	11	.0	----------	20	.7	1.6	206	2.6
22	Dec. 1	5	12	.08	46	15	9.9	.0	215	25	.9	2.0	220	4.7
Dec. 2	12	10	13	.10	46	16	7.6	.0	218	23	1.8	1.9	220	9.6
13	24	5	16	.06	47	17	9.8	.0	214	28	.9	1.7	236	----------
25	Jan. 4	5	17	Tr.	47	----------	13	.0	208	20	.9	1.5	217	----------
Jan. 5	15	5	15	Tr.	41	14	7.5	.0	222	----------	1.3	1.7	213	----------
16	26	10	14	.06	46	16	11	.0	222	18	1.1	2.0	206	----------
27	Feb. 6	5	16	.10	45	18	8.2	.0	222	----------	1.6	1.9	217	----------
Feb. 7	16	5	13	.10	----------	16	12	.0	220	12	2.0	1.9	214	----------
17	26	5	16	.05	46	14	16	.0	205	24	7.0	2.3	221	----------
27	Mar. 8	5	17	.05	43	16	17	.0	222	23	4.6	1.5	218	----------
Mar. 9	18	10	11	----------	46	----------	9.8	.0	195	15	2.9	2.0	207	----------
19	28	15	12	.05	----------	----------	9.6	.0	147	9.2	1.9	2.2	155	----------
30	Apr. 8	30	9.0	.25	27	8.8	6.5	.0	127	17	1.2	.3	132	6.2
Apr. 9	19	10	9.0	.01	26	9.8	7.3	.0	127	20	1.1	.4	160	4.5
20	29	5	15	.15	34	12	8.0	.0	144	20	Tr.	1.5	183	3.1
30	May 13	5	12	.04	33	13	7.0	.0	156	20	1.9	----------	180	2.3
May 14	23	7	15	.02	39	13	----------	.0	178	18	.6	.2	209	1.7
24	June 2	5	12	.05	35	12	7.9	.0	165	22	.8	----------	205	2.9
June 3	13	8	14	Tr.	----------	12	5.2	.0	159	19	1.2	.6	180	3.3
14	23	5	12	.15	37	13	5.7	.0	171	23	1.3	3.3	233	4.0
24	July 3	20	18	Tr.	41	15	6.4	.0	193	16	1.1	1.2	221	2.6
July 4	13	20	20	.05	44	----------	11	.0	----------	15	1.6	3.1	206	1.3
14	23	5	8.6	.08	44	10	13	.0	198	8.6	.6	Tr.	198	1.0
24	Aug. 2	10	5.2	.13	43	11	12	.0	206	14	1.1	1.0	197	.8
Aug. 3	12	5	13	.11	40	14	11	.0	199	14	Tr.	1.4	187	.7
13	22	10	17	.10	38	14	7.5	.0	173	13	.4	.4	185	1.1
23	Sept. 1	5	19	.18	35	12	9.0	.0	172	10	.4	1.5	175	1.4
Sept. 2	11	5	15	.11	37	12	11	.0	185	14	Tr.	.5	173	.6
Mean		10	15	.07	40	14	10	.0	188	18	1.4	1.6	200	----------

[a] Analyses September 10, 1906, to February 16, 1907, by W. M. Barr; February 17 to 26, 1907, by H. S. Spaulding; February 27 to September 11, 1907, by Walton Van Winkle.

[b] Gaging station at Anoka, Minn., 20 miles above.

2. Analyses of water from Mississippi River near Moline, Ill.

[Parts per million.]

Date (1906-7).		Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total solids.	Mean gage height (feet).
From—	To—													
Feb. 1	Feb. 9	15	29	0.32	36	19	13	0.0	203	25	1.7	4.5	241	4.4
10	18	20	19	.56	41	18	7.6	.0	205	29	1.7	4.5	219	3.2
19	28	70	11	.20	33	13	11	.0	158	21	2.3	7.0	188	4.8
Mar. 1	Mar. 10	65	15	----------	30	13	15	.0	144	19	3.2	4.0	168	5.3
11	20	60	18	.38	32	12	11	.0	168	15	3.0	3.8	185	5.3
21	31	150	18	.39	32	8.4	18	.0	151	23	4.0	4.0	168	6.6
Apr. 1	Apr. 10	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	9.9
11	20	55	11	.24	20	10.0	11	.0	91	24	2.2	3.5	124	12.8
21	30	25	8.0	.23	24	11	7.1	.0	118	17	1.7	2.5	128	10.3
May 1	May 10	20	18	.24	26	8.2	8.7	.0	123	21	1.0	2.5	152	7.8
11	20	55	12	.8	27	9.8	11	.0	131	24	0.4	8.3	156	6.5
21	31	100	10	.50	27	12	5.9	.0	116	21	1.1	2.0	149	6.8
June 1	June 10	90	12	.34	31	13	11	.0	----------	17	2.0	1.8	172	7.1
11	20	145	16	.31	37	16	7.7	.0	155	20	0.4	2.5	189	7.4
21	30	210	14	.65	42	15	6.8	.0	161	27	1.7	3.0	186	6.6
July 1	July 10	185	13	.31	40	14	8.1	.0	166	31	0.3	2.5	203	6.8
11	20	372	19	.42	41	15	8.6	.0	173	35	1.8	2.0	212	8.3
21	31	350	22	.32	41	16	10.0	.0	171	34	2.7	4.5	208	7.7
Mean		117	16	0.39	33	13	10	.0	152	24	1.8	3.7	179	----------

3. *Analyses of water from Mississippi River near Quincy, Ill.*

[Parts per million.]

Date (1906-7). From—	Date (1906-7). To—	Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total dissolved solids.	Mean gage height (feet).
Aug. 1	Aug. 10	150	17	0.10	38	17	16	0.0	180	25	1.0	5.5	224	5.4
11	20	540	23	.20	34	14	16	.0	161	23	2.1	5.0	192	6.4
21	30	360	21	2.0	36	17	18	.0	166	23	2.0	5.5	197	5.7
31	Sept. 9													5.6
Sept. 10	18	245	17	.5	31	13	10	.0	168	24	2.8	3.5	187	6.0
20	29	224	16	.40	35	18	11	.0	156	20	1.8	9.0	196	5.9
30	Oct. 9	263	17	.12	38	21	12	.0	162	22	2.0	4.5	200	6.0
Oct. 10	18	144	19	.02	38	21	11	.0	190	20	1.5	6.0	213	5.3
20	31	151	15	.04	42	19	12	.0	206	22	1.0	6.5	220	4.4
Nov. 1	Nov. 8	50	19	.04	41	19	14	.0	214	26	.5	4.3	223	4.8
9	19	30	17	.03	35	16	8.0	.0	174	14	.3	7.5	185	5.8
20	30	30	16	.05	36	17	11	.0	182	27	2.5	3.8	196	5.9
Dec. 1	Dec. 10	50	17	.32	37	19	11	.0	188	28	2.5	6.2	217	6.6
11	20	25	10	.11	35	18	13	.0	176	27	2.0	4.5	190	5.2
21	25	10.0	18	.28	37	24	16	.0	225	39	2.0	6.0	244	2.9
Jan. 1	Jan. 10	200	19	1.0	35	16	16	.0	218	27	3.0	5.0	210	4.5
11	20	475	26	2.2	36	18	9.8	.0	185	35	2.7	4.0	237	6.2
21	31	300	26	1.4	32	14	17	.0	140	25	2.7	4.5	203	9.1
Feb. 2	Feb. 9	96	21	.9	39	17	8.8	.0	180	30	2.7	5.2	218	4.2
10	18	80	30	.44	41	18	12	.0	205	31	2.5	5.0	239	4.9
19	28	182	15	.26	39	16	8.8	.0	183	22	3.2	6.0	207	5.8
Mar. 1	Mar. 10	110	16	.25	33	15	12	.0	151	19	5.0	3.3	188	6.5
11	20	190	18	.61	35	16	10	.0	175	26	4.0	3.3	192	7.1
21	31	195	17	.61	34	14	13	.0	176	26	5.0	2.8	193	7.5
Apr. 1	Apr. 10	250	18	.35	32	13	7.0	.0	141	21	2.8	2.5	180	9.8
11	20	40	14	.22	24	10	7.9	.0	121	22	2.4	2.5	144	12.9
21	30	40	8.4	.28	38	10	12	.0	138	24	1.1	6.5	170	11.9
May 1	May 10	45	10	.12	33	13	9.2	.0	163	22	.9	2.5	176	9.1
11	20	55	10	.34	31	11	8.7	.0	151	32	2.0	3.5	213	7.8
21	31	165	15	.7	32	16	8.7	.0	158	22	1.4	2.3	176	8.2
June 1	June 10	170	14	.13	34	15	6.9	.0	161	19	2.3	2.5	188	8.6
11	20	250	14	.62	40	17	8.4	.0	173	16	1.2	2.3	200	10.6
21	30	210	16	.32	45	17	8.7	.0	190	28	1.5	3.5	218	9.1
July 1	July 10	150	20	.12	44	19	13	.0	207	37	2.5	3.0	227	8.3
11	20	400	24	.66	40	15	10	.0	163	28	2.4	3.5	211	11.5
21	31	175	31	.5	45	17	15	.0	207	30	1.8	3.8	239	13.4
Mean		173	18	.46	36	16	11	.0	175	25	2.2	4.4	203	

4. *Analyses of water from Mississippi River near Chester, Ill.*

[Parts per million.]

Date (1906-7). From—	Date (1906-7). To—	Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total solids.
Aug. 1	Aug. 10	1,400	6.2	0.30	46	15	30	0.0	146	93	0.8	11	320
11	20	1,525	27	.14	38	14	27	.0	145	52	2.1	9.5	237
21	30	1,875	33	.30	40	16	17	.0	145	47	2.5	10.0	245
31	Sept. 9	1,650	16,	.04	39	13	20	.0	161	55	2.5	12	256
Sept. 11	19	840	24	.25	40	17	26	.0	164	48	1.4	10	249
20	29	980	19	.16	47	17	19	.0	167	55	1.2	16	260
30	Oct. 9	766	16	.05	39	17	24	.0	150	40	1.5	11	228
Oct. 10	19	1,100	19	.08	46	21	24	.0	190	54	2.0	10	266
22	31	530	22	.08	53	22	25	.0	236	58	1.2	12	306
Nov. 1	Nov. 9	540	22	.02	52	19	28	.0	219	66	1.5	15	316
15	19	710	24	.04	53	23	22	.0	200	78	1.7	13	310
20	28	634	19	.20	42	17	15	.0	180	54	3.5	10	254
Dec. 1	Dec. 10	293	20	.37	43	19	15	.0	195	49	2.0	10	265
11	20	220	17	1.30	46	20	16	.0	192	54	2.0	9.5	271
22	31	194	15	.12	52		24	.0	241	55	4.0	11	301
Jan. 1	Jan. 10	325	20	.56	43	18	16	.0	205	52	3.5	10	271
11	19	450	20	1.1	39	15	18	.0	175	51	2.5	7.0	260
21	31	850	35	1.2	35	10.0	18	.0	117	42	1.2	5.7	222
Feb. 1	Feb. 9	310	21	1.2	33	13	22	.0	148	36	7.0	6.2	214
10	18	181	23	.47	46	17	22	.0	189	49	5.0	12	277
21	28	587	24	.33	47	16	23	.0	187	63	4.0	12	304
Mar. 1	Mar. 10	580	21	.35	42	17	26	.0	161	55	5.0	7.5	266
11	20	390	34	.45	42	13	19	.0	146	44	3.0	18	257
21	31	800	19	.26	38	13	19	.0	166	53	4.0	5.8	238
Apr. 21	Apr. 30	445	20	1.2	47	20	12	.0	166	65	2.0	5.0	256
June 1	June 10	2,000	23	.13	44	16	14		156	64	2.4	7.0	284
11	20												
21	30	1,300	22	.41	59	16	24	.0	178	66	2.4	6.5	296
July 1	July 10	1,320	26	.26	48	14	21	.0	173	62	2.5	7.0	294
11	20	2,300	25	.18	50	17	13	.0	170	81	2.0	7.0	304
21	31	634	24	.14	47	14	21	.0	166	54	5.2	7.5	250
Mean		858	22	.39	44	16	21	.0	174	56	2.7	9.8	269

5. *Analyses of water from Mississippi River at Memphis, Tenn.*[a]

[Parts per million.]

Date (1908).		Tur-bidity.	Total iron (Fe).	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magne-sium (Mg).	Sodium and po-tassium (Na+K).	Car-bonate radicle (CO_3).	Bicar-bonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total dissolved solids.	Mean gage height (feet).
From—	To—														
Jan. 10	Jan. 20	420	----------	40	0.7	----------	14	----------	0.0	146	----------	0.3	6.0	198	32.8
21	30	350	----------	39	.7	32	17	----------	.0	129	----------	.5	7.0	209	34.9
31	Feb. 9	340	----------	34	.20	----------	----------	----------	.0	82	----------	.4	7.0	168	39.5
Feb. 10	19	270	----------	37	.7	29	9.0	----------	.0	90	----------	.5	5.5	165	28.7
20	Mar. 1	420	----------	36	1.2	32	18	----------	.0	112	----------	.6	7.0	186	18.0
Mar. 2	11	425	----------	34	.8	43	17	----------	.0	112	----------	.5	10	205	25.8
12	21	680	----------	43	.7	----------	12	----------	.0	102	----------	.3	9.5	172	29.7
22	31	550	----------	40	.7	----------	10	----------	.0	90	----------	.9	9.5	162	34.2
Apr. 1	Apr. 10	960	----------	34	1.3	37	12	----------	.0	115	----------	.2	12	188	32.9
11	20	680	----------	22	1.3	27	11	----------	.0	115	----------	1.6	6.5	156	23.6
21	30	550	----------	24	1.4	29	8.4	----------	.0	104	----------	1.8	8.0	161	21.5
May 1	May 10	1,150	----------	31	2.8	24	15	----------	.0	95	----------	1.1	9.0	174	24.7
11	20	375	----------	31	1.6	26	9.7	13	.0	95	36	2.9	5.0	188	30.8
21	30	485	----------	19	1.1	30	7.7	13	.0	93	36	5.5	5.1	169	25.8
31	June 9	420	----------	10	.12	----------	12	13	.0	122	46	5.3	6.3	188	19.2
June 11	20	1,600	----------	19	.05	42	12	----------	.0	153	63	4.9	5.9	247	27.3
21	30	1,300	----------	12	1.6	36	14	----------	.0	----------	53	4.9	5.5	231	28.2
July 1	July 10	1,400	----------	16	.18	46	11	28	.0	156	56	5.3	8.7	245	21.9
11	20	1,000	----------	13	.30	49	15	21	.0	----------	67	2.2	6.0	246	17.8
21	30	425	----------	14	.11	41	12	28	.0	172	67	2.4	12	250	22.9
31	Aug. 9	900	----------	16	.08	37	9.3	24	.0	143	41	1.8	9.0	205	22.9
Aug 10	19	950	----------	21	.20	39	12	21	.0	144	52	4.0	6.8	220	17.0
20	29	600	----------	22	.13	41	13	21	.0	149	47	4.6	8.0	236	14.8
30	Sept. 8	600	----------	17	.17	36	12	22	.0	144	40	1.7	8.5	207	14.1
Sept. 9	18	280	10	22	.16	38	12	17	[b] 8.4	130	33	1.2	8.4	204	11.8
19	28	270	10	24	.14	39	12	13	[b] 7.2	146	34	Tr.	11	218	10.1
29	Oct. 8	220	7.4	23	.22	39	10	20	[b] 7.2	145	37	Tr.	9.8	219	10.0
Oct. 9	18	240	8.8	14	.5	35	10	16	[b] Tr.	142	34	Tr.	9.4	198	10.9
19	28	270	11	21	.37	36	13	17	[b] 7.2	134	34	.20	9.6	208	9.9
29	Nov. 9	240	8.8	20	.12	43	13	18	[b] 3.6	159	40	Tr.	11	235	7.0
Nov. 10	19	230	7.9	21	.52	42	13	28	[b] 7.2	159	39	Tr.	14	257	9.0
20	Dec. 1	230	13	10	.42	36	11	18	[b] Tr.	127	43	Tr.	16	200	12.0
Dec. 2	12	180	8.0	5.6	.07	33	10	14	[b] 8.4	106	29	Tr.	9.0	162	11.6
13	22	170	3.5	24	.24	36	12	17	[b] 13	115	32	1.7	9.6	201	8.4
23	Jan. 1	265	7.9	26	.56	33	10	16	[b] Tr.	124	35	1.5	9.6	195	13.5
Mean		556	----------	24	.61	36	12	19	.0	129	43	1.7	8.6	202	----------

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[a] Analyses Jan. 10 to May 10, 1907, by Jas. R. Evans; May 11 to Sept. 8, 1907, by Walton Van Winkle; Sept. 9, 1907, to Jan. 1, 1908, by R. B. Dole, Chase Palmer, and W. D. Collins.

[b] Abnormal; computed as HCO_3 in the average.

6. *Analyses of water from Mississippi River at New Orleans, La.*[a]

[Parts per million.]

Date (1905-6).		Silica (SiO$_2$).	Iron (Fe).	Aluminum (Al).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO$_3$).	Bicarbonate radicle (HCO$_3$).	Sulphate radicle (SO$_4$).	Nitrate radicle (NO$_3$).	Chlorine (Cl).	Total dissolved solids.	Free carbon dioxide (CO$_2$).	Mean gage height (feet).[b]
From—	To—														
Apr. 29	May 6	9.5	0.11	0.63	29	7.5	12	----------	98	22	2.1	9.2	145	13	10.5
May 7	13	8.2	.12	.44	28	6.7	13	----------	100	23	2.1	11	150	25	10.6
14	20	8.6	.10	.72	32	7.9	14	----------	100	27	2.1	10	157	15	11.9
21	27	8.8	.25	.42	30	7.1	19	----------	103	23	2.1	11	158	38	12.3
28	June 3	8.8	.10	.54	33	7.7	19	----------	110	25	2.1	8.3	166	22	13.2
June 4	10	11	.06	.59	31	7.1	14	----------	105	24	2.1	7.5	156	16	13.9
11	17	12	.10	.72	33	7.3	12	----------	115	23	2.0	7.3	157	8.0	13.7
18	24	14	.12	.76	34	8.1	14	----------	122	24	2.0	9.8	176	15	12.3
25	July 1	14	.06	.67	35	8.9	14	----------	125	25	2.0	9.4	178	44	10.9
July 2	8	11	.11	.34	35	9.0	15	----------	125	30	2.8	9.9	185	9	10.7
9	15	11	.13	.30	34	8.5	18	----------	116	36	2.8	7.7	182	47	11.5
16	22	10	.12	.20	33	8.1	18	----------	110	35	2.7	12	183	30	11.9
23	29	12	.11	.29	32	7.7	15	----------	108	28	2.6	7.6	168	3	11.4
30	Aug. 5	13	.13	.32	33	8.5	21	----------	116	36	2.7	10	195	47	11.2
Aug. 6	12	15	.15	.27	32	7.8	16	----------	111	29	2.3	10	180	32	10.3
13	20	11	.27	.40	32	8.0	19	----------	115	27	2.3	11	179	15	9.1
21	26	12	.26	.23	32	8.2	14	----------	115	24	2.4	8.0	169	17	7.4
27	Sept. 2	11	.30	.28	33	8.7	17	----------	122	26	2.5	13	185	20	7.4
Sept. 3	9	11	.21	.24	33	9.0	21	----------	120	29	2.4	17	199	62	7.3
10	16	10	.10	.43	32	8.8	16	----------	118	26	2.3	10	181	20	4.8
17	23	13	.15	.53	34	9.1	15	----------	126	24	2.5	10	195	51	3.2
24	30	16	.21	.93	39	10	21	----------	132	30	2.4	18	210	21	4.8
Oct. 1	Oct. 7	16	.10	.43	33	8.9	17	----------	117	27	2.6	12	190	13	7.6
8	14	10	.09	.33	30	6.8	13	----------	106	18	2.3	7.8	157	22	5.4
15	21	12	.08	.55	33	8.7	14	----------	118	20	2.3	8.8	170	20	2.8
22	28	12	.09	.36	39	11	15	----------	140	23	2.2	11	192	10	1.9
29	Nov. 4	13	.10	.27	42	12	15	----------	151	25	3.0	11	210	19	3.5
Nov. 5	11	9.3	.09	.41	34	10	14	----------	123	22	2.8	11	168	31	5.2
12	18	10	.08	.41	32	9.0	11	----------	115	21	3.2	9.4	158	30	5.1
19	25	9.6	.11	.29	35	10	12	----------	117	23	3.0	11	169	39	4.7
26	Dec. 2	11	.08	.42	33	9.5	13	----------	126	25	2.8	11	181	23	3.5
Dec. 3	x 9	12	.11	.37	39	12	16	----------	142	24	2.8	15	207	23	2.8
10	16	9.4	.15	.18	42	12	16	----------	145	29	2.7	14	215	24	5.7
17	23	8.0	.13	.28	33	9.1	11	----------	115	22	3.0	9.5	172	33	8.4
24	30	6.8	.13	.32	29	7.6	11	----------	94	20	2.8	11	149	39	7.5
Jan. 1	Jan. 6	9.2	.12	.47	31	7.8	11	----------	98	20	2.3	11	150	18	8.0
7	13	9.2	.10	.38	31	8.0	9.4	----------	100	18	2.5	8.2	148	26	8.9
14	20	7.6	.09	.25	32	8.0	11	----------	102	25	2.7	11	157	28	10.5
21	27	9.2	.11	.37	28	6.7	8.3	----------	92	19	2.6	6.5	136	46	10.7
28	Feb. 3	9.2	.12	.33	29	7.0	8.5	----------	91	18	2.7	8.2	138	44	11.4
Feb. 4	10	7.8	.10	.29	28	6.8	7.8	----------	91	17	2.5	6.3	130	50	12.5
11	17	9.8	.11	.34	27	6.6	7.8	----------	85	18	2.3	6.8	131	37	12.4
18	24	11	.10	.27	28	7.0	8.4	----------	91	18	2.2	7.0	139	35	10.3
25	Mar. 3	9.2	.10	.32	30	8.1	9.7	----------	105	18	2.2	8.0	150	31	7.3
Mar. 4	10	13	.12	.44	35	10	11	----------	125	21	2.7	10	168	33	7.1
11	17	10	.10	.35	35	10	10	----------	116	26	2.8	8.7	165	48	9.8
18	24	12	.18	.50	30	8.0	9.6	----------	96	22	2.9	8.4	144	44	11.6
25	31	11	.15	.42	31	8.0	9.4	----------	98	21	2.8	7.3	145	45	8.0
Apr. 1	Apr. 7	9.2	.15	.37	30	7.8	9.5	----------	98	20	2.9	9.0	142	42	12.5
8	14	9.3	.14	.29	29	7.2	7.9	----------	91	18	2.1	5.3	132	52	13.4
15	21	8.0	.13	.35	27	7.0	8.3	----------	92	17	3.0	4.8	130	41	14.2
22	28	11	.13	.24	29	7.2	9.9	----------	92	20	2.5	6.1	137	45	15.5
Mean		11	.13	.40	32	8.4	13	.0	111	24	2.5	9.7	166	----------	----------

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[a] Analyses by J. S. Porter, chemist, New Orleans water and sewerage board.

[b] Gaging station at Carrollton, La., 5 miles above.

The following table sums up the six foregoing sets of analyses. In each column the average composition is restated in percentages of the anhydrous residue, with carbonates normal and Fe recalculated into Fe_2O_3. The alkalies in No. 5 were corrected by Palmer's later determination of potassium.

Analyses of Mississippi water restated.

1. At Minneapolis. Mean of 35 analyses of 10-day composite samples
2. Near Moline. Mean of 18 composite analyses.
3. Near Quincy. Mean of 36 composite analyses.
4. Near Chester. Mean of 31 composite analyses. Nos. 2, 3, and 4, by W. D. Collins.
5. At Memphis. Mean of 35 composite analyses.
6. At New Orleans. Mean of 52 analyses of 7-day composite samples.

	1	2	3	4	5	6
CO_3	48.03	42.27	43.15	33.23	30.23	34.98
SO_4	9.35	13.58	12.55	21.74	20.50	15.37
Cl	.83	2.09	2.21	3.79	4.10	6.21
NO_3	.73	1.01	1.10	1.05	.81	1.60
Ca	20.77	18.68	18.06	17.08	17.16	20.50
Mg	7.27	7.35	8.03	6.22	5.72	5.38
Na	5.19	5.65	5.52	8.15	8.09	8.33
K					1.52	
SiO_2	7.78	9.09	9.03	8.54	11.44	7.05
Al_2O_3						.45
Fe_2O_3	.05	.28	.35	.20	.43	.13
	100.00	100.00	100.00	100.00	100.00	100.00
Salinity, parts per million	200	179	203	269	202	166

In addition to the analyses made in the Geological Survey, the following analyses have been collected from other sources:

Analyses of water from the Mississippi.

1. At Brainerd, Minn. Analysis by C. F. Sidener, Minnesota Geol. and Nat. Hist. Survey Thirteenth Ann. Rept., p. 102, 1884.
2. At Little Falls, Minn.
3. At St. Cloud, Minn. Analyses 2 and 3 by Kennicott Water Softener Co., cited by Dole and Wesbrook, U. S. Geol. Survey Water-Supply Paper 193, p. 55, 1907
4. Above Minneapolis.
5. Below Minneapolis. Analyses 4 and 5 by J. A. Dodge, Minnesota Geol. and Nat. Hist. Survey Tenth Ann. Rept., p. 207, 1882. Organic matter rejected.
6. At La Crosse, Wis. Mean of three analyses by different analyses, cited in Wisconsin Geol. and Nat. Hist. Survey Bull. 35, p. 415.
7. At Savanna, Ill. Mean of two analyses received from Chicago, Milwaukee & St. Paul Ry.
8. Above Carrollton, La. Analysis by C. H. Stone (Science, vol. 22, p. 472, 1905). Recalculated from bicarbonates.

I. Parts per million.

	1	2	3	4	5	6	7	8
CO_3	100.6	90.0	96.0	104.6	93.4	65.1	104.7	44.2
SO_4	2.4	9.0	9.0	3.4	3.6	11.9	36.0	28.8
Cl	.9	12.0	24.0	1.7	1.9	5.4	5.0	16.1
NO_3				Tr.	Tr.	.3		
PO_4								.3
Ca	44.6	43.0	45.0	43.9	42.3	29.0	45.6	29.6
Mg	8.0	13.0	14.0	15.5	11.9	9.8	18.9	6.8
Na	10.0	8.0	16.0	3.3	3.2	7.9	12.1	10.0
K	3.4			1.4	2.3			2.3
SiO_2	18.3	4.3	5.8	13.5	16.7	10.2	2.2	7.4
Al_2O_3	2.9					2.4		.2
Fe_2O_3	2.9			.7	1.7			.1
Mn_3O_4								.2
	195.0	179.3	209.8	188.0	177.0	142.0	224.5	146.0

Analyses of water from the Mississippi—Continued.

II. Percentage composition of dissolved solids.

	1	2	3	4	5	6	7	8
CO_3	51.65	50.20	45.76	55.62	52.76	45.57	46.65	30.27
SO_4	1.05	5.02	4.29	1.80	2.04	8.62	16.03	19.69
Cl	.48	6.69	11.44	.91	1.08	4.03	2.22	11.05
NO_3				Tr.	Tr.	.21		
PO_4								.27
Ca	22.94	23.98	21.45	23.38	23.90	20.30	20.31	20.25
Mg	4.09	7.25	6.67	8.24	6.75	6.72	8.42	4.66
Na	5.14	4.46	7.63	1.77	1.81	5.58	5.38	6.86
K	1.75			.76	1.28			1.57
SiO_2	9.40	2.40	2.76	7.16	9.46	7.30	.99	5.07
Al_2O_3	2.01					1.67		.12
Fe_2O_3	1.49			.36	.92			.08
Mn_3O_4								.11
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

These tables, notwithstanding their irregularities, tell a definite story. The upper Mississippi is low in sulphates and chlorides, which tend to accumulate in the lower stream. The chlorides come in part from human contamination but more largely, together with sulphates, from western tributaries, notably from the Missouri. At New Orleans, also, there is probably some cyclic sodium brought in rainfall from the Gulf of Mexico. On the whole, carbonates predominate in the Mississippi water, with all else subordinate.[20]

NORTHERN TRIBUTARIES OF THE MISSISSIPPI.

North of Minnesota River the Mississippi receives many affluents, but only a few analyses of their waters are available. They are as follows. All the localities named are in Minnesota.

Analyses of water from the northern tributaries of the Mississippi.

1. Mille Lacs Lake. Analysis by J. A. Dodge, Geology of Minnesota, vol. 4, p. 38, 1899.
2. Platte River at Royalton. Not to be confused with Platte River of Nebraska.
3. Rum River at Anoka.
4. Sauk River at Sauk Center. Analyses 2, 3, and 4 by the Kennicott Water Softener Co., cited by Dole and Wesbrook in Water-Supply Paper 193, p. 55.
5. Lake Eddy at Brownton. Analysis received from Chicago, Milwaukee & St. Paul Ry.
6. Lake Minnetonka. Analysis by W. A. Noyes, Geology of Minnesota, vol. 2, p. 311, 1888.

I. Parts per million.

	1	2	3	4	5	6
CO_3	85.0	118.0	118.0	124.0	155.4	64.7
SO_4	1.3	17.0	.8	13.0	38.3	
Cl	.8	6.0	12.0	6.0	5.2	.8
Ca	22.0	58.0	50.0	47.0	58.1	28.1
Mg	15.4	14.0	17.0	25.0	33.8	8.0
Na	9.6	9.0	7.3	3.9	9.3	1.1
K	3.2					2.5
SiO_2	4.3	9.0	18.0	5.0	7.5	4.8
Fe_2O_3	2.4					
Al_2O_3						
	144.0	231.0	223.1	223.9	307.6	110.0

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[20] Bailey Willis (Jour. Geology, vol. 1, p. 509, 1893), cites some imperfect analyses of the Mississippi and Missouri near St. Louis. Iowa Geol. Survey, vol. 6, p. 365, 1896, contains other analyses of Mississippi water, but these too are incomplete. The early analyses of Mississippi water by Avequin and by Jones are of no value for present purposes. Partial analyses, containing some useful data, are given in Report of the sewage and water board, New Orleans, 1903. These relate to the lower Mississippi near New Orleans.

Analyses of water from the northern tributaries of the Mississippi—Continued.

II. Percentage composition of dissolved solids.

	1	2	3	4	5	6
CO_3	59.03	51.08	52.89	55.38	50.53	58.81
SO_4	.88	7.36	.36	5.81	12.46	--------
Cl	.59	2.60	5.37	2.68	1.68	.72
Ca	15.25	25.10	22.41	20.99	18.88	25.52
Mg	10.71	6.06	7.62	11.17	10.99	7.23
Na	6.68	3.90	3.28	1.74	3.02	1.03
K	2.24					2.32
SiO_2	2.97	3.90	8.07	2.23	2.44	4.37
Fe_2O_3	1.65	--------	--------	--------		--------
Al_2O_3	--------	--------	--------	--------		--------
	100.00	100.00	100.00	100.00	100.00	100.00

MINNESOTA RIVER BASIN.

Minnesota River, which drains an area of 16,350 square miles, enters the Mississippi between Minneapolis and St. Paul. For the river itself we have the following table of analyses made by Dole and his colleagues in the water-resources laboratory of the U. S. Geological Survey:

Analyses of water from Minnesota River at Shakopee, Minn.[a]

[Parts per million.]

Date (1906-7).		Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).[c]	Nitrate radicle (NO_3).	Chlorine (Cl).	Total dissolved solids.	Mean gage height (feet).
From—	To—													
Sept. 24	Oct. 4	110	28	0.05	68	33	20	0.0	270	123	1.8	3.5	419	6.6
Oct. 6	18	75	28	Tr.	77	40	21	[c]9.6	317	126	1.8	4.2	469	4.6
19	30	60	24	.10	82	--------	33	.0	331	134	1.3	6.5	477	4.6
31	Nov. 10	80	29	Tr.	84	38	27	.0	287	184	1.5	3.5	536	6.4
Nov. 12	22	70	29	.05	86	37	25	.0	329	171	.9	4.1	533	5.7
23	Dec. 4	70	20	.05	97	39	32	.0	366	182	.9	4.5	580	4.7
Dec. 5	Jan. 1	20	24	Tr.	116	--------	33	.0	444	215	2.6	7.5	696	4.6
Jan. 2	12	10	22	.05	150	58	--------	.0	459	206	1.4	8.7	688	3.4
14	24	10	26	Tr.	121	55	30	.0	--------	205	1.4	11	692	3.2
25	Feb. 6	5	24	Tr.	126	57	--------	.0	489	211	1.3	--------	722	2.8
Feb. 7	21	10	28	Tr.	102	48	39	.0	415	177	5.5	10	609	3.8
22	Mar. 5	10	16	Tr.	59	26	22	.0	201	94	2.8	4.8	337	6.0
Mar. 6	16	10	18	.03	69	22	20	.0	222	118	2.3	1.4	384	4.6
19	29	275	19	.40	43	19	15	.0	154	66	1.9	2.0	250	7.8
30	Apr. 10	110	13	.18	45	19	14	.0	178	82	1.8	2.0	288	9.4
Apr. 11	21	--------	11	.15	50	25	23	.0	212	107	1.3	--------	359	7.6
22	30	50	22	Tr	72	33	22	.0	266	128	7.8	2.9	439	5.7
May 3	May 14	30	14	.01	99	42	26	.0	294	180	Tr.	3.7	527	5.3
15	25	30	16	.05	94	43	20	.0	320	203	1.8	3.4	588	4.9
28	June 6	80	20	.18	91	40	18	.0	284	177	1.9	2.5	553	6.3
June 7	18	175	26	.20	78	34	17	.0	261	153	1.6	1.7	482	9.8
19	29	105	30	.10	77	32	19	.0	278	137	1.2	--------	447	13.1
July 1	July 12	80	27	.08	78	37	21	.0	310	140	3.4	3.6	477	8.7
13	24	330	28	.15	71	31	27	.0	287	114	2.7	7.4	419	7.3
25	Aug. 5	155	27	.03	71	31	11	.0	279	112	2.2	--------	408	6.2
Aug. 7	17	155	30	.05	82	37	27	.0	334	133	1.5	5.8	481	3.8
19	29	240	25	.04	66	30	21	.0	271	106	1.6	5.0	408	3.8
30	Sept. 9	140	--------	.05	66	29	15	.0	236	126	.4	1.9	397	4.2
Sept. 10	20	140	32	.04	77	32	19	[c]6.0	272	112	1.4	8.2	437	3.0
21	Oct. 1	165	23	.6	58	19	--------	.0	200	94	1.5	3.0	312	4.0
Mean		97	23	.09	82	35	23	.0	296	144	2.0	4.7	480	--------

[a] Analyses Sept. 24, 1906, to Feb. 6, 1907, by W. M. Barr; Feb. 7 to Mar. 5, 1907, by H. S. Spaulding; Mar. 6 to Sept. 9, 1907, by Walton Van Winkle; Sept. 10 to Oct. 1 1907, by R. B. Dole, Chase Palmer, and W. D. Collins.

[b] Gaging station at Mankato, Minn., 60 miles above.

[c] Abnormal; computed as HCO_3 in the average.

In addition to these analyses there are two others which represent the main trunk of the river. The percentage average from the Survey table is tabulated with them.

Analyses of water from Minnesota River.

1. Bigstone Lake at Ortonville, Minn., an enlargement of the river. Analysis by C. F. Sidener, Minnesota Geol. and Nat. Hist. Survey Thirteenth Ann. Rept. p. 98, 1884.
2. Minnesota River at Granite Falls, Minn. Analysis received from Chicago, Milwaukee & St. Paul Ry.
3. Minnesota River at Shakopee, Minn., the average from the Survey table, reduced to normal carbonates and with the alkalies corrected by Palmer's determination of potassium.

	Parts per million.			Percentage composition.		
	1	2	3	1	2	3
CO_3	111.5	108.0	145.6	20.13	22.37	31.59
SO_4	190.4	212.0	144.0	34.36	43.91	31.26
Cl	9.2	3.8	4.7	1.65	.78	1.02
NO_3			2.0			.43
Ca	44.3	92.0	82.0	8.00	19.06	17.81
Mg	48.7	19.0	35.0	8.61	3.93	7.61
Na	37.0	43.0	18.0	6.69	8.91	4.12
K	5.6		5.0	1.01		1.15
SiO_2	106.7	5.0	23.0	19.26	1.04	4.99
Fe_2O_3	1.6		.1	.29		.02
	555.0	482.8	459.4	100.00	100.00	100.00

The following analyses are of waters tributary to Minnesota River, arranged in order going downstream. All the localities named are in Minnesota.

Analyses of water from tributaries of Minnesota River.

1. Sulphur Creek at Ortonville.
2. Pomme de Terre River at Appleton.
3. Chippewa River at Montevideo. Mean of two analyses. Nos. 1, 2, and 3 received from Chicago, Milwaukee & St. Paul Ry.
4. Yellow Medicine River at Canby. Analysis received from Chicago & Northwestern Ry.
5. Redwood River at Florence, 1903.
6. Redwood River at Marshall, 1903. Analyses 5 and 6 by Kennicott Water Softener Co., cited by Dole and Wesbrook in Water-Supply Paper 193.
7. Redwood River at Marshall, 1919.
8. Pond at Tracy.
9. St. James Lake at St. James. Analyses 7, 8, and 9 from Chicago & Northwestern Ry.
10. Temperance Lake at Sherburne.
11. George Lake at Fairmont.
12. Budd Lake at Fairmont. Mean of three analyses, 1898-1901. Nos. 10, 11, and 12 from Chicago, Milwaukee & St. Paul Ry.
13. Budd Lake at Fairmont, 1917. Analysis received from Chicago & Northwestern Ry.
14. Lake at Alden.
15. Prior Lake. Analyses 14 and 15 from Chicago, Milwaukee & St. Paul Ry.

I. Parts per million.

	1	2	3	4	5	6	7	8
CO_3	237.0	221.0	269.6	131.0	102.0	134.0	183.8	129.2
SO_4	700.0	258.0	127.1	733.6	100.0	140.0	543.3	1,142.9
Cl	3.8	2.7	10.6	5.4	9.1	12.0	5.7	10.2
Ca	256.0	130.0	104.8	282.5	65.0	92.0	200.3	231.4
Mg	61.0	56.0	59.3	108.1	16.0	32.0	68.7	158.2
Na(K)	110.0	40.0	38.9	23.5	26.0	11.0	42.9	79.2
SiO_2	8.6	11.0	18.5	13.0	10.0	18.0	16.1	30.3
$(Al, Fe)_2O_3$				1.0	1.5	2.0	7.5	.7
	1,376.4	718.7	628.8	1,298.1	329.6	441.0	1,068.3	1,781.6

	9	10	11	12	13	14	15
CO_3	205.0	113.0	9.40	88.3	126.5	99.0	71.0
SO_4	188.9	27.0	Trace.	10.3	57.6	6.5	Trace.
Cl	9.9	3.1	2.7	5.6	4.2	23.0	1.4
Ca	107.5	34.0	34.0	28.7	64.3	32.0	32.0
Mg	60.3	22.0	14.0	17.7	23.6	19.0	9.9
Na(K)	13.4	20.0	6.7	10.4	8.1	22.0	1.0
SiO_2	19.3	9.9	4.4	1.2	17.8	4.5	4.1
$(Al, Fe)_2O_3$	.3				.2		
	604.6	229.0	155.8	162.2	302.3	206.0	119.4

Analyses of water from tributaries of Minnesota River—Contd.

II. Percentage composition of dissolved solids.

	1	2	3	4	5	6	7	8
CO_3	17.22	30.75	42.88	10.09	30.95	30.39	17.20	7.25
SO_4	50.86	35.90	20.21	56.51	30.34	31.75	50.86	64.13
Cl	.28	.38	1.69	.42	2.76	2.72	.53	.57
Ca	18.60	18.09	16.67	2.176	19.72	20.86	18.75	12.99
Mg	4.42	7.79	9.42	8.33	4.85	7.25	6.43	8.88
Na(K)	7.99	5.56	6.19	1.81	7.89	2.50	4.02	4.45
SiO_2	.63	1.53	2.94	1.01	3.03	4.08	1.51	1.70
$(Al, Fe)_2O_3$				.07	.46	.45	.70	.03
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

	9	10	11	12	13	14	15
CO_3	33.91	49.35	60.33	54.44	41.85	48.07	59.46
SO_4	31.24	11.79	Trace.	6.35	19.05	3.16	Trace.
Cl	1.64	1.35	1.73	3.45	1.39	11.14	1.17
Ca	17.78	14.85	21.82	17.70	21.27	15.54	26.80
Mg	9.97	9.61	8.99	10.91	7.81	9.22	8.29
Na(K)	2.22	8.73	4.30	6.41	2.68	10.68	.84
SiO_2	3.19	4.32	2.83	.74	5.89	2.19	3.44
$(Al, Fe)_2O_3$	.05				.06		
	100.00	100.00	100.00	100.00	100.00	100.00	100.00

These analyses are of interest in relation to the petrology of the Minnesota basin. In the western part of the valley Cretaceous rocks predominate; to the east Cambrian and Ordovician limestones, shales, and sandstones appear. The waters from the Cretaceous areas are very high in salinity and rich in sulphates derived from the solution of gypsum. The eastern waters are much less concentrated and approach the ordinary carbonate type. There are some discordances to be explained, but they are perhaps more apparent than real. The latest analysis of water from Redwood River is quite unlike the earlier pair; but the dissimilarity may be really due to the difference between high and low water. Differences of that order are not uncommon. The analyses of water from Budd Lake differ in a similar way, but No. 12 represents "city water," which may have been modified by treatment of some kind.

TRIBUTARIES OF THE MISSISSIPPI BETWEEN MINNESOTA AND CEDAR RIVERS.

Analyses of waters south of the Minnesota and north of Cedar River have been received from the Chicago, Milwaukee & St. Paul Railway Co. as follows:

Analyses of waters tributary to the Mississippi.

1. Whitewater Creek at Weaver, Minn.
2. Root River at Preston, Minn.
3. Rock Creek at Browns, Iowa.
4. Miles Creek at Miles Creek Station, Iowa.
5. Wapsipinicon River at Anamosa, Iowa.
6. Simmons Creek at Paralta, Iowa.

I. Parts per million.

	1	2	3	4	5	6
CO_3	143.4	148.1	168.6	131.3	90.4	127.2
SO_4	4.7	8.2	11.4	7.4	6.1	12.1
Cl	1.2	1.6	2.2	2.6	1.8	2.8
Ca	55.8	61.7	58.3	46.3	41.0	51.5
Mg	20.8	19.9	32.5	24.7	9.9	20.0
Na(K)	9.0	9.4	6.9	5.2	7.3	7.6
Oxides[a]	8.9	6.7	1.4	8.9	1.4	8.7
	243.8	255.6	281.3	226.4	157.9	229.9

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[a] Silica plus sesquioxides.

Analyses of waters tributary to the Mississippi—Continued.

II. Percentage composition of dissolved solids.

	1	2	3	4	5	6
CO_3	58.82	57.95	59.94	57.99	57.25	55.33
SO_4	1.93	3.21	4.05	3.27	3.86	5.26
Cl	.49	.61	.78	1.15	1.14	1.22
Ca	22.89	24.15	20.73	20.45	25.97	22.40
Mg	8.53	7.78	11.55	10.91	6.27	8.70
Na(K)	3.69	3.68	2.45	2.30	4.62	3.31
Oxides[a]	3.65	2.62	.50	3.93	.89	3.78
	100.00	100.00	100.00	100.00	100.00	100.00

[a] Silica plus sesquioxides.

These analyses are of typical carbonate waters with rather high salinity and low sulphates and chlorides. Two of them show the presence of magnesian limestones in more than the average amounts in their drainage basins.

IOWA RIVER BASIN.

Iowa River drains a large area in central Iowa, and Cedar River is its largest tributary. As a matter of convenience the two streams may be considered separately. For the main stem of Iowa River we have, first, the following table of analyses made in the water-resources laboratory of the United States Geoolgical Survey:

Analyses of water from Iowa River at Iowa City, Iowa.[a]

[Parts per million.]

Date (1906-7).		Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total dissolved solids.
From—	To—												
Sept. 6	Sept. 15	90	28	----------	57	20	17	[b]7.7	245	31	0.2	3.8	253
16	25	105	28	0.30	47	18	19	.0	222	----------	1.8	5.0	264
26	Oct. 6	125	24	.10	51	21	13	.0	223	36	1.7	6.7	265
Oct. 7	16	75	22	.10	56	23	14	.0	273	32	1.1	4.0	273
17	26	50	36	Tr.	64	26	13	.0	283	44	.5	3.9	312
27	Nov. 5	25	21	Tr.	63	22	12	.0	262	35	1.3	5.4	289
Nov. 6	15	20	14	Tr.	60	20	16	.0	268	30	1.5	4.4	291
16	25	15	10	.10	59	21	17	.0	275	36	Tr.	3.7	276
26	Dec. 5	35	15	.15	53	20	16	.0	253	36	4.4	4.5	270
Dec. 6	16	20	26	.10	61	18	16	.0	282	42	4.4	4.0	312
17	Jan. 4	70	27	.05	61	24	----------	.0	281	31	3.5	4.0	306
Jan. 5	15	135	14	.6	23	10	11	.0	90	31	5.2	2.1	139
16	28	115	18	.7	21	7.5	----------	.0	83	30	1.7	2.7	134
29	Feb. 7	10	.12	.15	39	15	14	.0	160	39	2.3	3.4	196
Feb. 8	17	15	8.8	.07	44	13	12	.0	165	44	2.2	6.7	211
18	27	75	6.2	.15	----------	9.2	12	.0	79	34	6.9	1.4	129
28	Mar. 9	240	9.2	.9	----------	11	14	.0	118	51	6.4	1.8	187
Mar. 10	19	170	18	.05	35	11	18	.0	141	36	4.0	2.0	192
20	29	90	----------	.16	46	15	12	.0	195	38	1.3	3.3	231
30	Apr. 8	285	15	.45	44	16	9.5	.0	208	36	4.1	----------	221
Apr. 9	18	50	14	.10	59	21	12	.0	228	49	1.0	3.2	285
19	28	30	13	.03	61	23	15	.0	270	49	Tr.	4.2	319
30	May 8	50	13	.40	46	18	15	.0	----------	47	.6	5.4	284
May 9	18	50	9.8	.15	57	24	12	.0	270	38	Tr.	3.3	284
19	28	540	36	1.4	48	14	11	.0	202	36	5.4	2.4	278
29	June 7	190	17	.10	47	16	9.1	.0	181	37	2.9	3.2	232
June 8	16	650	23	.40	38	13	11	.0	161	30	3.5	1.9	217
17	26	255	25	.30	47	17	26	.0	----------	32	3.4	4.3	270
27	July 7	350	26	.30	55	20	11	.0	252	33	4.4	2.6	268
July 8	17	1,200	25	.35	30	8.2	----------	.0	114	40	3.0	----------	172
18	27	375	22	.7	35	9.6	9.9	.0	153	22	7.2	----------	192
28	Aug. 7	162	22	.06	55	16	15	.0	238	29	3.1	1.6	266
Aug. 8	17	175	20	.10	48	17	11	.0	218	32	3.9	2.4	249
18	27	75	24	.19	59	18	8.9	.0	245	34	3.0	2.8	288
28	Sept. 6	80	16	.11	52	19	----------	.0	222	33	3.0	4.2	243
Sept. 7	16	50	17	.02	57	20	18	.0	267	38	.6	3.8	285
Mean		168	19	.25	49	17	14	.0	210	36	2.8	3.6	247

[a] Analyses Sept. 6, 1906, to Feb. 17, 1907, by W. M. Barr; Feb. 18 to 27, 1907, by Henry S. Spaulding; Feb. 28 to Sept. 16, 1907, by Walton Van Winkle.

[b] Abnormal; computed as HCO_3 in the average.

Several other analyses may be compared with the average from the preceding series, as follows:

Analyses of waters in Iowa River basin.

1. Iowa River at Iowa Falls, Iowa. Mean of six analyses of samples taken in July and August, 1913. Analyses by G. A. Gabriel, Iowa Geol. Survey, vol. 26, pp. 46, 47, 1915. Reduced to standard form.
2. Iowa River at Marshalltown, Iowa. Mean of six analyses by Gabriel, loc. cit.
3. Iowa River at Amana, Iowa.
4. Iowa River at Iowa City, Iowa. Mean of five analyses by Gabriel, loc. cit.
5. The same; average from the Survey table.
6. East Timber Creek at Ferguson, Iowa. Analyses 3 and 6 received from Chicago, Milwaukee & St. Paul Ry.

I. Parts per million.

	1	2	3	4	5	6
CO_3	158.8	140.4	156.9	118.8	104.2	113.7
SO_4	57.6	45.9	37.9	52.8	36.3	21.9
Cl	4.0	4.3	8.0	5.9	3.6	4.5
NO_3	1.0	1.4	--------	.8	2.8	--------
Ca	76.4	61.6	67.0	62.5	49.4	46.3
Mg	24.1	24.8	26.7	14.1	17.1	17.7
Na(K)	17.7	16.1	15.3	17.5	14.0	13.4
SiO_2	21.8	13.5	3.2	14.5	19.2	5.8
$(Al, Fe)_2O_3$	--------	--------		--------	--------	
Fe_2O_3	.5	.2	--------	.3	.4	--------
	361.9	308.2	315.0	287.2	247.0	223.3

Analyses of waters in Iowa River basin—Continued.

II. Percentage composition of dissolved solids.

	1	2	3	4	5	6
CO_3	43.87	45.56	49.81	41.36	42.17	50.91
SO_4	15.91	14.89	12.03	18.39	14.70	9.80
Cl	1.10	1.39	2.54	2.05	1.47	2.01
NO_3	.27	.45	--------	.28	1.15	--------
Ca	21.16	19.99	21.27	21.76	20.00	20.72
Mg	6.66	8.05	8.48	4.91	6.94	7.92
Na(K)	4.89	5.22	4.86	6.10	5.67	6.05
SiO_2	6.01	4.38	1.01	5.05	7.76	2.59
$(Al, Fe)_2O_3$	--------	--------		--------	--------	
Fe_2O_3	.13	.07	--------	.10	.14	--------
	100.00	100.00	100.00	100.00	100.00	100.00

The water of Cedar River has been analyzed in the water-resources laboratory of the Survey, with the following results:

Analyses of water from Cedar River near Cedar Rapids, Iowa.[a]

[Parts per million.]

Date (1906-7).		Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total dissolved solids.	Mean gage height (feet).
From—	To—													
Sept. 6	Sept. 15	80	20	--------	29	18	14	[b] 4.8	153	24	0.0	4.3	171	3.5
16	25	60	25	0.10	32	--------	8.7	.0	149	27	2.4	3.0	203	4.1
27	Oct. 6	50	26	.10	48	16	--------	.0	217	23	3.3	4.0	236	4.1
Oct. 7	16	20	23	Tr.	55	21	15	.0	246	28	4.4	3.2	269	3.4
17	27	15	26	Tr.	52	19	20	.0	229	29	.4	3.3	248	3.3
28	Nov. 6	20	27	Tr.	58	20	11	.0	255	29	1.8	4.6	277	3.7
Nov. 7	16	10	17	Tr.	60	19	14	.0	263	28	2.2	3.5	285	3.5
17	26	20	15	.05	64	20	16	.0	262	33	2.6	3.8	281	3.6
27	Dec. 6	25	17	.04	51	20	15	.0	240	33	.9	3.8	258	4.0
Dec. 7	16	15	21	.10	62	22	17	.0	273	37	4.4	3.8	309	3.7
17	26	5.0	13	.10	64	26	16	.0	309	40	4.8	4.0	311	4.3
27	Jan. 5	80	12	.20	51	17	13	.0	207	--------	4.4	3.1	228	4.2
Jan. 6	15	20	9.2	.08	47	17	9.7	.0	175	--------	5.2	2.5	193	4.4
16	26	75	15	Tr.	42	13	13	.0	167	29	3.6	2.3	193	4.9
27	Feb. 5	5.0	11	.05	61	19	--------	.0	258	31	5.2	3.9	260	4.5
Feb. 6	15	80	6.4	.05	58	15	14	.0	221	46	5.2	4.8	242	4.2
16	26	30	4.6	.10	24	6.6	11	.0	87	21	5.8	2.2	119	5.7
27	Mar. 7	70	9.8	.25	26	9.6	14	.0	--------	35	4.6	2.2	151	5.3
Mar. 8	19	65	14	.18	32	12	12	.0	--------	21	3.8	8.8	178	4.7
20	29	30	12	.15	37	9.4	16	.0	149	26	2.6	2.7	175	4.6
30	Apr. 8	135	15	Tr.	41	14	9.9	.0	175	29	2.8	2.3	203	4.7
Apr. 9	18	30	11	.03	53	16	--------	.0	213	34	2.6	2.7	246	4.0
19	28	10	3.0	.05	54	19	8.1	.0	210	46	.6	3.9	250	3.6
29	May 8	10	3.0	.05	51	20	8.6	.0	230	35	Tr.	3.8	241	3.6
May 9	18	10	4.0	.01	48	21	11	.0	226	33	.5	3.4	241	3.3
19	28	95	5.8	.18	--------	17	9.8	.0	204	32	3.0	4.2	225	3.4
29	June 8	55	11	.02	43	16	8.8	.0	207	--------	2.2	3.4	230	3.7
June 9	18	140	14	.02	47	14	7.0	.0	179	29	4.8	1.9	215	5.4
19	28	80	10	.05	48	13	9.8	.0	209	28	4.2	2.6	244	5.0
29	July 9	235	15	.15	49	11	15	.0	201	22	8.0	2.9	230	4.5
July 10	19	390	20	.48	38	11	6.4	.0	145	22	3.1	--------	179	6.3
20	29	105	14	.05	43	13	12	.0	189	22	2.8	2.5	207	6.4
30	Aug. 8	65	15	.01	55	15	15	.0	234	27	4.4	4.0	248	4.8
Aug. 9	18	140	20	.20	40	13	8.6	.0	166	22	2.2	2.8	192	5.2
19	28	50	10	.05	42	14	9.1	.0	198	23	2.3	3.3	213	4.5
29	Sept. 7	50	20	.15	51	14	11	.0	201	29	1.6	2.5	228	4.6
Sept. 8	17	10	13	.18	57	18	10	.0	253	31	1.9	3.8	253	3.8
Mean		64	14	.09	48	16	12	.0	209	30	3.1	3.4	228	--------

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[a] Analyses Sept. 6, 1906, to Feb. 15, 1907, by W. M. Barr; Feb. 16 to 26, 1907, by H. S. Spaulding; Feb. 27 to Sept. 17, 1907, by Walton Van Winkle.

[b] Abnormal; computed as HCO_3 in the average.

Several other analyses of waters in the Cedar River basin are available, and with them the average of the preceding table may be tabulated. They are as follows:

Analyses of waters in Cedar River basin.

1. Cedar River at Charles City, Iowa.
2. Cedar River at Waterloo, Iowa.
3. Cedar River at Cedar Rapids, Iowa. Nos. 1 to 3 are each an average of five analyses by G. A. Gabriel, of samples taken in July and August, 1913. Iowa Geol. Survey, vol. 26, pp. 43-44, 1915.
4. Cedar River at Cedar Rapids. E. G. Smith, analyst, 1893.
5. Cedar River at Cedar Rapids. C. O. Bates, analyst. Mean of several analyses of samples taken at different seasons of the year. Nos. 4 and 5 from Iowa Geol. Survey, vol. 6, p. 365, 1896.
6. Cedar River near Cedar Rapids. The Survey average.
7. Silver Creek at Covington, Iowa.
8. Clear Lake, Cerro Gordo County, Iowa. Drains through Shellrock River into the Cedar. Analyses 7 and 8 from Chicago, Milwaukee & St. Paul Ry.

I. Parts per million.

	1	2	3	4	5	6	7	8
CO_3	103.7	94.7	87.8	106.5	97.6	102.1	130.7	98.1
SO_4	29.3	34.0	41.4	15.1	21.3	29.8	15.3	4.2
Cl	8.2	4.1	5.3	2.1	6.6	3.4	3.1	6.0
NO_3	1.8	1.9	.9			3.1		
Ca	57.6	50.2	41.7	46.4	46.3	47.7	62.1	23.3
Mg	16.0	16.5	15.9	16.5	15.8	15.9	14.1	22.7
Na	16.3	17.4	15.7	3.0	5.9	11.9	11.0	11.3
K				3.9				
SiO_2	16.0	9.3	12.1	4.8	4.8	13.9	2.1	3.2
$(Al, Fe)_2O_3$				1.7	4.8			
Fe_2O_3	.7	.7	.1			.2		
	249.6	228.8	220.9	200.0	203.1	228.0	238.4	168.8

II. Percentage composition of dissolved solids.

	1	2	3	4	5	6	7	8
CO_3	41.55	41.39	39.74	53.25	48.06	44.80	54.83	58.12
SO_4	11.74	14.86	18.74	7.55	10.49	13.08	6.42	2.49
Cl	3.28	1.79	2.40	1.05	3.25	1.48	1.30	3.55
NO_3	.72	.83	.41			1.35		
Ca	23.08	21.94	18.88	23.20	22.80	20.91	26.05	13.80
Mg	6.41	7.21	7.20	8.25	7.78	6.97	5.91	13.45
Na	6.53	7.60	7.11	1.50	2.90	5.23	4.61	6.69
K				1.95				
SiO_2	6.41	4.07	5.48	.40	2.36	6.10	.88	1.90
$(Al, Fe)_2O_3$				.35	2.36			
Fe_2O_3	.28	.31	.04			.08		
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Apart from local variations of no marked significance, analyses 1 to 7 are of essentially the same type. They represent ordinary limestone waters, with differences due to the presence of more or less gypsum near the points of collection. The water of Clear Lake, however, is of a different character. It is a magnesian-limestone water, with magnesium in excess of the dolomite ratio, and it resembles the remarkable group of waters in southeastern Wisconsin.

DES MOINES RIVER BASIN.

Des Moines River rises in southern Minnesota, near the principal sources of Minnesota River. Most of its course, however, is in Iowa. Its valley is in a rich agricultural region, with abundant limestones and also large beds of gypsum, especially at Fort Dodge. These give the water of the river a distinctly sulphatic character, although carbonates generally, but not always, predominate in it. For the main stem of the river there are several individual analyses, but the following table, from the water-resources laboratory of the United States Geological Survey. claims first attention.

Analyses of water from Des Moines River at Keosauqua, Iowa.[a]

[Parts per million.]

Date (1906–7).		Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total dissolved solids.
From—	To—												
Sept. 10	Sept. 19	275	35	Tr.	50	21	27	0.0	233	51	2.2	4.5	303
20	29	425	23	0.10	47	12	20	.0	188	40	2.5	4.8	256
30	Oct. 9	150	23	.10	58	----------	14	.0	233	49	2.2	4.8	294
Oct. 10	19	65	32	.10	68	34	17	.0	----------	----------	1.8	6.1	368
20	29	20	31	Tr.	70	30	31	.0	----------	92	.6	8.1	396
30	Nov. 8	115	23	.05	64	25	20	.0	----------	65	3.1	5.4	336
Nov. 9	18	50	22	.05	71	28	19	.0	272	----------	1.3	3.5	361
19	28	60	17	.05	80	28	26	.0	310	90	1.8	5.1	399
29	Dec. 8	85	26	.15	74	27	22	.0	315	91	2.0	5.3	407
Dec. 9	18	30	27	.05	83	28	18	.0	----------	96	3.5	5.5	431
19	28	5	18	.10	100	38	27	.0	412	107	2.6	8.1	492
29	Jan. 7	525	34	----------	61	22	18	.0	220	83	2.6	4.6	345
Jan. 8	17	135	20	.9	50	17	13	.0	167	61	4.4	6.5	259
18	27	235	29	1.2	30	10	11	.0	99	52	3.9	4.0	207
28	Feb. 8	40	18	.45	48	17	16	.0	168	69	1.4	6.5	261
Feb. 10	19	220	23	.5	65	23	18	.0	231	104	2.2	8.5	346
20	Mar. 1	95	14	.35	40	13	16	.0	134	61	5.1	4.7	214
Mar. 2	12	650	20	1.0	41	14	12	.0	129	60	7.5	5.3	245
13	22	950	23	.9	43	15	22	.0	----------	79	7.3	3.8	258
23	31	450	18	.6	45	16	18	.0	175	64	4.2	3.3	258
Apr. 2	Apr. 11	300	18	.5	55	19	13	.0	218	62	2.6	3.5	288
12	21	75	15	.10	67	24	17	.0	266	76	4.0	3.9	339
22	May 1	35	19	.05	66	30	20	.0	274	89	.5	6.2	386
May 2	11	20	11	.15	71	24	20	.0	266	105	Tr.	8.8	383
12	21	80	5.2	.05	57	27	19	.0	238	94	1.1	9.6	335
22	31	1,740	30	1.0	53	19	13	.0	175	82	3.4	3.7	316
June 1	June 10	1,750	18	.5	51	16	12	.0	154	74	6.3	2.8	275
11	20	1,400	26	.8	----------	17	10	.0	----------	67	9.5	2.5	303
21	30	1,200	21	.16	60	19	12	.0	218	62	2.8	2.1	299
July 1	July 10	1,300	24	.6	55	20	15	.0	214	69	3.3	4.6	296
11	20	1,670	33	.8	----------	----------	13	.0	155	44	6.2	2.5	231
21	30	1,100	17	.16	42	14	8.4	.0	185	35	1.9	1.2	212
31	Aug. 9	830	33	.12	62	21	7.1	.0	249	52	5.0	1.8	310
Aug. 11	20	2,400	31	.6	47	13	19	.0	175	51	7.1	2.8	259
21	30	550	9.2	.04	64	22	23	.0	243	71	2.0	5.0	327
31	Sept. 9	500	----------	.18	49	16	20	.0	165	----------	2.2	3.4	251
Mean--------		542	22	.36	58	21	17	.0	216	71	3.3	4.8	312

[a] Analyses Sept. 10, 1906, to Feb. 19, 1907, by W. M. Barr; Feb. 20 to Mar. 1, 1907, by H. S. Spaulding; Mar. 2 to Sept. 9, 1907, by Walton Van Winkle.

The individual analyses of Des Moines River are given in the next table, and for convenience of comparison the averages of the Survey series, reduced to standard form, are grouped with them. They are arranged as nearly as possible in order going downstream from the headwaters.

Analyses of water from Des Moines River.

1. West Fork at Jackson, Minn. Mean of two analyses received from Chicago, Milwaukee & St. Paul Ry., 1888, 1892.
2. East Fork at Algona, Iowa, 1889.
3. West Fork at Estherville, Iowa, 1912.
4. West Fork at Emmetsburg, Iowa, 1912.
5. At Dakota City, Iowa, 1916.
6. At Fort Dodge, Iowa. Mean of four analyses, July-August, 1913.
7. At Moingona, Iowa, 1894.
8. At Boone, Iowa, 1912.
9. At Des Moines, Iowa. Mean of five analyses, 1913.
10. At Ottumwa, Iowa. Mean of five analyses, 1913.
11. At Ottumwa Junction, Iowa, 1889. From Chicago, Milwaukee & St. Paul Ry.
12. At Harvey, Iowa, 1912.
13. At Keosauqua, Iowa, 1912.
14. The same; Survey average, 1906-7.

Analyses 2, 5, and 7 were made in the laboratory of the Chicago & Northwestern Ry. Nos. 2 and 5 are recalculated from figures cited in Iowa Geol. Survey, vol. 6, p. 365, 1896. Analyses 3, 4, 6, 8, 9, 10, 12, and 13 are by G. A. Gabriel, Iowa, Geol. Survey, vol. 26, pp. 45, 46, 48, 1915. All are recalculated into standard form.

I. Parts per million.

	1	2	3	4	5	6	7
CO_3	116.9	45.8	121.0	122.0	198.8	134.6	165.9
SO_4	80.5	11.6	159.0	140.0	60.4	127.3	101.2
Cl	3.0	3.1	9.0	3.0	8.2	7.8	5.9
NO_3	--------	--------	.4	.3	--------	.9	--------
Ca	61.4	18.1	92.0	81.0	95.1	76.2	81.8
Mg	24.4	8.1	32.0	32.0	27.2	25.9	36.3
Na(K)	12.8	6.3	16.0	17.0	6.1	25.2	15.7
SiO_2	3.8	1.7	5.0	4.0	21.9	17.4	9.9
$(Al,Fe)_2O_3$			--------	--------	6.3	--------	1.5
Fe_2O_3	--------	--------	Tr.	Tr.	--------	.8	--------
	302.8	94.7	434.4	399.3	434.0	416.1	418.2

	8	9	10	11	12	13	14
CO_3	108.2	121.2	113.2	134.1	97.4	107.2	109.1
SO_4	109.0	119.4	93.7	108.8	89.0	101.0	71.0
Cl	8.0	6.0	7.0	23.3	11.0	13.0	4.8
NO_3	.1	.4	1.3	--------	.2	.2	3.3
Ca	60.0	71.0	64.6	67.2	63.0	70.0	58.0
Mg	25.0	20.4	22.7	23.0	19.0	24.0	21.0
Na(K)	21.0	27.2	19.2	47.4	12.0	8.0	17.0
SiO_2	10.1	18.1	13.6	3.4	10.0	16.0	22.0
$(Al,Fe)_2O_3$	--------	--------	--------		--------	--------	--------
Fe_2O_3	.1	.3	.2	--------	.5	.6	.5
	241.4	284.0	335.5	407.2	302.1	340.0	306.7

II. Percentage composition of dissolved solids.

	1	2	3	4	5	6	7
CO_3	38.60	48.36	27.86	30.55	45.81	32.35	39.67
SO_4	26.59	12.25	36.60	35.06	13.91	30.59	24.20
Cl	.99	3.27	2.07	.75	1.91	1.87	1.41
NO_3	--------	--------	.09	.07	--------	.22	--------
Ca	20.28	19.11	21.18	20.28	21.91	18.32	19.56
Mg	8.06	8.56	7.37	8.02	8.57	6.22	8.68
Na(K)	4.23	6.65	3.68	4.26	1.40	6.06	3.75
SiO_2	1.25	1.80	1.15	1.00	5.04	4.18	2.37
$(Al,Fe)_2O_3$			--------	--------	1.45	--------	.36
Fe_2O_3	--------	--------	Tr.	.01	--------	.19	--------
	100.00	100.00	100.00	100.00	100.00	100.00	100.00

	8	9	10	11	12	13	14
CO_3	31.69	31.57	33.74	32.93	32.24	31.53	34.96
SO_4	31.93	31.09	27.93	26.71	29.46	29.71	23.37
Cl	2.34	1.56	2.09	5.73	3.64	3.82	1.58
NO_3	.03	.10	.39	--------	.07	.06	1.09
Ca	17.58	18.49	19.26	16.50	20.86	20.59	19.09
Mg	7.32	5.31	6.77	5.65	6.29	7.06	6.91
Na(K)	6.15	7.08	5.72	11.64	3.97	2.35	5.59
SiO_2	2.93	4.72	4.05	.84	3.31	4.70	7.24
$(Al,Fe)_2O_3$	--------	--------	--------		--------	--------	--------
Fe_2O_3	.03	.08	.05	--------	.16	.18	.17
	100.00	100.00	100.00	100.00	100.00	100.00	100.00

For waters tributary to Des Moines River the following analyses are available:

Analyses of waters tributary to Des Moines River.

1. Lake Spaulding at Fulda, Minn. Mean of two analyses received from Chicago, Milwaukee & St. Paul Ry.
2. Timber Lake at Wilder, Minn. From Chicago & Northwestern Ry.
3. Heron Lake, Minn. Analysis by W. A. Noyes, Minnesota Geol. and Nat. Hist. Survey Eleventh Ann. Rept., p. 173, 1882.
4 Okabena Creek at Okabena, Minn.
5. Lake at Kinbrae, Minn. Analyses 4 and 5 from Chicago, Milwaukee & St. Paul Ry.
6. Raccoon River at Maple River Junction, Iowa, 1916. From Chicago & Northwestern Ry.
7. Raccoon River at Des Moines, Iowa, 1899. From Chicago, Milwaukee & St. Paul Ry. City water supply.
8. The same, 1912. Mean of three analyses by G. A. Gabriel, Iowa Geol. Survey, vol. 26, p. 48, 1915.

I. Parts per million.

	1	2	3	4	5	6	7	8
CO_3	123.9	187.5	116.0	110.7	151.6	100.1	116.8	113.6
SO_4	86.3	116.1	50.6	131.0	215.5	37.1	30.7	124.3
Cl	4.6	13.7	3.1	2.5	3.9	8.5	2.7	6.4
NO_3	--------	--------	3.8	--------	--------	--------	--------	13.7
Ca	59.3	70.7	56.3	72.0	45.5	43.3	55.8	72.3
Mg	27.3	51.9	21.8	28.2	67.4	15.0	19.7	21.3
Na	18.7	27.5	7.9	12.5	39.6	21.4	4.2	12.0
K			3.6					
SiO_2	7.2	22.7	7.2	1.0	3.5	5.3	7.4	16.2
$(Al,Fe)_2O_3$		1.7	1.7					--------
Fe_2O_3	--------	--------	--------	--------	--------	--------	--------	6.7
	327.3	491.8	272.0	358.0	527.0	230.7	237.3	386.5

II. Percentage composition of dissolved solids.

	1	2	3	4	5	6	7	8
CO_3	37.86	38.13	42.65	30.92	28.77	43.39	49.22	29.39
SO_4	26.37	23.61	18.62	36.62	40.89	16.08	12.94	32.16
Cl	1.41	2.78	1.14	.70	.74	3.68	1.14	1.66
NO_3	--------	--------	1.39	--------	--------	--------	--------	3.54
Ca	18.12	14.38	20.71	20.11	8.63	18.77	23.52	18.71
Mg	8.33	10.55	8.00	7.88	12.80	6.50	8.30	5.51
Na	5.71	5.59	2.94	3.49	7.51	9.28	1.77	3.11
K			1.32					
SiO_2	2.20	4.61	2.61	.28	.66	2.30	3.11	4.19
$(Al,Fe)_2O_3$		.35	.62					--------
Fe_2O_3	--------	--------	--------	--------	--------	--------	--------	1.73
	100.00	100.00	100.00	100.00	100.00	100.0	100.00	100.00

CHIPPEWA RIVER.

Chippewa River rises in the lake region of northern Wisconsin and enters the Mississippi near the south end of Lake Pepin. Its drainage basin has an area of 9,573 square miles. For the composition of its waters we have, first, the following table of analyses made in the water-resources laboratory of the United States Geological Survey:

Analyses of water from Chippewa River near Eau Claire, Wis.[a]

[Parts per million.]

Date (1906–7). From—	Date (1906–7). To—	Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4)[c]	Nitrate radicle (NO_3).	Chlorine (Cl).	Total dissolved solids.	Mean gage height (feet).
Sept. 14	Sept. 23	5	24	0.20	11	3.7	8.4	0.0	45	12	Tr.	3.2	111	6.4
24	Oct. 3	10	11	.30	12	4.0	7.1	.0	44	9.0	1.8	2.1	98	6.1
Oct. 4	13	5	5.8	.20	12	5.1	9.4	.0	45	14	Tr.	1.2	98	5.0
14	23	5	16	.15	13	6.3	7.0	.0	59	19	Tr.	1.3	103	4.9
24	Nov. 2	5	15	.15	10	5.2	8.1	.0	39	16	Tr.	2.9	102	7.8
Nov. 3	12	5	12	Tr.	16	5.2	8.6	.0	41	13	Tr.	2.3	109	6.8
13	22	5	12	Tr.	12	4.2	----------	.0	33	14	Tr.	1.5	87	6.4
23	Dec. 2	15	16	Tr.	10	----------	7.5	.0	39	17	.0	.9	93	6.5
Dec. 3	13	10	17	.40	12	4.2	9.2	.0	40	19	.0	1.2	94	5.4
14	25	5	15	.30	14	4.9	10	.0	53	17	.0	2.0	101	5.2
26	Jan. 4	5	15	.25	14	5.7	7.3	.0	36	----------	.9	1.5	97	5.0
Jan. 5	17	5	10	.25	16	5.3	----------	.0	58	13	Tr.	----------	94	4.9
18	27	10	12	.40	15	5.8	13	.0	61	9.9	.2	2.7	96	----------
28	Feb. 7	5	15	.25	17	4.8	5.6	.0	70	12	.8	.4	109	----------
Feb. 8	18	5	15	.25	17	8.5	11	.0	66	10	1.4	.6	97	----------
19	28	5	15	.25	17	4.1	8.7	.0	65	12	1.8	1.6	95	----------
Mar. 1	Mar. 10	5	18	.6	19	6.6	7.6	.0	68	15	1.2	1.5	104	----------
11	20	5	12	.30	14	----------	9.1	.0	60	16	2.1	2.3	100	5.1
21	31	20	4.6	.37	----------	2.8	5.4	.0	25	15	1.2	1.5	59	11.2
Apr. 1	Apr. 10	10	6.8	.19	6.2	3.7	5.2	.0	----------	18	1.1	.4	58	11.2
11	20	5	6.8	.15	11	2.4	8.5	.0	22	14	.9	.1	72	7.9
21	30	Tr.	12	.18	9.8	3.7	4.6	.0	29	17	Tr.	.7	73	7.0
May 1	May 12	Tr.	9.6	.24	----------	5.2	4.4	.0	39	16	Tr.	Tr.	72	7.3
13	22	5	7.4	.18	8.2	2.3	----------	.0	28	11	Tr.	.1	163	8.7
23	June 1	5	7.0	.19	7.0	2.4	4.9	.0	28	9.9	Tr.	2.4	89	8.2
June 2	11	5	5.8	.16	10	3.0	4.3	.0	38	8.7	.8	Tr.	68	6.6
12	21	5	5.2	.25	10	4.3	5.9	.0	46	15	Tr.	.2	87	6.0
22	July 1	5	10	.18	15	----------	9.5	.0	56	14	1.2	.8	90	6.0
July 3	12	10	9.8	.20	13	4.4	7.6	.0	45	15	1.0	.2	81	6.3
13	22	5	10	.30	14	----------	7.3	.0	----------	10	.5	.3	84	5.1
23	Aug. 2	7	12	.21	17	----------	10	.0	59	9.9	Tr.	.3	93	4.8
Aug. 3	13	5	14	.15	16	6.9	8.6	.0	61	----------	4.4	.3	90	.45
14	23	20	13	.19	16	----------	11	.0	55	12	Tr.	Tr.	94	.47
24	Sept. 2	5	11	.09	13	5.2	13	.0	59	12	.4	.3	88	.44
Sept. 3	12	5	14	.12	16	6.1	11	.0	72	15	.3	1.0	108	.42
Mean		7	12	.22	13	4.7	8.1	.0	48	14	.6	1.1	90	----------

[a] Analyses Sept. 14, 1906, to Feb 7, 1907, by W. M. Barr; Feb. 8 to Feb. 28, 1907, by H. S. Spaulding; Mar. 1 to Sept. 12, 1907, by Walton Van Winkle.

Two other analyses of waters in the Chippewa basin are available for use here and appear in the next table. With them the average from the Survey table, reduced to standard form, is included.

Analyses of waters in Chippewa basin.

1. Trout Lake, Vilas County, Wis. Analysis by E. B. Hall and C. Juday.
2. Red Cedar River at Menomonie, Wis. Analysis from Chicago & Northwestern Ry.
3. Chippewa River near Eau Claire, Wis. The Survey average. Analyses 1 and 2 are reduced from the figures given in Wisconsin Geol. and Nat. Hist. Survey Bull. 35.

	Parts per million.			Percentage composition of dissolved solids.		
	1	2	3	1	2	3
CO_3	11.0	64.1	23.6	24.54	53.24	30.49
SO_4	6.4	3.5	14.0	14.29	2.91	18.09
Cl	3.0	4.8	1.1	6.69	3.99	1.42
NO_3	--------	--------	.6	--------	--------	.77
Ca	6.7	21.7	13.0	14.96	18.02	16.80
Mg	2.5	11.0	4.7	5.59	9.14	6.07
Na	.8	4.7	8.1	1.79	3.90	10.47
K	.3			.67		
SiO_2	13.0	8.9	12.0	29.02	7.39	15.51
Fe_2O_3	1.1	1.7	.3	2.45	1.41	.38
Al_2O_3			--------			--------
	44.8	120.4	77.4	100.0	100.00	100.0

Trout Lake lies in an area of old crystalline rocks, overlain by glacial drift. Its low salinity and high proportion of silica reflect these conditions; and the Chippewa, which has other lakes of similar character at its headwaters, shows the same influences but in less degree. Its water is modified by tributaries of different type, and Red Cedar River is one of them.

BLACK AND LA CROSSE RIVERS.

Black and La Crosse rivers are two streams which enter the Mississippi at La Crosse, Wis. The following analyses of waters from their basins are recalculated from the figures given in Bulletin 35 of the Wisconsin Geological and Natural History Survey.

Analyses of water from Black and La Crosse basins.

1. Black River at North La Crosse. Mean of three incomplete analyses from Chicago, Milwaukee & St. Paul Ry. Omitted from percentage table.
2. Morrison Creek at McKenna, Jackson County, Wis. From Chicago, Milwaukee & St. Paul Ry. A tributary of Black River.
3. La Crosse River at La Crosse. Analysis by Dearborn Drug & Chemical Co.
4. Sparta Creek at Sparta, Wis. From Chicago, Milwaukee & St. Paul Ry.

	Parts per million.				Percentage composition.		
	1	2	3	4	2	3	4
CO_3	38.1	10.4	76.4	68.8	37.01	55.89	54.82
SO_4	7.3	4.3	7.7	1.5	15.30	5.62	1.20
Cl	5.1	.5	1.7	1.5	1.78	1.24	1.20
Ca	19.5	3.4	28.8	26.0	12.10	21.07	20.71
Mg	6.5	.7	13.8	12.3	2.49	10.10	9.80
Na(K)	5.5	5.1	4.2	1.4	18.15	3.07	1.12
SiO_3	(?)	3.7	2.6	14.0	13.17	1.91	11.15
(Al, $Fe)_2O_3$	(?)		1.5			1.10	
	--------	28.1	136.7	125.5	100.00	100.00	100.00

WISCONSIN RIVER BASIN.

Wisconsin River rises in the lake region of northern Wisconsin and enters the Mississippi below Prairie du Chien. Its drainage basin of 12,280 square miles is entirely within the State of Wisconsin. Its sources are in an area of the older crystalline rocks, but as it flows southward it drains sedimentary formations of various kinds. The water of the river therefore undergoes many changes in its course southward. For the composition of the water of the main stream, we have, first, the table of analyses made in the water-resources laboratory of the United States Geological Survey.

Analyses of water from Wisconsin River near Portage, Wis.[a]

[Parts per million.]

Date (1906-7).		Turbidity.	Silica (SiO₂).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO₃).	Bicarbonate radicle (HCO₃).	Sulphate radicle (SO₄).	Nitrate radicle (NO₃).	Chlorine (Cl).	Total dissolved solids.	Mean gage height (feet).
From—	To—													
Sept. 11	Sept. 20	10	26	0.25	14	7.3	9.2	0.0	66	----------	1.3	0.8	117	5.2
21	30	15	16	.40	14	7.2	----------	.0	68	13	.9	2.5	109	5.3
Oct. 1	Oct. 11	10	13	Tr.	16	8.5	7.8	.0	66	13	.5	1.5	105	4.8
12	22	5	15	.30	16	8.3	10	.0	75	16	.5	1.0	98	4.9
23	31	5	19	Tr.	16	8.9	7.6	.0	60	24	Tr.	4.0	108	6.5
Nov. 1	Nov. 10	5	17	Tr.	15	7.3	7.1	.0	51	15	Tr.	2.5	100	6.1
11	21	10	6.6	.10	14	6.2	7.8	.0	49	11	.4	1.5	100	5.7
22	Dec. 1	10	6.4	.10	13	5.4	7.6	.0	48	14	.4	6.0	93	6.8
Dec. 2	11	10	16	.30	----------	4.9	9.7	.0	43	19	1.3	1.3	89	6.8
12	22	10	22	.40	13	7.4	11	.0	59	19	.4	3.2	112	6.5
23	1	5	15	.40	14	6.8	----------	.0	48	25	Tr.	.9	105	----------
Jan. 2	Jan. 11	5	16	.40	15	7.6	7.8	.0	72	19	.4	1.8	106	----------
12	22	5	15	.20	----------	7.2	7.3	.0	72	23	1.4	2.8	102	----------
23	Feb. 1	5	13	.25	16	9.6	5.9	.0	71	----------	Tr.	1.8	105	----------
Feb. 2	12	5	13	.40	18	6.7	13	.0	76	25	2.4	----------	108	----------
13	23	5	13	.20	----------	7.6	10	.0	72	15	2.2	4.5	98	----------
24	Mar. 6	5	11	.18	17	8.3	12	.0	75	23	1.6	2.1	109	----------
Mar. 7	17	10	10	.23	15	----------	11	.0	73	----------	1.9	1.8	107	6.4
18	28	10	9.0	.20	11	7.2	5.1	.0	47	13	1.9	1.8	78	7.7
29	Apr. 7	5	5.8	.20	9.2	2.8	4.3	.0	26	11	1.7	1.2	65	12.3
Apr. 8	17	10	18	.15	11	4.8	----------	.0	49	21	1.0	.6	96	9.2
18	27	5	11	.20	10	4.9	5.9	.0	37	16	.5	1.9	78	7.8
28	May 7	5	7.6	.25	11	5.0	5.7	.0	35	17	Tr.	----------	87	7.9
May 8	17	Tr.	6.8	.20	----------	5.5	4.6	.0	43	11	Tr.	1.5	88	7.2
Mean		7	13	.22	14	6.8	8.1	.0	58	17	.9	2.1	98	----------

[a] Analyses Sept. 11, 1906, to Feb. 12, 1907, by W. M. Barr; Feb. 13 to Mar. 6, 1907, by H. S. Spaulding; Mar. 7 to May 17, 1907, by Walton Van Winkle.

[b] Gaging station at Necedah, Wis., 50 miles below.

The following analyses of waters tributary to the Wisconsin are taken from Bulletin 35 of the Wisconsin Geological and Natural History Survey, where they are all stated in terms of parts per million. Their percentage composition has been added by the present writer. The analyses are arranged in order from the headwaters of the Wisconsin downstream.

Analyses of waters in Wisconsin River basin.

1. Bass Lake, Vilas County. Analysis by E. B. Hall and C. Juday.
2. Lake at Woodruff, Vilas County. From G. B. Davidson, of Chicago & Northwestern Ry.
3. Lake Kewaugesaga, Vilas County. Hall and Juday.
4. Creek at Fosterville, Vilas County. Davidson.
5. Creek at Monico Junction, Oneida County. Davidson.
6. Small lake near Worden, Oneida County. Davidson.
7. Two Sisters Lake, Oneida County. Hall and Juday.
8. Minocqua Lake, Oneida County. From Chicago, Milwaukee & St. Paul Ry.
9. Prairie River at Merrill. From Chicago, Milwaukee & St. Paul Ry.
10. Summit Lake, Langlade County. Davidson.
11. Scott Creek near Marathon City. Davidson.
12. Creek at Stratford. Davidson.
13. Yellow River at Necedah. Davidson.
14. North Branch of Lemonweir River near Wyeville. Davidson.
15. Council Creek at Tomah. From Chicago, Milwaukee & St. Paul Ry.
16. Baraboo River at Baraboo. Davidson.
17. Silver Lake at Portage. From Chicago, Milwaukee & St. Paul Ry.
18. Black Earth Creek at Mazomanie. From Chicago, Milwaukee & St. Paul Ry.
19. Wisconsin River at Grand Rapids. From Chicago, Milwaukee & St. Paul Ry.
20. Wisconsin River at Portage. The average from the Survey table, reduced to standard form, is inserted for convenience of comparison.

I. Parts per million.

	1	2	3	4	5	6	7	8	9	10
CO₃	1.7	3.3	15.2	22.9	60.7	4.7	11.6	31.9	64.3	14.3
SO₄	1.4	2.9	7.9	4.4	41.5	24.9	8.2	1.3	1.9	19.4
Cl	2.5	1.8	2.7	1.6	6.8	------	5.6	.7	4.0	4.6
Ca	.6	2.4	7.2	9.8	34.5	8.0	4.5	12.6	23.1	11.3
Mg	1.2	.6	2.8	3.3	14.3	.8	2.2	3.4	8.4	3.8
Na	.3	1.2	2.6	3.2	4.4	4.7	4.5	4.8	10.4	3.1
K	.6		1.7			4.0	4.5			
SiO₂	5.0	4.1	16.5	1.7	18.6	4.0	22.9	------	.9	5.6
(Al, Fe)₂O₃	5.0	Tr.	6.2	4.8	3.7	1.7	8.5	2.6		1.3
	18.3	16.3	62.8	51.7	184.5	48.8	72.5	57.3	113.0	63.4

	11	12	13	14	15	16	17	18	19	20
CO₃	13.8	104.1	37.4	51.7	78.8	96.9	82.7	112.8	39.4	28.5
SO₄	19.8	18.3	9.2	8.0	9.2	4.6	2.1	18.8	1.5	17.0
Cl	2.4	1.6	.9	2.0	1.1	7.7	2.1	9.1	1.4	2.1
NO₃	------	------	------	------	------	------	------	------	------	.9
Ca	9.3	55.2	19.2	20.5	28.2	29.1	33.5	29.5	13.6	14.0
Mg	1.3	11.8	7.0	10.2	14.8	21.5	13.6	32.6	5.5	6.8
Na (K)	8.0	11.5	.7	1.9	5.1	7.2	1.4	5.9	6.0	8.1
SiO₂	10.4	10.9	8.4	13.5	3.6	2.9	10.8	14.9	3.8	13.0
(Al, Fe)₂O₃	8.7	.5.1	.5	1.3				2.9		------
Fe₂O₃	------	------	------	------	------	------	------	------	------	.3
	73.7	218.5	81.3	109.1	140.8	169.9	146.2	226.5	71.2	90.7

Analyses of waters in Wisconsin River basin—Continued.

II. Percentage composition of dissolved solids.

	1	2	3	4	5	6	7	8	9	10
CO_3	9.29	20.24	24.21	44.29	32.90	9.63	16.00	55.67	56.90	22.55
SO_4	7.65	17.79	12.59	8.51	22.49	51.03	11.31	2.27	1.68	30.59
Cl	13.66	11.04	4.29	3.10	3.68	------	7.72	1.22	3.54	7.25
Ca	3.28	14.73	11.42	18.96	18.70	16.39	6.21	21.99	20.45	17.82
Mg	6.56	3.68	4.46	6.38	7.75	1.64	3.04	5.93	7.43	5.98
Na	1.64	7.37	4.15	6.19	2.39	9.63	6.21	8.38	9.20	4.95
K	3.28		.2.72				6.21			
SiO_2	27.32	25.18	26.28	3.29	10.08	8.20	31.58	------	------	8.82
$(Al, Fe)_2O_3$	27.32	Tr.	9.88	9.28	2.01	3.48	11.72	4.54	.80	2.04
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

	11	12	13	14	15	16	17	18	19	20
CO_3	18.73	47.65	46.00	47.39	55.96	57.03	56.57	49.80	55.34	31.42
SO_4	26.87	8.38	11.32	7.33	6.54	2.71	1.44	8.30	2.10	18.74
Cl	3.25	.73	1.11	1.83	.78	4.53	1.44	4.02	1.97	2.31
NO_3	------	------	------	------	------	------	------	------	------	.99
Ca	12.62	25.27	21.16	18.79	20.03	17.13	22.91	13.03	19.10	15.45
Mg	1.76	5.40	8.61	9.35	10.51	12.65	9.30	14.39	7.72	7.50
Na (K)	10.85	5.26	.86	1.74	3.62	4.24	.95	2.60	8.43	8.93
SiO_2	14.11	4.99	10.33	12.38	2.56	1.71	7.39	6.58	5.34	14.33
$(Al, Fe)_2O_3$	11.81	2.32	.61	1.19				1.28		------
Fe_2O_3	------	------	------	------	------	------	------	------	------	.33
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

These analyses, although they are very dissimilar, are nevertheless interesting. Nos. 1, 2, 3, and 7 are of lakes in northern Wisconsin and resemble analyses of similar lakes in Maine. All these waters contain very high proportions of silica, and in Nos. 1 and 2 the salinity is remarkably low. These waters derive their solid constituents from glacial drift that overlies granite and represent a definite type. Analyses 9 and 12 to 18 represent characteristic carbonate waters, which owe their peculiarities in great part to limestone and other sedimentary rocks. The water of Black Earth Creek (No. 18) is extremely high in magnesium, and its source is evidently in a magnesian area. No. 20, the Survey average for Wisconsin River, represents a blending of all the different types, which was, of course, to be expected.

ROCK RIVER.

Rock River rises in southeastern Wisconsin and flows into the Mississippi near Rock Island. Its drainage basin, of about 11,000 square miles, begins in the magnesian area of Wisconsin, and below this its course is in the glacial drift of Illinois. For the headwaters of the Rock, all in Wisconsin, the following ten analyses are available, as recalculated from the figures given by Weidman and Schultz:[21]

Analyses of waters in Rock River basin.

1. Creek at Burnett Junction, Dodge County.
2. Honey Creek near Lowell, Dodge County. Analyses 1 and 2 from G. M. Davidson, of the Chicago & Northwestern Ry.
3. Rock River at Watertown Junction. Analysis from Chicago, Milwaukee & St. Paul Ry.
4. Rock River at Jefferson. From G. M. Davidson.
5. Oconomowoc River at North Lake. From Chicago, Milwaukee & St. Paul Ry.
6. Garvin Lake. Mean of three analyses.
7. Okauchee Lake.
8. North Lake.
9. Lake Mendota. Mean of two analyses. Analyses 6, 7, 8, and 9 by E. B. Hall and C. Juday.
10. Yahara River at Madison, Dane County. From G. M. Davidson.

I. Parts per million.

	1	2	3	4	5	6	7	8	9	10
CO_3	186.6	177.4	119.1	133.0	138.3	73.3	108.4	122.0	77.2	108.0
SO_4	20.1	34.3	3.5	88.8	4.2	11.9	13.9	13.7	15.3	11.4
Cl	15.8	6.3	6.8	6.4	3.2	5.5	4.0	5.5	3.0	9.2
Ca	71.7	72.6	32.6	66.6	43.9	22.7	34.3	40.3	19.8	33.0
Mg	37.7	37.4	28.6	34.1	30.8	19.0	25.9	28.0	21.6	26.2
Na	10.3	4.1	6.6	7.6	2.1	2.8	3.2	3.5	3.6	7.5
K						1.1	1.4	1.8	2.2	
SiO_2	14.9	14.0	6.7	4.4	1.0	10.2	17.6	16.1	15.2	.3
$(Al, Fe)_2O_3$	1.5	2.0		1.5		4.1	1.5	1.8	2.2	.3
	358.6	248.1	203.9	342.4	223.5	150.6	210.2	232.7	160.1	195.9

II. Percentage composition of dissolved solids.

	1	2	3	4	5	6	7	8	9	10
CO_3	52.04	50.97	58.41	38.84	61.88	48.68	51.57	52.43	48.22	5.13
SO_4	5.61	9.86	1.71	25.94	1.88	7.90	6.61	5.89	9.56	5.82
Cl	4.40	1.74	3.36	1.87	1.43	3.65	1.90	2.37	1.87	4.70
Ca	19.99	20.87	15.99	19.45	19.64	15.07	16.32	17.32	12.37	16.84
Mg	10.51	10.75	14.02	9.96	13.78	12.62	12.32	12.03	13.50	13.38
Na	2.87	1.19	3.23	2.22	.94	1.86	1.52	1.50	2.25	3.83
K						.73	.67	.77	1.37	
SiO_2	4.16	4.03	3.28	1.28	.45	6.77	8.37	6.92	9.49	.15
$(Al, Fe)_2O_3$	.42	.59		.44		2.72	.72	.77	1.37	.15
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

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[21] Wisconsin Geol. and Nat. Hist. Survey Bull. 35, 1915.

For the main stem of Rock River in Illinois there are two tables of analyses by W. D. Collins,[22] as follows:

Analyses of water from Rock River near Rockford, Ill.

[Parts per million.]

Date (1906-7).		Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total solids.
From—	To—												
Aug. 1	Aug. 10	450	14	0.20	32	19	11	0.0	187	17	3.0	5.5	207
11	20	228	22	.24	29	21	11	.0	174	21	3.6	2.5	198
21	30	310	19	1.7	28	17	11	.0	161	16	2.5	6.0	179
31	Sept. 9	148	20	.12	40	26	7.9	.0	253	22	3.5	4.5	249
Sept. 10	19	140	6.6	.50	41	22	11	.0	272	18	3.6	4.5	229
20	29	60	15	.08	54	33	18	.0	295	15	4.0	5.5	275
30	Oct. 8	60	8.8	.04	44	26	10.0	.0	252	16	4.0	4.5	243
Oct. 10	18	30	13	.07	52	26	13	.0	315	17	4.0	5.0	296
20	29	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------
Nov. 1	Nov. 8	20	13	.05	53	33	12	.0	320	19	5.0	4.5	286
10	19	10.0	11	.04	55	32	7.5	.0	314	21	3.5	6.0	287
20	29	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------
Dec. 1	Dec. 10	20	13	.07	48	32	9.5	.0	291	21	4.0	5.2	256
11	20	15	12	.13	52	32	13	.0	310	25	4.0	7.5	295
21	31	10.0	18	.14	57	34	14	.0	347	34	4.0	5.5	320
Jan. 1	Jan. 10	380	21	1.5	35	19	16	.0	184	28	4.0	3.5	218
11	20	290	18	.8	32	18	10	.0	218	30	4.0	4.0	228
21	31	177	17	1.2	28	14	11	.0	139	17	3.0	5.0	173
Feb. 1	Feb. 7	50	22	.7	39	23	12	.0	234	30	3.5	5.0	243
10	18	40	18	.26	46	25	9.0	.0	265	21	5.5	5.5	261
19	28	80	13	1.8	34	17	9.2	.0	176	19	4.5	6.0	194
Mar. 1	Mar. 10	20	13	.25	44	26	7.9	.0	227	22	7.0	5.8	233
11	20	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------
21	31	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------
Apr. 1	Apr. 10	270	16	.39	41	20	7.6	.0	208	24	2.8	2.8	223
11	20	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------
21	30	35	8.0	.16	50	36	4.8	.0	264	24	2.5	5.0	266
May 1	May 10	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------
11	20	40	9.2	.15	52	22	8.2	.0	292	25	9.0	3.0	306
21	31	70	8.8	.15	51	27	11	.0	287	23	3.2	4.0	268
June 1	June 10	80	8.6	.26	53	29	8.2	.0	267	25	3.6	3.0	268
11	20	100	8.8	.18	57	33	7.7	.0	272	25	4.0	3.0	275
21	30	110	15	.17	62	29	9.2	.0	287	19	3.0	3.5	283
July 1	July 10	210	21	.78	51	20	7.6	.0	260	18	6.0	2.5	243
11	20	240	18	.54	53	24	7.2	.0	253	13	6.0	3.0	239
21	31	340	28	.38	48	24	11	.0	226	20	2.5	6.0	247
Mean		134	15	.44	45	25	10	.0	252	22	4.1	4.6	250

Analyses of water from Rock River near Sterling, Ill.

[Parts per million.]

Date (1906-7).		Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total solids.
From—	To—												
Aug. 1	Aug. 10	600	11	0.20	40	25	14	0.0	225	18	6.0	5.7	247
11	20	425	23	.12	30	18	13	.0	158	18	3.3	7.7	187
21	30	565	23	2.4	30	17	9.7	.0	153	13	3.5	4.5	183
31	Sept. 9	410	20	.12	49	31	6.2	.0	264	19	3.5	5.0	268
Sept. 11	17	600	17	.30	47	23	15	.0	278	19	2.0	6.0	265
20	29	290	13	.10	50	31	5.7	.0	285	17	4.0	5.5	265
30	Oct. 7	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------
Oct. 11	18	144	13	.03	55	26	7.7	.0	312	22	3.5	10	297
20	28	216	13	.03	56	34	10	.0	330	18	3.0	5.5	303
Nov. 1	Nov. 8	100	20	.10	55	34	18	.0	326	30	3.0	6.5	301
10	16	30	6.8	.03	53	32	10	.0	330	24	0.4	7.0	288
20	29	60	13	.03	55	37	10	.0	303	26	5.0	5.0	280
Dec. 1	Dec. 10	50	17	.04	52	32	9.2	.0	293	26	2.5	6.2	275
11	20	50	8.8	.06	56	35	15	.0	--------	33	--------	--------	304
21	31	20	12	.22	54	29	16	.0	350	21	5.0	6.5	337
Jan. 1	Jan. 10	280	10	.20	37	24	14	.0	227	26	4.5	5.0	252
11	19	187	26	.56	41	24	13	.0	245	36	4.0	3.5	273
21	30	210	16	1.3	29	14	18	.0	139	24	5.0	5.2	176
Feb. 1	Feb. 7	45	17	.64	57	31	22	.0	285	40	1.8	11	312
12	17	40	9.6	.40	48	27	12	.0	235	44	4.5	16	270
19	28	60	12	.13	42	21	15	.0	213	26	5.5	5.3	224
Mar. 2	Mar. 10	60	15	.21	46	26	13	.0	--------	24	6.5	4.0	276
11	20	90	20	.14	59	28	17	.0	278	25	0.3	7.5	282
21	31	110	15	.26	49	21	12	.0	245	19	5.4	3.8	260
Apr. 1	Apr. 10	240	15	.46	46	22	19	.0	240	31	4.6	2.8	242
11	20	80	16	.20	48	26	11	.0	242	29	3.7	3.5	260
21	30	75	9.6	.32	51	36	6.9	.0	269	29	2.4	5.0	280
May 1	May 10	55	16	.13	51	21	9.8	.0	282	29	6.0	3.0	294
11	20	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------
21	31	285	9.0	.15	50	29	11	.0	262	29	3.8	3.5	260
June 1	June 10	385	13	.57	50	28	9.7	.0	267	27	3.7	3.3	271
11	20	200	14	.32	62	31	10	.0	289	21	5.0	3.0	299
21	30	220	18	.25	62	29	10	.0	314	22	3.6	5.0	287
July 1	July 10	475	13	.30	52	24	6.6	.0	277	19	5.0	3.0	253
11	20	500	17	.14	52	21	7.3	.0	248	21	2.6	3.5	244
21	31	618	24	.19	53	25	10	.0	255	18	1.7	5.0	255
Mean		229	15	.31	49	27	12	.0	263	25	3.8	5.5	267

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[22] U. S. Geol. Survey Water-Supply Paper 239, 1910.

Reduced to percentages, with carbonates normal and Fe restated as Fe_2O_3, the two tables by Collins give the following averages:

Percentage composition of Rock River waters.

1. Rock River near Rockford, Ill.
2. Rock River near Sterling, Ill.

	1	2
CO_3	49. 54	48. 48
SO_4	8. 79	9. 35
Cl	1. 84	2. 06
NO_3	1. 64	1. 42
Ca	17. 98	18. 34
Mg	9. 99	10. 10
Na(K)	3. 99	4. 49
SiO_2	5. 99	5. 61
Fe_2O_3	. 24	. 15
	100. 00	100. 00
Salinity, parts per million	250. 3	267. 3

In addition to the foregoing analyses there are two others of waters in the lower part of the Rock River basin. With them, as a matter of convenience, a single analysis of water from Plum River may be included. Plum River is a relatively small stream that enters the Mississippi at Savanna, Ill., about 50 miles north of Rock River. The data are as follows:

Analyses of water in Rock River basin, etc.

1. Lake at Nelson, Ill. Received from Chicago & Northwestern Ry.
2. Leaf River at Leaf River Station, Ill.
3. Plum River at Savanna, Ill. Analyses 2 and 3 from Chicago, Milwaukee & St. Paul Ry.

	Parts per million.			Percentage composition.		
	1	2	3	1	2	3
CO_3	107. 0	185. 6	132. 8	33. 27	62. 44	57. 49
SO_4	95. 8	Tr.	9. 7	29. 80	Tr.	4. 18
Cl	8. 7	3. 8	3. 5	2. 71	1. 29	1. 53
Ca	63. 2	61. 4	49. 2	19. 67	20. 61	21. 29
Mg	28. 8	33. 4	24. 8	8. 96	11. 25	10. 72
Na(K)	5. 6	10. 1	4. 7	1. 76	3. 42	2. 05
SiO_2	11. 6	2. 9	6. 3	3. 62	. 99	2. 74
$(Al, Fe)_2O_3$	. 7			. 21		
	321. 4	297. 2	231. 0	100. 00	100. 00	100. 00

The analyses of waters in Rock River basin are especially interesting, because they reinforce the evidence, which has already been discussed in relation to the Lake Michigan area, of the magnesian character of southeastern Wisconsin—a definite hydrochemical province. All the waters at the head of Rock River are strongly magnesian, and this peculiarity is manifest throughout the length of the stream. The same peculiarity appears in the Illinois River basin.

ILLINOIS RIVER BASIN.

Illinois River, which drains nearly half of the State of Illinois, is formed by the union of the Desplaines and the Kankakee. Its normal drainage basin has an area of about 27,900 square miles; but it is also affected by the Chicago drainage canal, which carries the sewage of Chicago diluted by water from Lake Michigan.[23] The effect of this addition will be considered later. The two components of the Illinois may be studied first.

DESPLAINES AND KANKAKEE RIVERS.

Desplaines River rises in southeastern Wisconsin and drains an area of 1,392 square miles. Near its mouth, at Lockport, it receives the water of the Chicago drainage canal and therefore becomes much polluted. The analyses cited later are of water taken much farther upstream. Kankakee River rises in northern Indiana and drains an area of 5,146 square miles. For the composition of its water we have, first, the table of analyses by Collins, which gives an average for an entire year, as follows:

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[23] For other details see Collins, W. D., U. S. Geol. Survey Water-Supply Paper 239, 1910.

Analyses of water from Kankakee River near Kankakee, Ill.

[Parts per million.]

Date (1906-7).		Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total solids.
From—	To—												
Aug. 4	Aug. 10	30	22	0.20	58	21	18	0.0	218	69	4.0	4.7	329
11	18	40	16	.10	56	20	8.5	.0	213	53	3.0	5.5	273
21	30	70	21	.07	54	21	17	.0	218	57	3.5	3.5	326
31	Sept. 9	50	17	.14	57	24	14	.0	201	52	2.0	4.5	283
Sept. 10	19	10.0	14	.12	55	27	12	.0	226	56	0.6	5.0	289
20	29	30	12	.15	58	18	16	.0	226	38	1.8	5.5	286
Oct. 1	Oct. 8	50	16	.06	58	22	16	.0	225	53	2.0	5.0	285
11	19	20	11	.04	61	-----	12	.0	250	60	1.7	6.0	300
21	29	30	15	.06	63	27	17	.0	262	63	1.0	8.0	302
30	Nov. 8	10.0	17	.03	64	24	13	.0	263	62	0.6	4.8	306
Nov. 9	19	30	11	.04	55	16	10	.0	219	74	4.0	6.5	295
20	30	20	16	.05	61	22	22	.0	203	83	8.0	6.0	314
Dec. 1	Dec. 10	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
11	14	10.0	17	.34	55	31	25	.0	180	90	8.0	10	312
21	30	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
31	Jan. 9	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Jan. 12	12	50	19	.44	42	16	11	.0	179	65	8.0	4.2	253
13	25	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
26	Feb. 7	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Feb. 8	18	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
19	28	20	15	.19	56	16	11	.0	195	68	3.2	5.5	293
Mar. 1	Mar. 10	25	10	.36	52	20	14	.0	185	71	4.0	3.3	266
11	20	160	15	.39	55	18	11	.0	190	73	4.6	3.0	304
21	31	190	19	.46	58	17	11	.0	195	61	4.0	4.0	286
Apr. 1	Apr. 10	30	16	.61	45	16	12	.0	181	43	4.0	4.2	247
11	20	12	12	.41	51	17	8.7	.0	188	42	3.6	3.5	220
21	30	15	11	.30	63	27	9.3	.0	218	65	2.4	3.5	293
May 1	May 10	90	10	.25	51	17	9.3	.0	183	53	8.8	4.0	255
11	20	25	7.2	.20	54	22	9.0	.0	202	55	6.2	4.0	285
21	31	30	8.4	.34	61	23	10	.0	219	58	3.2	3.5	310
June 1	June 10	80	19	.68	58	21	11	.0	210	58	7.2	3.0	289
11	20	35	8.8	.22	70	19	9.6	.0	223	40	4.0	4.5	293
21	30	110	19	.45	76	23	6.8	.0	273	42	3.2	3.0	299
July 1	July 10	45	15	.32	71	25	8.2	.0	258	46	3.5	3.0	312
11	20	138	16	.74	52	18	5.5	.0	198	34	6.8	3.0	237
21	31	60	17	.34	69	25	8.7	.0	253	46	6.6	4.0	294
Mean		50	15	.27	58	21	12	.0	215	57	4.1	4.9	288

In addition to the foregoing table we have the following analyses of water in this basin:

Analyses of water from Desplaines and Kankakee rivers.

1. Desplaines River at Wadsworth, Ill. Mean of five analyses received from Chicago, Milwaukee & St. Paul R. R.
2. Creek at Walkerton, Ind.
3. Yellow River at Bremen, Ind. Analyses 2 and 3 received from Baltimore & Ohio R. R. and represent tributaries of the Kankakee.
4. Kankakee River at Kankakee, Ill. Analysis received from Cleveland, Chicago, Cincinnati & St. Louis R. R.

	Parts per million.				Percentage composition.			
	1	2	3	4	1	2	3	4
CO_3	150.7	119.3	155.0	77.6	36.50	32.31	48.52	40.97
SO_4	121.1	35.2	24.3	28.5	29.33	9.52	7.62	20.34
Cl	7.2	63.0	16.8	2.8	1.74	17.06	5.24	1.47
Ca	71.5	64.3	75.0	37.8	17.33	17.42	23.48	19.92
Mg	39.3	17.7	23.1	12.4	9.53	4.79	7.23	6.54
Na(K)	20.6	40.8	10.9	12.6	4.99	11.06	3.41	6.72
SiO_2	2.4	20.0	14.4	6.2	.58	7.84	4.50	3.24
$(Al,Fe)_2O_3$				1.5				.80
	412.8	369.3	319.5	189.4	100.00	100.00	100.00	100.00

The water of Yellow River appears to be normal. The other analyses, especially No. 2, indicate pollution. The high magnesium in No. 1 is doubtless derived from the remarkable magnesian area near the source of Desplaines River in Wisconsin.

FOX RIVER.

Fox River, with a drainage basin of 2,700 square miles, rises in southeastern Wisconsin and enters the Illinois at Ottawa. Its source is in a highly magnesian region, close to that of the other Fox River which drains into Lake Michigan. The two rivers must not be confused. For the Fox River of Illinois Collins[24] made two sets of analyses, which appear in the following tables.

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[24] U. S. Geol. Survey Water-Supply Paper 239, 1910.

Analyses of water from Fox River near Elgin, Ill.

[Parts per million.]

Date (1906–7).		Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total solids.
From—	To—												
Aug. 3	Aug. 10	110	26	0.20	42	36	11	0.0	283	27	2.5	6.0	304
11	20	30	15	.10	40	35	10	.0	240	31	3.4	4.7	270
21	30	50	10	.06	44	34	19	.0	252	31	3.0	7.0	280
31	Sept. 8	50	12	.05	41	34	17	.0	291	29	1.2	6.5	264
Sept. 11	19	50	9.4	.20	32	35	14	.0	260	29	1.8	5.0	234
20	29	40	9.4	.03	43	29	10	.0	273	24	2.0	6.5	265
30	Oct. 9	40	7.0	.03	43	34	11	.0	254	49	1.7	5.0	252
Oct. 10	18	20	5.8	.08	42	35	7.7	.0	270	31	1.2	5.5	265
20	29	30	8.2	.05	51	37	19	.0	300	33	0.6	7.2	285
Nov. 1	Nov. 8	20	10	.04	51	35	10	.0	316	36	1.5	7.5	306
9	19	10.0	6.0	.03	50	33	13	.0	310	36	1.2	5.5	289
20	30	15	8.6	.03	57	37	14	.0	300	45	3.0	7.0	293
Dec. 1	Dec. 10	10.0	11	.06	55	27	12	.0	300	51	4.0	7.5	315
11	20	10.0	10	.13	62	37	8.8	.0	309	46	2.5	6.5	348
21	31	5.0	9.2	.12	65	39	13	.0	365	53	3.5	5.5	373
Jan. 1	Jan. 10	40	20	.07	61	20	18	.0	309	51	3.5	6.0	378
11	20												
21	31	50	14	.64	45	22	10	.0	188	42	2.5	7.0	249
Feb. 1	Feb. 9	15	14	.20	53	30	10	.0	250	49	3.0	6.2	310
10	18	7.0	15	.13	56	31	8.4	.0	231	42	4.0	6.0	317
19	28	15	12	.13	44	23	14	.0	220	44	4.0	6.5	265
Mar. 1	Mar. 10	5.0	11	.36	45	26	13	.0	232	38	2.7	4.3	274
11	20	10.0	12	.27	55	21	10	.0	245	40	1.7	5.0	277
21	31	25	11	.15	48	23	7.7	.0	235	45	1.5	5.5	258
Apr. 1	Apr. 10	25	10	.13	54	25	7.4	.0	256	35	1.7	5.5	277
11	20												
21	30	25	10	.28	55	34	11	.0	267	43	2.4	2.3	292
May 1	May 10	20	11	.12	54	22	10	.0	247	48	2.5	4.0	304
11	20	35	20	.20	56	23	9.0	.0	292	47	2.6	3.3	329
21	31	55	12	.12	52	29	5.5	.0	234	50	2.0	3.5	273
June 1	June 10	35	11	.19	56	24	5.8	.0	247	35	2.5	3.3	292
11	20	80	9.2	.25	61	29	8.4	.0	265	32	1.5	3.5	281
21	30	80	16	.30	64	33	5.1	.0	272	29	3.5	3.0	308
July 1	July 10	50	12	.15	56	31	10	.0	275	28	2.0	4.5	291
11	20	55	12	.17	56	27	8.7	.0	272	35	2.7	2.5	284
21	31	35	17	.17	56	29	6.6	.0	273	26	2.0	3.3	269
Mean		34	12	.15	51	30	11	.0	268	38	2.4	5.2	290

Analyses of water from Fox River near Ottawa, Ill.

[Parts per million.]

Date (1906–7).		Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total solids.
From—	To—												
Aug. 2	Aug. 10	135	13	0.15	47	35	20	0.0	278	45	3.0	12	335
11	20	345	13	.14	41	34	20	.0	246	50	3.3	16	293
21	30												
31	Sept. 9	105	5.0	.07	45	39	17	.0	257	43	2.7	9.5	298
Sept. 10	19	40	6.1	.10	43	32	18	.0	275	50	2.4	12	288
20	29	30	6.8	.09	49	36	10.0	.0	261	43	2.5	10	287
30	Oct. 9	155	9.4	.06	55	31	19	.0	254	53	5.0	8.0	307
Oct. 10	19	20	4.2	.07	55	36	15	.0	290	61	2.0	11	334
20	28	10.0	7.2	.06	60	39	21	.0	320	60	1.0	12	349
30	Nov. 8	20	8.6	.06	60	39	17	.0	330	54	1.5	8.0	351
Nov. 9	19	10.0	4.6	.02	60	40	10	.0	320	56	0.6	9.0	332
21	30	40	12	.07	67	37	13	.0	298	72	6.0	7.0	348
Dec. 1	Dec. 9	20	11	.11	65	36	9.5	.0	315	68	3.0	7.5	357
12	20	15	9.2	.19	72	39	12	.0	311	75	6.5	8.3	376
21	31	40	13	.16	71	40	15	.0	351	82	5.5	8.7	409
Jan. 1	Jan. 10												
11	20	310	31	.40	52	25	15	.0	238	58	8.0	5.0	305
21	30	40	21	.40	46	23	16	.0	204	49	7.0	5.0	273
Feb. 1	Feb. 9	10.0	7.8	.09	58	31	13	.0	251	64	5.5	6.5	334
10	18	7.0	16	.15	59	31	12	.0	268	57	6.5	7.5	329
19	28	5.0	12	.05	63	24	15	.0	244	70	4.6	8.2	319
Mar. 1	Mar. 10	50	8.8	.09	60	29	16	.0	230	78	5.4	6.0	372
11	20	30	11	.22	64	29	8.2	.0	262	80	4.0	13	322
21	31	10.0	8.0	.15	61	18	15	.0	250	71	6.0	8.2	336
Apr. 1	Apr. 10	30	12	.19	63	30	9.3	.0	257	69	6.0	3.3	331
11	20	20	21	.92	62	23	35	.0	276	66	5.0	5.0	367
21	31	15	7.0	.22	60	29	9.3	.0	264	56	3.8	5.0	314
May 1	May 10	15	8.2	.17	62	22	17	.0	287	63	4.0	6.0	343
11	20	15	9.4	.43	58	26	8.7	.0	284	54	4.0	5.0	344
21	31	200	16	.32	66	36	14	.0		55	5.0	3.8	360
June 1	June 10	90	11	.28	61	31	12	.0	257	63	8.8	6.0	326
11	20	95	8.8	.26	67	31	8.4	.0	272	50	3.0	5.0	319
21	30	218	9.2	.19	71	31	5.5	.0	280	49	9.0	5.0	326
July 1	July 10	550	16	.37	61	27	7.9	.0	277	45	5.0	5.0	307
11	20	300	17	.22	72	30	8.5	.0	286	60	10	6.0	379
21	31	192	13	.38	85	38	9.3	.0	287	95	12	14	416
Mean		94	11	.20	60	32	14	.0	275	61	4.9	7.9	335

In addition to these tables we have six other analyses of waters in the Fox River basin, as follows, reduced to standard form:

Analyses of water in Fox River basin.

1. Lake Geneva, Wis. Mean of four analyses by E. B. Hall and C. Juday.
2. The same. Analysis received from G. M. Davidson, of the Chicago & Northwestern Ry.
3. Lake Cravath, Whitewater, Wis. Analysis received from Chicago, Milwaukee & St. Paul Ry.
4. Nippersink Creek at Genoa Junction, Wis. Received from Davidson. Analyses 1 to 4 are reduced from figures given in Wisconsin Geol. and Nat. Hist. Survey Bull. 35, p. 596, 1915.
5. Fox River at Cary, Ill. Analysis published by G. M. Davidson in Western Railway Club Proc., Feb. 17, 1903.
6. Fox River at Elgin, Ill. Mean of three analyses received from Chicago, Milwaukee & St. Paul Ry.

I. Parts per million.

	1	2	3	4	5	6
CO_3	92.3	115.0	160.0	153.4	130.7	120.5
SO_4	13.2	11.4	7.5	32.4	16.2	17.0
Cl	4.2	8.8	2.4	3.2	7.6	4.9
Ca	20.7	29.6	39.3	61.7	41.5	38.0
Mg	26.9	30.0	36.2	26.7	27.6	26.1
Na	4.3	8.5	14.8	7.5	9.5	10.0
K	2.5					
SiO_2	9.5	3.6	1.5	13.3	8.2	4.8
$(Al, Fe)_2O_3$	1.1	.5		2.0	2.0	
	174.7	207.4	261.7	300.2	243.3	221.3

Analyses of water in Fox River basin—Continued.

II. Percentage composition of dissolved solids.

	1	2	3	4	5	6
CO_3	52.83	55.47	61.14	51.10	53.69	54.47
SO_4	7.56	5.49	2.87	10.80	6.67	7.68
Cl	2.40	4.24	.92	1.07	3.13	2.21
Ca	11.85	14.27	15.02	20.56	17.07	17.18
Mg	15.40	14.46	13.83	8.87	11.32	11.79
Na	2.46	4.10	5.65	2.50	3.90	4.51
K	1.43					
SiO_2	5.44	1.73	.57	4.43	3.38	2.16
$(Al, Fe)_2O_3$	.63	.24		.67	.84	
	100.00	100.00	100.00	100.00	100.00	100.00

The very high magnesium in these analyses is also shown in the analyses of other waters in eastern Wisconsin, which belong to the basin of Lake Michigan. The Niagara dolomite and "Lower Magnesian" limestone determine the character of these waters.

ILLINOIS RIVER.

For the main stem of the Illinois, Collins gives tables of analyses of water from three stations, as follows:

Analyses of water from Illinois River near La Salle, Ill.

[Parts per million.]

Date (1906-7).		Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total solids.
From—	To—												
Aug. 1	Aug. 10	70	14	0.50	33	18	22	0.0	174	41	7.0	28	265
11	20	50	19	.10	39	18	17	.0	170	28	6.0	20	262
21	30	235	25	.05	38	19	20	.0	172	34	1.0	18	252
31	Sept. 9	50	10	.03	39	24	8.0	.0	169	30	3.0	17	235
Sept. 10	19	50	8.4	.30	39	18	15	.0	171	32	5.0	18	221
20	29	110	6.8	.07	42	17	12	.0	175	39	7.0	21	241
30	Oct. 9	290	13	.20	50		18	.0	180	49	7.0	19	284
Oct. 10	19	60	6.8	.09	45	23	18	.0	200	43	3.5	7.5	260
20	28	40	9.8	.04	51	22	21	.0	220	45	4.0	19	268
30	Nov. 8	40	7.8	.02	51	23	24	.0	240	53	6.0	16	275
Nov. 9	19	30	10	.12	63	29	25	.0	224	64	4.0	18	276
20	30	100	10	.06	57	26	17	.0	210	66	6.0	13	300
Dec. 1	Dec. 10	120	13	.12	54	27	15	.0	219	72	7.0	14	320
11	20	128	13	.32	51	24	16	.0	195	62	6.0	11	284
21	31	174	10	.12	53	26	17	.0	210	64	7.0	12	311
Jan. 1	Jan. 10	206	15	.10	52	23	17	.0	220	68	9.0	9.7	296
11	20	248	18	.36	51	21	11	.0	206	56	8.0	9.2	298
21	31							.0					
Feb. 1	Feb. 9	15	5.6	.28	52	20	13	.0	200	53	8.0	11	289
10	18	10	11	.08	53	22	17	.0	214	51	6.5	16	311
19	28	30	8.0	.13	48	20	14	.0	195	50	7.0	13	273
Mar. 1	Mar. 10												
11	20	100	13	.22	51	20	19	.0	198	55	3.2	10.0	257
21	31	150	12	.26	46	19	12	.0	205	57	10	9.0	272
Apr. 1	Apr. 10	105	18	.38	50	20	13	.0	205	73	6.8	7.0	299
11	20	40	12	.15	56	27	16	.0	215	78	7.0	6.5	344
21	30	35	9.4	.20	54	27	10	.0	207	52	4.6	10	266
May 1	May 10	100	11	.31	50	18	12	.0	208	52	12	9.8	272
11	20	48	6.0	.80	52	19	18	.0	185	48	14	14	300
21	31	230	8.0	.27	54	22	9.5	.0	208	49	9.6	8.5	279
June 1	June 10	95	13	.38	51	19	10.0	.0	213	38	14	8.3	307
11	20	280	9.6	.38	59	22	12	.0	227	31	0.3	3.0	276
21	30	161	16	.50	60	24	14	.0	233	37	3.6	10	276
July 1	July 10	1,610	18	.15	53	18	11	.0	197	47	6.0	10	256
11	20	270	15	.18	53	19	13	.0	206	36	7.0	9.0	255
21	31	130	15	.13	57	21	15	.0	228	34	7.0	12	288
Mean		159	12	.21	50	22	16	.0	203	50	6.6	13	27

Analyses of water from Illinois River near Peoria, Ill.

[Parts per million.]

Date (1906–7).		Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total solids.
From—	To—												
Aug. 1	Aug. 9	50	13	0.10	40	20	28	0.0	182	21	10.0	27	266
31	Sept. 9	60	12	.20	42	20	15	.0	166	28	4.0	20	245
Sept. 10	19	30	20	.14	45	18	23	.0	187	29	4.0	19	260
20	29	40	6.4	.10	42	18	15	.0	177	24	5.0	20	222
30	Oct. 9	40	8.4	.03	44	18	22	.0	174	40	6.0	22	249
Oct. 10	19	40	9.8	.04	46	23	22	.0	196	46	7.0	20	279
20	29	30	8.8	.02	43	19	21	.0	190	35	4.0	18	233
30	Nov. 8	20	14	.06	46	20	18	.0	216	40	5.5	20	264
Nov. 9	19	10.0	6.4	.03	48	22	18	.0	195	41	7.0	21	250
20	30	20	8.8	.08	49	22	18	.0	185	52	7.0	18	259
Dec. 1	Dec. 10	20	10	.11	51	24	14	.0	213	64	8.0	15	310
11	20	40	11	.28	54	24	20	.0	198	62	10	13	293
21	31	15	17	.14	52	24	20	.0	229	59	12	12	294
Jan. 1	Jan. 10	30	20	.20	52	23	21	.0	239	59	6.0	12	310
11	20	80	21	.64	50	22	14	.0	207	69	7.5	8.7	309
21	31	235	12	----------	41	17	18	.0	139	50	7.0	7.5	223
Feb. 1	Feb. 9	149	14	1.3	40	16	14	.0	148	50	11	8.0	242
10	18	12	11	.49	49	20	13	.0	185	65	11	11	275
Mar. 1	Mar. 10	20	10	.11	49	21	19	.0	180	60	7.1	9.8	279
11	20	45	14	.22	52	20	18	.0	204	59	12	11	275
21	31	45	6.6	.25	52	24	14	.0	198	57	10	9.5	272
Apr. 1	Apr. 10	35	13	.26	50	22	19	.0	195	59	12	8.8	272
11	20	35	13	.15	50	18	15	.0	207	54	15	7.5	304
21	30	33	10	.14	53	24	13	.0	210	55	11	12	271
May 1	May 10	15	7.4	.16	51	18	12	.0	233	53	8.0	9.8	276
11	20	20	10	.28	51	22	12	.0	205	60	8.8	9.5	289
21	31	20	14	.28	52	24	9.8	.0	218	50	9.2	10.0	283
June 1	June 10	44	8.6	.12	52	22	15	.0	224	43	3.2	8.5	277
11	20	30	8.0	.32	61	24	16	.0	----------	37	3.0	11	290
21	30	60	8.8	.16	58	20	15	.0	217	42	8.0	10	272
July 1	July 10	30	11	.12	56	23	15	.0	229	39	3.5	12	270
11	20	60	13	.18	52	16	8.7	.0	195	34	7.2	10	257
21	31	23	14	.15	55	20	14	.0	209	37	6.5	8.5	257
Feb. 19	Feb. 27	25	11	.07	50	20	18	.0	195	57	7.0	13	275
Mean........		43	12	.21	49	21	17	.0	198	48	7.8	13	271

Analyses of water from Illinois River near Kampsville, Ill.

[Parts per million.]

Date (1906–7).		Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total solids.	Mean gage height (feet).
From—	To—													
Aug. 1	Aug. 10	105	11	0.20	46	21	34	0.0	208	31	5.0	24	278	14.8
11	20	218	12	.30	39	19	20	.0	185	30	5.4	22	262	15.0
21	30	230	11	.05	44	17	20	.0	177	33	5.0	20	249	15.0
31	Sept. 9	147	8.2	.06	40	18	17	.0	172	34	4.0	20	236	15.1
Sept. 11	19	135	7.2	.15	41	20	15	.0	181	29	4.2	18	228	15.2
20	29	135	8.0	.10	44	16	17	.0	187	30	7.0	20	244	14.9
30	Oct 9	218	17	.10	41	16	18	.0	170	29	6.0	17	233	15.2
Oct. 10	19	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	15.0
20	28	80	9.2	.08	49	24	42	.0	226	47	3.0	62	341	15.0
30	Nov. 8	50	14	.03	47	20	21	.0	221	39	4.0	19	269	14.8
Nov. 10	19	80	6.8	.03	50	24	22	.0	220	39	4.0	21	274	14.8
20	30	170	17	.32	45	20	16	.0	196	44	6.0	12	246	15.2
Dec. 1	Dec. 10	290	19	.65	46	21	17	.0	206	52	3.0	10	269	15.7
11	20	40	13	.17	54	22	13	.0	226	64	4.0	13	311	15.8
21	31	40	19	.36	58	30	18	.0	265	70	3.0	11	323	15.6
Jan. 1	Jan. 8	290	25	.49	51	22	21	.0	235	60	3.0	9.5	298	15.7
11	20	400	16	.64	34	15	11	.0	158	53	3.5	4.7	227	17.2
21	31	310	15	.28	33	15	17	.0	150	42	4.0	6.5	215	22.9
Feb. 1	Feb. 9	200	11	.45	34	18	15	.0	153	44	7.0	5.7	221	22.0
10	18	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	19.8
19	26	230	9.6	.24	27	9.1	44	.0	126	38	.4	34	----------	19.2
Mar. 1	Mar. 10	60	14	1.0	24	10.0	18	.0	114	30	.4	4.8	160	17.9
11	20	70	12	.25	52	20	16	.0	220	34	3.0	10	269	16.5
21	31	210	12	.46	47	17	21	.0	210	41	3.0	12	266	16.1
Apr. 1	Apr. 10	280	11	.53	53	23	15	.0	223	38	6.0	9.0	280	17.8
11	20	60	7.4	.12	54	22	12	.0	235	48	6.0	6.5	278	20.2
21	30	90	4.4	.11	56	28	18	.0	237	52	1.3	9.5	299	21.3
May 1	May 10	330	13	.16	50	22	15	.0	208	47	4.6	10	280	18.9
11	20	130	7.0	.57	49	24	18	.0	219	49	4.0	18	306	16.5
21	31	150	8.8	.12	56	24	13	.0	218	54	4.8	8.3	280	15.8
June 1	June 10	340	10	.26	51	25	13	.0	223	44	4.0	7.3	271	16.6
11	20	495	12	.26	58	25	17	.0	----------	35	2.5	11	293	17.6
21	30	166	13	.32	68	23	9.4	.0	244	47	10	13	310	16.1
July 1	July 10	325	12	.12	55	21	16	.0	239	34	8.0	10	281	15.0
11	20	238	18	.25	50	19	13	.0	202	31	6.0	10	260	16.5
21	31	74	15	.34	54	20	11	.0	219	27	1.2	8.0	242	19.7
Mean.......		188	12	.27	47	20	18	.0	202	42	4.3	15	267	----------

VERMILION AND SANGAMON RIVERS.

Vermilion River[25] drains an area of 1,317 square miles, and joins the Illinois at La Salle. Sangamon River, a more southern tributary of the Illinois, has a drainage basin of 5,670 square miles. These two rivers are represented by the following tables of analyses by Collins.

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[25] Not to be confused with the Vermilion River which rises near this one but flows into the Wabash.

Analyses of water from Vermilion River near Streator, Ill.

[Parts per million.]

Date (1906-7).		Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total solids.
From—	To—												
Aug. 1	Aug. 10	40	23	0.10	44	36	27	0.0	248	72	2.5	10	357
11	20	30	13	.10	40	35	23	.0	247	74	2.1	14	321
21	30	50	10	.60	39	33	16	.0	198	64	2.5	13	280
31	Sept. 9	60	15	.24	39	28	----------	.0	165	57	2.5	6.0	243
Sept. 10	19	20	9.6	.14	36	28	18	.0	198	56	1.6	5.0	247
20	29	40	11	.16	43	23	18	.0	205	56	1	8.0	254
31	Oct. 9	50	5.8	.20	37	23	20	.0	190	53	1	7	240
Oct. 10	18	20	4.6	.05	41	28	22	.0	212	66	1.7	10	268
22	29	20	9.0	.05	47	28	24	.0	260	60	1.2	10	294
30	Nov. 8	20	9.0	.03	49	34	23	.0	213	69	.3	9.3	309
Nov. 9	19	20	11	.02	48	33	20	.0	254	70	.3	10.0	322
20	30	60	17	.10	55	31	18	.0	260	64	7	9.3	317
Dec 2	Dec. 10	110	11	.17	61	30	23	.0	280	68	8	5.5	333
11	20	30	15	.14	63	32	18	.0	274	69	16	4.5	351
21	31	20	17	.12	67	34	21	.0	329	86	10	5.7	397
Jan. 1	Jan. 10	280	28	.52	56	28	30	.0	257	68	16	4.0	367
11	20	335	19	.72	55	26	14	.0	239	69	14	4.7	340
21	31	315	20	.36	46	20	13	.0	175	56	14	5.7	285
Feb. 1	Feb. 9	25	17	.17	69	33	18	.0	278	83	16	7	402
10	18	40	9.4	.22	62	29	13	.0	247	80	18	7.7	359
19	28	50	14	.09	57	29	21	.0	238	74	17	6.5	335
Mar. 1	Mar. 10	100	12	.32	69	22	20	.0	245	76	24	8.3	342
11	20	260	19	.30	55	20	11	.0	217	55	14	6.5	335
21	31	150	28	.22	57	22	22	.0	245	86	28	6.5	363
Apr. 1	Apr. 10	35	19	.16	60	30	13	.0	250	46	26	3.8	339
11	20	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------
21	30	35	9.8	.12	62	38	8.9	.0	256	77	19	5.5	333
May 1	May 10	100	16	.14	60	24	8.7	.0	237	72	4.8	4.5	351
11	20	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------
21	31	80	11	.34	62	31	20	.0	247	80	22	6.3	340
June 1	June 10	45	9.2	.26	62	35	17	.0	255	70	28	4	356
11	20	55	9.4	.08	74	37	12	.0	276	76	20	4	368
21	30	85	13	.21	70	29	14	.0	262	66	14	5	329
July 1	July 10	420	16	.25	61	25	16	.0	241	69	13	6	326
11	20	560	19	.50	50	21	10	.0	200	50	12	5	273
21	31	70	20	.22	78	37	12	.0	300	70	20	6.5	388
Mean		107	14	.22	55	29	18	.0	241	68	12	6.9	325

Analysis of water from Sangamon River near Decatur, Ill.

[Parts per million.]

Date (1906-7).		Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total solids.	Mean gage height (feet).
From—	To—													
Aug. 1	Aug. 10	240	26	0.2	46	21	13	0.0	223	20	4.5	8.2	262	----------
11	20	260	20	.2	46	20	48.8	.0	214	23	4.8	3.5	233	----------
21	30	270	18	.06	53	22	8.5	.0	235	25	4.0	2.7	264	----------
31	Sept. 9	117	17	.09	61	27	13	.0	305	26	4.0	4.5	297	----------
Sept. 10	19	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------
21	29	70	15	.03	55	24	18	.0	315	22	2.5	10	302	----------
Oct. 1	Oct. 9	60	12	.05	54	30	15	.0	283	26	3.0	5.5	286	----------
10	19	20	10	.15	53	30	21	.0	297	27	2.5	5.0	275	----------
20	29	50	11	.06	64	35	20	.0	353	21	1.0	9.0	332	----------
Nov. 1	Nov. 8	30	15	.10	67	44	19	.0	380	33	1.0	7.8	338	----------
9	17	20	11	.02	50	28	16	.0	360	25	.9	8.5	324	----------
20	30	168	16	.14	52	25	12	.0	240	39	8.0	3.5	274	----------
Dec. 1	Dec. 10	196	17	.40	51	28	13	.0	278	37	7.0	5.5	283	----------
11	20	30	29	.16	58	30	21	.0	285	36	6.0	5.5	316	----------
22	31	25	15	.28	62	30	12	.0	314	42	8.0	7.0	332	----------
Jan. 1	Jan. 10	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	8.2
11	20	240	36	.74	45	20	17	.0	227	64	7.0	3.5	291	10.0
21	31	220	40	1.9	42	18	15	.0	186	42	8.0	5.5	279	12.2
Feb. 1	Feb. 8	20	23	.13	59	28	15	.0	290	43	12	5.2	319	6.9
11	18	25	22	.07	59	22	15	.0	231	40	10	8.0	317	6.0
20	27	20	21	.16	60	27	15	.0	290	37	8.0	6.5	317	6.0
Mar. 1	Mar. 10	20	14	.15	57	29	15	.0	----------	40	14	5.0	325	5.9
11	20	410	30	.30	45	20	14	.0	192	32	8.0	5.5	210	10.6
21	31	100	20	.22	53	27	15	.0	267	45	12	4.5	305	7.5
Apr. 1	Apr. 10	40	18	.19	58	26	11	.0	268	42	14	7.3	287	6.9
11	20	10	15	.23	47	18	11	.0	252	42	----------	4.5	292	5.7
21	30	30	13	.25	55	32	9.5	.0	265	46	11	3.2	286	5.5
May 1	May 10	100	17	.18	55	24	9.8	.0	247	46	18	5.5	292	6.4
11	20	60	12	.15	54	28	12	.0	271	38	19	5.5	288	6.2
21	31	140	19	.46	64	30	9.8	.0	----------	37	12	3.7	336	8.6
June 1	June 10	95	16	.30	53	24	14	.0	----------	23	20	4.3	292	8.4
11	20	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	7.6
21	30	340	19	.60	54	21	7.7	.0	218	26	14	2.0	240	7.3
July 1	July 10	90	20	.16	71	28	10	.0	287	29	9.0	5.0	334	5.8
11	20	425	18	.56	47	16	8.2	.0	197	22	7.0	4.0	230	7.4
21	31	210	21	.32	63	24	17	.0	280	45	12	4.3	326	7.4
Mean		126	19	.27	55	26	14	.0	268	35	8.5	5.4	293	----------

Analyses of water from Sangamon River near Springfield, Ill.

[Parts per million.]

Date (1906-7). From—	Date (1906-7). To—	Turbidity.	Silica (SiO$_2$).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO$_3$).	Bicarbonate radicle (HCO$_3$).	Sulphate radicle (SO$_4$).	Nitrate radicle (NO$_3$).	Chlorine (Cl).	Total solids.
Aug. —	Aug. 10	180	17	0.10	44	24	19	0.0	-----	27	4.0	9.7	275
11	20	248	18	.80	36	18	13	.0	192	24	4.2	5.2	222
21	30	320	17	1.40	41	24	16	.0	192	26	4.0	8.5	228
31	Sept. 9	163	20	.15	51	28	4.9	.0	203	34	3.0	7.0	284
Sept. 10	19	70	12	.50	48	22	17	.0	294	28	2.8	10	271
20	29	30	9.6	.05	44	23	16	.0	225	24	1.3	8.5	223
30	Oct. 6	100	9.4	.10	51	24	15	.0	250	36	2.0	14	272
Oct. 11	19	40	21	.10	47	28	25	.0	289	33	2.0	8.5	277
20	28	20	9.6	.05	57	33	20	.0	307	33	.20	10	291
30	Nov. 8	10.0	19	.05	59	29	19	.0	315	36	.10	11	311
Nov. 11	19	20	7.2	.10	62	32	14	.0	320	36	.30	13	315
21	30	182	19	.06	50	25	17	.0	256	36	2.0	7.5	267
Dec. 1	Dec. 10	168	21	.40	53	25	15	.0	270	37	3.0	8.0	274
11	20	80	13	.20	55	17	16	.0	263	37	5.0	5.5	278
21	31	20	30	2.8	55	29	27	.0	301	51	7.0	6.5	319
Jan. 1	Jan. 10	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
11	19	80	22	.20	47	21	18	.0	257	32	.10	8.7	296
21	31	280	16	.50	32	14	13	.0	137	28	5.0	6.2	193
Feb. 1	Feb. 9	20	20	.15	47	23	17	.0	238	40	.10	7.5	273
10	18	10.0	14	.20	54	26	16	.0	257	46	11	8.5	293
19	28	30	16	.09	58	26	16	.0	274	40	6.5	8.5	305
Mar. 1	Mar. 10	50	12	.17	44	21	14	.0	213	35	3.0	5.0	243
11	20	10.0	12	.15	56	18	11	.0	264	43	10	7.0	275
21	31	10.0	13	.11	58	24	14	.0	247	49	4.0	3.8	279
Apr. 1	Apr. 10	8.0	18	.19	58	25	12	.0	267	36	2.3	4.5	288
11	20	5.0	13	.23	56	26	13	.0	266	46	1.4	5.0	296
21	30	14	11	.19	58	34	9.3	.0	271	44	3.4	5.5	289
May 1	May 10	25	13	.12	53	20	12	.0	257	47	4.4	5.0	299
11	20	12	14	.15	54	22	18	.0	268	43	5.0	6.3	289
21	31	5.0	12	.13	58	26	16	.0	-----	43	2.8	4.3	292
June 1	June 10	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
11	20	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
21	30	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
July 1	July 10	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
11	20	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
21	31	20	19	.28	64	25	13	.0	270	38	1.0	5.0	276
Mean		74	16	.32	52	24	16	.0	247	37	3.4	7.5	276

Analyses of water from Sangamon River near Chandlerville, Ill.

[Parts per million.]

Date (1906-7). From—	Date (1906-7). To—	Turbidity.	Silica (SiO$_2$).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO$_3$).	Bicarbonate radicle (HCO$_3$).	Sulphate radicle (SO$_4$).	Nitrate radicle (NO$_3$).	Chlorine (Cl).	Total solids.	Mean gage height (feet).
Aug. 1	Aug. 10	125	18	0.20	54	26	23	0.0	290	25	1.7	8.8	293	3.7
11	20	115	17	.50	39	22	11	.0	182	26	3.4	5.5	231	4.6
21	30	330	15	.07	43	19	18	.0	193	31	4.0	5.0	232	4.2
31	Sept. 9	300	18	.09	50	24	7.4	.0	236	26	2.7	6.5	247	3.6
Sept. 10	19	160	20	.18	53	33	13,	.0	320	32	2.0	7.0	317	2.7
20	23	140	17	.06	51	27	16	.0	325	28	2.1	12	318	2.3
30	Oct. 9	110	14	.04	56	33	20	.0	287	30	1.7	9.5	287	2.7
Oct. 10	13	50	14	.04	56	32	31	.0	295	33	1.5	13	295	2.7
24	29	-----	-----	-----	-----	-----	-----	.0	-----	-----	-----	-----	-----	2.3
Nov. 1	Nov. 8	20	12	.03	66	33	20	0.	363	39	1.0	11	340	2.7
9	18	40	7.2	.01	64	32	16	.0	345	32	.5	12	310	1.9
20	30	-----	-----	-----	-----	-----	-----	.0	-----	-----	-----	-----	-----	3.2
Dec. 1	Dec. 10	270	20	.10	49	24	27	.0	260	42	6.0	12	266	4.4
11	20	160	16	.22	55	27	13	.0	252	37	4.0	7.0	294	10.5
21	31	113	13	.72	58	28	14	.0	283	41	4.0	9.0	296	9.3
Jan. 1	Jan. 10	155	24	.49	55	32	18	.0	306	38	8.0	7.5	318	10.7
11	20	90	22	.40	51	23	15	.0	260	44	6.0	6.5	309	11.5
21	31	225	23	2.6	25	7.6	7.9	.0	105	24	5.0	5.5	184	15.5
Feb. 1	Feb. 9	50	15	.36	52	25	16	.0	234	36	5.5	6.0	272	12.8
11	18	45	17	.19	53	24	14	.0	252	42	6.5	8.2	279	10.5
19	28	20	9.8	.15	52	24	14	.0	247	38	6.0	6.7	283	9.9
Mar. 1	Mar. 10	30	10	.16	57	25	8.8	.0	237	51	5.0	8.0	266	8.5
11	20	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	6.5
21	31	180	16	.50	50	24	10.0	.0	239	40	6.0	8.5	274	11.6
Apr. 1	Apr. 10	130	14	.22	49	23	11	.0	237	43	20	7.0	265	10.4
11	20	60	16	.11	45	22	11	.0	274	40	6.8	7.0	309	8.4
21	30	80	10	.61	55	30	13	.0	245	43	9.2	7.5	294	7.3
May 1	May 10	120	12	.11	53	27	10.0	.0	242	40	10	8.3	279	9.3
11	20	124	10	.23	56	27	12	.0	252	40	10	7.3	316	9.0
21	31	200	11	.80	53	27	16	.0	230	43	13	6.3	295	9.3
June 1	June 10	204	18	.16	49	26	16	.0	235	34	9.2	6.0	302	10.1
11	20	170	14	.30	57	24	12	.0	234	35	9.0	5.0	298	11.0
21	30	350	16	.15	62	20	20	.0	265	36	6.2	6.5	286	8.9
July 1	July 10	10	16	.21	63	25	15	.0	270	28	16	6.0	293	7.3
11	20	450	14	.09	60	20	10.0	.0	229	28	6.2	5.0	259	10.4
21	31	248	18	.38	43	17	11	.0	182	27	3.8	4.5	213	11.1
Mean		154	15	.32	52	25	15	.0	255	36	6.1	7.6	282	-----

SUMMARY.

In the foregoing pages there are ten tables of analyses by W. D. Collins of water from the Illinois and its tributaries. Each table except one gives the average composition of a stated water for an entire year. For the Illinois at Peoria the table is less complete, as the dates given in it show. All the localities named are in Illinois. Reduced to percentages, with carbonates normal and Fe recalculated to Fe_2O_3, the averages are as follows. Each one, except No. 5, is the mean of 36 analyses of composite samples of ten daily collections. For No. 5 there are only 34 analyses.

Percentage composition of the dissolved solids in Illinois River and tributaries.

1. Kankakee River near Kankakee.
2. Fox River near Elgin.
3. Fox River near Ottawa.
4. Illinois River near Lasalle.
5. Illinois River near Peoria.
6. Illinois River near Kampsville.
7. Vermilion River near Streator.
8. Sangamon River near Decatur.
9. Sangamon River near Springfield.
10. Sangamon River near Chandlerville

	1	2	3	4	5	6	7	8	9	10
CO_3	38.01	46.80	41.43	37.05	36.69	38.51	36.84	44.66	43.72	44.37
SO_4	20.49	13.50	18.71	18.52	18.08	16.27	21.14	11.86	13.31	12.73
Cl	1.76	1.85	2.42	4.81	4.90	5.81	2.14	1.83	2.70	2.69
NO_3	1.47	.85	1.50	2.45	2.94	1.67	3.73	2.88	1.22	2.16
Ca	20.86	18.11	18.38	18.53	18.45	18.21	17.10	18.64	18.71	18.40
Mg	7.55	10.65	9.81	8.15	7.91	7.75	9.01	8.81	8.64	8.85
Na(K)	4.31	3.90	4.29	5.93	6.40	6.97	5.59	4.74	5.76	5.31
SiO_2	5.40	4.26	3.37	4.46	4.52	4.65	4.35	6.44	5.76	5.31
Fe_2O_3	.15	.08	.09	.10	.11	.16	.10	.14	.18	.18
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Salinity [a]	278	282	326	270	266	258	322	295	278	283

[a] Parts per million.

A glance at the figures given in this table will show its relation to the magnesian area of Wisconsin and also, partially, the influence of the Chicago Drainage Canal. Fox River rises in the magnesian area, and its waters, with those of the Illinois, show in columns 2 to 6 the gradual diminution in the magnesian content, which, however, is high throughout. The other tributaries of the Illinois are also highly magnesian, and perhaps from the same source. Illinois is covered over most of its area by glacial drift, which is rich in pebbles of magnesian limestone. Did those pebbles come from the Niagara dolomite of Wisconsin?

In columns 4, 5, and 6, representing Illinois River, the proportion of chlorine is notably high. This impurity is received from the drainage canal, which carries the sewage of Chicago. The influence of the canal is even more clearly shown by the sanitary analyses of the late A. W. Palmer.[26] His annual averages for 1900, representing Illinois River, follow; the percentages have been calculated by F. W. Clarke. The localities are arranged in order going downstream.

Chlorine in Illinois and Mississippi rivers.

	Total dissolved solids (parts per million).	Chlorine.	
		Parts per million.	Per cent.
Illinois River—			
At Morris	235.3	23.1	9.82
At Ottawa	269.4	21.4	7.94
At Lasalle	245.4	18.7	7.62
At Averyville	245.2	17.5	7.14
At Havana	236.3	14.8	6.27
At Kampsville	234.3	14.0	5.98
At Grafton	232.6	13.1	5.63
Mississippi River at Grafton	150.1	3.1	2.06

The decrease in the proportion of chlorine as we follow the Illinois downstream is most striking; but even more surprising are the data concerning the Mississippi a little farther south, at Alton. Here samples were taken 100 feet from the Illinois shore, one-fourth the distance across, in midstream, three-fourths over, and 100 feet from the Missouri shore. The figures represent averages covering periods ranging from nine months to nearly the entire year 1900.

Chlorine in Mississippi River at Alton, Ill.

	Total dissolved solids (parts per million).	Chlorine.	
		Parts per million.	Per cent.
100 feet from Illinois shore	194.1	7.7	3.97
One-fourth distance across	182.8	7.1	3.87
Midstream	160.6	4.4	2.74
Three-fourths distance across	155.0	4.1	2.65
100 feet from Missouri shore	154.2	3.5	2.27

The influence of Illinois River on the east side of the Mississippi is perfectly evident. The chief cause of the diminution of chlorine in the Illinois is, of course, the dilution of the water by other less contaminated sources of supply. In the Kankakee at Wilmington the proportion of chlorine during the same period was only 1.21 per cent, and in Fox River it was 1.98 per cent, calculated from the total matter in solution. Kankakee and Fox rivers represent an approximation to the normal chlorine of the region; the Illinois, into which they flow, shows the exaggeration produced by artificial means. Near the ocean the normal chlorine in fresh waters is much higher and the effects of pollution are less conspicuous than in inland streams.[27]

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[26] Chemical survey of the waters of Illinois, 1897-1902, Illinois Univ., 1903.

[27] A good summary of the relations between normal and polluted waters in the eastern and middle States is given by M. O. Leighton in U. S. Geol. Survey Water-Supply 79, 1903. The subject of normal chlorine is considered, and the classical "chlorine map" of Massachusetts is reproduced. See also Rivers Pollution Commission Sixth Rept., 1868, on the domestic water supply of Great Britain. This report contains abundant data on chlorine in waters.

KASKASKIA AND MUDDY RIVERS.

Kaskaskia and Muddy rivers are large streams that enter the Mississippi between the Illinois and the Ohio. Their courses are entirely within the State of Illinois. For the composition of their waters we have the three following tables of analyses by W. D. Collins.[28]

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[28] U. S. Geol. Survey Water-Supply Paper 239, 1910.

Analyses of water from Kaskaskia River near Shelbyville, Ill.

[Parts per million.]

Date (1906-7).		Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total solids.	Mean gage height (feet).
From—	To—													
Aug. 1	Aug. 10	40	9.2	0.10	44	23	15	0.0	245	30	0.5	6.2	256	1.8
11	20	270	13	.30	38	23	15	.0	233	28	2.1	6.5	243	2.2
21	30	204	16	.60	47	24	15	.0	217	22	3.5	5.0	236	2.4
31	Sept. 9	50	20	.11	55	30	3.0	.0	274	30	2.0	5.0	279	1.7
Sept. 10	19	50	9.6	.30	38	23	17	.0	--------	25	1.2	10.0	218	1.4
20	29	40	9.0	.06	50	29	24	.0	289	26	3.5	7.5	286	1.4
30	Oct. 9	121	33	.13	45	25	17	.0	220	38	.6	6.0	285	1.8
Oct. 10	19	30	6.4	.06	42	32	18	.0	241	31	1.2	6.5	252	1.7
20	29	20	14	.02	57	28	19	.0	330	36	.2	9.0	301	1.4
30	Nov. 6	20	13	.03	64	38	23	.0	355	37	.3	9.5	340	1.3
Nov. 10	19	30	8.8	.10	63	36	14	.0	345	33	.6	10.0	334	1.6
20	30	195	23	.04	52	29	15	.0	275	31	3.0	5.3	273	6.5
Dec. 1	Dec. 10	100	17	.24	54	25	13	.0	267	38	7.0	5.5	268	7.7
11	20	40	18	.24	56	26	14	.0	267	33	8.0	6.7	285	7.1
21	31	30	12	.24	53	26	15	.0	293	42	10	5.5	296	6.1
Jan. 1	Jan. 10	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	6.5
11	20	194	25	1.0	42	19	10	.0	207	42	5.5	4.0	258	13.2
22	31	220	14	.36	34	16	11	.0	153	31	5.0	5.0	192	12.0
Feb. 1	Feb. 9	20	16	--------	58	28	15	.0	271	37	10	4.2	298	5.4
10	18	25	13	.13	57	26	12	.0	280	40	9.0	7.0	304	4.5
19	28	25	14	.09	57	26	15	.0	280	37	12	5.2	297	4.4
Mar. 1	Mar. 10	100	17	.19	52	27	19	.0	237	38	13	4.8	292	5.2
11	20	260	19	.78	45	19	12	.0	196	46	12	6.5	267	9.6
21	31	50	17	.17	55	25	13	.0	260	40	22	4.3	281	5.8
Apr. 1	Apr. 10	10	16	.19	56	25	10	.0	270	40	12	4.0	282	4.4
11	20	8	17	.15	49	19	9.5	.0	257	40	9.0	3.5	282	3.7
21	30	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	3.7
May 1	May 10	30	16	.12	54	20	8.4	.0	257	35	12	3.8	290	4.0
11	20	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	4.1
21	31	275	14	.21	57	28	13	.0	276	39	15	3.8	303	4.2
June 1	June 10	80	14	.34	51	23	9.6	.0	225	28	12	2.8	264	7.1
11	20	85	16	.23	67	28	8.9	.0	--------	34	1.1	2.8	313	5.3
21	30	303	15	.21	66	28	7.9	.0	280	29	8.0	3.8	272	4.7
July 1	July 10	40	15	.14	70	29	9.5	.0	304	34	2.0	6.0	315	3.2
11	20	415	18	.30	59	25	10	.0	258	30	16	--------	274	4.4
21	31	255	19	.27	65	27	14	.0	268	28	8.0	4.5	284	5.4
Mean		110	16	.23	53	26	13	.0	262	34	6.9	5.6	279	--------

Analyses of water from Kaskaskia River near Carlyle, Ill.

[Parts per million.]

Date (1906-7).		Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total solids.	Mean gage height (feet).
From—	To—													
Aug. 1	Aug. 10	120	16	0.20	42	24	15	0.0	271	19	2.0	9.0	273	--------
11	20	224	11	.10	44	24	16	.0	218	24	1.9	7.5	235	--------
22	30	300	20	.06	36	17	16	.0	--------	--------	--------	--------	204	--------
31	Sept. 8	262	21	.07	43	20	7.1	.0	198	23	1.7	5.5	225	--------
Sept. 10	19	127	61	.15	42	22	22	.0	221	25	.5	6.0	284	--------
20	29	106	16	.07	46	20	14	.0	251	26	1.2	9.5	274	--------
30	Oct. 9	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------
Oct. 10	19	70	13	.08	44	18	17	.0	204	32	.9	12	233	--------
21	28	40	14	.8	55	25	24	.0	284	29	.5	7.5	273	--------
30	Nov. 8	20	17	.03	53	26	15	.0	270	29	.6	8.5	268	2.3
Nov. 10	19	20	8.8	.03	56	25	20	.0	294	28	.5	11	269	2.3
20	30	273	22	.18	21	16	13	.0	154	24	3.0	5.0	198	4.8
Dec. 1	Dec. 10	293	18	.28	37	16	17	.0	205	38	5.5	11	225	14.1
11	20	184	17	.64	43	23	16	.0	192	28	5.0	6.0	251	14.7
21	31	30	14	.20	56	28	16	.0	272	45	4.0	7.5	291	9.0
Jan. 1	Jan. 10	270	28	2.5	24	11	15	--------	116	40	5.0	5.0	200	19.1
11	19	133	23	1.0	31	11	14	.0	148	40	5.0	4.7	213	20.0
21	31	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	21.2
Feb. 1	Feb. 9	40	17	.32	39	18	13	.0	175	33	6.0	6.0	214	17.5
10	18	50	13	.20	51	21	14	.0	224	41	6.0	6.5	262	8.5
19	28	37	16	.08	55	23	18	.0	260	46	7.0	7.0	301	7.5
Mar. 1	Mar. 10	110	13	.34	47	21	14	.0	203	52	6.0	5.8	277	9.2
11	20	350	24	1.1	28	8.9	6.0	.0	119	28	3.0	7.0	189	17.4
21	31	140	15	.15	40	19	11	--------	180	38	10	6.5	239	14.0
Apr. 1	Apr. 10	90	10.0	.15	54	26	12	--------	210	48	8.0	7.3	281	7.2
11	20	10.0	11	1.1	57	24	16	--------	.274	46	6.0	7.0	292	5.9
21	30	175	12	.19	49	26	14	--------	217	44	3.6	88.3	268	5.8
May 1	May 10	180	21	.66	42	18	11	.0	178	40	6.0	6.0	239	11.2
11	20	205	12	.42	44	22	14	.0	213	46	14	7.5	249	10.4
21	31	600	15	.15	45	20	13	.0	208	35	7.0	6.8	242	--------
June 1	June 10	380	15	.47	29	12	11	.0	116	31	3.8	4.8	166	16.8
11	20	235	15	.53	46	18	11	.0	198	19	7.0	3.8	225	14.1
21	30	285	16	.28	57	21	11	.0	255	32	6.0	5.3	271	8.4
July 1	July 10	150	17	.16	61	24	10.0	.0	265	27	8.0	6.0	298	5.3
11	20	210	16	.16	52	24	12	.0	245	30	5.0	7.0	255	4.2
21	31	550	17	.36	44	16	11	.0	194	30	8.0	5.0	239	9.8
Mean		184	17	.39	47	20	14	.0	213	34	4.8	6.9	248	--------

Analyses of water from Muddy River near Murphysboro, Ill.

[Parts per million.]

Date (1906-7).		Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total solids.	Mean gage height (feet).
From—	To—													
Aug. 1	Aug. 10	158	17	0.10	33	17	24	0.0	101	68	1.0	20	258	----------
11	20	730	28	1.6	15	15	22	.0	75	49	2.1	19	189	----------
21	29	550	27	5.0	17	8.4	13	.0	54	41	1.0	11	158	----------
31	Sept. 9	224	11	1.7	24	11	9.5	.0	67	64	1.7	21	213	----------
Sept. 10	19	445	17	2.5	18	8.7	13	.0	43	41	2.0	11	150	----------
20	29	248	15	.30	21	11	14	.0	63	48	1.5	15	166	----------
30	Oct. 9													----------
Oct. 12	17	123	14	.7	39	18	25	.0	154	74	3.5	16	274	----------
20	29	80	23	1.0	30	13	27	.0	88	89	1.0	15	247	----------
31	Nov. 8	40	21	.08	34	16	32	.0	108	107	1.0	14	285	
Nov. 10	19	190	13	.15	38	17	27	.0	90	112	.4	17	278	0.2
20	30	728	16	1.3	12	6.3	12	.0	31	28	1.5	6.3	115	15.7
Dec. 1	Dec. 10	385	44	5.0	17	8.1	21	.0	54	65	2.5	13	217	6.6
11	20	408	45	4.0	18	4.4	17	.0	36	50	4.0	6.8	219	11.7
21	31	290	33	4.5	16	10	20	.0	54	70	2.0	8.7	204	10.4
Jan. 1	Jan. 10													23.3
11	20	200	44	4.1	9.6	4.1	16	.0	45	42	3.0	5.5	183	24.4
21	31	240	32	4.5	17	5.2	15	.0	35	46	3.0	5.5	146	19.2
Feb. 2	Feb. 9	185	29	3.0	19	8.7	23	.0	53	72	5.0	8.2	218	8.2
11	18	40	24	1.5	30	15	29	.0	88	106	3.5	17	294	1.8
19	28	100	16	.55	33	18	30	.0	89	137	1.7	23	342	3.1
Mar. 1	Mar. 10	290	37	4.9	21	12	25	.0	46	93	3.2	11	252	6.2
11	20	340	32	4.9	17	6.1	16	.0	49	51	1.7	6.5	193	12.4
21	31	170	16	5.3	28	12	17	.0	79	72	1.6	10	230	7.5
Apr. 1	Apr. 10	100	19	1.11	43	22	34	.0	144	120	3.2	19	339	1.8
11	20	35	16	.21	51	21	35	.0	46	186	1.2	25	424	2.3
21	30	80	15	.8	46	26	31	.0	104	138	1.1	21	343	4.2
May 1	May 10	340	17	2.5	24	6.9	18	.0	79	81	1.8	12	229	5.6
11	20	190	18	2.20	18	9.3	20	.0	57	61	1.8	8.3	193	7.1
21	31	150	26	.7	29	12	19	.0	72	62	1.0	10	210	2.8
June 1	June 10													9.3
11	20	230	19	1.4	14	7.4	11	.0	32	24	5.0	7.0	122	18.5
21	30	435	20	.83	20	10	12	.0	66	38	1.5	8.0	139	9.6
July 1	July 10	65	22	1.3	24	5.8	14	.0	78	42	.6	9.0	178	5.3
11	20	80	17	.15	31	12	16	.0	97	59	1.1	13	206	4.3
21	31	210	39	2.8	22	7.9	20	.0	90	45	.8	11	212	9.6
Mean		245	24	2.1	25	12	20	.0	72	72	2.0	13	225	----------

Reduced to percentage form the three tables of analyses give the subjoined averages.

Percentage composition of dissolved solids in Kaskaskia and Muddy rivers.

1. Kaskaskia River near Shelbyville.
2. Kaskaskia River near Carlyle.
3. Muddy River near Murphysboro.

	1	2	3
CO_3	45.44	42.09	17.15
SO_4	11.98	13.64	34.88
Cl	1.98	2.82	6.30
NO_3	2.43	1.92	.97
Ca	18.68	18.86	12.11
Mg	9.16	8.02	5.82
Na(K)	4.58	5.61	9.69
SiO_2	5.64	6.81	11.63
Fe_2O_3	.11	.23	1.45
	100.00	100.00	100.00
Salinity, parts per milion	284	249	206

The water of Kaskaskia River resembles that of the Sangamon very closely. The two drainage basins are alike in every essential particular. Muddy River, on the other hand, is evidently abnormal because of pollution, probably from the drainage of coal mines.

OHIO RIVER BASIN.

Ohio River, the second largest tributary of the Mississippi, drains an area of about 214,000 square miles. It is formed by the union of the Allegheny and Monongahela at Pittsburgh, Pa. Among its chief affluents are the Muskingum, Miami, and Wabash, on the north, and the Kentucky, Cumberland, and Tennessee, on the south. For all of these, and also for some of their tributaries, tables of analyses giving annual averages appear in Water-Supply Papers 236 and 239.

HEADWATER STREAMS

The three following tables, from Water-Supply Paper 236, contain analyses made by Dole and his colleagues in the United States Geological Survey:

Analyses of water from Allegheny River at Kittanning, Pa.[a]

[Parts per million, unless otherwise stated.]

Date (1906-7).		Turbidity.	Total iron (Fe).	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total dissolved solids.	Mean gage height (feet).
From—	To—														
Sept. 13	Sept. 23	19	0.2	12	Tr.	21	4.2	19	0.0	51	35	0.0	28	140	2.49
24	Oct. 3	15	1.2	8.6	0.06	22	4.0	19	.0	61	25	Tr.	29	142	2.86
Oct. 4	14	46	3.5	6.0	Tr.	18	2.0	12	.0	40	19	.6	20	107	5.68
15	24	21	1.2	11	Tr.	14	1.8	11	.0	34	13	.4	13	87	5.51
25	Nov. 3	29	1.5	9.2	.1	12	2.2	9.6	.0	37	12	.6	12	81	5.94
Nov. 4	14	5	.2	7.8	.1	12	1.8	7.6	.0	36	14	.7	13	77	5.11
15	25	29	2.0	4.4	.2	12	2.2	9.3	.0	37	14	.9	12	74	7.67
27	Dec. 5	8	.2	6.0	.1	12	2.0	9.1	.0	33	14	.9	11	71	5.49
Dec. 6	16	65	2.6	4.8	.15	10	3.0	4.4	.0	26	12	1.5	8.2	59	10.30
17	26	13	.9	7.6	.17	10	3.2	5.0	.0	26	13	1.1	8.4	63	7.79
27	Jan. 5	36	1.6	6.2	.22	11	3.6	7.1	.0	28	16	1.7	11	73	8.15
Jan. 7	15	38	1.4	5.4	.21	8.5	2.0	5.7	.0	21	12	1.0	6.7	54	11.20
16	25	35	1.8	5.4	.21	9.2	2.2	5.2	.0	19	14	1.1	7.4	55	10.20
26	Feb. 5	6	.5	7.4	.2	13	3.8	9.1	.0	32	23	1.1	10	80	5.63
Feb. 6	16	4	.4	6.8	.16	15	3.4	9.0	.0	41	23	1.2	13	89	4.60
18	27	6	.2	2.4	.09	16	3.4	9.8	[b] 9.4	22	22	.6	16	85	4.89
28	Mar. 10	5	.4	6.8	.13	14	3.2	9.3	.0	34	20	1.1	13	83	5.27
Mar. 11	20	--------	6.5	7.0	.3	9.2	2.2	8.0	.0	28	16	1.5	8.2	65	11.46
21	31	27	1.5	3.8	.10	7.4	1.6	5.4	.0	24	12	.6	6.0	47	11.47
Apr. 1	Apr. 10	8	.7	7.0	.13	10	2.6	7.2	.0	29	14	1.3	9.4	67	7.11
11	20	5	.4	6.4	.10	12	2.8	9.4	.0	27	16	1.0	12	73	5.77
21	30	40	1.1	12	.16	9.6	2.4	9.1	.0	27	14	1.0	10	72	8.16
May 1	May 11	19	.9	11	.10	8.6	2.2	9.1	.0	29	12	1.0	7.6	66	8.06
11	20	19	.6	17	.18	10	2.0	8.8	.0	37	12	.7	11	81	6.48
21	30	29	1.0	5.4	.10	10	1.6	8.0	.0	30	12	.6	11	64	6.99
31	June 9	36	1.3	14	.15	10	1.9	8.8	.0	43	10	.5	9.1	78	7.82
June 10	20	20	.8	7.2	.10	10	2.0	8.5	.0	35	14	.3	9.7	71	6.28
26	30	18	1.0	7.6	.11	14	2.0	13	.0	45	14	.4	13	88	4.92
July 1	July 10	28	1.2	12	.15	14	2.8	11	.0	44	14	.7	13	89	5.25
12	22	15	1.0	10	.14	15	3.4	12	.0	45	18	.6	14	94	4.21
23	Aug. 1	26	1.1	9.0	.14	17	4.0	14	.0	50	22	.3	17	109	3.27
Aug. 2	11	15	.6	10	.12	18	4.4	15	.0	51	22	.3	17	111	2.98
12	21	5	.3	5.4	.10	23	5.4	19	.0	63	26	.2	25	132	1.92
22	31	2	.2	6.4	.13	26	6.0	21	.0	71	30	.1	32	154	1.75
Sept. 1	Sept. 10	19	1.1	8.0	.19	25	6.0	22	.0	67	32	.2	32	155	1.99
Mean		21	1.2	7.9	.13	14	3.0	11	.0	38	17	.7	14	87	--------

[a] Analyses Sept. 13 to Dec. 5, 1906, by R. B. Dole; Dec. 6, 1906, to Mar. 31, 1907, by R. B. Dole and M. G. Roberts; Mar. 4 to Sept. 10, 1907, by Chase Palmer and M. G. Roberts.

[b] Abnormal; computed as HCO_3 in the average.

Analyses of water from Monongahela River at Elizabeth, Pa.[a]

[Parts per million, unless otherwise stated.]

Date (1906-7).		Turbidity.	Total iron (Fe).	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total dissolved solids.	Mean gage height (feet).[b]
From—	To—														
Aug. 25	Sept. 3	42	2.7	13	1.0	12	2.2	9.6	0.0	23	34	0.7	2.8	94	8.60
Sept. 4	13	34	2.0	7.4	.5	15	2.4	9.4	.0	22	45	.6	3.5	97	7.02
14	23	9	.1	7.2	Tr.	4.0	4.0	11	.0	8.7	1.2	1.2	4.7	118	7.36
24	Oct. 3	10	1.1	6.2	.4	16	4.2	12	.0	4.8	64	.6	4.8	121	7.75
Oct. 4	13	18	3.1	4.8	1.1	12	2.8	6.2	.0	16	40	.5	3.8	94	8.13
14	23	29	3.4	9.6	.9	12	2.0	6.3	.0	17	32	1.5	3.4	83	9.06
24	Nov. 2	31	2.3	7.4	.9	10	3.0	6.3	.0	21	28	1.2	3.0	74	7.91
Nov. 3	12	42	3.3	5.4	.7	13	2.6	7.2	.0	12	40	1.8	3.4	82	7.06
13	22	85	6.3	5.2	.4	15	2.8	7.9	.0	9.8	42	1.6	4.1	90	7.46
23	Dec. 2	75	3.0	7.6	.8	10	1.4	5.8	.0	20	21	2.6	2.6	66	8.37
Dec. 3	12	60	3.7	5.6	.5	10	3.6	6.0	.0	15	28	1.0	3.5	69	11.02
13	21	--------	5.6	6.2	.56	8.6	2.4	4.6	.0	15	19	1.5	1.9	56	14.56
22	Jan. 2	47	2.5	5.6	.25	10	3.0	5.4	.0	15	27	1.5	2.9	63	12.40
Jan. 3	12	80	3.5	4.4	.5	9.8	3.0	4.6	.0	15	24	1.5	2.4	64	13.25
13	22	350	17	8.2	.7	8.0	--------	4.9	.0	22	18	2.5	3.4	77	24.96
23	Feb. 1	21	1.8	6.0	.07	12	3.6	.0	.0	9.8	44	1.7	2.4	80	9.14
Feb. 2	11	110	6.1	5.4	.19	11	.6	5.5	.0	12	32	2.5	1.7	64	12.44
12	21	27	2.8	5.8	.12	13	2.0	6.5	.0	17	37	2.1	2.9	73	10.18
22	Mar. 3	28	2.3	5.6	.25	10	1.4	5.5	.0	15	32	2.1	2.9	66	10.42
Mar. 4	13	190	4.4	6.0	.26	9.6	.4	5.2	.0	18	22	1.9	1.7	54	13.12
14	24	350	7.5	18	1.0	11	.6	8.5	.0	19	26	2.0	2.9	83	20.00
25	Apr. 3	50	2.5	5.4	.1	14	3.2	6.6	.0	16	44	Tr.	2.6	85	8.22
Apr. 4	13	12	1.6	7.8	.06	18	3.0	12	.0	11	65	2.5	4.2	119	7.28
14	23	45	2.8	8.8	.46	11	1.8	6.3	.0	16	33	2.8	3.5	78	10.04
24	May 3	65	2.6	8.8	.9	8.8	1.0	5.5	.0	18	20	3.0	2.9	63	11.15
May 4	13	45	2.1	17	.46	11	1.0	6.8	.0	23	25	1.8	3.0	80	10.82
14	23	37	2.5	18	.33	11	1.0	9.6	.0	23	27	1.5	3.4	81	9.43
24	June 2	40	2.1	12	.95	13	1.2	9.4	.0	22	32	1.8	2.9	87	8.05
June 3	12	45	1.9	7.4	.21	11	.8	7.2	.0	22	26	1.5	3.9	70	11.19
13	22	180	4.0	11	.28	17	1.8	8.5	.0	50	24	3.0	3.6	96	11.50
23	July 3	38	2.3	2.2	.05	14	2.4	5.2	.0	20	37	Tr.	3.6	79	7.50
July 4	13	70	3.2	11	.28	12	2.0	8.5	.0	21	34	2.7	3.8	90	9.14
14	23	285	13	14	1.4	8.2	1.0	6.6	.0	21	15	2.8	2.2	76	14.53
24	Aug. 1	205	5.3	9.8	.46	11	1.8	--------	.0	--------	22	2.5	2.6	72	11.23
Aug. 3	12	39	2.6	10	.28	13	2.8	7.7	.0	17	37	2.0	3.4	85	7.90
13	22	70	1.9	7.0	.35	13	2.8	9.3	.0	13	38	3.5	4.8	86	6.85
23	Sept. 2	90	3.5	8.4	.6	12	2.2	--------	.0	32	28	1.0	4.6	82	9.40
Mean		82	3.7	8.4	.49	12	2.2	7.3	.0	18	33	1.8	3.2	81	--------

[a] Analyses Aug. 25 to Oct. 23, 1906, and from Nov. 3 to Dec. 2, 1906, by D. B. Role; Oct. 24 to Nov. 2, 1906, and from Dec. 3, 1906, to Apr. 3, 1907, by R. B. Dole and M. G. Roberts; Apr. 4 to Sept. 2, 1907, by Chase Palmer and M. G. Roberts

[b] Gaging station at Lock No. 4, 10 miles above.

Analyses of water from Youghiogheny River near McKeesport, Pa.[a]

[Parts per million.]

Date (1906-7).		Turbidity.	Silica (SiO_2).	Iron (Fe).	Aluminum (Al).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total dissolved solids.	Acidity free as H_2SO_4.	Mean gage height (feet).[b]
From—	To—															
Sept. 6	Sept. 16	4	11	6.7	--------	37	14	13	0.0	0.0	--------	Tr.	5.5	397	72	0.06
17	26	22	12	5.8	--------	52	17	21	.0	.0	300	Tr.	6.0	453	75	--------
27	Oct. 6	5	10	7.0	--------	42	16	16	.0	.0	245	0.0	5.0	374	66	.06
Oct. 7	16	3	8.2	.5	5.0	29	8.4	12	.0	.0	172	.7	4.8	298	34	.65
17	26	8	8.4	.4	6.0	29	5.6	10	.0	.0	167	.8	5.8	249	20	.52
27	Nov. 5	11	9.0	.5	7.2	29	5.6	12	.0	.0	174	.4	5.4	251	30	.21
Nov. 6	15	8	7.8	.8	--------	34	5.8	14	.0	.0	227	.6	5.7	311	53	.05
16	25	140	5.6	.2	4.0	22	3.2	8.8	.0	.0	127	.8	4.6	184	22	2.04
26	Dec. 5	49	5.6	.07	--------	15	4.0	10	.0	.0	97	.8	3.4	118	16	1.25
Dec. 6	16	190	5.2	.09	0.8	12	4.2	3.9	.0	[c] 3.9	40	2.8	3.8	84	.0	4.50
17	27	50	3.8	.12	2.6	14	4.8	4.4	.0	.0	73	2.8	3.8	119	10	3.41
28	Jan. 7	190	7.8	.07	3.4	17	5.4	4.1	.0	.0	85	2.1	3.7	138	10	5.31
Jan. 8	17	230	6.0	.06	2.0	14	4.2	--------	.0	[c] 5.1	62	2.1	3.1	103	.0	8.20
18	26	210	8.6	.06	5.6	20	5.6	5.7	.0	.0	104	1.9	3.6	164	10	7.60
29	Feb. 7	47	8.6	.35	8.2	23	7.5	6.9	.0	.0	141	2.0	4.8	226	33	3.70
Feb. 8	17	43	8.2	.2	8.8	23	7.2	6.6	.0	.0	142	1.9	4.0	224	30	2.62
18	27	55	7.2	.13	5.8	18	5.8	5.0	.0	.0	107	2.0	3.8	171	20	4.26
28	Mar. 9	80	6.4	.15	3.7	--------	3.8	2.7	.0	.0	82	.5	3.8	127	15	3.21
Mar. 10	22	1,600	8.8	.10	2.3	--------	5.2	5.5	.0	[c] 7.5	86	1.6	2.6	140	.0	10.34
23	Apr. 1	140	11	.18	10	28	7.6	7.7	.0	.0	165	1.6	3.0	239	22	3.42
Apr. 2	14	110	11	.15	11	30	8.6	11	.0	.0	184	.6	5.0	277	66	2.00
15	24	240	16	.07	2.8	17	5.2	7.6	.0	.0	86	1.3	4.2	140	17	3.26
25	May 4	82	7.6	.05	2.2	16	4.6	7.9	.0	.0	74	1.1	2.4	123	11	3.16
May 5	15	540	14	.06	0.5	20	6.4	8.2	.0	[c] 7.3	78	1.1	5.0	143	.0	3.85
16	25	45	8.4	.06	4.2	19	6.2	9.1	.0	.0	104	.7	4.2	157	11	2.37
26	June 4	160	7.2	.05	2.2	16	5.2	7.2	.0	.0	74	.7	3.0	118	6.9	3.26
June 5	14	290	8.2	.03	0.7	13	3.6	9.1	.0	[c] 6.1	54	1.1	2.4	98	.0	4.37
15	24	60	8.4	.04	2.2	17	5.2	8.8	.0	.0	80	1.1	4.2	129	3.4	3.09
25	July 4	7	7.8	.04	2.4	24	6.8	11	.0	.0	116	.7	6.6	181	22	1.36
July 5	14	52	9.4	.09	2.8	30	8.2	13	.0	.0	152	.6	5.8	236	28	1.51
16	26	46	6.8	.05	--------	14	3.8	14	.0	[c] Tr.	66	1.3	4.8	112	.0	2.67
27	Aug. 5	106	6.8	.04	1.3	16	4.2	7.9	.0	.0	76	1.2	3.2	120	3.9	2.16
Aug. 6	15	31	7.8	.03	2.1	24	7.0	10	.0	.0	116	.7	4.8	183	14	1.35
16	26	15	8.4	.1	3.6	30	8.8	12	.0	.0	160	.6	7.4	255	24	1.18
27	Sept. 6	55	10	.05	3.3	30	8.2	11	.0	.0	153	1.1	8.4	242	16	.90
Mean		141	8.5	.70	4.0	23	6.7	9.3	.0	.0	123	1.1	4.5	197	22	--------

[a] Analyses Sept. 6 to Nov. 5, 1906, by R. B. Dole; Nov. 6, 1906, to Apr. 1, 1907, by R. B. Dole and M. G. Roberts; Apr. 2 to Sept. 6, 1907, by Chase Palmer and M. G. Roberts.

[b] Gaging station at West Newton, Pa., 10 miles above.

[c] Omitted from the average.

In the next table the average analyses of the three river waters are restated in the form of the percentage composition of the anhydrous solid residues. Bicarbonates are reduced to normal carbonates, and the alkalies are corrected by Palmer's determinations of potassium.

Percentage composition of three river waters in Ohio basin.

1. Allegheny River. Mean of 36 analyses of 10 day composite samples.
2. Monongahela River. Mean of 37 composite analyses.
3. Youghiogheny River. Mean of 35 composite analyses.

	1	2	3
CO_3	21.51	11.47	Tr.
SO_4	19.55	42.52	66.40
Cl	16.10	4.12	2.33
NO_3	.82	2.32	.60
Ca	16.10	15.47	12.42
Mg	3.46	2.84	3.63
Na	11.04	8.12	4.38
K	2.09	1.42	.98
SiO_2	9.09	10.82	4.60
Fe_2O_3	.24	.90	.55
Al_2O_3	--------	--------	4.11
	100.00	100.00	100.00
Salinity, parts per million	87	81	185

All three river basins lie in a densely populated region, with many coal mines, iron works, and other industrial enterprises. Their waters are therefore much contaminated, and most so in the Youghiogheny, which is the principal tributary of the Monongahela. In this river as it nears Pittsburgh acid contamination has almost completely destroyed the carbonates and replaced them by sulphates, as shown in the analyses. The Allegheny is less affected, and the Monongahela in this respect is intermediate between the other two. A regular gradation in composition appears in passing from analysis No. 1 to No. 3.

This industrial contamination is doubtless very variable. In times of industrial depression or of strikes it should be much less, and during floods the acid or polluted waters should be temporarily swept away by purer waters from the upper courses of the streams.

For these rivers and their tributaries a good number of railroad or boiler-water analyses are available. These are best arranged in groups, and in each one the analyses will follow the courses of the streams in order from the headwaters downward.

First, there are two analyses of water from the Allegheny, as follows:

Analyses of water from Allegheny River.

1. At Eclipse, Pa. Received from Lake Shore & Michigan Southern R. R. (New York Central system).
2. At Rankin, Pa. Received from Baltimore & Ohio R. R.

	Parts per million.		Percentage composition discharge solids.	
	1	2	1	2
CO_3	25.2	20.3	34.31	19.44
SO_4	8.8	24.7	12.01	23.64
Cl	12.6	17.4	17.12	16.70
Ca	14.5	17.6	19.74	16.81
Mg	3.2	3.8	4.32	3.60
Na(K)	8.1	11.3	11.10	10.81
Oxides [a]	1.0	9.4	1.40	9.00
	73.4	104.5	100.00	100.00

[a] Silica plus sesquioxides.

Kittanning, the station at which the Survey samples were collected, is between these two; and the salinity, 87 parts per million, and the composition of the water are also intermediate. Rankin is very near Pittsburgh and shows the effect of industrial contamination.

For the Monongahela the following five analyses are of value. All were received from the Baltimore & Ohio Railroad.

Analyses of Monongahela River water.[a]

1. At Fairmont, W. Va.
2. At Glassport, Pa.
3. At Versailles, Pa,
4. At Rand, Pa.
5. At Glenwood, Pa.

I. Parts per million.

	1	2	3	4	5
CO_3	11.7	6.0	12.0	9.1	42.9
SO_4	9.8	24.6	44.5	81.5	64.1
Cl	2.0	4.0	6.4	8.8	6.8
Ca	8.9	10.3	19.8	29.9	39.8
Mg	1.8	2.4	4.0	6.1	9.3
Na(K)	1.3	2.6	4.2	5.7	4.4
Oxides [b]	10.3	17.0	8.9	6.0	3.1
	45.8	66.9	99.8	147.1	170.4

[a] For an early analysis of Monongahela water see Howard, C. D., West Virginia Agr. Exper. Sta. Bull. 89.

[b] Silica plus sesquioxides.

II. Percentage composition of dissolved solids.

	1	2	3	4	5
CO_3	25.59	8.95	12.02	6.18	25.17
SO_4	21.41	36.83	44.57	55.42	37.60
Cl	4.32	6.05	6.44	6.00	4.01
Ca	19.56	15.35	19.86	20.30	23.37
Mg	3.85	3.58	4.04	4.14	5.45
Na(K)	2.80	3.92	4.17	3.89	2.60
Oxides [a]	22.47	25.32	8.90	4.07	1.80
	100.00	100.00	100.00	100.00	100.00

[a] Silica plus sesquioxides.

Following the river downstream the increase in salinity, as shown in parts per million, is very striking. The pollution, as appears in the proportion of sulphates, increases in somewhat the same way although not so regularly. The irregularity is probably due to local causes. Analysis No. 1 is most nearly that of a normal water.

The following analyses of water from tributaries of the Monongahela were received from the Baltimore & Ohio Railroad. All are reduced to standard form as usual. The localities mentioned are in West Virginia.

Analyses of waters in Monongahela basin.

1. West Fork of the Monongahela at Clarksburg.
2. West Fork of the Monongahela at Jayenn.
3. Lake Kester at Oral. Mean of two analyses.
4. Bingamon Creek at Enterprise.
5. Buffalo Creek at Glover Gap.
6. Buffalo Creek at Farrington.
7. Tygarts Valley River at Arden.
8. Tygarts Valley River at Grafton.
9. Cheat River at Rowlesburg.

I. Parts per million.

	1	2	3	4	5	6	7	8	9
CO_3	19.1	30.2	16.6	48.5	13.1	12.9	16.1	5.5	31.6
SO_4	11.8	46.3	8.1	42.1	9.8	9.4	2.4	4.9	29.2
Cl	4.9	5.9	2.5	6.6	3.0	7.2	.9	.9	13.8
Ca	13.2	24.6	11.2	36.5	7.9	9.8	10.1	4.3	24.3
Mg	2.7	5.0	1.9	8.0	2.9	1.6	1.0	.9	5.4
Na(K)	3.2	11.4	1.6	4.3	1.9	4.6	.6	.6	9.0
Oxides [a]	8.2	6.0	7.9	3.2	11.5	18.5	5.3	7.5	3.1
	63.1	129.4	49.8	149.2	50.1	64.0	36.4	24.6	116.4

II. Percentage composition of dissolved solids.

	1	2	3	4	5	6	7	8	9
CO_3	30.33	23.35	33.32	32.46	26.09	20.11	44.17	22.26	27.17
SO_4	18.74	35.81	16.25	28.22	19.51	14.73	6.61	20.09	25.12
Cl	7.73	4.56	5.01	4.45	6.01	11.21	2.57	3.83	11.85
Ca	20.93	18.99	22.44	24.45	15.78	15.34	27.74	17.26	20.88
Mg	4.26	3.83	3.93	5.37	5.86	2.53	2.69	3.57	4.62
Na(K)	5.01	8.84	3.24	2.88	3.89	7.26	1.67	2.45	7.71
Oxides [a]	13.00	4.62	15.81	2,17	22.86	28.82	14.55	30.54	2.65
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

[a] Silica plus sesquioxides.

Four more analyses of water from tributaries of the Monongahela, through the Youghiogheny, are given in the next table. They also were received from the Baltimore & Ohio Railroad.

Analyses of water from the Youghiogheny basin.

10. West Fork of Youghiogheny River at Toll Gate, W. Va.
11. Bear Run at Bear Run station, Pa.
12. Indian Creek at Indian Creek station, Pa.
13. Youghiogheny River at Versailles, Pa. Mean of two analyses.

	Parts per million.				Percentage composition.			
	10	11	12	13	10	11	12	13
CO_3	29.5	10.5	11.5	70.4	36.20	33.25	29.22	25.66
SO_4	4.0	2.9	4.8	73.0	4.87	9.20	12.22	26.63
Cl	3.0	.9	4.9	6.0	3.70	2.97	12.36	2.20
Ca	15.9	6.1	6.9	46.9	19.59	19.27	17.53	17.11
Mg	3.1	1.3	1.7	18.3	3.84	4.04	4.21	6.66
Na(K)	2.0	.6	3.2	3.9	2.39	1.92	8.00	1.42
Oxides [a]	23.9	9.2	6.5	55.7	29.41	29.35	16.46	20.32
	81.4	31.5	39.5	274.2	100.00	100.00	100.00	100.00

[a] Silica plus sesquioxides.

Although these 13 analyses of waters in the Monongahela basin are not elaborate, they still give some suggestive information. Analyses 1 and 2, 7 to 9, and 10 to 13 show clearly the increase in pollution as represented by the sulphate radicle as the streams are followed downward. This appears very distinctly in the last group. The analysis of Youghiogheny water differs widely from the mean in the Survey table, but the sample was taken at a point above McKeesport, where the contamination reached a maximum. At Versailles the carbonates are still conspicuous, but the sulphates exceed them in quantity. The salinity of the river varies enormously, almost from day to day, but that is evidently due to variations between low and high water and has no other real significance.

BEAVER RIVER.

Beaver River, which enters the Ohio at Rochester, Pa., 26 miles northwest of Pittsburgh, is formed by the union of the Mahoning and the Shenango. For the main trunk of the river no analyses are available; but for its subordinate waters the following data are useful.

Analyses of waters in Beaver River basin.

1. Mahoning River at Youngstown, Ohio.
2. Shenango River at Sharon, Pa. Analyses 1 and 2 received from Lake Shore & Michigan Southern R. R. (New York Central system).
3. Shenango River at New Castle Junction, Pa.
4. Big Run at New Castle Junction, Pa.
5. Creek at Fombell, Pa. Analyses 3 to 5 received from Baltimore & Ohio R. R.

I. Parts per million.

	1	2	3	4	5
CO_3	57.5	40.3	37.7	14.6	10.6
SO_4	71.8	10.0	63.3	21.0	11.1
Cl	10.4	3.9	7.9	5.0	3.4
Ca	41.1	22.4	37.1	15.9	8.5
Mg	11.9	5.1	8.7	1.5	2.0
Na(K)	15.1	2.6	5.1	3.2	2.2
Oxides [a]	5.0	1.7	3.9	19.0	8.0
	212.8	86.0	163.7	80.2	45.8

II. Percentage composition of dissolved solids.

	1	2	3	4	5
CO_3	27.01	46.97	23.04	18.16	23.20
SO_4	33.76	11.39	38.64	26.19	24.23
Cl	4.87	4.59	4.82	6.21	7.47
Ca	19.31	26.10	22.66	19.87	18.45
Mg	5.60	5.98	5.29	1.89	4.26
Na(K)	7.11	2.98	3.12	4.01	4.85
Oxides [a]	2.34	1.99	2.43	23.67	17.54
	100.00	100.00	100.00	100.00	100.00

[a] Silica plus sesquioxides.

MUSKINGUM RIVER.

For Muskingum River, which enters the Ohio at Marietta, there is the following table of analyses made by Dole and his colleagues in the water-resources laboratory of the Geological Survey:

Analyses of water from Muskingum River at Zanesville, Ohio.[a]

[Parts per million.]

Date (1906-7).		Turbidity.	Total iron (Fe).	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total dissolved solids.	Mean gage height (feet).
From—	To—														
Sept. 3	Sept. 13	130	3.5	15	0.10	47	10	27	0.0	136	40	0.2	60	281	8.1
14	23	100	2.9	23	.30	55	12	27	.0	155	41	.9	71	314	7.8
24	Oct. 3	70	2.2	32	Tr.	58	13	36	.0	154	52	.0	--------	356	8.1
Oct. 4	13	85	2.9	15	Tr.	55	11	46	.0	--------	53	2.1	--------	339	9.0
14	23	48	2.6	13	Tr.	52	12	--------	.0	132	51	1.9	65	334	8.8
24	Nov. 2	45	1.4	27	.06	53	11	33	5.3	136	50	1.0	62	305	8.6
Nov. 3	13	24	.7	14	.03	60	13	36	Tr.	160	49	1.0	77	326	8.2
14	24	80	1.8	12	.06	55	11	33	Tr.	168	50	1.1	--------	301	10.2
25	Dec. 4	32	1.4	11	.16	41	9.8	19	Tt.	111	43	3.0	38	216	9.5
Dec. 5	15	150	5.6	15	.23	37	8.4	20	3.6	96	40	4.5	--------	207	11.3
16	27	--------	3.9	10	.19	35	8.4	14	.0	92	38	3.6	29	182	11.4
28	Jan. 4	--------	7.2	7.6	.14	32	6.0	12	.0	86	--------	3.8	28	169	13.6
Jan. 10	20	--------	11	13	.75	22	3.6	7.1	.0	61	--------	4.2	13	128	18.6
21	Mar. 4	85	3.2	11	.19	37	7.6	12	4.8	89	--------	3.7	29	192	11.7
Mar. 9	31	480	--------	18	.20	28	--------	14	17	36	35	2.1	19	160	17.0
Apr. 6	Apr. 20	17	1.7	9.0	.11	44	9.8	22	.0	117	45	1.5	36	225	10.3
21	30	215	5.8	25	.25	36	7.0	19	.0	93	39	1.6	29	207	13.5
May 1	May 10	42	1.8	15	.23	38	8.4	17	.0	102	40	1.5	28	197	11.1
11	June 1	81	2.3	16	.09	26	8.8	21	.0	76	42	.0	36	187	11.3
June 2	18	105	4.0	12	.18	26	7.6	17	--------	--------	35	1.5	24	181	11.8
19	July 4	3	1.0	--------	.5	30	9.6	24	2.4	70	42	.0	46	188	8.9
July 5	20	110	4.0	12	.18	42	9.2	19	.0	127	38	1.2	38	227	9.5
21	31	260	7.7	10	.4	28	5.8	14	.0	83	26	.8	20	150	12.6
Aug. 2	Aug. 11	62	1.1	11	.10	46	9.0	21	.0	130	36	.8	37	223	8.8
12	21	2	.3	11	.06	58	12	31	Tr.	160	45	.4	65	296	8.0
22	31	48	1.4	7.6	.13	58	12	38	Tr.	145	50	.5	--------	328	8.1
Sept 1	Sept. 10	35	1.0	11	.16	64	12	--------	Tr.	156	51	.4	--------	373	7.8
Mean [a]		96	3.2	14	.18	43	9.5	23	1.3	115	43	1.6	40	244	--------

[a] Analyses Sept. 3 to Oct. 23, 1906, by R. B. Dole; Oct. 21 to Mar. 31, 1907, by R. B. Dole and M. G. Roberts; Apr. 6 to Sept. 10, 1907, by Chase Palmer and M. G. Roberts.

The following analyses of waters in the Muskingum basin were received from the Baltimore & Ohio Railroad and are reduced here to standard form. The localities given are all in Ohio.

Analyses of waters in the Muskingum basin.

1. Fork of Mohican River at Lexington.
2. Clear Fork Creek at Butler.
3. West Fork of Licking River at Utica.
4. Licking River at Black Hand. (Not to be confused with the Licking River of Kentucky, which enters the Ohio opposite Cincinnati.)
5. Leatherwood Creek at Spencers.
6. Leatherwood Creek at Campbells.
7. Willis Creek at Cambridge.
8. Crooked Creek at New Concord.
9. Muskingum River at Zanesville.
10. Jonathans Creek at Glenford.

I. Parts per million.

	1	2	3	4	5	6	7	8	9	10
CO_3	107.3	103.8	133.9	124.2	101.6	74.6	80.7	121.6	89.2	72.7
SO_4	56.9	28.3	71.0	46.5	87.0	142.8	91.1	44.0	51.3	27.2
Cl	3.9	3.9	10.8	6.8	9.0	12.7	19.5	4.9	21.7	3.9
Ca	60.6	53.6	72.6	67.2	76.6	71.9	61.3	66.6	54.1	48.3
Mg	20.8	16.5	26.1	21.0	16.4	22.4	13.2	14.7	15.2	6.9
Na(K)	2.6	2.6	9.8	4.4	5.8	8.2	19.6	12.6	15.7	2.6
Oxides[a]	5.6	7.2	7.4	6.0	20.0	8.0	4.1	4.1	9.4	32.3
	257.7	215.9	331.6	276.1	316.4	340.6	289.5	268.5	256.6	193.9

[a] Silica plus sesquioxides.

II. Percentage composition of dissolved solids.

	1	2	3	4	5	6	7	8	9	10
CO_3	41.64	48.08	40.38	44.99	32.09	21.90	27.89	45.28	34.75	32.50
SO_4	22.07	13.14	21.41	16.82	27.50	41.95	31.47	16.38	20.04	14.02
Cl	1.53	1.83	3.26	2.48	2.85	3.72	6.72	1.82	8.45	2.04
Ca	23.52	24.83	21.90	24.34	24.19	21.09	21.19	24.80	21.07	24.89
Mg	8.06	7.62	7.87	7.60	5.20	6.58	4.55	5.49	5.90	3.57
Na(K)	.99	1.18	2.97	1.60	1.85	2.40	6.77	4.70	6.14	1.31
Oxides	2.19	3.32	2.21	2.17	6.32	2.36	1.41	1.53	3.65	16.67
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Some of the waters represented in the foregoing table were evidently contaminated. Nos. 6, 7, and 9 show this fact very clearly.

SCIOTO RIVER.

For the Scioto itself no analyses have been found, but the three which follow are of its tributaries. They were received from the Baltimore & Ohio Railroad. The basin of the Scioto lies entirely in Ohio.

Analyses of waters from the Scioto basin.

1. Big Walnut Creek at Big Walnut.
2. East Fork of Paint Creek at Madison Mills,
3. Sugar Creek at Jasper Mills.

	Parts per million.			Percentage composition.		
	1	2	3	1	1	3
CO_3	56.5	175.9	186.8	19.37	53.97	42.87
SO_4	110.0	30.0	93.3	37.72	9.23	21.41
Cl	5.9	3.9	3.9	2.03	1.21	.90
Ca	49.8	71.4	96.5	12.09	21.90	22.15
Mg	20.2	35.0	40.1	6.93	10.76	9.21
Na(K)	3.8	2.6	2.6	1.32	.78	.59
Oxides[a]	45.3	7.0	12.5	15.54	2.15	2.87
	291.5	325.8	435.7	100.00	100.00	100.00

[a] Silica plus sesquioxides.

MIAMI RIVER.

For the Miami in western Ohio we have only the series of analyses covering an entire year, as made by Dole and his colleagues. Their table follows:

Analyses of water from Miami River at Dayton, Ohio.[a]

[Parts per million.]

Date (1906-7).		Turbidity.	Total iron (Fe).	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total dissolved solids.	Mean gage height (feet).
From—	To—														
Sept. 16	Sept. 25	32	3.1	16	Tr.	58	28	10	9.0	264	38	0.9	5.0	300	0.7
26	Oct. 5	32	.9	21	Tr.	65	28	9.0	9.0	280	35	2.8	5.8	318	.8
Oct. 6	15	18	.4	17	Tr.	63	26	9.6	.0	297	37	3.1	5.0	309	.6
16	25	14	.10	18	Tr.	65	27	9.0	.0	301	40	2.9	5.0	317	.8
26	Nov. 4	5	.15	20	Tr.	66	28	11	8.2	291	41	2.0	5.5	327	1.0
Nov. 5	14	8	Tr.	20	Tr.	69	29	9.8	Tr.	317	41	2.0	5.3	335	2.0
15	24	75	2.1	14	0.24	64	27	9.8	11	250	40	7.0	4.3	304	2.8
25	Dec. 4	16	.5	19	.05	75	28	7.4	3.6	278	60	15	4.0	346	2.4
Dec. 5	14	26	.7	26	.07	75	28	8.2	10	269	62	12	4.7	355	2.5
15	24	80	1.4	15	.23	64	23	6.8	.0	239	52	13	3.0	296	3.0
25	Jan. 4	----------	3.2	16	.19	68	24	7.1	.0	272	52	12	3.5	318	4.2
Jan. 5	14	210	3.0	14	.5	50	17	6.5	.0	184	36	18	3.6	238	6.5
15	24	450	6.7	15	.7	42	14	7.1	.0	161	29	11	3.4	212	7.5
25	Feb. 4	75	1.8	16	.6	61	23	8.8	12	229	44	16	4.1	301	3.3
Feb. 5	14	45	.5	8.8	.05	60	26	8.0	12	215	51	10	3.8	282	2.9
15	24	11	.4	24	.06	58	25	6.9	13	212	42	11	4.1	298	2.8
25	Mar. 6	260	4.2	25	.08	67	25	7.4	8.4	246	49	9.0	3.8	320	2.9
Mar. 27	Apr. 6	37	1.0	15	.12	64	24	8.0	12	228	44	10.0	4.6	299	2.2
Apr. 7	16	25	.3	20	.14	50	26	8.4	12	200	44	15	5.4	282	2.1
17	26	25	.6	19	.11	58	25	3.5	16	217	41	15	4.2	298	2.2
27	May 6	20	.4	15	.16	62	24	6.3	13	229	39	19	3.8	297	2.5
May 7	16	18	.4	23	.11	58	23	3.3	14	217	40	18	4.3	292	2.0
17	28	37	1.3	14	.10	52	26	3.0	12	218	41	15	3.8	275	1.8
29	June 8	240	4.4	19	.19	53	20	12	10	197	34	15	4.8	264	3.8
June 9	18	280	7.0	18	.7	49	18	11	9.6	180	27	17	3.8	252	5.2
19	28	75	2.6	17	.12	60	22	11	2.4	249	33	6.2	4.8	283	2.5
29	July 8	90	1.6	17	.03	42	26	8.2	.0	206	37	1.2	4.2	240	1.9
July 9	19	----------	7.9	30	.35	51	20	14	.0	----------	26	6.4	2.4	254	4.0
20	29	----------	3.2	8.6	.04	26	18	12	.0	----------	32	Tr.	.6	163	3.4
30	Aug. 8	----------	1.6	9.2	Tr.	56	24	12	.0	----------	37	1.5	.6	258	2.2
Aug. 9	18	----------	1.0	18	.03	55	25	11	.0	----------	39	1.5	1.4	273	1.4
19	28	35	.9	9.8	.05	69	29	12	.0	323	34	.0	5.4	331	1.1
29	Sept. 7	43	.9	15	.04	63	24	14	.0	287	41	2.5	5.8	304	1.2
Sept. 8	17	140	2.6	19	.13	59	25	13	.0	251	36	2.2	4.8	289	1.7
Mean		84	2.0	17	.15	59	24	9.0	5.8	244	40	8.6	4.1	289	----------

[a] Analyses Sept. 9 to Dec. 4, 1906, by R. B. Dole; Dec. 5, 1906, to Mar. 6, 1907, by R. B. Dole and M. G. Roberts; Mar. 27 to June 28, 1907, by Chase Palmer and M. G. Roberts; June 29 to Sept. 17, 1907, by R. B. Dole, Chase Palmer, and W. D. Collins.

WABASH RIVER.

Wabash River, the largest northern affluent of the Ohio, has been very thoroughly studied in the water-resources branch of the United States Geological Survey. For the main stem of the river there are two tables of analyses, giving the mean composition of the water during an entire year. These tables follow:

Analyses of water from Wabash River near Logansport, Ind.[a]

[Parts per million.]

Date (1906-7).		Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total dissolved solids.
From—	To—												
Sept. 9	Sept. 18	105	------	0.15	66	62	382	[b] 7.9	190	82	0.0	741	1,461
19	29	50	11	Tr.	102	60	------	.0	259	97	.0	690	1,515
30	Oct. 9	20	17	.10	109	63	------	.0	242	100	.0	737	1,596
Oct. 12	21	10	8.0	.10	117	68	434	.0	258	114	Tr.	866	1,785
22	31	10	9.6	.20	128	77	473	.0	276	101	.0	915	1,882
Nov. 1	Nov. 10	10	10	.10	112	------	478	.0	314	112	.4	960	1,940
11	20	10	13	.08	133	74	461	.0	317	138	.0	889	1,905
21	30	125	11	.20	91	33	169	.0	206	93	18	320	841
Dec. 1	Dec. 10	150	19	.40	77	36	112	.0	218	97	11	223	681
11	21	145	22	.85	68	25	61	.0	166	75	11	114	498
22	31	50	17	.20	92	36	105	.0	259	102	18	198	703
Jan. 1	Jan. 10	295	29	------	48	15	34	.0	127	61	9.7	57	323
12	20	240	21	1.2	52	17	28	.0	144	44	13	51	309
21	30	280	27	1.2	52	17	33	.0	150	52	5.6	49	320
31	Feb. 9	10	8.4	.10	97	35	97	.0	298	99	6.4	175	651
Feb. 10	20	Tr.	16	Tr.	102	36	119	.0	292	94	6.0	222	727
21	Mar. 3	10	10	Tr.	94	35	115	.0	278	111	8.4	204	711
Mar. 4	13	370	6.4	.05	83	34	118	.0	------	88	7.3	218	713
14	23	650	38	1.2	43	15	22	.0	116	46	16	35	311
24	Apr. 3	145	12	.25	57	19	38	.0	187	60	4.4	60	374
Apr. 4	14	30	10	.20	60	25	83	.0	240	76	6.7	153	559
15	25	5	8.0	.22	------	33	98	.0	258	87	7.9	222	697
26	May 7	10	10	.07	89	36	115	.0	234	89	3.2	223	748
May 8	17	8	5.0	.04	87	32	98	.0	242	89	4.3	185	672
18	28	20	------	.04	90	33	------	.0	260	85	4.1	233	713
29	June 7	90	9.8	.20	66	22	59	.0	195	60	6.1	117	478
June 8	18	150	18	.15	67	18	31	.0	194	42	7.5	63	388
19	28	230	11	.15	61	20	53	.0	207	53	5.0	89	422
29	July 8	50	11	.05	88	29	------	.0	277	63	4.4	188	620
July 10	21	900	14	.10	63	20	62	.0	195	50	8.8	95	425
22	31	140	11	.02	67	22	53	.0	239	56	2.9	83	434
Aug. 1	Aug. 10	50	11	.05	84	33	102	.0	288	64	2.2	174	659
11	20	85	9.0	.05	85	35	108	.0	292	73	1.8	214	734
21	30	75	20	.05	89	44	176	.0	295	80	1.8	313	932
31	Sept. 9	75	9.8	.08	67	24	94	.0	217	48	3.5	150	527
Mean		132	14	23	82	35	142	.0	234	79	5.9	292	807

[a] Analyses Sept. 9, 1906, to Feb. 9, 1907, by W. M. Barr; Feb. 10 to Mar. 3, 1907, by H. S. Spaulding; Mar. 4 to Sept. 9, 1907, by Walton Van Winkle.

[b] Abnormal; computed as HCO_3 in the average.

Analyses of water from Wabash River at Vincennes, Ind.[a]

[Parts per million.]

Date (1906-7).		Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K)	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total dissolved solids.	Mean gage height (feet).[b]
From—	To—													
Sept. 9	Sept. 19	50	8.0	0.05	54	26	46	0.0	232	55	1.3	84	421	1.6
20	Oct. 1	90	5.4	.05	65	24	49	.0	254	56	1.3	90	436	1.3
Oct. 2	16	------	12	.10	61	25	31	.0	232	64	4.4	60	376	2.3
17	30	15	12	Tr.	75	26	54	.0	266	68	4.4	89	470	1.4
31	Nov. 13	25	10	Tr.	73	30	60	.0	279	60	1.8	104	504	1.1
Nov. 14	24	205	11	Tr.	68	27	------	.0	246	65	2.2	84	436	3.9
25	Dec. 4	180	12	.25	63	20	36	.0	200	71	11	53	360	9.1
Dec. 5	15	290	5.2	.40	64	18	19	.0	188	67	16	29	322	8.9
15	25	135	12	.40	59	16	21	.0	196	58	18	26	330	13.2
26	Jan. 5	190	13	.6	62	22	19	.0	209	61	5.3	21	307	10.5
Jan. 7	17	170	15	.7	45	16	12	.0	------	39	13	13	232	22.8
18	27	315	30	------	------	------	8.1	.0	147	39	6.5	8.3	209	23.3
28	Feb. 6	120	18	.9	47	19	12	.0	168	------	6.1	8.8	242	19.4
Feb. 7	18	40	12	.10	69	23	------	.0	264	73	8.1	24	348	7.0
19	28	30	12	.05	69	22	25	.0	255	60	8.8	30	358	6.0
Mar. 1	Mar. 10	50	15	.15	69	25	29	.0	256	72	8.5	28	356	6.4
11	25	625	36	1.8	46	22	10	.0	171	46	6.1	21	287	18.6
26	Apr. 15	75	16	.18	58	17	12	.0	216	------	7.8	16	288	8.0
Apr. 16	24	75	9.0	.09	------	23	20	.0	246	61	7.9	27	339	5.3
27	May 8	50	10	.28	62	24	26	.0	228	61	6.9	37	350	7.9
May 10	19	85	6.4	.17	61	24	20	.0	264	57	.8	27	335	5.9
20	June 1	425	3.0	.21	51	17	19	.0	192	46	6.6	14	248	6.8
June 3	13	195	5.6	.01	51	15	13	.0	------	------	16	15	295	15.8
14	26	170	14	.05	62	------	21	.0	220	51	11	33	329	7.2
27	July 7	300	16	.20	62	22	17	.0	255	44	7.5	20	317	6.0
July 8	18	280	12	.20	62	20	21	.0	252	45	.9	24	316	5.5
19	31	300	16	.02	53	17	15	.0	208	37	3.5	14	283	8.2
Aug. 1	Aug. 14	450	14	.01	62	20	21	.0	253	50	2.0	13	311	4.3
15	26	130	13	.09	62	21	24	.0	262	45	1.9	20	302	3.8
27	Sept. 6	80	9.2	.04	64	24	29	.0	264	45	1.1	26	322	3.8
Sept. 7	16	30	28	.01	61	20	28	.0	241	49	1.1	43	362	3.7
Mean		172	13	.24	61	22	25	.0	230	55	6.4	36	336	------

[a] Analyses Sept. 9, 1906, to Feb. 6, 1907, by W. M. Barr; Feb. 7 to 28, 1907, by H. S. Spaulding; Mar. 1 to Sept. 16, 1907, by Walton Van Winkle.

[b] Gaging station at Mount Carmel, Ill., 30 miles below.

In addition to the data given in the foregoing tables, the following analyses have been received:

1. At Fort Recovery, Ohio.
2. At Lafayette, Ind. Analyses 1 and 2 from Lake Shore & Michigan Southern R. R. (New York Central system).
3. At Lafayette, Ind.
4. At Terre Haute, Ind. Analyses 3 and 4 from Erie R. R.

Analyses of water from the Wabash.

	Parts per million.				Percentage composition.			
	1	2	3	4	1	2	3	4
CO_3	96.9	137.3	128.5	135.6	30.79	38.77	32.21	37.42
SO_4	96.4	40.2	69.2	60.1	30.65	11.35	17.35	16.57
Cl	2.8	43.9	49.3	35.9	.89	12.37	12.36	9.91
NO_3	8.9	4.3	------	------	2.81	1.20	------	------
Ca	71.8	74.1	82.8	72.2	22.82	20.95	20.75	19.92
Mg	19.8	22.1	19.7	25.6	6.29	6.25	4.95	7.16
Na(K)	5.1	28.4	31.9	23.3	1.62	8.04	8.01	6.42
SiO_2	13.0	3.8	12.7	8.6	4.13	1.07	3.17	2.36
$(Al,Fe)_2O_3$			4.8	.9			1.20	.24
	314.7	354.1	398.9	362.2	100.00	100.00	100.00	100.00

The next group of analyses represents waters tributary to the Wabash north of White River and nearer to its sources. All the localities except No. 1 are in Indiana. Analyses 4 and 8 were received from the Erie Railroad; No. 3 from the Cleveland, Cincinnati, Chicago & St. Louis Railway; the others from the Lake Shore & Michigan Southern (New York Central System).

Analyses of waters in the Wabash basin.

1. St. Mary's Reservoir, Celina, Ohio. The main source of the Wabash.
2. Lake Manitou at Rochester.
3. Round Lake at Laketon.
4. Center Lake at Warsaw.
5. Salamonie River at Montpelier.
6. Mississinewa River at Eaton.
7. Pipe Creek at Peru.
8. Eel River at North Manchester.
9. Wild Cat Creek at Mulberry.
10. Pine Creek at Templeton.

I. Parts per million.

	1	2	3	4	5	6	7	8	9	10
CO_3	72.0	67.6	113.7	109.6	108.8	152.5	167.0	92.7	244.7	116.1
SO_4	54.1	16.3	92.4	66.0	152.1	57.3	34.5	67.2	130.7	34.3
Cl	24.6	1.3	5.3	14.5	106.5	41.4	3.1	6.2	12.5	2.0
NO_3	------	------	------	------	9.3	6.6	10.9	------	------	19.4
Ca	47.5	27.7	72.4	87.2	101.5	84.3	87.4	49.6	106.1	67.2
Mg	13.8	13.5	18.7	8.0	31.1	30.4	24.2	13.8	44.3	23.5
Na(K)	15.9	2.9	15.3	9.4	52.4	18.5	3.7	23.8	51.4	1.3
SiO_2	8.7	.5	2.0	9.9	10.4	5.0	4.6	10.8	2.2	4.8
$(Al, Fe)_2O_3$			2.7	4.1				16.8		
	236.6	129.8	322.5	308.7	572.1	396.0	335.4	280.9	591.9	288.6

II. Percentage composition of dissolved solids.

	1	2	3	4	5	6	7	8	9	10
CO_3	30.44	52.06	35.25	35.49	19.06	38.51	49.76	33.01	41.34	40.24
SO_4	22.85	12.60	28.65	21.38	26.57	14.47	10.28	23.93	22.09	18.83
Cl	10.39	1.04	1.64	4.70	18.60	10.46	.92	2.21	2.10	.68
NO_3	------	------	------	------	1.62	1.67	3.26	------	------	6.72
Ca	20.07	21.31	22.44	28.24	17.74	21.29	26.09	17.65	17.93	23.29
Mg	5.84	10.39	5.80	2.60	5.43	7.67	7.22	4.92	7.48	8.12
Na(K)	6.73	2.21	4.74	3.05	9.16	4.68	1.10	8.48	8.68	.45
SiO_2	3.68	.39	.63	3.21	1.82	1.25	1.37	3.84	.38	1.67
$(Al, Fe)_2O_3$			.85	1.33				5.96		
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

The largest tributary of the Wabash is White River, which divides into two branches, the East Fork and West Fork. For these there are the following tables of analyses, which were made in the water-resources laboratory of the United States Geological Survey:

Analyses of water from East Fork of White River near Azalia, Ind.[a]

[Parts per million.]

Date (1906-7).		Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total dissolved solids.
From—	To—												
Sept. 12	Sept. 23	25	29	Tr.			8.6	0.0	293	24	1.8	8.0	305
24	Oct. 3	55	13	0.10	56	24	7.6	.0	268	30	2.2	5.5	264
Oct. 5	15	25	18	.10	64	25	15	.0	290	26	3.9	3.7	290
16	25	10	9.6	Tr.	66	26	12	.0	300	25	.9	4.1	290
26	Nov. 4	10	13	Tr.	63	29	16	.0	319	35	.5	5.9	302
Nov. 5	16	5	15	.05	70	28	13	.0	316	33	1.4	2.0	305
17	27	95	11	.30	53	18	12	.0	225	34	4.4	2.4	236
28	Dec. 7	25	18	.05	67	24		.0	307	40	9.7	2.7	311
Dec. 8	18	40	22	.10	62	20	13	.0	266	37	8.8	2.3	289
19	28	10	13	.05	66	27	5.6	.0	303	33	9.7		306
29	Jan. 7	125	21	1.2	42		7.5	.0	176	28	4.4	1.3	106
Jan. 8	17	70	16	Tr.	45	15	4.8	.0	184	35	7.9	1.6	197
18	27	120	16	.40	43	16	6.3	.0	177	23	7.0	2.0	196
28	Feb. 7	5	22	Tr.	70	27		.0	300	32	7.3	2.2	307
Feb. 8	17	5	12	.10	79	26		.0	320	39	9.2	2.7	312
18	27	5	15	Tr.	68	28	11	.0	318	34	6.2	2.5	331
28	Mar. 10	50	15	Tr.	60	22	9.4	.0	267	34	9.9	2.3	272
Mar. 11	20	220	21	.8	42		11	.0	192	18	8.6	2.5	209
21	30	30	11	.15	64	21	7.9	.0	284	31	5.0	2.8	280
31	Apr. 9	10	10	.10	60	22	5.6	.0		30	8.8	2.0	269
Apr. 10	19	3	11	.05	58	24	7.6	.0	279	33	12	2.3	283
21	29	20	6.6	.20	56	23	7.8	.0	246	36	9.6	2.4	261
30	May 9	10	8.0	.01	59	24	6.7	.0	268	31	7.5	2.3	280
May 10	21	75	6.8	.04		24	6.2	.0	266	32	4.4	2.5	256
22	31	105	9.0	.16	58	23	5.9	.0	258	33	6.0	2.2	269
June 1	June 11	245	14	.25	54	17	5.9	.0	230	23	4.4	1.6	240
12	23	60	25	.20	64	19	5.2	.0	269	28	4.4	1.9	292
24	July 3	10	15	.01	66	24	7.3	.0	323	26	4.2	3.1	305
July 4	14	245	13	.35	58	21	9.2	.0	263	26	6.0	1.6	256
15	24	75	15	.12	64	23	13	.0	300	27	7.8	2.0	303
25	Aug. 3	50	13	.08	67		12	.0	304	28	4.9	2.5	297
Aug. 4	13	10	13	.01	72	26	14	.0	316	35	1.6	3.8	334
14	24	10	18	Tr.		25		.0	316	31	1.1		329
25	Sept. 3	10	12	.10	65	25	9.2	.0	308	29	2.2	4.0	291
Sept. 4	13	5	14	.01	64	25	13	.0	320	29	2.6	5.3	300
14	23	30	16	Tr.	67	22	11	[b] 8.4	261	26	2.2	6.0	286
24	Oct. 3	25	21	Tr.	66	22	12	[b] 12	259	28	1.7	6.2	292
Mean		52	15	.14	61	23	9.5	.0	276	30	5.6	3.1	279

[a] Analyses Sept. 12, 1906, to Feb. 17, 1907, by W. M. Barr; Feb. 18 to 27, 1907, by H. S. Spaulding; Feb. 28 to Sept. 13, 1907, by Walton Van Winkle; Sept. 14 to Oct. 3, 1907, by R. B. Dole, Chase Palmer, and W. D. Collins.

[b] Abnormal; computed as HCO_3 in the average.

Analyses of water from West Fork of White River near Indianapolis, Ind.[a]

[Parts per million.]

Date (1906-7).		Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total dissolved solids.
From—	To—												
Sept. 8	Sept. 18	25	27	0.10	81	36	78	0.0	301	67	1.7	145	590
19	28	20	20	Tr.	83	43	127	.0	303	78	.5	262	793
29	Oct. 8	25	22	.7	78	37	91	[b] 6.5	280	74	.9	195	668
Oct. 9	19	15	11	.10	84	37	109	.0	293	73	1.1	215	701
20	31	10	8.4	.10	93		138	.0	331	125	.7	207	705
Nov. 1	Nov. 11	10	19	Tr.	95	38	129	.0	344	75	1.3	251	798
12	21	10	14	.20	95	36	123	.0	353	79	2.2	216	754
23	Dec. 2	40	18	Tr.	73	27	44	.0	266	78	13	63	448
Dec. 3	12	30	22	.13	77	34	47	.0	287	85	9.7	72	474
13	22	30	20	.20	71	33	26	.0	254	76	13	38	382
23	Jan. 4	40	16	.8	79	28	34	.0	290	68	8.8	55	412
Jan. 5	14	125	13	.5	50		14	.0	205	41	14	14	249
15	25	125	18	.6	48	17	20	.0		36	9.5	13	245
26	Feb. 4	20	12	.10	79	26	20	.0	293	56	6.3	35	378
Feb. 5	14	10	10	.10	86	32	38	.0	349	61	7.6	52	451
16	25	Tr.	10	.10	82	29	38	.0	311	60	9.7	60	441
26	Mar. 7	5	15	.08	79	31	49	.0	314	52	5.8	65	454
Mar. 8	17	235	9.0	.20	62	23	26	.0		38	9.7	30	305
18	27	35	16	Tr.	64	24	21	.0	262	42	4.7	26	339
28	Apr. 7	10	7.0	.10	66	24	32	.0	266	47	10	46	351
Apr. 8	17	5	12	.18	75	27	36	.0	281	55	5.8	62	422
18	27	5	8.8	.20	65	30	41	.0	273	60	4.8	67	414
29	May 8	10	8.8	.05	69	30	34	.0	280	59	6.2	57	425
May 9	19	10	10	.02	72	29	35	.0	282	48	4.1	57	416
20	30	20	6.8	.02	74	27	35	.0	282	58	8.3	70	415
June 1	June 10	80	9.6	.01	61	22	18	.0	236	44	5.6	33	343
11	20	50	23	.05	67	21	14	.0	260	42	3.4	21	332
21	30	25	16	.06	69	26		.0	298	45	7.9	34	365
July 1	July 11	50	13	.10	70	27	29	.0	298	49	7.1	43	380
13	22	130	14	.05	66	19	17	.0	259	20	6.0	15	300
23	Aug. 2	80	9.0	.01	72	22	26	.0	305	40	6.6	27	357
Aug. 3	13	30	15	Tr.	74	28	31	.0	312	45	7.3	38	415
14	23	20	11	.02	77	30	42	.0	326	51	4.9	50	430
24	Sept. 3	20	12	.30	70	29	42	.0	295	58	1.3	54	408
Sept. 4	12	10	15	.08	75	22	37	.0	298	47	4.8	42	396
Mean		39	14	.15	74	29	48	.0	291	58	6.1	78	450

[a] Analyses Sept. 8, 1906, to Feb. 14, 1907, by W. M. Barr; Feb. 16 to 25, 1907, by H. S. Spaulding; Feb. 26 to Sept. 12, 1907, by Walton Van Winkle.

[b] Abnormal; computed as HCO_3 in the average.

The following analyses of waters in the White River basin were received from the Lake Shore & Michigan Southern Railroad (New York Central System).

Anlyses of waters in White River basin.

1. West Fork of White River at Muncie, Ind.
2. West Fork of White River at Indianapolis, Ind.
3. Pogues Run at Indianapolis.
4. Fall Creek at Indianapolis.

	Parts per million.				Percentage composition.			
	1	2	3	4	1	2	3	4
CO_3	124.5	129.3	69.6	148.1	49.71	44.47	26.63	35.42
SO_4	23.5	41.4	78.2	99.4	9.39	14.23	29.94	23.76
Cl	7.1	8.6	21.3	27.1	2.82	2.96	8.14	6.48
NO_3	2.6	11.0			1.03	3.78		
Ca	57.9	67.4	47.9	85.5	23.12	23.19	18.34	20.45
Mg	21.4	23.7	11.1	29.4	8.56	8.16	4.25	7.03
Na(K)	4.6	5.6	28.6	24.0	1.82	1.92	10.93	5.75
Oxides[a]	8.9	3.8	4.6	4.6	3.55	1.29	1.77	1.11
	250.5	290.8	261.3	418.1	100.00	100.00	100.00	100.00

[a] Silica plus sesquioxides.

For a large part of its course the Wabash forms the boundary between Indiana and Illinois, and from the latter State it receives several large tributaries. Three of these, the Vermilion,[29] the Embarrass, and the Little Wabash, have been studied by W. D. Collins and the analyses were published in Water-Supply Paper 239, 1910. His tables, giving annual averages, are as follows:

Analyses of water from Vermilion River near Danville, Ill.

[Parts per million.]

Date (1906-7).		Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total solids.
From—	To—												
Aug. 2	Aug. 10	135	20	0.40	48	31	27	0.0	272	39	0.7	5.7	299
11	20	300	18	.5	38	24	11	.0	193	27	2.7	3.2	216
22	30	425	19	.20	36	15	15	.0	163	25	4.5	4.5	222
31	Sept. 9	117	15	.10	56	28	15	.0	241	36	3.0	5.0	282
Sept. 10	19	50	13	.30	44	28	8.7	.0	285	38	.8	5.0	267
20	29	142	20	.12	49	24	15	.0	282	32	1.8	7.0	264
30	Oct. 9	90	11	.07	52	26	18	.0	270	36	1.2	5.0	275
Oct. 10	19												
20	29	20	12	.04	59	36	23	.0	326	41	.6	7.5	322
30	Nov. 8	10.0	13	.10	63	36	20	.0	350	46	.3	6.5	342
Nov. 9	19	20	6.2	.03	60	36	21	.0	330	44	.6	7.5	318
20	30	161	16	.05	53	25	10.0	.0	220	46	8.0	3.5	279
Dec. 1	Dec. 10	125	21	.06	56	26	12	.0	254	47	14	4.2	302
11	20	50	12	.17	56	27	8.0	.0	236	42	16	4.8	301
21	31	40	10.0	.24	58	28	14	.0	275	46	12	4.5	314
Jan. 1	Jan. 10	270	19	.37	39	22	14	.0	189	67	12	4.7	254
11	19	296	17	.6	43	18	13	.0	190	47	5.5	3.0	245
21	31	90	20	1.1	50	22	13	.0	189	41	16	5.0	263
Feb. 1	Feb. 9	10.0	15	.16	62	27	13	.0	265	47	16	5.2	330
10	18	45	18	.09	56	23	14	.0	240	55	12	5.0	316
20	28	10.0	8.4	.13	57	24	14	.0	247	50	16	5.0	299
Mar. 1	Mar. 10	7.0	11	.13	49	23	14	.0	243	39	8.0	3.8	279
11	20	230	15	.70	49	20	13	.0	180	50	12	3.5	256
21	31	160	15	.54	48	22	9.3	.0	207	48	24	4.8	250
Apr. 1	Apr. 10	25	14	.18	55	25	9.3	.0	236	44	24	4.0	266
11	20	5.0	8.6	.23	54	21	10.0	.0	242	45	19	2.5	264
21	30	19	4.7	1.3	56	35	8.7	.0	247	52	11	3.0	295
May 1	May 10	45	18	.26	50	18	9.5	.0	227	45	24	3.8	274
11	20	25	9.2	.15	56	24	9.2	.0	243	40	24	3.8	288
21	31	35	11	.15	56	28	9.2	.0	239	44	24	3.8	276
June 1	June 10	330	13	.18	50	26	8.1	.0	175	37	20	4.2	230
11	20	65	11	.25	63	26	8.7	.0	250	42	16	4.3	304
21	30	100	14	.57	61	24	8.6	.0	245	34	10.0	3.0	258
July 1	July 10	70	17	.25	65	25	6.7	.0	267	37	16	5.0	301
11	20	460	13	.24	64	21	8.2	.0	221	34	18	3.3	290
21	31	55	17	.23	64	25	8.9	.0	265	35	24	4.0	285
Mean		115	14	.29	54	25	13	.0	243	42	12	4.5	281

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[29] Another Vermilion River is an affluent of the Illinois. The sources of the two are near together.

Analyses of water from Embarrass River near Charleston, Ill.

[Parts per million.]

Date (1906-7). From—	Date (1906-7). To—	Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total solids.
Aug. 1	Aug. 10	215	27	0. 35	48	25	20	0. 0	251	31	2. 8	7. 5	297
11	20	268	21	. 20	39	18	12	. 0	182	22	2. 1	4. 2	230
22	30	400	22	. 06	36	18	16	. 0	182	24	3. 5	2. 0	226
31	Sept. 9	100	18	. 08	57	29	15	. 0	282	28	1. 7	5. 5	282
Sept. 10	19	214	21	. 30	38	20	7. 3	. 0	190	22	1. 4	3. 5	214
20	27	220	17	. 45	38	18	11	. 0	192	23	2. 5	5. 5	212
30	Oct. 9	182	19	. 04	56	28	28	. 0	287	27	3. 0	5. 0	316
Oct. 10	19	70	11	. 16	58	31	16	. 0	315	36	1. 5	5. 0	310
20	28	30	10. 0	. 14	61	33	21	. 0	322	32	0. 5	7. 2	291
29	Nov. 10												
Nov. 11	19	100	6. 4	. 10	59	39	16	. 0	320	30	0. 4	7. 2	293
20	30	200	18	. 06	37	22	11	. 0	246	18	5. 0	5. 3	258
Dec. 1	Dec. 10	160	26	. 20	54	25	18	. 0	280	32	8. 0	4. 0	283
11	20	144	13	. 09	54	26	11	. 0	257	26	8. 0	5. 5	277
21	31	224	12	. 32	57	31	10. 0	. 0	286	34	8. 0	6. 0	300
Jan. 1	Jan. 10	280	17	. 57	43	21	13	. 0	219	34	9. 0	5. 0	236
11	18	275	30	. 80	38	16	15	. 0	200	35	7. 0	4. 2	254
21	31	100	32	3. 6	41	20	10. 0	. 0	200	22	8. 0	4. 2	232
Feb. 1	Feb. 8	20	11	. 15	55	24	8. 0	. 0	253	33	6. 0	5. 0	271
10	18	25	19	. 13	52	21	13	. 0	260	43	8. 5	5. 0	291
19	28	25	14	. 08	42	23	14	. 0	267	33	8. 0	5. 0	281
Mar. 1	Mar. 10	25	11	. 26	52	24	13	. 0	250	41	8. 0	4. 5	289
11	20	800	18	. 24	45	18	11	. 0	173	39	10. 0	7. 5	237
21	31	100	15	. 23	51	25	15	. 0	242	39	16	4. 3	278
Apr. 1	Apr. 10	10. 0	9. 0	. 26	54	24	9. 6	. 0	249	48	16	5. 5	269
11	20	8. 0	10. 0	. 16	52	25	9. 9	. 0	250	34	14	4. 5	264
21	30	70	11	. 45	49	29	6. 3	. 0	225	32	9. 2	5. 5	256
May 1	May 10	20	13	. 12	52	24	15	. 0	267	32	12	5. 5	285
11	20	30	8. 2	. 16	49	22	12	. 0	256	35	10. 0	7. 3	281
21	31	30	5. 0	. 50	50	23	10. 0	. 0	250	31	10. 0	4. 3	276
June 1	June 10	200	16	. 36	50	24	13	. 0	228	25	13	3. 8	267
11	20	90	17	. 34	65	29	7. 5	. 0	284	32	6. 0	3. 5	277
21	30	200	16	. 23	57	21	11	. 0	281	29	13	4. 5	269
July 1	July 10	80	20	. 15	66	25	13	. 0	280	26	18	4. 5	312
11	20	422	22	. 26	50	21	13	. 0	217	27	7. 0	3. 0	243
21	31	100	26	. 21	64	24	14	. 0	270	30	10. 0	3. 2	301
Mean		155	17	. 34	51	24	13	. 0	249	31	7. 6	4. 9	270

Analyses of water from Embarrass River near Lawrenceville, Ill.

[Parts per million.]

Date (1906-7). From—	Date (1906-7). To—	Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total solids.
Aug. 1	Aug. 10	280	24	0. 30	42	22	29	0. 0	207	33	1. 2	26	278
11	20	220	15	. 14	33	18	18	. 0	150	23	2. 4	23	231
21	30	268	17	. 30	33	18	32		123	26	1. 5	45	240
31	Sept. 16	148	15	. 20	42	22	19	. 0	205	24	. 8	26	251
Sept. 17	26												
27	Oct. 12					19							
Oct. 13	19	20	18	. 08	59	27	49	. 0	274	45	7. 0	64	426
20	29	20	16	. 10	55	25	43	. 0	270	36	. 3	61	371
30	Nov. 8	20	11	. 10	60	34	87	. 0	305	49	. 2	114	472
Nov. 9	18	20	16	. 05	72	31	48	. 0	335	50	5. 5	75	468
20	30	220	15	. 20	66		55	. 0	229	64	. 3	88	458
Dec. 14	Dec. 20												
21	31	103	21	. 32	49	23	20	. 0	227	46	5. 0	20	308
Jan. 1	Jan. 10	214	20	3. 7	19	8. 5	18	. 0	100	27	2. 5	9. 5	166
11	20	161	31	1. 4	28	16	17	. 0	136	36	4. 5	9. 2	205
21	31	159	25	1. 7	24	9. 5	17	. 0	104	30	4. 0	8. 2	174
Feb. 2	Feb. 9	45	14	. 22	46	20	27	. 0	203	43	2. 0	20	268
10	18	12	11	. 13	52	22	21	. 0	234	44	6. 0	24	284
19	28	8. 0	18	. 07	54	24	25	. 0	244	54	6. 0	32	342
Mar. 1	Mar. 10	50	14	. 15	52	18	33	. 0	205	29	4. 2	46	342
11	20	280	22	2. 2	26	10. 0	15	. 0	111	38	9. 2	14	192
21	31	120	19	. 78	44	16	19	. 0	198	39	14	16	274
Apr. 1	Apr. 10												
11	20	15	13	. 13	55	26	28	. 0	240	42	3. 3	40	325
21	30	112	10	. 32	45	24	29	. 0	243	43	2. 6	51	296
May 1	May 10	210	13	. 62	37	12	22	. 0	143	35	2. 4	28	238
11	20	80	11	. 15	42	17	31	. 0	183	52	3. 2	40	287
21	31	120	19	. 30	34	15	17	. 0	141	34	1. 5	26	235
June 1	June 10	200	9. 2	. 29	26	9. 3	13	. 0	91	17	2. 7	12	120
11	20	100	18	. 59	48	23	17	. 0	187	28	2. 0	19	251
21	30	220	18	. 90	51	18	19	. 0	190	26	1. 4	36	255
July 1	July 10	43	17	. 14	55	20	20	. 0	231	25	7. 0	18	275
11	20	181	13	. 11	39	18	28	. 0	158	21	2. 1	38	246
21	31	68	15	. 22	45	17	15	. 0	170	24	6. 0	22	222
Mean		118	17	. 53	44	19	28	. 0	195	35	3. 7	35	283

Analyses of water from Little Wabash River near Carmi, Ill.

[Parts per million.]

Date (1906-7).		Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total solids.	Mean gage height (feet).
From—	To—													
Aug. 1	Aug. 10	20	38	0.20	27	15	18	0.0	171	19	0.8	----------	219	----------
11	20	40	22	.20	31	16	22	.0	160	26	1.9	12	211	----------
21	30	144	28	.25	23	8.3	14	.0	97	25	1.5	14	174	----------
31	Sept. 9	142	38	.32	21	13	14	.0	91	22	1.5	6.3	163	----------
Sept. 10	19	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------
20	29	90	18	.30	23	13	15	.0	95	24	2.0	5.5	147	----------
30	Oct. 9	127	19	.35	16	10	14	.0	76	21	1.5	9.0	138	1.3
Oct. 10	18	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	0.7
20	29	70	30	2.0	22	9.3	21	.0	93	32	.6	6.5	188	0.6
30	Nov. 7	30	26	.6	24	14	16	.0	118	44	.9	11	187	0.5
Nov. 9	19	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	0.6
20	30	430	18	.6	13	4.0	6.4	.0	39	19	3.0	1.0	111	6.4
Dec. 1	Dec. 9	192	27	1.5	17	9.1	16	.0	69	33	3.5	8.8	153	4.5
12	20	273	39	3.7	15	3.8	15	.0	52	23	2.5	6.5	185	8.4
21	31	151	39	3.7	16	5.3	16	.0	64	38	2.5	5.5	184	7.5
Jan. 1	Jan. 10	220	31	9.9	7.8	6.2	15	.0	54	26	6.0	4.2	140	17.1
11	20	94	35	3.2	10.0	3.8	13	----------	51	31	1.2	4.0	159	19.8
41	31	60	17	.40	11	5.2	10.0	.0	44	30	4.0	5.5	138	26.0
Feb. 1	Feb. 9	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	21.6
10	18	40	21	2.8	25	9.6	16	.0	108	42	2.0	7.5	193	5.8
19	28	35	15	.9	32	12	21	.0	126	51	1.5	16	219	0.9
Mar. 1	Mar. 10	100	24	2.2	28	15	25	.0	104	74	3.0	11	239	3.5
11	20	330	25	4.9	8.5	6.7	19	.0	57	35	1.5	7.3	187	11.8
21	31	145	48	6.5	15	6.7	18	----------	69	38	2.7	6.0	240	22.3
Apr. 1	Apr. 10	60	24	2.3	36	15	14	----------	126	51	2.8	8.0	227	5.8
11	20	60	19	1.3	36	17	17	.0	153	52	1.8	8.3	236	1.9
21	30	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	1.8
May 1	May 10	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	3.7
11	20	140	25	1.1	21	11	12	.0	86	43	2.5	9.0	182	2.7
21	31	155	18	.74	22	7.9	11	.0	74	30	1.2	7.0	151	3.1
June 1	June 10	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	8.8
11	20	155	26	1.1	19	7.7	10.0	.0	64	14	1.5	5.5	149	9.8
21	30	220	22	4.9	20	4.8	12	.0	102	24	2.4	6.0	153	4.7
July 1	July 10	110	14	1.6	18	3.9	8.1	.0	80	22	1.7	6.0	134	2.0
11	20	120	15	.19	18	6.4	11	.0	83	22	1.2	6.5	137	1.7
21	31	160	33	1.7	14	4.8	10.0	.0	53	19	1.5	5.0	150	----------
Mean		135	26	2.0	20	9.1	15	.0	88	32	2.1	7.5	176	----------

Apart from the individual analyses, most of them of local significance, there are eight tables of analyses of waters in the Wabash basin. Each of these tables gives the average composition of a water during an entire year. In the next table the averages are restated in terms of the percentage composition of the dissolved solids, with bicarbonates reduced to normal carbonates and Fe recalculated into Fe_2O_3.

The alkalies in analysis No. 3 are corrected by Palmer's later determination of potassium.

Percentage composition of Wabash waters.

1. Wabash River near Logansport, Ind. Mean of 33 analyses of 10-day composite samples.
2. Wabash River near Vincennes, Ind. Mean of 31 composites.
3. East Fork of White River near Azalia, Ind. Mean of 37 composites.
4. West Fork of White River near Indianapolis, Ind. Mean of 35 composites.
5. Vermilion River near Danville, Ill. Mean of 36 composites.
6. Embarrass River near Charleston, Ill. Mean of 36 composites.
7. Embarrass River near Lawrenceville, Ill. Mean of 34 composites.
8. Little Wabash River near Carmi, Ill. Mean of 31 composites.

	1	2	3	4	5	6	7	8
CO_3	15.04	34.09	47.85	31.76	42.02	45.12	34.45	27.42
SO_4	10.32	16.57	10.58	12.88	14.77	11.41	12.57	20.26
Cl	38.15	10.84	1.10	17.32	1.59	1.81	12.57	4.75
NO_3	.77	1.93	1.97	1.36	4.20	2.80	1.32	1.33
Ca	10.72	18.37	21.51	16.44	19.00	18.79	15.80	12.67
Mg	4.57	6.63	8.11	6.44	8.79	8.82	6.82	5.76
Na	18.55	7.56	2.75	10.66	4.57	4.79	10.06	9.50
K			.77					
SiO_2	1.83	3.92	5.29	3.10	4.92	6.26	6.11	16.47
Fe_2O_3	.05	.09	.07	.04	.14	.20	.30	1.84
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Salinity [a]	765	336	279	450	284	271.5	278.4	158

These waters of the Wabash basin show no uniformity of type. Nos. 3, 5, and 6 are ordinary carbonate waters and contain rather more than the average proportion of magnesium. Nos. 1, 2, 4, and 7 are abnormally high in chlorine, which is an indication of pollution. No. 1, of water from the Wabash at Logansport, is in this respect unusually bad. The source of the comtamination is not indicated.

CACHE RIVER.

Cache River drains an area of about 600 square miles in southwestern Illinois, and enters the Ohio a short distance above the mouth of the latter. In its basin there are extensive swamps. The analyses, by W. D. Collins, appear in the following table, from Water-Supply Paper 239:

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[a] Parts per million.

Analyses of water from Cache River near Mounds, Ill.

[Parts per million.]

Date (1906-7). From—	To—	Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total solids.	Mean gage height (feet).
Aug. 1	Aug. 10	210	4.6	0.20	26	10.0	13	0.0	121	4.3	1.0	7.2	166	----------
11	20	220	20	1.0	18	7.4	29	7.4	93	20	.9	5.0	141	----------
21	30	155	31	.60	22	7.0	38	.0	90	35	1.0	15	211	----------
31	Sept. 9	130	16	.17	22	9.1	20	.0	94	14	1.0	6.5	139	----------
Sept. 10	19	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------
20	29	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	3.8
30	Oct. 9	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	7.4
Oct. 10	19	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	8.4
20	31	40	9.2	.26	33	13	17	.0	159	27	.7	7.0	190	3.2
Nov. 1	Nov. 8	40	22	.19	42	8.7	25	.0	211	44	.6	19	284	2.9
15	21	155	26	.25	19	3.8	39	.0	108	43	1.5	23	244	3.0
22	30	168	28	.80	19	4.5	37	.0	85	35	2.0	14	229	8.5
Dec. 1	Dec. 10	273	23	2.8	9.7	3.6	11	.0	59	14	1.2	6.0	129	5.2
11	20	90	22	3.2	9.7	3.0	7.4	.0	41	18	3.0	3.0	126	7.7
21	31	50	28	2.8	9.2	6.4	14	.0	59	17	2.7	3.0	117	11.5
Jan. 1	Jan. 10	182	39	6.5	8.3	3.1	17	.0	72	19	1.2	3.7	170	17.3
11	20	112	29	5.2	12	4.0	11	.0	62	18	2.7	4.7	142	23.6
21	31	50	24	2.8	12	6.3	14	.0	66	19	2.4	4.0	121	24.5
Feb. 1	Feb. 9	40	23	2.5	13	3.7	12	.0	58	22	3.5	4.5	129	19.4
10	17	20	19	4.8	15	5.6	11	.0	74	13	1.0	6.7	115	13.4
19	28	175	21	4.9	14	3.9	8.2	.0	70	16	6.0	5.5	121	7.3
Mar. 1	Mar. 10	100	33	----------	12	5.4	13	.0	42	15	1.2	3.0	138	8.8
11	20	290	43	4.5	15	1.5	7.0	.0	57	9.2	2.4	4.0	169	15.8
21	31	130	21	7.4	16	4.0	9.0	.0	64	16	1.2	3.8	119	17.5
Apr. 1	Apr. 10	340	24	2.6	18	5.6	8.7	.0	69	15	7.0	3.3	125	10.1
11	20	55	18	3.4	16	6.3	9.0	.0	94	13	.6	4.5	138	5.0
21	31	45	10.0	1.5	23	8.5	6.9	.0	96	12	1.5	4.5	118	6.0
May 1	May 10	145	12	1.5	28	5.8	19	.0	104	36	1.0	13	----------	9.2
11	20	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	14.8
21	21	125	22	.58	16	3.5	7.0	.0	52	12	.6	4.0	92	10.3
June 1	June 10	195	11	.56	20	5.3	8.6	.0	69	27	1.4	5.3	100	11.7
11	20	149	18	3.8	25	9.0	3.9	.0	94	17	1.3	3.0	140	18.8
21	30	65	20	4.5	24	8.5	6.2	.0	85	11	8.0	4.5	131	16.2
July 1	July 10	103	15	.20	23	5.9	8.8	.0	97	9.7	2.0	4.5	116	8.2
11	20	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	7.1
21	31	160	24	2.6	25	9.0	13	.0	100	10.0	.7	10.0	158	11.6
Mean		134	22	2.5	19	6.0	15	.0	85	19	2.1	6.8	149	----------

TRIBUTARIES OF THE OHIO SOUTHWEST OF WHEELING.

Southwest of Wheeling there are several creeks for which analyses have been obtained, and also Little Kanawha and Kanawha rivers. Six analyses of waters in this group have been received from the Baltimore & Ohio Railroad and are given, with one other composite analysis, in the following table. The localities named are all in West Virginia.

Analyses of waters southwest of Wheeling, W. Va.

1. Grave Creek at Cameron.
2. Big Grave Creek at Roseby Rock.
3. Fish Creek at Littleton.
4. Fish Creek at Bellton.
5. Little Kanawha River at Kanawha.
6. Little Kanawha River at Parkersburg.
7. Kanawha River at South Charleston. Mean of four composites of 28 daily samples, taken between July 26 and August 28, 1918. Analyses by A. A. Chambers in the water resources laboratory of the Geological Survey.

I. Parts per million.

	1	2	3	4	5	6	7
CO_3	33.3	48.7	22.5	20.5	33.4	22.9	28.0
SO_4	27.2	21.7	11.5	11.5	2.4	4.7	10.4
Cl	3.9	2.0	2.0	2.0	4.9	16.1	6.4
NO_3	--------	--------	--------	--------	--------	--------	.8
Ca	17.4	31.3	17.1	16.7	20.9	12.6	14.8
Mg	2.9	6.1	1.6	1.0	1.4	2.8	4.5
Na (K)	15.6	1.3	1.3	1.3	3.2	10.4	8.3
SiO_2	--------	--------	--------	--------	--------	--------	38.2
Fe_2O_3	--------	--------	--------	--------	--------	--------	1.0
Oxides [a]	22.6	8.0	18.0	19.0	64.8	25.0	--------
	122.9	119.1	74.0	72.0	131.0	94.5	112.4

[a] Silica plus sesquioxides.

Analyses of waters southwest of Wheeling, W. Va.—Continued.

II. Percentage composition of dissolved solids.

	1	2	3	4	5	6	7
CO_3	27.09	40.89	30.46	28.51	25.50	24.23	24.94
SO_4	22.13	18.21	15.52	15 93	1.84	5.00	9.26
Cl	3.21	1.66	2.67	2.74	3.73	17.04	5.65
NO_3	--------	--------	--------	--------	--------	--------	.67
Ca	14.15	26.30	23.13	23.26	15.96	13.30	13.13
Mg	2.36	5.13	2.18	1.42	1.08	2.92	4.02
Na(K)	12 68	1.07	1.73	1.77	2.41	11.05	7.35
SiO_2	--------	--------	--------	--------	--------	--------	34.09
Fe_2O_3	--------	--------	--------	--------	--------	--------	.89
Oxides [a]	18.38	6.74	24.31	26.37	49.48	26.46	--------
	100.00	100.00	100.00	100.00	100.00	100.00	100.00

[a] Silica plus sesquioxides.

The waters represented in this table are all from areas of sedimentary rocks. With one possible exception they appear to issue from formations in which shales and sandstones are largely in excess of limestones. The high proportion of silica and oxides and the low proportion of calcium give evidence in favor of this conclusion, even if nothing were definitely known of the local geology. The very high sodium and chlorine in the little Kanawha at Parkersburg is due to the proximity of oil and brine wells.

KENTUCKY RIVER.

West of the Kanawha the principal southern affluents of the Ohio are Big Sandy, Licking, Kentucky, Green, Cumberland, and Tennessee rivers. For the Kentucky we have the following table of analyses by Dole and his associates:

Analyses of water from Kentucky River at Frankfort, Ky.[a]

[Parts per million.]

Date (1906-7).		Turbidity.	Total iron (Fe).	Silica (SiO₂).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO₃).	Bicarbonate radicle (HCO₃).	Sulphate radicle (SO₄).	Nitrate radicle (NO₃).	Chlorine (Cl).	Total dissolved solids.	Mean gage height (feet).
From—	To—														
Aug. 28	Sept. 7	70	2.7	15	0.9	--------	2.2	11	0.0	77	5.4	Tr.	1.4	102	6.4
Sept. 8	17	180	4.0	28	1.2	18	4.2	8.9	.0	80	6.4	1.5	1.7	120	6.8
18	27	165	5.2	23	1.4	21	2.6	7.2	.0	76	7.6	2.4	1.9	117	6.4
28	Oct. 7	160	4.9	21	.8	30	4.6	9.1	.0	111	8.2	2.6	1.7	147	7.3
Oct. 8	18	105	2.7	19	.6	27	4.8	6.5	.0	103	8.7	2.8	2.4	133	7.0
19	28	50	2.0	5.2	.4	21	4.2	5.5	.0	83	7.6	1.7	2.2	105	6.0
29	Nov. 8	43	--------	19	.3	22	4.6	6.8	.0	89	2.0	2.0	2.4	111	5.8
Nov. 9	19	32	--------	14	.12	25	4.4	7.2	.0	90	7.9	2.1	2.2	112	5.8
20	30	--------	8.8	12	.7	26	4.0	6.5	.0	89	10	5.0	3.0	117	8.9
Dec. 1	Dec. 12	105	1.9	15	.6	26	5.4	4.3	.0	80	--------	6.2	--------	117	6.2
13	23	450	9.3	15	.65	27	4.8	3.6	.0	99	6.9	7.4	1.8	125	10.6
24	Jan. 2	270	5.8	18	1.4	25	4.6	3.0	.0	79	7.9	6.4	1.7	118	10.2
Jan. 3	12	210	3.2	14	.4	28	4.8	3.6	.0	94	9.4	7.4	1.4	121	9.5
13	22	700	16	15	.7	26	5.2	5.2	.0	96	7.4	7.0	1.8	125	19.1
23	Feb. 1	150	4.2	14	.8	22	4.8	5.0	.0	--------	8.1	5.0	1.2	95	9.6
Feb. 2	11	65	3.5	13	.16	13	4.0	3.8	5.8	45	8.1	.4	1.4	73	8.4
12	21	36	1.9	9.8	.09	18	3.8	5.5	14	40	8.9	.9	2.4	83	8.0
22	Mar. 3	200	10	4.0	.15	18	3.4	4.3	12	46	8.9	1.8	2.0	78	10.1
Mar. 4	13	210	5.8	12	.35	19	3.6	6.2	.0	74	8.7	4.1	1.6	96	10.4
14	23	650	23	21	.4	18	3.4	6.5	.0	70	8.2	4.0	1.3	100	13.0
24	Apr. 2	43	1.4	11	.12	21	4.0	5.7	2.9	73	8.2	2.8	2.4	92	6.7
Apr. 3	12	90	2.1	15	.18	18	3.2	6.9	.0	63	8.4	2.2	2.5	88	8.0
14	23	26	1.4	22	.21	13	1.3	8.7	2.4	49	6.2	1.5	2.6	86	7.3
24	May 3	24	.5	12	.06	14	1.4	6.4	.0	59	7.7	.3	2.2	86	6.8
May 4	13	90	3.0	18	.10	18	3.0	7.9	.0	89	4.0	.5	1.4	100	9.0
14	23	49	1.9	34	.6	20	2.4	9.1	.0	82	7.6	2.0	1.9	131	7.2
25	June 3	26	.8	15	.10	21	3.8	7.9	2.9	77	7.7	1.5	2.4	102	6.7
June 4	13	375	13	22	1.3	13	1.7	9.1	.0	51	7.2	1.8	2.4	106	9.4
14	24	215	5.6	16	.61	14	1.3	9.9	.0	54	11	1.5	1.4	93	8.3
26	July 5	68	2.3	12	.11	16	3.8	6.1	8.4	49	7.1	Tr.	1.8	81	6.3
July 7	16	40	1.8	16	.05	17	4.8	9.1	12	46	12	Tr.	2.2	85	6.4
17	26	190	3.8	28	.52	17	--------	9.9	8.4	58	12	.0	2.4	108	6.2
27	Aug. 5	33	1.4	7.8	.26	21	--------	6.6	17	41	9.9	.0	2.6	87	5.9
Aug. 6	15	45	2.1	16	.49	21	--------	7.5	.0	72	9.1	1.3	.6	96	5.7
16	25	20	1.0	16	.16	22	--------	8.3	.0	78	9.4	1.2	3.6	99	6.1
26	Sept. 4	70	2.4	22	.70	22	--------	7.2	.0	78	8.7	1.3	3.0	112	6.4
Mean		150	4.7	16	.49	21	3.7	6.8	2.4	73	8.3	2.5	2.0	104	--------

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[a] Analyses Aug. 28, 1906, to Jan. 22, 1907, by R. B. Dole; Jan. 23 to Apr. 2, 1907, by R. B. Dole and M. G. Roberts; Apr. 3 to July 5, 1907, by Chase Palmer and M. G. Roberts; July 7 to Sept. 4, 1907, by R. B. Dole, Chase Palmer, and W. D. Collins.

For one tributary of Kentucky River the following analysis is available, made by C. H. Kidwell and Margaret D. Foster in the water-resources laboratory of the United States Geological Survey.

Analysis of water from Elkhorn Creek, 4½ miles northeast of Frankfort, Ky.

1. Parts per million.
2. Percentage composition of dissolved solids.

	1	2
CO_3	92.7	39.90
SO_4	19.0	8.18
Cl	6.7	2.88
NO_3	4.6	1.98
Ca	57.0	24.54
Mg	5.0	2.15
Na	12.0	5.16
K	2.0	.86
Al_2O_3	1.3	.56
Fe_2O_3	.1	.01
SiO_2	32.0	13.78
	232.4	100.00

CUMBERLAND RIVER.

Cumberland River drains an area of about 18,000 square miles in Tennessee and Kentucky. For this river there are two tables of analyses by Dole and his associates, as follows:

Analyses of water from Cumberland River near Nashville, Tenn.[a]

[Parts per million.]

Date (1906-7).		Tur-bidity.	Total iron (Fe.)	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magne-sium (Mg).	Sodium and po-tassium (Na+K).	Car-bonate radicle (CO_3).	Bicar-bonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total dissolved solids.	Mean gage height (feet).
From—	To—														
Oct. 24	Nov. 3	75	--------	29	4.0	33	3.2	--------	0.0	115	--------	0.6	2.0	139	8.8
Nov. 4	13	28	--------	26	.20	26	1.2	--------	.0	90	--------	.7	3.5	112	8.0
14	23	30	--------	27	.30	24	1.2	--------	.0	76	--------	.8	3.0	109	18.1
24	Dec. 3	35	--------	28	.20	24	2.0	--------	.0	81	--------	.8	2.5	106	17.1
Dec. 4	13	50	--------	29	.20	22	2.8	--------	.0	83	--------	.6	2.8	111	9.5
14	23	75	--------	28	.30	27	3.6	--------	.0	85	--------	.5	3.0	114	20.0
24	Jan. 2	135	--------	33	.20	27	2.8	--------	.0	85	--------	.8	1.0	128	21.3
Jan. 3	12	150	--------	22	.30	23	--------	--------	.0	81	--------	.6	.18	110	25.0
13	22	60	--------	31	.10	26	3.6	--------	.0	93	--------	1.0	1.7	118	15.1
23	Feb. 1	75	--------	20	.40	21	4.4	--------	.0	78	--------	.6	2.0	106	18.7
Feb. 2	11	65	--------	13	.30	26	3.6	--------	.0	90	--------	.4	2.0	107	14.2
12	23	90	--------	21	.30	22	3.2	--------	.0	83	--------	.3	1.0	97	11.4
24	Mar. 5	180	--------	31	.30	23	3.6	--------	.0	--------	--------	.4	1.2	114	29.8
Mar. 6	16	350	--------	31	.10	22	--------	--------	.0	78	--------	.5	1.0	112	28.7
17	26	110	--------	25	.30	24	--------	--------	.0	81	--------	.4	2.0	112	22.1
27	Apr. 5	70	--------	15	.30	27	4.0	--------	.0	93	--------	.5	2.0	107	10.3
Apr. 6	15	135	--------	27	.10	20	5.2	--------	.0	78	--------	.2	1.5	100	18.7
16	25	45	--------	9.6	Tr.	17	7.6	--------	.0	76	--------	1.8	1.5	87	11.6
26	May 5	95	--------	12	.20	18	--------	--------	.0	78	--------	1.6	2.0	91	10.3
May 6	15	75	--------	11	.20	18	6.4	--------	.0	73	--------	1.1	--------	88	24.3
15	24	85	--------	20	.30	30	3.2	5.7	.0	98	16	2.7	1.4	128	14.0
25	June [a]3	80	--------	24	.20	--------	4.5	2.9	.0	110	14	2.0	1.5	150	10.2
June 4	13	425	--------	20	.8	31	4.1	7.9	.0	100	16	4.3	2.4	146	16.8
14	23	110	--------	17	.35	22	4.1	5.7	.0	82	18	3.2	1.4	121	14.4
24	July 3	245	--------	14	.24	29	4.7	6.0	.0	115	16	1.9	1.8	138	9.3
July 4	14	100	--------	15	.25	32	4.5	8.9	.0	113	14	1.4	2.4	140	8.2
15	25	30	--------	12	.25	31	5.8	11	.0	--------	14	.9	4.8	140	8.1
26	Aug. 4	70	--------	13	.12	32	--------	8.6	.0	113	9.7	1.7	2.0	122	7.8
Aug. 5	14	195	--------	7.8	.03	33	--------	13	.0	118	14	1.7	3.3	127	8.0
15	24	110	--------	5.2	.20	36	1.8	15	.0	115	20	.6	2.0	135	7.5
25	Sept. 3	80	--------	8.2	.20	33	--------	10	.0	102	14	1.6	1.5	125	7.8
Sept. 5	14	250	--------	14	.45	26	--------	8.2	.0	95	17	.8	2.0	128	8.2
25	Oct. 13	450	12	24	1.3	26	1.4	11	.0	90	10	1.6	1.8	127	8.8
Oct.[a] 14	24	215	6.1	28	1.0	24	3.0	16	[b]Tr.	95	13	1.3	3.6	140	8.0
25	Nov. 3	45	3.0	19	.9	27	.9	14	[b]Tr.	99	12	1.0	2.4	130	7.4
Mean		126	--------	20	.42	26	3.6	9.6	.0	92	14	1.2	2.1	119	--------

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[a] Analyses Oct. 24, 1906, to May 15, 1907, by Jas. R. Evans; May 15 to Sept. 14, 1907, by Waltop Van Winkle; Sept. 25 to Nov. 3, 1907, by R. B. Dole, Chase Palmer, and W. D. Collins.

[b] Abnormal; computed as HCO_3 in the average.

Analyses of water from Cumberland River near Kuttawa, Ky.[a]

[Parts per million.]

Date (1906-7).		Tur-bidity.	Total iron (Fe).	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magne-sium (Mg).	Sodium and po-tassium (Na+K).	Car-bonate radicle (CO_3).	Bicar-bonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total dissolved solids.	Mean gage height (feet).
From—	To—														
Jan. 11	Jan. 20	45	--------	29	0.20	27	7.2	--------	0.0	110	--------	0.6	2.7	147	17.1
21	Feb. 2	95	--------	18	.40	24	3.6	--------	.0	78	--------	1.0	1.7	--------	24.2
Feb. 3	12	70	--------	25	.30	24	3.6	--------	.0	85	--------	.4	1.5	118	16.3
13	23	170	--------	25	.10	23	--------	--------	.0	85	--------	.6	1.5	104	11.7
24	Mar. 7	320	--------	31	.20	22	4.8	--------	.0	--------	--------	.3	1.8	108	36.8
Mar. 8	17	290	--------	38	.40	24	3.2	--------	.0	80	--------	.8	1.5	122	33.4
18	27	180	--------	23	.20	22	5.6	--------	.0	--------	--------	.5	2.5	108	27.5
28	Apr. 6	85	--------	18	.20	26	--------	--------	.0	102	--------	.4	3.0	124	9.7
Apr. 7	16	35	--------	10	.10	27	4.0	--------	.0	83	--------	.9	1.5	96	21.1
17	26	100	--------	7.6	.20	26	3.6	--------	.0	80	--------	2.2	2.0	91	10.9
27	May 6	95	--------	8.4	Tr.	25	4.8	--------	.0	80	--------	2.9	4.0	94	9.9
May 6	15	340	--------	11	.6	27	4.2	8.2	.0	99	7.1	5.0	1.0	112	34.7
17	26	130	--------	17	.30	31	4.6	7.2	.0	118	7.2	3.0	4.0	131	16.6
27	June 5	120	--------	11	.40	33	5.4	4.4	.0	121	13	1.5	4.0	137	10.1
June 6	16	490	--------	17	.8	25	3.1	--------	.0	101	6.9	1.7	2.0	122	22.3
17	28	180	--------	14	.40	27	3.4	8.0	.0	105	6.7	2.5	3.5	123	11.1
29	July 8	80	--------	16	.20	31	3.9	--------	.0	126	8.2	1.9	3.5	137	5.5
July 9	18	142	--------	12	.20	34	4.2	9.1	.0	--------	8.1	1.5	4.0	135	4.3
19	29	20	1.0	17	.07	34	4.8	8.2	3.6	111	8.7	1.4	3.9	136	3.7
30	Aug. 8	25	1.1	27	.06	36	5.7	10	2.4	124	8.7	1.8	4.2	153	2.8
Aug. 9	22	200	6.1	24	.26	35	4.6	9.5	2.4	123	8.6	1.6	3.8	152	4.1
Sept. 2	Sept. 11	220	6.6	19	.24	35	5.6	11	4.8	112	11	1.4	5.0	149	3.0
12	21	350	12	26	1.2	28	4.6	8.5	Tr.	100	13	3.8	3.0	145	6.9
22	Oct. 1	300	12	19	.9	21	3.6	6.6	Tr.	73	9.0	3.5	4.2	108	6.2
Oct. 2	11	220	10	16	.52	29	4.1	6.4	Tr.	96	10	2.2	3.0	125	4.1
12	21	200	11	7.4	.24	28	4.0	6.9	7.2	82	10	.8	3.0	107	4.9
22	31	150	6.6	16	.35	31	4.7	9.4	Tr.	115	10	2.4	5.0	133	1.9
Nov. 1	Nov. 10	90	3.5	9.2	.11	34	5.2	7.1	4.8	107	11	2.2	4.8	129	4.0
11	21	270	12	12	.32	31	4.8	9.0	4.8	99	13	2.0	3.8	128	9.3
22	Dec. 1	220	10	13	.54	30	3.7	6.9	Tr.	102	11	2.0	3.0	141	13.0
Dec. 2	11	170	3.3	17	.04	22	3.4	8.5	.0	--------	10	2.4	2.4	105	7.5
12	21	70	2.2	14	.04	32	2.2	5.4	.0	106	11	2.3	2.4	126	7.2
22	31	260	7.9	15	.15	34	4.6	8.2	.0	110	12	3.0	2.2	137	14.8
Jan. 1	Jan. 11	240	8.0	15	.10	27	3.1	5.7	.0	84	8.9	2.0	2.2	111	--------
Mean		176	--------	18	.30	28	4.3	7.8	.9	100	9.7	1.8	3.0	124	--------

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[a] Analyses Jan. 11 to May 6, 1907, by Jas. R. Evans; May 6 to July 18, 1907, by W. D. Collins; July 19, 1907, to Jan. 11, 1908, by R. B. Dole, Chase Palmer and W. D. Collins.

[b] Gaging station at Clarkesville, Tenn., 70 miles above.

TENNESSEE RIVER.

Tennessee River, the largest tributary of the Ohio, drains an area of 39,000 square miles in Tennessee and Kentucky. For this river there are two tables of analyses from the water-resources laboratory of the Geological Survey.

Analyses of water from Tennessee River near Knoxville, Tenn.[a]

[Parts per million.]

Date. (1906–7).		Turbidity.	Suspended. matter.	Coefficient of fineness.	Total iron (Fe).	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total dissolved solids.	Mean gage height (feet).
From—	To—																
Oct. 26	Nov. 4	48	21	0.44	--------	18	0.40	26	1.6	--------	0.0	83	--------	0.2	6.0	111	2.5
Nov. 5	14	75	28	.37	--------	26	.6	18	--------	--------	.0	59	--------	.8	--------	93	1.9
15	24	280	212	.76	--------	29	.8	20	3.6	--------	.0	77	--------	.2	12	128	8.4
25	Dec. 4	300	194	.65	--------	26	.9	22	4.0	--------	.0	78	--------	.3	12	124	3.4
Dec. 5	15	215	173	.81	--------	30	.7	23	2.8	--------	.0	93	--------	.3	10	131	2.4
16	30	105	79	.75	--------	24	.10	21	2.8	--------	.0	73	--------	.7	18	136	4.2
31	Jan. 9	80	64	.80	--------	25	.30	21	1.2	--------	.0	66	--------	.9	7.0	105	5.8
Jan. 10	19	25	16	.64	--------	28	.20	20	1.2	--------	.0	68	--------	1.0	10	118	2.8
20	29	25	15	.60	--------	13	.20	20	2.0	--------	.0	63	--------	.8	12	96	2.8
30	Feb. 8	55	33	.60	--------	16	.40	23	3.6	--------	.0	76	--------	.4	4.5	99	3.0
Feb. 25	Mar. 7	45	32	.71	--------	14	.10	24	2.4	--------	.0	80	--------	.4	6.5	103	4.5
Mar. 8	17	60	48	.80	--------	10	.40	26	3.2	--------	.0	85	--------	.3	11	114	5.7
18	27	275	237	.86	--------	37	.20	20	6.4	--------	.0	85	--------	.7	8.5	136	3.4
28	Apr. 6	240	193	.80	--------	38	.20	19	--------	--------	.0	78	--------	.4	10	136	2.8
Apr. 7	16	135	136	1.01	--------	30	.30	26	--------	--------	.0	98	--------	.2	6.5	133	4.4
17	26	155	164	1.06	--------	15	.20	22	--------	--------	.0	85	--------	1.1	9.0	105	3.9
27	May 6	170	196	1.15	--------	20	.30	20	3.6	--------	.0	73	--------	.9	7.5	99	3.9
May 7	14	105	88	.84	--------	12	.20	20	4.4	--------	.0	73	--------	.8	6.5	88	5.1
15	24	55	58	1.06	--------	15	.20	22	5.5	12	--------	102	4.3	.5	10	109	2.4
25	June 3	85	60	.71	--------	12	.40	22	5.7	--------	--------	95	5.0	.5	11	110	2.3
June 4	13	325	450	1.38	--------	17	.6	21	4.3	12	.0	90	5.8	1.3	10	120	6.9
14	23	335	365	1.09	--------	20	.40	24	4.7	--------	.0	103	4.9	2.0	6.0	125	5.6
24	July 3	460	290	.63	--------	25	.30	21	5.0	7.9	.0	101	7.2	1.4	7.0	126	2.9
July 4	13	267	221	.83	--------	19	.40	20	4.8	--------	.0	99	5.6	.6	9.5	120	2.0
14	24	310	300	.97	--------	19	--------	23	5.0	8.2	.0	93	8.1	1.1	7.0	118	3.3
Aug. 4	Aug. 13	350	184	.53	9.1	30	1.4	24	5.6	7.2	Tr.[b]	98	6.9	1.2	11	141	1.8
14	23	425	177	.42	7.2	30	1.1	--------	5.3	9.1	Tr.[b]	101	6.6	1.2	9.6	139	1.7
24	Sept. 2	400	202	.50	11	33	1.4	28	5.9	6.9	[b]3.6	89	7.1	1.0	11	143	1.7
Sept. 3	13	285	117	.41	6.1	44	1.0	25	6.4	10	[b]3.6	92	7.1	Tr.	17	164	1.8
14	28	700	506	.72	18	49	1.9	22	5.7	6.6	Tr.[b]	88	8.4	1.5	13	164	3.1
30	Oct. 15	110	81	.74	3.8	57	1.1	24	6.5	3.8	[b]4.8	85	6.2	.5	14	162	1.7
Oct. 16	26	20	45	2.25	.9	15	.08	26	7.4	6.6	[a]4.8	96	6.5	--------	5.8	119	.8
Mean--------		204	156	.81	--------	25	.54	22	4.3	8.2	.0	86	6.4	.8	9.6	122	--------

[a] Analyses Oct. 26, 1906, to May 14, 1907, by Jas. R. Evans; May 15 to July 24, 1907, by W. D. Collins; Aug. 4 to Oct. 26, 1907, by R. B. Dole, Chase Palmer, and W. D. Collins.

[b] Abnormal; computed as HCO_3 in the average.

Analyses of water from Tennessee River near Gilbertsville, Ky.[a]

[Parts per million.]

Date. (1906–7).		Turbidity.	Suspended. matter.	Coefficient of fineness.	Total iron (Fe).	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total dissolved solids.	Mean gage height (feet).[b]
From—	To—																
Oct. 24	Nov. 10	40	35	0.87	--------	30	0.8	11	--------	--------	0.0	56	--------	0.4	2.0	99	6.0
Nov. 11	21	290	258	.89	--------	28	.6	12	2.8	--------	.0	51	--------	.8	1.0	94	9.6
22	Dec. 10	225	186	.83	--------	36	.40	14	3.2	--------	.0	49	--------	.8	1.5	102	15.4
Dec. 11	20	205	161	.78	--------	31	.6	13	4.8	--------	.0	54	--------	1.0	1.5	109	8.1
21	30	125	94	.75	--------	15	.30	17	3.2	--------	.0	61	--------	.7	7.0	96	11.2
31	Jan. 10	270	245	.91	--------	28	.40	14	4.8	--------	.0	61	--------	1.1	3.0	120	19.6
Jan. 11	20	30	21	.70	--------	26	.40	16	6.0	--------	.0	71	--------	1.2	2.7	102	10.8
21	30	35	19	.54	--------	12	.20	19	4.0	--------	.0	76	--------	.5	2.5	88	12.9
31	Feb. 9	190	158	.83	--------	27	.40	16	1.2	--------	.0	--------	--------	1.0	2.0	84	18.0
Feb. 10	19	95	74	.78	--------	17	.30	17	1.6	--------	.0	68	--------	.4	2.2	85	10.3
20	Mar. 1	380	290	.76	--------	26	.40	15	4.4	--------	.0	54	--------	.3	2.0	79	7.3
Mar. 2	11	170	142	.84	--------	22	.10	20	4.8	--------	.0	64	--------	.3	1.0	86	22.3
12	21	210	185	.88	--------	38	.20	24	--------	--------	.0	88	--------	.7	3.8	130	19.2
22	31	40	32	.80	--------	21	.20	17	5.2	--------	.0	68	--------	.3	2.0	95	12.8
Apr. 1	Apr. 10	210	196	.93	--------	32	.20	22	2.0	--------	.0	73	--------	.1	2.0	112	7.4
11	22	80	75	.94	--------	16	.40	16	6.0	--------	.0	68	--------	1.3	3.5	82	9.2
23	May 2	115	124	1.08	--------	18	.30	17	6.4	--------	.0	73	--------	1.1	4.5	90	10.0
May 3	12	105	96	.91	--------	16	.20	18	--------	--------	.0	73	--------	1.0	4.0	90	17.6
14	24	175	172	.98	--------	--------	1.0	--------	2.8	5.7	.0	61	12	1.8	1.0	106	17.0
25	June 3	90	143	1.59	--------	11	.20	22	2.5	9.2	.0	73	13	2.2	1.4	112	7.0
June 4	13	50	57	1.14	--------	11	.17	21	4.8	5.4	.0	73	11	Tr.	2.3	91	8.4
14	25	125	109	.87	--------	6.6	.40	20	4.9	8.6	.0	72	12	4.0	4.8	114	10.8
26	July 7	250	201	.80	--------	8.8	--------	26	3.8	3.8	.0	93	11	3.1	2.2	103	6.3
July 8	17	140	135	.96	--------	14	.30	21	2.2	7.5	.0	82	12	2.1	1.9	102	4.6
18	28	160	100	.62	--------	11	.28	21	5.6	10	.0	82	13	1.8	2.9	118	5.3
29	9	115	76	.66	--------	15	.21	24	5.2	--------	.0	87	13	1.8	4.0	--------	3.7
Aug. 10	20	75	91	1.21	--------	12	.05	21	4.5	--------	.0	--------	14	1.9	2.5	95	3.4
21	31	85	80	.94	--------	11	.29	21	3.8	6.7	.0	76	14	2.7	4.3	107	3.4
Sept. 2	Sept. 11	80	82	1.02	--------	15	.28	24	5.8	10	.0	88	9.6	.5	4.0	112	3.1
12	23	190	106	.56	1.6	20	.6	21	5.3	6.1	.0	87	7.9	2.0	4.2	108	3.3
24	Oct. 3	290	170	.59	4.9	27	1.0	21	4.9	5.4	.0	90	7.1	1.2	4.8	121	6.5
Oct. 4	14	375	184	.49	7.0	19	1.2	19	3.5	12	[c]4.8	71	7.4	1.1	6.0	107	4.1
15	24	40	94	2.35	--------	12	.08	20	3.6	9.4	[c]3.6	72	6.4	Tr.	3.0	89	2.5
Mean--------		153	127	.90	--------	20	.39	19	4.1	7.7	.0	72	11	1.2	3.0	101	--------

[a] Analyses Oct. 24, 1906, to May 12, 1907, by J. R. Evans; May 14 to Sept. 11, 1907, by Walton Van Winkle; Sept. 12 to Oct. 24, 1907, by R. B. Dole, Chase Palmer, and W. D. Collins.

[b] Gaging station at Johnsonville, Tenn., 80 miles above.

[c] Abnormal; computed as HCO_3 in the average.

GREEN RIVER.

For the water of Green River one analysis was made by C. H. Kidwell and Margaret D. Foster in the water-resources laboratory of the U. S. Geological Survey.

Analysis of water from Green River at Mumfordville, Ky.

1. Parts per million.
2. Percentage composition of dissolved solids.

	1	2
CO_3	73.2	41.40
SO_4	10.0	5.66
Cl	2.6	1.47
NO_3	1.9	1.08
Ca	37.0	20.93
Mg	6.8	3.85
Na	8.5	4.80
K	1.4	.79
Al_2O_3	1.3	.73
Fe_2O_3	.1	.06
SiO_2	34.0	19.23
	176.8	100.00

Reduced to percentages the five tables of analyses by Dole and his colleagues assume the following form, with the alkalies corrected by Palmer's later determinations:

Percentage composition of dissolved solids in three rivers in Ohio basin.

1. Kentucky River at Frankfort, Ky. 36 composite analyses.
2. Cumberland River near Nashville, Tenn. 35 composites.
3. Cumberland River, near Kuttawa, Ky. 34 composites.
4. Tennessee River near Knoxville, Tenn. 32 composites.
5. Tennessee River, near Gilbertsville, Ky. 33 composites.

	1	2	3	4	5
CO_3	38.51	36.66	40.57	35.34	34.57
SO_4	8.32	11.38	7.85	5.34	10.74
Cl	2.01	1.71	2.43	8.00	2.93
NO_3	2.51	.98	1.46	.67	1.17
Ca	21.06	21.14	22.67	18.33	18.56
Mg	3.71	2.93	3.48	3.58	4.00
Na	5.82	6.18	4.29	5.42	5.08
K	1.41	2.27	2.34	1.82	2.83
SiO_2	16.05	16.26	14.59	20.83	19.54
Fe_2O_3	.60	.49	.32	.67	.58
	100.00	100.00	100.00	100.00	100.00
Salinity, parts per million	104	119	124	122	101

SUMMARY FOR OHIO BASIN.

For the main stem of the Ohio no satisfactory analyses have been found, although sanitary analyses—that is, partial analyses made with reference to the water supply of cities—are abundant. With such analyses the present investigation has little or nothing to do.

In the foregoing pages 19 tables of analyses have been given relative to nine basins tributary to the Ohio. These analyses were all made in the water-resources laboratory of the United States Geological Survey and for present purposes may be taken as standards. Seven of the tables refer to tributaries of tributaries—that is, of the Monongahela and the Wabash. Three of the main subbasins of the Ohio are represented by two sets of analyses each; and in the next table for comparative use, only those of water at the station nearest the mouth of a given river are included. The new table, then, gives the average composition, in percentage form, of the dissolved solids in each water. The analyses by Chambers of water from the Kanawha appear to be sufficiently complete for inclusion with the other nine.

Comparative analyses of tributaries of the Ohio.

1. Monongahela River. Mean of 37 analyses of composite samples each, representing 10 daily collections.
2. Allegheny River. Mean of 36 composites.
3. Muskingum River. Mean of 27 composites.
4. Miami River. Mean of 34 composites.
5. Wabash River at Vincennes, Ind. Mean of 31 composites.
6. Cache River. Mean of 36 composites.
7. Tennessee River near Gilbertsville, Ky. Mean of 33 composites.
8. Cumberland River near Kuttawa, Ky. Mean of 34 composites.
9. Kentucky River. Mean of 36 composites.
10. Kanawha River. Mean of 4 composites of 28 samples.

	1	2	3	4	5	6	7	8	9	10
CO_3	11.47	21.51	24.71	43.64	34.09	30.97	34.57	40.57	38.51	24.94
SO_4	42.52	19.55	18.36	13.88	16.57	14.08	10.74	7.85	8.32	9.26
Cl	4.12	16.10	17.07	1.42	10.84	5.04	2.93	2.43	2.01	5.65
NO_3	2.32	.82	.69	2.98	1.93	1.55	1.17	1.46	2.51	.67
Ca	15.47	16.10	18.36	20.46	18.37	14.07	18.56	22.67	21.06	13.13
Mg	2.84	3.46	4.06	8.33	6.63	4.44	4.00	3.48	3.71	4.02
Na	8.12	11.04	9.39	2.49	7.56	11.11	5.08	4.29	5.82	7.35
K	1.42	2.09	1.28	.83			2.83	2.34	1.41	
SiO_2	10.82	9.09	5.98	5.89	3.92	16.30	19.54	14.59	16.05	34.09
Fe_2O_3	.90	.24	.10	.08	.09	2.44	.58	.32	.60	.89
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Salinity [a]	81	87	244	289	336	135	101	124	104	112

[a] Parts per million.

NOTE.—In seven of these columns the alkalies are corrected by Palmer's later determinations of potassium.

That these analyses form no definite group is clear. Each river is a blend of different waters and therefore has no hydrochemical character of its own. The Allegheny and Monongahela, as has already been shown, are seriously contaminated by industrial refuse, and so too, in much less degree, is the Wabash. The northern tributaries of the Ohio in Ohio and Indiana flow through a region which is in large part agricultural but in which there are many populous manufacturing cities, so that the streams are not now in their natural condition. The rivers south of the Ohio appear to be much less polluted. and to resemble one another more closely than those of the north. The latter show high salinity, the others are much more dilute.

Although no analyses have been made giving the average composition of the Ohio itself, a fair approximation to it can be obtained by combining the data furnished in the last table. It is necessary, however, to weight the analyses, as for the present purpose they are of very unequal value. The tributaries of the Ohio differ in relative importance, for some are small and others large. Their contributions to the Ohio are different in quantity and in composition, but their run-off and their salinity are known and give the necessary data for weighting. Each analysis is multiplied by the corresponding run-off, and the sum of all the products thus obtained is then divided by the sum of the run-offs. Cache River is omitted from the calculation as being too insignificant to have any appreciable effect upon the final mean. Its drainage area is only 600 square miles, and its salinity is low. The data so obtained, with figures showing the relative magnitude of the several drainage basins, appear in the following table, in which the figures for drainage areas and run-off are as given by R. B. Dole and H. Stabler in Water-Supply Paper 234.

Estimated composition of Ohio River water.

River.	Relative magnitude of tributary basin.		Average composition as computed.	
	Drainage area (square miles).	Annual run-off dissolved solids (tons per square mile).		
Monongahela	7,620	217	CO_3	30.29
Allegheny	11,100	160	SO_4	16.97
Muskingum	7,740	232	Cl	7.17
Miami	5,400	210	NO_3	1.64
Wabash	33,000	249	Ca	18.25
Tennessee	39,000	159	Mg	4.70
Cumberland	18,000	171	Na	6.48
Kentucky	7,870	164	K	1.62
Kanawha	11,000	160	Fe_2O_3	.43
			SiO_2	12.45
				100.00

The validity of the combination thus obtained depends upon the assumption that the other tributaries of the Ohio, great and small, would give much the same average as has been found here. That assumption is a reasonable one, and the composition assigned to the river is probably near the truth. It is to be hoped that this average may be checked at some future time by actual analyses of the water from some point near Cairo, Ill.

MISSOURI RIVER BASIN.

Missouri River, the largest tributary of the Mississippi, is formed by the union of Madison, Jefferson, and Gallatin rivers at Gallatin City, Mont. Its drainage area is 528,000 square miles, and its length more than 2,000 miles. It has many large tributaries, such as Yellowstone, James, Cheyenne, Big Sioux, Niobrara, Platte, Kansas, and Osage rivers, and for these there are abundant analytical data.

MISSOURI RIVER.

For the main stream the following tables of analyses, made in the water resources laboratory of the United States Geological Survey, claim first attention.

Analyses of water from Missouri River near Florence, Nebr.[a]

[Parts per million.]

Date (1906-7).		Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total dissolved solids.	Mean gage height (feet).[b]
From—	To—													
Oct. 1	Oct. 10	2,400	30	0.20	53	17	57	0.0	----------	197	1.3	8.0	442	7.1
11	20	1,080	18	.05	88	37	34	.0	215	178	.9	8.7	467	6.2
21	31	880	44	.6	68	25	72	.0	----------	175	.3	9.0	496	6.7
Nov. 1	Nov. 10	1,470	36	.5	73	25	53	.0	231	184	1.0	8.7	526	6.4
11	20	625	27	.5	82	30	57	.0	247	195	.9	9.1	543	5.8
21	30	350	29	.20	94	30	45	.0	298	212	1.8	9.5	597	5.1
Dec. 2	Dec. 13	325	24	.18	92	38	51	.0	305	211	.9	12	565	4.7
14	23	80	25	.10	102	38	58	.0	337	237	1.0	12	663	3.7
25	Jan. 3	90	23	.05	91	33	52	.0	300	222	.9	14	608	----------
Jan. 4	13	120	23	.05	82	30	----------	.0	270	199	.9	14	545	----------
15	26	230	28	.10	97	27	60	.0	309	233	1.4	15	615	----------
27	Feb. 6	40	34	Tr.	96	32	60	.0	310	224	1.6	15	620	----------
Feb. 7	16	110	27	.15	80	27	50	.0	251	178	1.5	12	499	----------
17	27	1,400	36	1.2	50	13	38	.0	154	132	1.6	6.2	340	----------
28	Mar. 12	750	37	1.4	56	13	38	.0	156	143	2.6	5.5	403	10.4
Mar. 14	23	2,700	39	2.0	51	18	38	.0	156	144	2.9	8.7	393	12.6
24	Apr. 2	2,700	16	1.0	45	10	62	.0	160	153	1.2	10	394	12.0
Apr. 3	12	3,330	43	.7	54	15	49	.0	176	128	1.2	7.1	402	12.2
14	23	3,600	55	1.2	61	----------	58	.0	162	204	1.5	6.9	540	12.8
25	May 4	3,800	67	.65	53	----------	56	.0	152	217	1.2	6.0	548	11.5
May 5	14	3,100	21	.35	52	17	50	.0	163	154	3.6	6.9	390	11.0
15	24	1,460	41	.8	56	18	43	.0	177	167	1.1	8.2	435	10.3
25	June 3	7,200	16	.10	58	16	56	.0	164	197	1.7	4.6	455	14.0
June 4	13	4,000	10	.18	58	16	56	.0	164	190	3.8	6.2	444	14.8
14	24	2,800	76	1.2	59	----------	50	.0	162	180	3.8	6.1	530	15.9
25	July 4	3,200	21	.07	61	12	40	.0	166	----------	1.8	5.0	----------	15.8
July 5	14	4,000	20	.9	51	16	51	.0	152	179	3.1	----------	416	16.6
15	24	3,600	16	.13	50	12	44	.0	161	113	5.0	7.0	325	16.9
25	Aug. 3	1,600	19	.04	49	7.9	50	.0	171	108	5.5	7.6	340	15.2
Aug. 4	13	2,000	21	.05	47	14	44	.0	163	110	2.0	14	326	13.3
14	23	1,000	26	.04	66	20	37	.0	262	81	1.6	6.0	353	11.9
24	Sept. 3	900	25	.38	46	14	36	.0	146	96	.9	8.8	300	10.6
Sept. 4	13	1,200	33	.06	48	13	42	.0	158	115	.9	7.0	322	9.7
14	23	1,000	36	.10	48	13	40	[c] 4.8	146	113	.7	8.4	332	9.2
24	Oct. 3	900	35	.35	54	17	44	[c] 7.2	150	----------	Tr.	7.8	362	8.8
Oct. 4	14	1,000	33	.14	54	14	46	[c] 4.8	161	134	1.2	9.6	373	8.5
Mean		1,726	31	.44	65	20	49	.0	203	168	1.8	8.9	454	----------

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[a] Analyses Oct. 1, 1906, to Feb. 6, 1907, by W. M. Barr; Feb. 17 to 27, 1907, by H. S. Spaulding; Feb. 28 to Sept. 13, 1907, by Walton Van Winkle; Sept. 14 to Oct. 14, 1907, by R. B. Dole, Chase Palmer, and W. D. Collins.

[b] Gaging station near Omaha, Nebr., 5 miles below.

[c] Abnormal; computed as HCO_3 in the average.

Analyses of water from Missouri River near Kansas City, Kans.[a]

[Parts per million.]

Date (1906-7).		Turbidity.	Silica (SiO₂).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO₃).	Bicarbonate radicle (HCO₃).	Sulphate radicle (SO₄).	Nitrate radicle (NO₃).	Chlorine (Cl).	Total dissolved solids.	Mean gage height (feet).[b]
From—	To—													
Oct. 4	Oct. 13	2,500	31	0.30	60	19	49	0.0	198	138	2.2	13	419	8.5
14	23	900	26	Tr.	69	21	40	.0	215	154	.4	13	438	7.2
24	Nov. 2	1,230	33	.5	64	21		.0	217	128	2.2	15	426	8.7
Nov. 3	12	1,500	31	.40	69	22	49	.0	219	150	2.2	13	447	9.0
13	22	870	38	.40	75	24	50	.0	236	164	.9	13	486	8.6
23	Dec. 2	475	30	.20	77	22	53	.0	270	158	.4	15	495	7.6
Dec. 3	12	500	38	.40	77	21		.0	275	146	1.8	17	510	7.0
13	22	300	30	.40	85	27	51	.9	307	175	.9	20	525	.5
23	Jan. 2	190	41	.12	91	29	55	.0	334		1.3	22	580	4.5
Jan. 3	12	350	39	.40	78	26	49	.0	265	158	2.6	18	503	7.4
13	22	270	35	.35	79	23	52	.0	265	159	3.1	18	493	6.3
23	Feb. 2	140	41	.08	90	30	55	.0	326	176	2.2	23	579	5.1
Feb. 3	12	35	43	.20	84	28	68	.0	328	167	2.2	24	590	5.4
13	22	1,020	70	2.8	61	22	61	.0			4.4	16	454	10.2
23	Mar. 5	1,400	74	.20	56	17	43	.0	156		1.7	8.5	414	13.5
Mar. 6	15	1,500	41	1.4	52	15	37	.0	164	122	3.4	9.5	392	12.0
16	25	3,450	65	2.1			39	.0	164	123	1.9	11	435	13.5
26	Apr. 4	2,150	55	2.1		10	41	.0	157		2.5	6.3	362	12.7
Apr 5	14	2,800	62	2.4	53	15	42	.0	168	137	2.2	8.7	440	13.1
15	24	3,600	41	.5	68	11	55	.0	162	179	3.0	9.5	462	13.2
25	May 4	3,800	89	1.8		20	60	.0		171	Tr.	11	549	12.0
May 5	14	2,800	47	3.2		16	48	.0	160	176	5.3	11	478	11.3
15	24	1,200	49	1.2	58		43	.0	176		3.5	12	394	10.1
25	June 3	3,850	43	1.1		17	46	.0	171	170	3.9	14	460	13.0
June 4	13	5,350	20	1.0	53	14	52	.0	161	168	.7	8.5	424	17.7
14	23	3,200	26	.10	56	14	56	.0	157	168	2.6	8.4	418	17.8
24	July 4	4,000	25	1.2	57		45	.0	178	131	3.5	8.8	406	18.6
July 5	14	4,400	22	.05	53	10	46	.0	159	143	3.7	8.3	383	19.8
15	24	3,600	24	.48	47	13	38	.0	157	103	4.1	6.7	316	22.6
25	Aug. 3	2,000	15	Tr.	46		37	.0	183	101	3.4	6.0	323	19.1
Aug. 4	13	2,700	22	.30	44	12	29	.0		99	3.0	5.5	295	16.5
14	23	2,400	21	.28	44	14		.0	136	95	.9	7.0	291	13.8
24	Sept. 2	2,000	18	.05	45	14		.0	152	92	1.3		293	11.1
Sept. 3	12	1,700	20	.03	45	12	31	.0	155	87	1.6	11	307	9.9
13	22	1,200	27	.33	53	10	38	.0	171	105	1.8	13	337	8.5
23	Oct. 2	1,075	27	.26	53	12	36	.0	167	108	1.6	13	339	8.3
Oct. 4	13	1,100	26	1.0	53	11	43	[c] Tr	171	110	1.5	17	349	8.6
14	21	1,000	28	.28	56	9.8	45	[c] Tr.	180	120	1.3	16	389	7.6
Mean		1,909	37	.73	62	18	44	.0	202	135	2.2	13	426	

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[a] Analyses Oct. 4, 1906, to Feb. 12, 1907, by W. M. Barr; Feb. 13 to 22, 1907, by H. S. Spaulding; Feb. 23 to Sept. 12, 1907, by Walton Van Winkle; Sept. 13 to Oct. 21, 1907, by R. B. Dole, Chase Palmer, and W. D. Collins.

[b] Sampling station above the entrance of Kansas River; gaging station below that stream.

[c] Abnormal; computed as HCO_3 in the average.

Analyses of water from Missouri River near Ruegg, Mo.[a]

[Parts per million.]

Date (1906-7).		Turbidity.	Silica (SiO₂).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO₃).	Bicarbonate radicle (HCO₃).	Sulphate radicle (SO₄).	Nitrate radicle (NO₃).	Chlorine (Cl).	Total dissolved solids.	Mean gage height (feet).[b]
From—	To—													
Sept. 27	Oct. 7	1,800	29	Tr.	41	12	31	0.0	134	82		14	291	10.3
Oct. 8	17	1,900	29	0.20	54	13	38	.0	195		2.0	12	363	7.6
19	28	930	46	.10	66	19	55	.0	232	134	1.3	18	445	6.6
29	Nov. 7	1,150	23	.20	67	22		.0	225	126	1.3	21	424	7.7
Nov. 8	17	1,650	21	.25	68	22	53	.0		133	2.4	15	442	7.6
18	27	780	24	.20	69	19	42	.0	226	126	1.8	16	421	7.6
29	Dec. 9	500	28	.5	56	29	31	.0	227	104	.9	16	383	7.7
Dec. 10	20	425	29	.30	69	24	35	.0	245	103	2.2	18	429	7.3
21	31	300	27	.30	70	26	40	.0	288	114	2.6		438	5.2
Jan. 1	Jan. 10	375	25	.40		24	36	.0	268	100	2.2	21	420	6.9
11	20	550	31	.80	54	19	31	.0	188	92	3.2	14	342	10.6
21	30	1,400			31	11	28	.0			4.1	10	262	14.6
31	Feb. 9	350	49	1.4	40	14	21	.0	127		3.0	8.4	274	8.1
Feb. 10	19	400	22	.45	67	20	31	.0		128	4.0	18	378	7.6
20	Mar. 1	1,400	30	.45	58	16	35	.0	184	97	4.5	14	348	11.0
Mar. 2	11	1,000	14	.22	48	15	32	.0	159	94	3.7	12	292	10.4
12	21	2,000	41	1.7	50	11	27	.0	164	88	4.1	11	319	12.9
23	Apr. 2	1,970	27	.7	42	13	39	.0		112	1.1	14	345	11.2
Apr. 3	12	2,600	56	1.8	50	14	34	.0	149	96	3.4	8.9	350	11.2
13	22	4,000	46	1.0	51	15	45	.0	173	125	5.0	10	401	11.1
23	May 3	3,200	47	1.6	51	16	38	.0	151	146	2.0	9.3	413	11.7
May 4	13	2,300	48	1.6	46	15	28	.0	144	102	3.6	7.6	342	13.4
14	23	1,500	33	1.2	39	10	18	.0	130	68	4.1	6.7	271	14.1
24	June 4	2,800	17	.20		14	36	.0	185	98	3.0	11	317	10.4
June 5	15	4,800	28	.20	52	15	39	.0	160	142	6.6	9.2	385	15.9
16	25	4,250	16	.10	55	8.4	44	.0	151	135	2.7	6.9	354	15.6
26	July 5	3,600	18	.40	54	8.6	36	.0	149	95	5.0	6.3	306	17.4
July 6	16	3,600	23		45		37	.0	159		1.9	7.0	333	15.8
17	26	4,000	16	.25	49	12		.0	176	77	5.5	5.5	315	18.6
27	Aug. 6	3,300	18	.19	43		38	.0	144	87	2.7	6.0	282	16.0
Aug. 7	17	3,900	20	.10	40	12	40	.0	141	90	2.7	7.3	285	13.2
18	27	2,600	17	.01	39	12	31	.0	141	80	2.2	7.3	254	11.5
28	Sept. 6	1,000	19	.14	46	14	32	.0	153	85	1.1	10	277	9.1
Sept. 7	16	1,280	28	.06	46	12	38	[c]4.8	156	84	1.3	14	300	8.0
17	26	1,000	28	.19	50	14	38	[c]4.8	167	88	1.5	14	319	7.0
27	Oct. 6	900	36	.06	53	14	37	[c]9.6	173	95	1.4	17	351	6.8
Mean		1,931	29	.51	52	16	36	.0	178	104	2.9	12	346	

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[a] Anlyses Sept. 27, 1906, to Feb. 19, 1907, by W. M. Barr; Feb. 20 to Ma 1, 1907, by H. S. Spaulding; Mar. 2 to Sept. 6, 1907, by Walton Van Winkle; Sept. 7 to Sept. 16, 1907, by R. B. Dole, Chase Palmer, and W. D. Collins.

[b] Gaging station at Hermann, Mo., 70 miles above.

[c] Abnormal; computed as HCO_3 in the average.

Reduced to standard form the averages from the preceding tables are as follows: The alkalies are corrected by Palmer's determinations of potassium.

Reduced analyses of Missouri water.

1. At Florence. 36 composite analyses.
2. At Kansas City. 37 composites.
3. At Ruegg. 36 composites.

	Parts per million.			Percentage composition.		
	1	2	3	1	2	3
CO_3	101.8	103.3	88.6	22.42	24.23	25.63
SO_4	171.1	139.5	105.2	37.69	32.74	30.44
Cl	9.0	13.4	12.1	1.99	3.15	3.52
NO_3	1.8	2.3	2.9	.40	.54	.85
Ca	66.2	64.1	53.2	14.58	15.04	15.22
Mg	20.3	18.7	16.1	4.48	4.37	4.68
Na	43.8	39.3	31.4	9.64	9.22	9.07
K	7.7	6.4	6.5	1.70	1.50	1.90
SiO_2	31.6	38.0	29.3	6.95	8.97	8.49
Fe_2O_3	.7	1.0	.7	.15	.24	.20
	454.0	426.0	346.0	100.00	100.00	100.00

In addition to the data given in the preceding tables, the following analyses have been collected and reduced to standard form:

Analyses of water from Missouri River.

1. Near Gallatin City, Mont., half a mile below the junction of Madison, Gallatin and Jefferson rivers. Received from the analyst, A. D. Burkett.
2. At Great Falls, Mont. Analysis by Edgar and Mariner, cited in U. S. Geol. Survey, Eighteenth Ann. Rept., pt. 4, p. 612, 1897.
3. At Bismarck, N. Dak. Analysis by C. F. Sidener for Northern Pacific Ry.
4. At Chamberlain, S. Dak. Mean of two analyses.
5. At Running Water, S. Dak.
6. At Council Bluffs, Iowa. Nos. 4, 5, and 6 received from Chicago, Milwaukee & St. Paul Ry.
7. At Atchison, Kans. From Atchison, Topeka & Santa Fe Ry.
8. The same. From Kennicott Water Softener Co.
9. The same. From Missouri Pacific Ry.
10. At Lansing, Kans. Analysis by F. W. Bushong.
11. At Kansas City, Mo. From Union Pacific R. R.
12. The same. From Atchison, Topeka & Santa Fe Ry. Analyses 7, 8, 10, and 12, from Water-Supply Paper 273, p. 211, 1911.

I. Parts per million.

	1	2	3	4	5	6
CO_3	78.7	30.6	122.2	82.7	83.7	112.8
SO_4	45.7	28.8	152.2	84.3	87.6	96.1
Cl	14.1	8.6	15.1	7.8	7.8	7.6
NO_3						
Ca	35.9	10.1	79.0	43.1	60.1	61.3
Mg	12.1	6.2	25.2	15.4	10.3	17.0
Na(K)	[a] 29.0	19.3	37.3	30.6	22.4	34.3
SiO_2	24.4	9.4	9.0	7.0	3.4	5.3
$(Al, Fe)_2O_3$	5.1					
Fe_2O_3						
	245.0	113.0	440.0	270.9	275.3	334.4

[a] By difference.

Analyses of water from Missouri River—Continued.

I. Parts per million—Continued.

	7	8	9	10	11	12
CO_3	80.0	60.0	94.5	135.3	104.3	112.0
SO_4	89.0	123.0	84.4	119.0	83.1	76.0
Cl	17.0	12.0	13.0	22.0	7.8	20.0
NO_3				.7		
Ca	46.0	47.0	51.4	85.0	44.0	62.0
Mg	14.0	12.0	17.2	23.0	14.0	13.0
Na(K)	35.0	38.0	29.8	56.0	47.2	39.0
SiO_2	20.0	9.0	27.2	30.0	64.1	15.0
$(Al, Fe)_2O_3$			4.1	.2	11.1	
Fe_2O_3	1.3	.5				
	302.3	301.5	322.4	471.2	375.3	337.0

II. Percentage composition of dissolved solids.

	1	2	3	4	5	6
CO_3	31.76	27.10	27.78	30.53	30.41	33.74
SO_4	18.71	25.45	34.56	31.12	31.82	28.74
Cl	5.80	7.62	3.44	2.88	2.83	2.28
NO_3						
Ca	14.75	8.93	17.96	15.91	21.83	18.33
Mg	5.00	5.48	5.72	5.68	3.74	5.09
Na(K)	[a] 11.84	17.13	8.49	11.30	8.14	10.23
SiO_2	10.04	8.29	2.05	2.58	1.23	1.59
$(Al,Fe)_2O_3$	2.10					
Fe_2O_3						
	100.00	100.00	100.00	100.00	100.00	100.00

	7	8	9	10	11	12
CO_3	26.46	19.90	29.31	28.71	27.71	33.23
SO_4	29.44	40.80	26.18	25.26	22.14	22.57
Cl	5.62	3.98	4.28	4.67	2.08	5.94
NO_3				.15		
Ca	15.22	15.58	15.94	18.04	11.72	18.40
Mg	4.63	3.98	5.34	4.88	3.73	3.86
Na(K)	11.58	12.62	9.24	11.88	12.58	11.55
SiO_2	6.62	2.98	8.44	6.37	17.08	4.45
$(Al,Fe)_2O_3$			1.27		2.96	
Fe_2O_3	.43	.16		.04		
	100.00	100.00	100.00	100.00	100.00	100.00

[a] By difference.

MADISON AND YELLOWSTONE RIVERS.

The course of Madison River, one of the three components of the Missouri, is partly through the Yellowstone National Park, where it is formed by the junction of Firehole and Gibbon rivers. The main stream of Yellowstone River issues from Yellowstone Lake, crosses Montana, and joins the Missouri near the North Dakota boundary. Gardiner River enters the Yellowstone near Mammoth Hot Springs. The drainage area of the Yellowstone is nearly 70,000 square miles.

In the next table of analyses the first six are of waters in the Yellowstone National Park. They were made by Gooch and Whitfield in the chemical laboratory of the United States Geological Survey and are here reduced to the standard form adopted throughout this work.[30]

Analyses of lake and river waters in Madison and Yellowstone basins.

1. Firehole River above Upper Basin.
2. Firehole River at Marshall's.
3. Yellowstone Lake.
4. Gardiner River above Hot River.
5. Gardiner River below Hot River.
6. Hot River. Temperature 58° C.; specific gravity, 1.00157.
7. Yellowstone River at Billings, Mont. C. F. Sidener, analyst.
8. Yellowstone River at Glendive, Mont. Analyses 7 and 8 received from Northern Pacific Ry.
9. Popo Agie River at Lander, Wyo. Drains through Wind and Big Horn rivers into the Yellowstone.
10. Little Goose Creek at Sheridan, Wyo. Drains through Tongue River into the Yellowstone. Analyses 9 and 10 by E. E. Slosson, Wyoming Exper. Sta. Bull. 24, 1895.

I. Parts per million.

	1	2	3	4	5	6	7	8	9	10
CO_3	20.1	75.4	24.9	57.8	119.0	290.1	70.8	75.3	44.2	186.7
SO_4	7.4	10.1	8.4	13.0	96.2	507.6	93.4	97.1	6.3	164.6
Cl	10.5	73.7	9.4	4.9	30.1	160.4	14.5	10.3	11.1	27.8
B_4O_7	Tr.	6.8	------	------	------	14.3	------	------	------	------
AsO_2	------	------	------	------	------	.4	------	------	------	------
Ca	5.2	6.6	8.6	25.0	74.9	236.0	47.9	53.3	3.9	52.9
Mg	1.1	.7	.3	.5	17.5	63.1	13.7	12.6	10.1	28.9
Na	15.1	93.0	15.6	20.0	31.1	150.6	27.2	25.4	20.7	45.0
K	9.4	17.0	4.7	7.9	10.5	46.2			6.5	13.5
Li	Tr.	1.1	------	Tr.	Tr.	1.1	------	------	------	------
NH_4	.2	------	.4	------	------	.1	------	------	------	------
SiO_2	40.7	96.5	42.0	46.9	27.2	50.0	6.0	8.0	9.0	21.5
Al_2O_3	5.5	5.9	4.0	7.9	1.9	9.7			.7	3.3
Fe_2O_3	Tr.	Tr.								
	115.2	386.8	118.3	183.9	408.4	1529.6	273.5	282.0	112.5	544.2

II. Percentage composition of dissolved solids.

	1	2	3	4	5	6	7	8	9	10
CO_3	17.45	19.49	21.05	31.43	29.14	18.97	25.85	26.70	39.29	34.31
SO_4	6.42	2.61	7.10	7.07	23.56	33.19	34.15	34.43	5.60	30.25
Cl	9.11	19.05	7.95	2.66	7.37	10.49	5.31	3.65	9.87	5.11
B_4O_7	Tr.	1.76	------	------	------	.93	------	------	------	------
AsO_2	------	.00	------	------	------	.03	------	------	------	------
Ca	4.51	1.71	7.27	13.59	18.34	15.43	17.52	18.90	3.46	9.72
Mg	.96	.18	.25	.27	4.29	4.11	5.02	4.47	8.96	5.31
Na	13.10	24.04	13.19	10.88	7.61	9.85	9.95	9.01	18.40	8.27
K	8.18	4.39	3.97	4.30	2.57	3.02			5.77	2.48
Li	Tr.	.28	------	Tr.	Tr.	.07	------	------	------	------
NH_4	.17	------	.34	------	------	.01	------	------	------	------
SiO_2	35.33	24.96	35.50	25.50	6.66	3.27	2.20	2.84	8.00	3.95
Al_2O_3	4.77	1.53	3.38	4.30	.46	.63			.63	.60
Fe_2O_3	Tr.	Tr.				------				
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

These analyses are very suggestive. Firehole River receives much of its water from springs that deposit siliceous sinter and is therefore remarkably high in silica. Yellowstone Lake is equally high in silica, and much of it is derived from rocks in which plagioclase feldspars are abundant. Gardiner River, on the other hand, flows near Mammoth Hot Springs, which deposit calcareous sinter. Its water is originally a carbonate water, but below Hot River it is more sulphatic, owing to the influence of its tributary. The two analyses of Yellowstone River show it to be a mixed water, rich in both carbonates and sulphates and poor in silica. Its two minor tributaries are quite different and doubtless are more or less affected by alkaline salts along their courses. Popo Agie River is especially rich in alkalies, which may have come in part from the leaching of irrigated soils.

LAKE DE SMET.

Lake De Smet is an isolated body of water, highly saline, which lies west of Powder River in Sheridan County, Wyo. It is within the general area of the Yellowstone basin. The following analyses were made by W. T. Schaller in the chemical laboratory of the United States Geological Survey:

Analyses of water from Lake De Smet.

1. Lake De Smet.
2. Shell Creek, a feeder of Lake De Smet.

	Parts per million.		Percentage composition.	
	1	2	1	2
CO_3	67	22	1.00	2.08
HCO_3	536	273	7.99	25.68
SO_4	4,129	467	61.55	43.94
Cl	58	8	.87	.75
Ca	71	109	1.05	10.26
Mg	406	77	6.06	7.24
Na	1,342	83	20.00	7.80
K	82	5	1.22	.47
$(Al,Fe)_2O_3$	3	4	.05	.37
SiO_2	14	15	.21	1.41
	6,708	1,063	100.00	100.00

TRIBUTARIES OF THE MISSOURI IN NORTH AND SOUTH DAKOTA.

Analyses of waters of tributaries of the Missouri in North and South Dakota.

1. Little Missouri River at Medora, N. Dak.
2. Heart River at Mandan, N. Dak. Analyses 1 and 2 received from Northern Pacific Ry.
3. Belle Fourche River at Nisland, S. Dak. An affluent of Cheyenne River
4. Rapid Creek at Rapid City, S. Dak. An affluent of Cheyenne River.
5. White River at Crawford, Nebr.
6. Ditto at Dakota Junction, Nebr. Analyses 3, 4, 5, and 6 received from Chicago & Northwestern Ry.
7. Beaver Creek at Linton, N. Dak. Received from Chicago, Milwaukee & St. Paul Ry.
8. James River at James, S. Dak. (Also known as Dakota River.)
9. James River at Ashton, S. Dak.
10. James River at Mitchell, S. Dak.
11. James River at Menno, S. Dak.
12. Elm River at Ordway, S. Dak.
13. Firesteel River at Mitchell, S. Dak. Elm and Firesteel rivers are tributaries of the James.
14. East Fork of Vermilion River at Montrose, S. Dak.
15. East Fork of Vermilion River at Parker, S. Dak. Mean of two analyses.
16. West Fork of Vermilion River at Parker, S. Dak. Mean of four analyses.

Analyses Nos. 8, 9, 10, 11, 15, and 16, received from Chicago, Milwaukee & St. Paul Ry.; Nos. 12, 13, and 14, from Chicago & Northwestern Ry.

I. Parts per million.

	1	2	3	4	5	6	7	8
CO_3	427.2	270.8	278	92.4	126.4	129.1	270.8	249.6
SO_4	425.8	337.1	2,065	49.1	6.3	22.2	196.5	169.4
Cl	7.9	18.4	76	3.4	5.1	3.6	Trace.	95.1
Ca	49.9	67.8	450	48.0	60.9	59.4	74.8	58.8
Mg	20.4	36.5	132	20.4	8.0	5.4	31.9	40.5
Na(K)	443.4	233.0	466	2.2	17.7	33.4	154.6	188.9
$(Al,Fe)_2O_3$	9.0	7.0	4	5.0	.7	.9	4.4	6.3
SiO_2			10	11.1	29.9	34.0		
	1,383.6	970.6	3,481	231.6	255.0	288.0	733.0	808.6

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[30] See U. S. Geol. Survey Bull. 47 for analyses of Yellowstone Park waters.

Analyses of waters of tributaries of the Missouri in North and South Dakota—Continued.

I, Parts per million—Continued.

	9	10	11	12	13	14	15	16
CO_3	155.7	165.9	116.4	380.8	340.4	181.3	195.6	115.2
SO_4	141.2	420.9	421.1	322.2	536.3	575.8	1,026.3	281.2
Cl	36.3	80.2	67.1	384.0	24.9	4.6	5.4	3.6
Ca	46.9	103.5	82.6	126.2	119.3	178.4	273.6	78.8
Mg	23.4	39.6	32.2	63.7	134.1	92.9	123.4	48.6
Na(K)	111.8	183.0	177.8	431.0	140.0	35.2	100.1	41.6
$(Al,Fe)_2O_3$	5.7	.9	3.8	2.5	8.1	5.0	2.1	2.0
SiO_2				22.7	16.9	15.8		
	521.0	994.0	901.0	1,733.1	1,320.0	1,089.0	1,726.5	571.0

II. Percentage composition of dissolved solids.

	1	2	3	4	5	6	7	8
CO_3	30.87	27.90	7.96	39.89	49.57	44.83	36.94	30.87
SO_4	30.79	34.73	59.33	21.20	2.47	7.71	26.81	20.95
Cl	.57	1.90	2.18	1.47	2.00	1.25	Trace.	11.76
Ca	3.61	6.98	12.94	20.77	23.88	20.63	10.20	7.27
Mg	1.47	3.76	3.80	8.80	3.14	1.87	4.35	5.01
Na(K)	32.04	24.01	13.39	.94	6.94	11.60	21.09	23.36
$(Al,Fe)_2O_3$	.65	.72	.12	2.15	.27	.31	.61	.78
SiO_2			.28	4.78	11.73	11.80		
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

	9	10	11	12	13	14	15	16
CO_3	29.89	16.70	12.92	21.95	25.79	16.65	11.33	20.17
SO_4	27.10	42.34	46.74	18.60	40.63	52.87	59.44	49.25
Cl	6.97	8.06	7.45	22.16	1.89	.42	.31	.63
Ca	9.00	10.41	9.17	7.28	9.04	16.39	15.85	13.80
Mg	4.49	4.00	3.57	3.68	10.16	8.53	7.15	8.51
Na(K)	21.46	18.40	19.73	24.87	10.60	3.23	5.80	7.29
$(Al,Fe)_2O_3$	1.09	.09	.42	.15	.61	.46	.12	.35
SiO_2				1.31	1.28	1.45		
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

These 16 analyses are with four exceptions characterized by high salinity. In all but two of them the proportion of sulphates is very high, and in the James the proportion increases regularly as the river is followed downstream. In eight of these analyses the figure for alkalies is also remarkably high—an indication of much saline matter in the soils of the region through which the river flows.

EASTERN TRIBUTARIES OF THE MISSOURI.

Analyses of waters of eastern tributaries of the Missouri.

1. Big Sioux River at Dell Rapids, S. Dak.
2. Big Sioux River at Sioux Falls, S. Dak.
3. Big Sioux River at Canton, S. Dak. Analyses 1 to 3 received from Chicago, Milwaukee & St. Paul Ry.
4. Big Sioux River at Hawarden, Iowa. Received from Chicago & Northwestern Ry.
5. Rock River at Luverne, Minn. Analysis by W. A. Noyes, Geology of Minnesota, vol. 1, p. 550, 1884. A tributary of the Big Sioux.
6. Otter River at Ashton, Iowa. A tributary of Rock River. Received from Chicago & Northwestern Ry.
7. East Floyd Creek at Sanborn, Iowa.
8. West Floyd Creek at Sheldon, Iowa. Mean of two analyses.
9. Floyd Creek at Sheldon, Iowa.
10. Floyd River at Sioux City, Iowa. Mean of two analyses. Analyses 7 to 10 received from Chicago, Milwaukee & St. Paul Ry.
11. Little Sioux River at Grant Center, Iowa.
12. Kingsley Creek at Kingsley, Iowa.
13. East Soldier Creek at Charter Oak, Iowa.
14. Boyer River at Early, Iowa. Analysis from Chicago & Northwestern Ry., cited in Iowa Geol. Survey, vol. 6, p. 365, 1896.
15. Mosquito Creek at Earling, Iowa.
16. Mosquito Creek at Underwood, Iowa.
17. East Branch of Nishnabotna Creek at Manning, Iowa.
18. Creek at Aspinwall, Iowa. A tributary of Nishnabotna River.
19. Fishing River at Mosby, Mo.
20. Grand River at Chillicothe, Mo.

Analyses of waters of eastern tributaries of the Missouri—Con.

21. Shoal Creek at Ludlow, Mo. A tributary of Grand River.
22. Medicine Creek at Powersville, Mo. A tributary of Grand River.
23. Medicine Creek at Newtown, Mo.
24. Medicine Creek at Laredo, Mo.
25. Chariton River near Derby, Iowa.

Analyses 12 and 14 from Chicago & Northwestern Ry. Analyses 11, 13, and 15 to 25 received from Chicago, Milwaukee & St. Paul Ry.

I. Parts per million.

	1	2	3	4	5	6	7	8	9
CO_3	142.6	135.2	94.9	162.0	131.7	202.2	209.9	197.1	249.7
SO_4	156.5	152.0	97.0	190.7	24.7	377.9	30.0	70.5	66.8
Cl	3.9	10.1	38.2	14.8	1.1	7.6	1.8	1.9	2.8
Ca	89.5	82.1	55.7	98.1	56.3	159.8	87.9	89.5	109.2
Mg	31.4	32.2	18.3	44.9	20.3	66.6	31.2	34.2	40.5
Na	23.8	26.9	46.8	26.4	9.0	29.4	15.5	17.6	22.1
K					1.4				
Al_2O_3	3.1	.5	37.6	.3	.9	20.0	1.7	4.8	11.9
Fe_2O_3					8.7				
SiO_2				7.5	20.9	22.8			
	450.8	439.0	388.5	544.7	275.0	886.3	378.0	415.6	503.0

	10	11	12	13	14	15	16	17	18
CO_3	161.7	154.2	180.6	191.7	143.0	147.4	153.9	59.4	151.1
SO_4	90.9	67.4	308.5	31.7	62.8	20.6	10.5	15.8	35.5
Cl	2.4	.9	39.8	2.4	11.8	3.2	1.8	3.2	5.5
Ca	85.3	75.8	164.4	83.3	62.3	62.6	62.2	25.8	68.0
Mg	27.4	22.9	50.7	26.7	22.6	20.6	19.0	8.3	21.8
Na(K)	18.4	19.1	25.8	15.7	32.5	13.6	16.3	9.5	16.4
$(Al, Fe)_2O_3$	6.1	4.4	3.4	6.5	2.2	5.6	11.8	18.0	2.7
SiO_2			18.8						
	392.6	354.7	792.0	358.0	337.2	273.6	275.5	140.0	301.0

	19	20	21	22	23	24	25
CO_3	177.0	91.4	141.1	104.3	127.7	87.5	106.3
SO_4	41.3	17.1	18.2	80.4	17.3	12.3	12.1
Cl	6.7	3.6	5.7	8.6	1.8	3.5	3.5
Ca	100.3	45.7	72.6	63.0	53.6	41.4	43.6
Mg	15.7	9.1	12.8	17.8	16.3	10.2	13.1
Na(K)	10.3	10.5	12.4	17.6	14.3	8.3	14.2
Oxides [a]	11.4	3.9	1.7	5.6	2.6	6.3	2.9
	362.7	181.3	264.5	297.3	233.6	169.5	195.7

II. Percentage composition of dissolved solids.

	1	2	3	4	5	6	7	8	9
CO_3	31.63	30.80	24.43	29.74	47.94	22.82	55.53	47.43	49.64
SO_4	34.71	34.62	24.96	35.01	8.64	42.64	7.94	16.97	13.28
Cl	.87	2.30	9.83	2.72	.44	.86	.48	.46	.56
Ca	19.85	18.70	14.34	18.01	20.51	18.03	23.25	21.54	21.71
Mg	6.97	7.33	4.71	8.24	7.43	7.51	8.25	8.22	8.05
Na	5.28	6.13	12.05	4.85	3.31	3.32	4.10	4.22	4.39
K					.51				
Al_2O_3	.69	.12	9.68	.05	.36	2.25	.45	1.16	2.37
Fe_2O_3					3.21				
SiO_2				1.38	7.65	2.57			
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

	10	11	12	13	14	15	16	17	18
CO_3	41.23	44.74	22.80	53.55	42.41	53.88	55.86	42.43	50.19
SO_4	23.18	19.55	38.95	8.85	18.63	7.52	3.81	11.29	11.79
Cl	.61	.26	5.03	.67	3.50	1.17	.65	2.28	1.82
Ca	21.75	21.99	20.76	23.27	18.47	22.88	22.58	18.43	22.58
Mg	6.98	6.64	6.40	7.46	6.70	7.52	6.90	5.93	7.24
Na(K)	4.69	5.54	3.26	4.39	9.64	4.97	5.91	6.78	5.44
$(Al, Fe)_2O_3$	1.56	1.28	.43	1.81	.65	2.06	4.29	12.86	.94
SiO_2			2.37						
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

	19	20	21	22	23	24	25
CO_3	48.80	50.42	53.34	35.08	54.67	51.62	54.32
SO_4	11.39	9.43	6.88	27.05	7.40	7.26	6.18
Cl	1.85	1.98	2.16	2.89	.77	2.06	1.79
Ca	27.65	25.21	27.45	21.19	22.95	24.43	22.28
Mg	4.33	5.02	4.84	5.99	6.98	6.02	6.69
Na(K)	2.84	5.79	4.69	5.92	6.12	4.89	7.26
Oxides [a]	3.14	2.15	.64	1.88	1.11	3.72	1.48
	100.00	100.00	100.00	100.00	100.00	100.00	100.00

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[a] Silica plus sesquioxides.

These analyses of water from eastern tributaries of the Missouri are arranged in order from west to east, following the course of the Missouri downward. In this way they show the fairly regular change in character of the waters, from the high salinity of the northwestern streams to the moderate salinity of those in the agricultural regions of Iowa and Missouri. There is a tendency toward a gradual lowering of the proportion of sulphates in the waters, and the more eastern rivers have the character of ordinary carbonate solutions derived in great part directly from the soil but originally from sedimentary rocks in which limestones predominate. The changes are not absolutely regular, for there are local variations, but their general drift is clear.

NIOBRARA RIVER AND ADJACENT LAKES.

Niobrara River rises in eastern Wyoming, traverses the State of Nebraska, and after a course of about 450 miles, enters the Missouri near Yankton, S. Dak. Two analyses of water from the Niobrara, made by E. T. Erickson in the chemical laboratory of the United States Geological Survey, are given below.

Analyses of water from Niobrara River.

1. At Alliance, Nebr.
2. At Valentine, Nebr.

	Parts per million.		Percentage composition.	
	1	2	1	2
CO_3	111.4	69.0	41.40	39.01
SO_4	10.6	.0	3.96	.00
Cl	2.9	Tr.	1.08	Tr.
Ca	49.3	28.0	18.33	15.82
Mg	5.8	2.4	2.15	1.36
Na	33.8	14.5	12.58	8.20
K	2.9	6.6	1.08	3.65
SiO_2	52.3	56.5	19.42	31.96
	269.0	177.0	100.00	100.00

These analyses are peculiar on account of their relatively high proportions of silica and alkalies. The samples of water, however were from the barren sand hills of northwestern Nebraska, which may perhaps contain soluble or colloidal silica. More data relative to the Niobrara are desirable.

In the sand hills mentioned above are many small lakes that occupy shallow depressions and are without outward surface drainage. Some of these lakes are remarkable for their high content in salts of potassium, which are now extracted from the waters for commercial purposes. The following analyses of some of these waters were made by Mr. Erickson.[31]

Analyses of water from the potash lakes of Nebraska.

1. Floyd Lake.
2. Plant Lake.
3. Stoughton Lake.
4. Hathorne Lake.
5. Mitchell Lake.
6. Jesse Lake. (For another analysis of water from Jesse Lake, by J. H. Show, see Colorado School of Mines Quart., vol. 10, No. 3, p. 21, 1915.) Lakes 1 to 6 are all in Sheridan County.
7. Phelan Lake, Morrill County.
8. Alkali Lake.
9. Ashburgher Lake.
10. Sturgeon Lake. Lakes Nos. 8 to 10 are in Garden County. The analyses all represent the percentage composition of the solid residues. Calcium is absent, and magnesium is present only in traces.

For 18 other analyses of waters from this group of lakes, by J. H. Show, see Nebraska Geol. Survey, vol. 4, p. 28.

	1	2	3	4	5	6	7	8	9	10
CO_3	21.65	28.39	14.13	33.80	34.43	26.52	31.42	30.33	36.27	28.65
HCO_3	11.20	13.07	13.26	19.52	12.36	10.69	11.34	21.37	13.90	17.41
SO_4	20.02	12.44	20.28	1.90	3.29	14.84	11.90	4.72	1.10	5.90
Cl	4.15	2.36	14.62	3.99	6.16	3.71	1.47	2.36	5.58	4.61
Na	19.05	21.77	30.11	29.60	25.49	20.74	23.05	28.33	28.56	20.49
K	23.84	21.93	7.60	11.03	18.21	23.40	20.82	12.89	14.51	22.94
SiO_2	.09	.04	------	.16	.06	.10	------	------	.08	------
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Salinity, per cent	5.36	7.12	3.09	3.79	10.52	4.49	5.17	2.67	6.34	2.73
Specific gravity at 25° C	1.044	1.062	1.025	1.033	1.096	1.038	1.044	1.022	1.056	1.022

PLATTE RIVER BASIN.

Platte River is formed by the union of two branches, the North and South Platte. From the head of the North Platte the system has a length of more than 1,200 miles, but the course of the united rivers in Nebraska is only about 450 miles. The analyses to be considered first are the three tables by Dole published in Water-Supply Paper 236.

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[31] For details relative to these lakes, see Hicks, W. B., U. S. Geol. Survey Bull. 715, pp. 125-139, 1921.

Analyses of water from North Platte River near North Platte, Nebr.[a]

[Parts per million.]

Date (1906-7).		Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total dissolved solids.	Mean gage height (feet).
From—	To—													
Sept. 10	Sept. 19	120	----------	0.10	57	8.5	28	0.0	161	54	Tr.	5.0	262	1.9
20	Oct. 1	110	63	1.1	50	17	36	.0	167	114	1.8	6.7	285	2.0
Oct. 2	14	90	50	.10	40	11	29	.0	168	63	.4	6.1	277	1.9
15	24	85	42	.15	46	11	31	.0	155	72	Tr.	7.9	289	2.0
25	Nov. 3	290	50	.15	41	11	27	.0	155	62	1.0	5.7	264	2.4
Nov. 4	13	240	25	.30	40	11	----------	.0	169	69	1.3	9.2	292	2.4
14	23	150	43	.40	50	12	35	.0	189	91	.4	9.0	327	2.1
24	Dec. 3	130	44	.20	46	11	35	.0	168	78	.4	6.7	300	2.2
Dec. 4	13	160	48	.35	50	16	37	.0	179	----------	1.3	8.0	333	----------
14	23	140	52	.15	51	15	39	.0	205	102	Tr.	9.2	372	----------
24	Jan. 2	150	43	1.2	47	14	37	.0	178	88	Tr.	8.1	306	----------
Jan. 3	12	20	35	Tr.	52	14	37	.0	198	97	.4	9.5	326	----------
13	22	20	36	.05	56	15	41	.0	212	102	.2	9.4	359	----------
23	Feb. 1	150	37	.12	54	14	39	.0	187	84	.0	11	351	----------
Feb. 3	12	150	30	.12	46	9.5	31	.0	162	76	.7	7.3	272	----------
13	22	300	34	.10	52	12	----------	.0	146	41	2.8	6.7	270	----------
23	Mar. 4	210	45	.15	47	12	34	.0	170	82	1.6	7.0	309	----------
Mar. 5	15	240	31	.08	52	14	36	.0	167	----------	.9	10	331	----------
16	25	165	30	Tr.	47	13	34	.0	186	86	.4	9.0	319	----------
26	Apr. 4	1,840	56	.05	52	11	30	.0	146	112	.8	4.0	331	----------
Apr. 5	14	800	52	.10	43	11	26	.0	145	77	1.8	6.7	314	2.5
15	24	675	43	.30	44	12	28	.0	145	84	.7	7.3	285	2.4
25	May 4	440	41	.55	38	----------	24	.0	135	67	.5	4.8	258	2.5
May 5	14	165	38	.20	39	11	23	.0	144	68	1.1	5.5	264	2.3
15	24	370	40	.22	42	10	31	.0	156	63	1.9	4.5	272	2.4
25	June 3	680	35	.40	41	7.9	26	.0	146	59	1.8	5.3	260	3.2
June 4	13	350	34	.48	38	9.4	21	.0	137	58	5.0	4.7	246	3.4
14	23	375	26	.18	43	6.2	32	.0	148	56	6.2	4.4	249	3.3
24	30	290	13	.05	39	5.1	26	.0	156	54	1.3	2.5	219	3.5
Mean......		307	40	.26	46	12	32	.0	165	76	1.2	6.9	295	----------

[a] Analyses Sept. 10. 1906, to Feb. 12, 1907, by W. M. Barr; Feb. 13 to 22, 1907, by H. S. Spaulding; Feb. 24 to June 30, 1907, by Walton Van Winkle.

Analyses of water from Platte River near Columbus, Nebr.[a]

[Parts per million.]

Date (1906-7).		Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total dissolved solids.	Mean gage height (feet).
From—	To—													
Oct. 1	Oct. 11	20	31	Tr.	56	15	40	0.0	189	112	0.0	12	361	1.8
12	21	50	33	0.10	55	16	40	.0	187	113	.7	11	353	2.2
22	Nov. 2	350	37	.20	44	----------	34	----------	.0	74	.4	8.4	296	3.0
Nov. 3	12	625	47	.20	52	13	39	.0	181	86	1.8	9.6	349	3.5
13	22	300	32	.20	66	17	50	.0	195	134	.4	13	412	3.2
23	Dec. 2	210	26	.20	64	17	----------	.0	187	167	Tr.	14	441	3.0
Dec. 3	13	180	36	.07	73	22	----------	.0	204	----------	.4	19	543	----------
14	23	50	35	.05	77	25	77	.0	220	223	.9	19	561	----------
24	Jan. 2	60	27	.10	65	25	51	.0	190	181	.9	15	446	----------
Jan. 3	12	20	26	.05	71	23	49	.0	207	206	.9	17	510	----------
13	22	15	32	Tr.	74	21	46	.0	152	191	.7	16	496	----------
23	Feb. 1	20	22	.08	74	23	55	.0	216	186	1.4	17	487	----------
Feb. 2	12	15	22	.10	73	20	56	.0	198	189	5.2	16	473	----------
15	24	215	31	Tr.	46	15	----------	.0	148	101	2.3	8.5	309	----------
25	Mar. 6	115	30	Tr.	66	16	52	.0	192	----------	1.4	13	443	----------
Mar. 7	16	580	35	.9	72	20	52	.0	186	194	2.3	17	530	----------
17	26	325	28	.25	68	23	39	.0	200	----------	2.0	20	522	----------
27	Apr. 5	700	33	.35	57	16	60	.0	184	172	1.2	16	454	3.2
Apr. 6	15	2,000	26	.35	56	13	47	.0	175	144	2.7	----------	385	3.0
16	26	800	32	.20	63	18	46	.0	182	155	1.6	13	437	2.8
27	May 6	900	50	1.0	58	14	39	.0	161	130	1.1	10	407	3.2
May 7	15	580	38	.6	55	16	41	.0	168	128	.9	11	389	2.9
Mean........		374	32	.20	63	18	48	.0	186	152	1.3	14	437	----------

[a] Analyses Oct. 1, 1906, to Feb. 12, 1907, by W. M. Barr; Feb. 15 to 24, 1907, by H. S. Spaulding; Feb. 25 to Mar. 6, 1907, by Walton Van Winkle.

Analyses of water from Platte River at Fremont, Nebr.[a]

[Parts per million.]

Date (1906-7).		Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total dissolved solids.
From—	To—												
Oct 10	Oct. 20	100	50	0.10	47		36	0.0	199	37	0.0	4.9	265
21	31	290	44	.40	44	12		.0	157	51	.9	4.5	246
Nov. 1	Nov. 10	540	49	.40	47	12	32	.0	161	71	1.3	7.3	303
11	20	400	42	.40	54	14	41	.0		97	.9	9.0	359
21	30	170	43	.16	53	19		.0	184	86	.9	7.7	328
Dec. 1	Dec. 10	270	51	.20	52	14	34	.0	193	107	1.3	8.5	364
11	20	125	46	Tr.	61	16	38	.0	218	111	.4	7.5	385
21	30		44	Tr.	60	14	33	.0	221	93	Tr.	8.1	352
31	Jan. 9	80	38	.15	53	15	34	.0	185	97	1.4	8.4	339
Jan. 10	27	10	47	Tr.	62	13	40	.0	237	79	1.3	7.8	391
28	Feb. 6	10	47	.15	57	15	34	.0	209	80	1.9	7.1	335
Mar. 13	Mar. 22	675	40	.28	53	13	31	.0	199	82	Tr.	8.8	341
24	Apr. 5	460	35	.32	57	16	32	.0	192	95	.6	7.1	387
Apr. 6	17	1,050	44	.30	47	11	26	.0	176	75	.8	6.9	298
18	27	540	49	.45		13	33	.0	181	83	Tr.	10	347
28	May 8	510	62	.6	45	11	37	.0	168	71	1.1	5.4	322
May 9	18		50	.40	49	12		.0	170	71	.7	5.7	308
19	29	485	50	.40	43	13	24	.0	168	57	2.3	4.8	280
30	June 8	700	44	.23	41	9.3	23	.0	160	51	2.4	6.7	256
June 9	18	600	41	.12	38	8.3	23	.0	160	50	3.0	4.0	251
20	29	625	55	.8	40	11	27	.0	169	52	1.8	3.8	283
30	July 10	850		.10	41	5.9	29	.0	154	45	1.8	4.5	228
July 11	20	1,050	51	.8	38	4.4	25	.0	142	42	2.4	2.6	241
21	30	500	32	.08	39	4.5		.0	152	49	.9		337
31	Aug. 10	375	42	.20	41	8.7	34	.0	186	49	Tr.	6.5	260
Aug. 11	20	450	45	.15	44	10	27	.0	167	64	.9	5.7	274
21	31	95	49	.15	43	9.9	25	.0	166	51	Tr.	5.0	274
Sept. 1	Sept. 10	230	44	.12	43	9.5	24	.0	165	46	1.8	4.8	253
11	21	90	63	.10	45	8.2	15	[b] 4.8	161	37	.3	6.6	271
22	Oct. 1	95	62	.10	40	4.2	20	[b] 4.8	155	24	.3	3.0	243
Oct. 2	11	200	60	.66	41	8.6	31	[b] 6.0	162	41	1.0	6.0	270
12	23	75	45	.06	45	9.4	32	[b] 4.8	167	58	.5	7.4	280
24	Nov. 2	100	51	.14	46	9.7	32	[b] 6.0	160	61	.8	7.8	290
Mean		379	47	.26	47	11	30	.0	178	66	1.0	6.4	302

[a] Analyses Oct. 10, 1906, to Feb. 6, 1907, by W. M. Barr; Mar. 13, to Sept. 10, 1907, by Walton Van Winkle; Sept. 11 to Nov. 2, 1907, by R. B. Dole, Chase Palmer, and W. D. Collins.

[b] Abnormal; computed as HCO_3 in the average.

Fairly comparable with the data given in the foregoing tables are the 23 analyses of water from the Platte made by Prof. Samuel Avery for the Office of Experiment Stations of Nebraska. The samples analyzed were taken at Lexington once a month between February, 1903, and January, 1905. Reduced to standard form the average of the analyses is as follows:

Mean composition of Platte River water at Lexington, Nebr.

	Parts per million.	Percentage composition.
CO_3	74.4	24.56
SO_4	87.2	28.78
Cl	8.0	2.64
Ca	49.6	16.37
Mg	11.8	3.89
Na	32.1	10.59
K	4.8	1.58
$(Al, Fe)_2O_3$	4.2	1.39
SiO_2	30.9	10.20
	303.0	100.00

The four sets of analyses, stated in percentage form, compared as follows:

Comparative table of Platte River analyses.

1. At North Platte. Survey average, 29 composite analyses.
2. At Lexington. Avery's analyses, 23 monthly samples.
3. At Columbus. Survey average, 22 composites.
4. At Fremont. Survey average, 33 composites.

	1	2	3	4
CO_3	27.52	24.56	21.75	29.56
SO_4	25.80	28.78	36.19	22.26
Cl	2.03	2.64	3.33	2.16
NO_3	.40		.32	.34
Ca	15.63	16.37	15.00	15.85
Mg	4.08	3.89	4.29	3.72
Na	10.85	10.59	11.42	10.13
K		1.58		
$(Al, Fe)_2O_3$		1.39		
Fe_2O_3	.13		.08	.13
SiO_2	13.56	10.20	7.62	15.85
	100.00	100.00	100.00	100.00
Salinity, parts per million	295.95	303	420	296

For data relative to tributaries of the Platte there is first a group of analyses by W. P. Headden [32] of water from several streams at the headwaters of the South Platte, in the Rocky Mountains of Colorado. Reduced to standard form they are as follows:

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[32] Colorado Agr. Exper. Sta. Bull. 82, 1903.

Analyses of waters from tributaries of the Platte in Colorado.

1. Thompson River 3 miles west of Loveland.
2. St. Vrain Creek 3 miles west of Longmont.
3. Boulder Creek, water from tap at Boulder. Contains traces of Li.
4. Clear Creek 1 miles west of Golden. Contains traces of Li and Cu.
5. Cache la Poudre River above the North Fork.
6. Cache la Poudre River 150 feet above the headgate of Laramie County ditch.
7. Cache la Poudre River from faucet in chemical laboratory of Agricultural Experiment Station at Fort Collins.
8. Cache la Poudre River 2 miles above Greeley.
9. Cache la Poudre River 3 miles east of Greeley.
10. South Platte River below mouth of Cache la Poudre River, 1 mile south and miles east of Greeley.

I. Parts per million.

	1	2	3	4	5	6	7	8	9	10
CO_3	15.2	24.3	9.3	10.2	12.8	10.7	46.1	115	99	89
SO_4	85.5	112.8	4.0	32.4	3.3	2.2	31.0	942	521	559
Cl	.9	2.1	3.0	2.7	1.5	2.9	1.4	40	30	38
Ca	29.2	33.0	6.7	16.3	5.3	6.4	30.9	193	143	137
Sr	------	.3	.1	Tr.	------	------	.3	------	------	------
Mg	9.7	13.3	1.1	2.6	1.0	1.3	7.6	104	48	47
Mn	------	------	.1	------	------	------	------	------	------	------
Zn	------	------	Tr.	.1	------	------	------	------	------	------
Na	5.8	16.8	2.0	5.7	4.0	2.4	7.0	155	97	122
K	.6	1.0	.8	3.2	.9	1.1	2.3	5	4	4
Al_2O_3	.3	.4	.4	2.7	.1	.3	.3	1	1	1
Fe_2O_3				2.1						
Mn_2O_3	.1	.1	------	.8	.1	.1	.1	Tr.	1	1
SiO_2	6.7	6.9	8.8	19.5	8.7	7.6	9.0	15	14	13
	154.0	211.0	36.4	98.3	37.7	35.0	136.0	1,570	958	1,101

II. Percentage composition of dissolved solids.

	1	2	3	4	5	6	7	8	9	10
CO_3	9.87	11.52	25.61	10.37	31.91	30.58	33.68	7.34	10.34	8.78
SO_4	55.52	53.46	11.02	32.99	9.07	6.29	23.36	59.99	54.33	55.28
Cl	.58	1.00	8.16	2.74	4.03	8.29	1.10	2.52	3.19	3.79
Ca	18.96	15.64	18.39	16.60	14.53	18.29	22.58	12.31	15.00	13.24
Sr	------	.14	.17	Tr.	------	------	.19	------	------	------
Mg	6.30	6.30	3.09	2.67	2.93	3.73	5.53	6.65	5.00	4.69
Mn [a]	------	------	.30	------	------	------	------	------	------	------
Zn	------	------	Tr.	.14	------	------	------	------	------	------
Na	3.76	7.96	5.62	5.80	10.80	6.86	5.12	9.84	10.09	12.02
K	.39	.47	2.20	3.21	2.72	3.14	1.66	.34	.46	.41
Al_2O_3	.19	.19	1.21	2.74	.44	.86	.18	.07	.16	.27
Fe_2O_3				2.12						
Mn_2O_3	.08	.05	------	.76	.07	.25	.11	Tr.	.01	.26
SiO_2	4.35	3.27	24.23	19.86	23.50	21.71	6.49	.94	1.42	1.26
	100.0	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

[a] Bivalent manganese, reported originally as MnO.

In the preceding table analyses Nos. 5 to 10 are peculiarly instructive. Cache la Poudre River flows first through a rocky canyon, over boulders of schist and granite, and then emerges upon the plains. Its waters are then diverted into irrigation ditches and reservoirs and finally reach the Platte near Greeley. At first we have a very pure mountain stream, relatively high in carbonates, rich in silica, and low in salinity. At the end of the series we have waters in which sulphates predominate and the salinity is very high. The change is great in all respects and is partly due to the use of the water for irrigating an originally arid soil containing much soluble matter. The traces of zinc and copper in the water of Clear Creek are evidently derived from the drainage of mines around Central City and Blackhawk.

For two other tributaries of the Platte, Laramie and Elkhorn rivers, the following analyses are available:

Analyses of water from Laramie and Elkhorn rivers.

1. Laramie River about 20 miles above Laramie, Wyo. Mean of three analyses.
2. Laramie River about 50 miles below Laramie. Nos. 1 and 2 by E. E. Slosson; Wyoming Exper. Sta. Bull., 24, 1895.
3. Elkhorn River at Norfolk, Nebr. Received from Chicago & Northwestern Ry.

	Parts per million.			Percentage composition.		
	1	2	3	1	2	3
CO_3	58.0	84.0	111.1	27.35	19.59	49.93
SO_4	23.6	161.0	5.1	11.16	37.48	2.29
Cl	6.5	27.0	3.6	3.11	6.32	1.62
Ca	29.1	64.6	59.2	13.75	15.07	26.61
Mg	5.1	22.0	4.0	2.45	5.10	1.79
Na	15.5	38.0	14.1	7.34	8.82	6.34
K	2.7	8.4		.85	1.96	
$(Al, Fe)_2O_3$	4.7	4.8	3.2	2.26	1.12	1.44
SiO_2	67.2	19.4	22.2	31.73	4.54	9.98
	212.4	429.2	222.5	100.00	100.00	100.00

The two analyses of Laramie water show the effect upon it of irrigation. The water below Laramie has received much material from irrigated soils. The high silica in No. 1 is abnormal for water of the western plains. Elkhorn River is a characteristic carbonate water such as are common in the streams farther east.

In southeastern Wyoming, within the basin of the North Platte, there are many saline "lakes," which, however, are essentially beds of salts that are covered by water only during part of the year. Some of these beds have been worked as commercial sources of sodium sulphate.[33] The available analyses are as follows, expressed here in percentages.

Analyses of saline lakes in Wyoming.

1. Wilmington Lake, Natrona County. Analysis by E. E. Slosson, Wyoming Exper. Sta. Bull. 49, p. 119, 1901.
2. Soda Lake, Albany County, sec. 4, T. 14 N., R. 75 W. Analysis from U. S. Dept. Agr. Bur. Soils Fifth Rept., p. 1089, 1903. Analyst not named.
3. Big Lake.
4. Track Lake.
5. Red Lake. Nos. 3, 4, and 5 are in Albany County and are known as the Union Pacific Lakes. Analyses by H. Pemberton and G. P. Tucker, Franklin Inst. Jour., vol. 135, p. 52, 1893.

	1	2	3	4	5
HCO_3	----------	1.83	----------	----------	----------
CO_3	32.75	1.02	----------	----------	----------
SO_4	16.62	61.17	58.16	64.30	64.57
Cl	10.78	4.95	8.85	2.74	3.06
B_4O_7	----------	----------	2.03	1.14	.57
Ca	----------	.78	.93	.53	.59
Mg	----------	4.09	3.03	1.09	1.32
Na	39.85	24.31	27.00	30.20	29.89
K	----------	1.85	----------	----------	----------
	100.00	100.00	100.00	100.00	100.00
Salinity, parts per million	119,700	82,420	52,600	77,300	93,100
Specific gravity	----------	----------	1.0487	1.0725	1.0087

The figures for salinity given in the foregoing table are to be regarded as merely approximate. The salinity must vary as the concentration of the water

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[33] For additional information concerning these lakes see Ricketts, L. C., Wyoming Territorial Geologist, Ann. Rept. for 1888, p. 45; and Schultz, A. R., U. S. Geol. Survey Bull. 430, p. 570, 1910.

varies. The occurrence of borates, as shown in three of the analyses, is not common in natural waters.

KANSAS RIVER BASIN.

Kansas River (also known as Kaw River) is formed by the union of Smoky Hill and Republican rivers at Junction, and enters the Missouri at Kansas City, Kans. The drainage basin of the entire system is about 61,440 square miles, of which 34,550 square miles is in Kansas. Parker and Bailey[34] studied the quality of its waters with more than ordinary thoroughness and in addition to the usual chemical analyses give many concurrent determinations of turbidity and also details as to the geologic relations of the various streams of the system. Their report also contains numerous "assays" of waters, which, however, are too incomplete to be utilized here. Beginning with Smoky Hill River the analytical data are as follows:

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[34] Parker, H. N., and Bailey, E. H. S., U. S. Geol. Survey, Water-Supply Paper 273, 1911.

Analyses of water from Smoky Hill River at Lindsborg, Kans.

[Parts per million. Drainage area, 8,480 square miles. Analyses made in the chemical laboratories of the University of Kansas, E. H. S. Bailey, director.]

Date (1906-7). From—	Date (1906-7). To—	Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate (CO_3).	Bicarbonate (HCO_3).	Sulphate (SO_4).	Nitrate (NO_3).	Chlorine (Cl).	Total dissolved solids.
Nov. 27	Dec. 6	110	27	[a] 0.9	112	21	171	0.0	258	227	0.5	203	893
Dec. 7	16	63	----------	.8	123	24	150	.0	203	254	.4	230	981
17	26	55	49	.40	116	26	172	.0	305	250	.8	214	954
26	Jan. 6	31	27	.8	111	13	210	.0	277	220	1.8	240	939
Jan. 7	17	53	24	1.0	120	14	161	.0	295	227	3.5	192	899
18	28	385	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------
29	Feb. 7	55	24	1.7	130	19	158	.0	346	205	1.1	190	877
Feb. 9	19	117	69	.08	70	21	148	.0	284	176	.2	154	686
21	Mar. 3	59	62	.06	107	22	163	.0	277	245	1.1	169	874
Mar. 4	14	95	41	.30	108	20	161	.0	255	208	.6	174	843
15	26	149	18	.50	123	26	153	.0	252	246	1.0	179	866
27	Apr. 7	199	18	.80	128	27	196	.0	290	252	.5	235	1,007
Apr. 8	18	93	23	.80	136	20	139	.0	382	197	.9	164	844
19	May 1	115	17	.80	117	23	176	.0	310	219	1.5	216	901
May 5	15	214	16	1.2	112	27	199	.0	290	239	1.5	251	960
16	26	405	19	1.0	120	19	202	.0	285	257	2.0	246	997
28	June 9	29	11	.8	122	34	199	.0	300	243	2.2	251	1,004
June 10	21	35	22	1.0	100	23	195	.0	55	217	2.8	242	917
22	July 2	62	26	.8	133	29	163	.0	215	286	3.2	191	929
July 5	16	243	39	2.5	158	28	106	.0	172	401	5.0	103	941
18	29	1,210	29	4.0	68	9.5	38	.0	165	77	3.0	54	357
30	Aug. 10	910	24	1.3	90	25	144	.0	143	215	1.7	160	751
Aug. 11	20	2,030	30	.9	125	20	96	.0	195	257	4.5	96	715
21	Sept. 1	90	21	.6	120	20	126	.0	198	243	2.7	118	720
Sept. 2	14	57	26	.08	122	30	150	[b] 6.0	195	284	2.0	175	886
22	Oct. 8	143	24	.50	101	15	168	.0	215	256	2.3	204	896
Oct. 10	27	78	20	.12	124	22	195	.0	235	235	.9	230	927
28	Nov. 16	51	27	.16	114	26	200	.0	295	242	.9	256	982
Nov. 17	29	29	24	.12	93	24	178	.0	275	255	.8	227	738
Mean		247	28	.86	114	22	161	.0	256	237	1.8	191	867

[a] Aluminum = 0.8.

[b] Abnormal; computed as HCO_3 in the average.

NOTE.—Analyses from Nov. 27, 1906, to Feb. 7, 1907, and from Mar. 15 to Nov. 16, 1907, by F. W. Bushong; from Feb. 9 to Mar. 14, 1907 and from Nov. 17 to 29, 1907 by Archie J. Weith.

Additional analyses of water from Smoky Hill River are as follows:

Analyses of water from Smoky Hill River, Kans.

1. South Fork of Smoky Hill River at Somena.
2. North Fork of Smoky Hill River at McAllaster. Analyses 1 and 2 received from Union Pacific R. R.
3. Smoky Hill River at Salina. Received from Missouri Pacific Ry.
4. Smoky Hill River below Salina. Analysis by E. H. S. Bailey.

	Parts per million.				Percentage composition.			
	1	1	1	4	1	2	3	4
CO_3	119.2	138.0	246	164	26.26	25.82	32.84	16.03
SO_4	143.5	184.0	188	251	21.60	34.43	25.10	24.54
Cl	18.1	15.0	36	229	3.98	2.81	4.81	22.38
NO_3	4.3	----------	----------	----------	.97	----------	----------	----------
Ca	94.4	101.0	170	142	20.79	18.90	22.70	13.88
Mg	15.0	32.0	35	27	3.30	5.99	4.67	2.64
Na(K)	36.2	26.0	40	182	7.97	4.86	5.34	17.79
$(Al, Fe)_2O_3$	2.6	3.4	2	7	.57	.64	.07	.69
SiO_2	20.7	35.0	32	21	4.56	6.55	4.47	2.05
	454.0	534.4	749	1,023	100.00	100.00	100.00	100.00

The principal tributaries of Smoky Hill River are Saline and Solomon rivers. For these there are first the two following tables of analyses:

Analyses of water from Saline River at Sylvan Grove, Kans.

[Parts per million. Drainage area 2,300 square miles. Analyses made by F. W. Bushong in the chemical laboratories of the University of Kansas, E. H. S. Bailey, director.]

Date (1906-7).		Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate (CO_3).	Bicarbonate (HCO_3).	Sulphate (SO_4).	Nitrate (NO_3).	Chlorine (Cl).	Total dissolved solids.
From—	To—												
Nov. 27	Dec. 6	65	27	[a] 0.9	114	47	738	0.0	370	497	0.4	982	2,623
Dec. 7	16	33	----------	1.2	147	56	852	.0	382	540	.4	1,108	2,910
17	26	41	55	1.0	152	58	865	.0	407	566	.7	1,170	3,086
27	Jan. 5	45	28	1.0	137	46	681	.0	327	480	.4	980	2,688
Jan. 6	15	27	23	1.2	148	56	807	.0	334	541	1.4	1,086	2,832
16	25	27	44	1.2	151	52	777	.0	427	521	.9	1,004	2,784
26	Feb. 4	28	49	.6	148	51	714	.0	320	554	.4	954	2,648
Feb. 5	15	49	20	.14	144	52	776	.0	406	530	.2	1,041	2,716
16	25	46	93	.30	145	41	726	.0	367	462	.4	934	2,566
26	Mar. 7	37	86	.62	159	55	866	.0	374	520	.4	1,131	3,031
Mar. 8	17	32	23	.25	115	54	774	[b] 3.1	311	475	.2	960	2,503
18	27	49	18	.8	145	59	822	.0	336	549	.6	1,118	2,884
28	Apr. 7	70	14	.8	144	62	934	.0	330	427	.4	1,269	3,200
Apr. 8	17	51	13	3.2	151	63	971	.0	337	607	.4	1,339	3,357
18	27	44	10	1.6	142	68	1,021	.0	345	551	.7	1,380	3,408
28	May 9	41	12	1.5	134	62	949	.0	340	582	.9	1,280	3,176
May 10	20	50	14	.50	138	60	1,005	.0	320	621	1.0	1,348	3,370
21	31	43	15	1.2	136	67	1,150	.0	322	670	.6	1,580	3,835
June 3	June 12	218	15	3.0	120	53	862	.0	277	498	.9	1,148	2,880
13	22	75	17	1.4	116	44	689	.0	282	447	1.1	928	2,423
23	July 5	1,130	35	4.0	97	32	295	.0	208	273	4.5	368	1,210
July 6	15	590	27	1.2	110	24	392	.0	252	302	1.7	504	1,485
16	25	860	28	1.2	114	26	238	.0	238	245	1.5	276	1,043
26	Aug. 4	240	27	1.8	120	42	444	[b] 9.0	225	350	.7	592	1,712
Aug. 5	14	158	27	1.8	124	45	591	.0	263	401	1.0	796	2,106
16	26	916	32	3.4	84	22	182	.0	222	153	2.7	224	790
27	Sept. 5	140	31	.12	106	37	425	[b] 6.0	252	296	1.3	564	1,571
Sept. 6	17	72	27	.05	125	60	905	.0	305	457	1.1	1,023	2,587
18	28	78	15	.12	142	79	1,022	.0	305	578	3.8	1,448	3,488
29	Oct. 10	668	19	.12	124	43	555	[b] 3.0	290	366	3.0	741	1,998
Oct. 12	22	46	17	.10	148	74	991	.0	355	562	.6	1,340	3,366
23	Nov. 2	55	18	.18	167	61	973	.0	355	554	.7	1,300	3,382
Nov. 3	13	43	27	.40	149	40	932	.0	380	554	.3	1,268	3,191
14	29	41	23	.10	109	64	914	.0	390	544	.6	1,216	3,010
Mean........		180	28	1.1	132	52	760	.0	323	479	1.0	1,012	2,908

[a] Al=2.

[b] Abnormal; computed as HCO_3 in the average.

Analyses of water from Solomon River at Beloit, Kans.

[Parts per million. Drainage area, 5,540 square miles. Analyses made in the chemical laboratories of the University of Kansas, E. H. S. Bailey, director.]

Date (1906-7).		Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate (CO_3).	Bicarbonate (HCO_3).	Sulphate (SO_4).	Nitrate (NO_3).	Chlorine (Cl).	Total dissolved solids.	Mean gage height (feet).
From—	To—													
Dec. 1	Dec. 13	25	35	1.0	112	16	107	0.0	337	118	0.4	56	534	----------
14	24	18	19	.9	109	20	95	.0	366	118	2.7	80	615	----------
25	Jan. 3	13	32	1.0	107	15	107	[a] 8.4	325	116	4.6	72	585	----------
Jan. 4	13	20	37	1.2	116	20	70	.0	319	118	4.8	58	525	0.8
15	24	9	48	1.6	109	15	98	----------	----------	134	4.4	----------	655	.6
25	Feb. 3	7	51	.8	91	12	94	[a] 2.4	208	148	3.0	71	602	.6
Feb. 4	24	19	39	.20	94	13	74	.0	303	71	3.9	57	544	.9
25	Mar. 6	17	95	.20	94	18	95	.0	317	112	4.8	62	625	.7
Mar. 7	16	22	28	.18	95	15	72	.0	306	110	3.0	50	509	1.6
17	26	50	31	4.0	89	8.2	76	.0	300	103	1.0	54	514	.9
27	Apr. 6	47	29	.6	91	10	85	[a] 5.3	302	110	.4	66	544	1.1
Apr. 7	17	52	28	1.6	95	15	83	[a] 7.0	330	113	.6	46	552	.6
27	May 6	32	24	2.4	98	19	83	.0	327	110	1.0	64	526	1.2
May 7	16	41	28	.9	98	9.3	76	.0	305	108	1.5	63	527	1.5
17	27	36	32	1.1	94	3	106	[a] 14.0	295	118	1.5	98	606	1.2
28	June 6	46	30	.8	99	19	104	.0	333	117	1.8	88	617	1.5
June 7	16	67	31	2.0	82	15	72	.0	267	102	2.7	49	476	1.4
17	26	50	39	2.0	86	20	83	.0	295	101	3.5	60	508	1.5
27	July 8	7.767	34	5.0	73	17	53	.0	218	92	12.0	36	428	4.0
July 9	18	156	51	3.0	91	20	61	.0	272	99	2.8	32	460	1.4
19	28	750	36	6.0	66	12	42	.0	165	76	5.5	22	330	2.3
29	Aug. 7	195	28	4.0	80	25	67	.0	254	83	7.5	50	429	----------
Aug. 8	17	32	39	.50	102	22	97	.0	340	115	2.7	78	573	----------
18	29	90	29	1.4	77	14	60	.0	240	69	4.0	40	380	----------
30	Sept. 11	49	34	.10	78	16	74	[a] 12.0	237	77	3.2	54	437	----------
Sept. 12	21	43	36	.03	84	19	106	.0	305	97	2.3	96	570	----------
22	Oct. 2	34	22	.14	50	21	138	.0	135	131	1.2	130	506	----------
Oct. 3	16	188	23	.12	66	13	66	.0	200	74	4.0	54	373	----------
18	28	35	37	.14	96	18	111	.0	320	115	1.2	104	613	----------
29	Nov. 7	34	31	.14	109	22	114	.0	360	125	1.2	106	664	----------
Nov. 8	18	40	35	.10	112	22	109	.0	372	133	.9	101	656	----------
19	Dec. 5	33	34	.10	87	21	114	.0	367	132	.3	90	594	----------
Mean		313	35	1.4	92	16	86	.0	294	108	3.0	67	534	----------

[a] Abnormal; computed as HCO_3 in the average.

NOTE.—Analyses from Dec. 1, 1906, to Feb. 3, 1907, and from Mar. 17 to Nov. 18, 1907, by F. W. Bushong; from Feb. 4 to Mar. 16 and from Nov. 19 to Dec. 5, 1907, by Archie J. Weith.

Additional analyses of water from Saline and Solomon rivers are as follows:

Analyses of water from Saline and Solomon rivers, Kans.

1. Saline River above New Cambria. E. H. S. Bailey, analyst.
2. Solomon River at Minneapolis. Received from Atchison, Topeka & Santa Fe Ry.
3. Solomon River at Solomon. Bailey, analyst.
4. Elm Creek at Lenora.
5. Mulberry Creek at Beloit. Analyses 4 and 5 from Missouri Pacific Ry. Elm and Mulberry creeks are tributaries of the Solomon.
6. Solomon River at Beloit. Analysis by F. M. Darst. Received from Kansas State Board of Health.

I. Parts per million.

	1	2	3	4	5	6
CO_3	340	91	156	157.0	149.6	115.1
SO_4	420	53	257	.0	147.8	104.1
Cl	858	42	270	7.6	131.6	32.0
Ca	140	55	128	74.0	111.9	86.0
Mg	47	11	24	16.0	21.4	14.5
Na (K)	647	39	226	8.9	101.1	9.9
Al_2O_3	--------	Tr.	--------	2.0	.5	14.0
Fe_2O_3	5		5			
SiO_2	24	28	40	47.0	25.1	37.4
	2,481	319	1,106	312.5	689.0	413.0

II. Percentage composition of dissolved solids.

	1	2	3	4	5	6
CO_3	13.70	28.53	14.11	50.24	21.71	27.87
SO_4	16.93	16.61	23.24	.00	21.45	25.21
Cl	34.59	13.17	24.41	2.43	19.10	7.75
Ca	5.63	17.24	11.57	23.68	16.24	20.82
Mg	1.90	3.45	2.17	5.12	3.11	3.51
Na (K)	26.08	12.22	20.43	2.85	14.67	2.40
Al_2O_3	--------	Tr.	--------	.64	.07	3.39
Fe_2O_3	.20		.45			
SiO_2	.97	8.78	3.62	15.04	3.65	9.05
	100.00	100.00	100.00	100.00	100.00	100.00

The following analyses represent minor tributaries of Smoky Hill River:

Analyses of water from tributaries of Smoky Hill River, Kans.

1. Big Creek at Ellis. Received from Union Pacific R. R.
2. Gypsum Creek at Gypsum City.
3. Turkey Creek at Swayne. Nos. 2 and 3 received from Missouri Pacific Ry.
4. Lyons Creek at Jacobs. Received from Atchison, Topeka & Santa Fe Ry.
5. Lime Creek at Herington. Received from Chicago, Rock Island & Pacific Ry.
6. Chism Creek at Herington. Received from Missouri Pacific Ry.

I. Parts per million.

	1	2	3	4	5	6
CO_3	170	145.0	133	218	104	276.0
SO_4	18	134.0	1,504	138	43	141.0
Cl	18	8.1	31	24	19	5.6
Ca	77	67.0	517	128	49	105.0
Mg	20	25.0	90	37	23	57.0
Na(K)	23	55.0	78	34	13	52.0
$(Al,Fe)_2O_3$	3	4.9	5	Tr.	3	1.4
SiO_2	35	23.0	40	31	14	23.0
	364	462.0	2,398	610	268	661.0

II. Percentage composition of dissolved solids.

	1	2	3	4	5	6
CO_3	46.70	31.39	5.55	35.74	38.81	41.75
SO_4	4.94	29.00	62.72	22.62	16.04	21.33
Cl	4.94	1.75	1.29	3.93	7.09	.85
Ca	21.61	14.50	21.56	20.98	18.29	15.89
Mg	5.50	5.41	3.75	6.07	8.58	8.62
Na(K)	6.32	11.91	3.26	5.58	4.85	7.87
$(Al,Fe)_2O_3$	.82	1.06	.20	Tr.	1.12	.21
SiO_2	9.62	4.98	1.67	5.08	5.22	3.48
	100.00	100.00	100.00	100.00	100.00	100.00

For Republican River, which unites with the Smoky Hill to form the Kansas, there are first the tables of analyses by Bailey and his colleagues—one of the river itself, the other of a tributary, Prairie Dog Creek. They are as follows:

Analysis of water from Republican River at Junction, Kans.

[Parts per million except as otherwise stated. Drainage area 25,840 miles. Analyses made in the chemical laboratories of the University of Kansas, E. H. S. Bailey, director.]

Date (1906-7). From—	Date (1906-7). To—	Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K)	Carbonate (CO_3).	Bicarbonate (HCO_3)	Sulphate (SO_4).	Nitrate (NO_3).	Chlorine (Cl).	Total dissolved solids.	Mean gage height (feet).[a]	Mean discharge (cubic feet per second).	Run-off per square mile (cubic feet per second).	Suspended matter (tons per 24 hours).	Dissolved matter (tons per 24 hours).
Nov. 26	Dec. 5	325	39	1.1	68	14	68	0.0	338	47	0.7	29	397	6.1	830	0.032	500	890
Dec. 6	15	305	--------	1.2	74	43	52	.0	330	48	2.0	27	399	6.0	800	.031	380	860
16	25	152	46	.8	79	19	56	[b] 11	320	69	2.6	37	436	5.6	720	.028	210	850
26	Jan. 4	320	39	2.4	78	10	51	.0	372	58	.9	36	518	6.3	890	.034	570	1,240
Jan. 6	16	257	42	3.5	71	22	56	[b] 8.9	298	59	4.4	40	419	5.7	740	.029	350	840
17	26	108	62	.6	82	7.2	75	[b] 7.7	338	70	3.3	35	471	5.7	740	.029	150	940
27	Feb. 5	55	65	1.2	82	18	83	[b] 18	340	59	1.3	35	485	−5.7	740	.029	110	970
Feb. 6	15	205	57	.26	71	17	64	[b] 10	294	56	1.5	30	419	6.0	800	.031	350	900
16	26	925	145	.20	55	6.0	44	.0	243	37	2.4	14	429	7.1	1,150	.044	2,540	1,330
27	Mar. 8	526	79	.56	65	14	35	.0	260	45	3.1	20	423	6.6	980	.038	1,800	1,120
Mar. 10	20	446	36	.18	68	15	58	.0	277	53	2.1	31	382	6.5	950	.037	1,200	980
21	30	200	38	2.5	68	7.3	59	.0	305	45	1.1	28	405	6.3	890	.034	480	970
31	Apr. 9	185	38	2.5	73	11	59	.0	318	55	.3	25	396	6.1	830	.032	350	890
Apr. 10	20	144	36	1.8	76	6.3	55	[b] 7	320	56	1.5	32	407	5.9	780	.030	260	860
21	30	146	39	1.5	79	19	62	.0	327	60	1.2	33	419	5.8	760	.029	240	860
May 1	May 10	131	39	2.2	70	12	54	.0	312	55	1.7	31	398	5.9	780	.030	240	840
12	21	138	44	1.0	78	7.9	57	.0	330	58	1.6	32	427	5.9	780	.030	280	900
22	31	120	43	1.0	80	4.5	67	[b] 5.0	330	65	1.4	37	441	6.0	800	.031	340	950
June 1	June 10	1,966	35	4	49	13	45	.0	228	36	7.5	21	312	6.4	920	.036	3,850	780
11	21	3,760	41	9	48	19	24	.0	195	36	11	15	290	7.0	1,100	.042	7,870	860
22	July 1	1,485	43	6	65	12	50	.0	242	40	5.5	20	336	6.3	890	.034	2,420	810
July 2	16	2,070	39	2.0	64	16	53	.0	255	49	8	25	345	5.9	780	.030	3,090	730
18	27	3,350	42	7	46	13	61	.0	177	21	3.5	19	262	7.0	1,100	.042	7,270	780
28	Aug. 30	1,300	33	1.8	65	14	62	.0	198	62	3.8	47	399	--------	--------	--------	--------	--------
Aug. 31	Sept. 10	45	44	.07	75	21	75	[b] 7.0	277	77	1.5	51	449	5.3	660	.026	--------	800
Mean		746	48	2.2	69	14	57	.0	295	53	3.0	30	402	--------	850	--------	1,515	915

[a] Gaging station at Clay Center, Kans.

[b] Abnormal; computed as HCO_3 in the average.

NOTE.—Analyses from Nov. 26, 1906, to Feb. 5, 1907, and from Mar. 21 to Sept. 10, 1907, by F. W. Bushong; from Feb. 6 to Mar. 20, 1907, by Archie J. Weith.

Analyses of water from Prairie Dog Creek at Long Island, Kans.

[Parts per million. Drainage area (estimated), 900 square miles. Analyses made in the chemical laboratories of the University of Kansas, E. H. S. Bailey, director.]

Date (1906-7). From—	Date (1906-7). To—	Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate (CO_3).	Bicarbonate (HCO_3).	Sulphate (SO_4).	Nitrate (NO_3).	Chlorine (Cl).	Total dissolved solids.
Dec. 5	Dec. 14	40	33	0.20	87	19	31	0.0	386	13	0.3	9.0	355
15	25	13	37	.40	92	19	35	[a] 12	422	16	.5	12	399
26	Jan. 4	23	43	1.2	79	9.5	28	[a] 12	340	31	4.2	8.0	335
Jan. 5	15	13	38	.8	92	18	36	[a] 12	390	15	4.8	10	379
16	26	8	38	.6	94	18	42	------	------	20	1.3	------	403
27	Feb. 6	11	59	1.0	96	17	38	[a] 18	435	20	1.1	14	430
Feb. 7	16	31	49	.02	52	18	46	.0	359	16	1.2	7.2	355
17	Mar. 2	60	59	.20	71	14	------	.0	308	13	1.5	7.9	339
Mar. 3	13	47	64	.52	81	15	37	.0	353	14	.7	8.0	379
14	23	101	30	2.0	82	18	34	.0	367	11	.9	8.2	337
24	Apr. 5	54	34	1.0	88	8.4	31	.0	403	8.3	.5	7.1	364
Apr. 6	17	39	30	3.4	88	8.1	32	.0	412	9.2	1.2	8.8	362
18	May 4	29	32	1.6	88	17	37	.0	384	11	1.1	11	354
May 5	16	29	36	2.0	89	6.7	33	.0	387	12	1.6	9	358
17	26	61	39	1.2	89	5.2	39	.0	415	9.1	3.5	10	389
27	June 6	53	39	.8	90	22	39	.0	395	8.6	4.1	11	375
June 8	19	672	20	12	58	12	46	.0	285	14	12	9	337
21	July 3	2,435	49	5	54	11	32	.0	250	13	10	7	289
July 4	14	610	61	5	80	19	43	[a] 7	362	16	7.5	11	385
15	28	1,506	55	7	55	12	33	.0	240	16	8	5	290
29	Aug. 7	248	44	2	73	18	38	.0	335	15	4.0	14	351
Aug. 8	17	1,730	38	10	62	18	35	.0	278	15	6	10	426
24	Sept. 4	269	32	.08	60	15	43	.0	250	16	8.0	7.5	279
Sept. 5	15	100	32	.03	67	17	33	.0	290	16	4.0	9	301
26	Oct. 6	224	20	.12	54	18	35	.0	235	16	1.2	7.3	236
Oct. 7	16	93	28	.50	51	14	29	.0	202	18	4.5	6.5	234
17	30	71	35	.20	43	13	32	.0	245	15	3.5	6.5	268
Nov. 1	Nov. 12	189	25	1.2	54	14	30	.0	278	14	3.8	8.5	281
13	22	85	29	.16	69	14	25	.0	270	15	3.2	7.0	274
23	Dec. 4	283	30	.12	71	19	36	.0	300	14	3.5	9.0	307
Mean		304	39	2.0	74	15	36	.0	334	15	3.6	8.9	339

[a] Abnormal; computed as HCO_3 in the average.

NOTE.—Analyses from Dec. 5, 1906, to Feb. 6, 1907, and from Mar. 14 to Dec. 4, 1907, by F. W. Bushong; from Feb. 7 to Mar. 13, 1907, by Archie J. Weith.

Analyses of waters in Republican River basin.

1. Arikaree River at Benkelman, Nebr. Analysis by F. W. Bushong.
2. Sappa Creek at Oberlin, Kans. Mean of four analyses by Bushong.[25]
3. Pond at Belleville, Kans. Received from the Chicago, Rock Island & Pacific Railway Co.
4. Republican River above Junction City, Kans. E. H. S. Bailey, analyst.

	Parts per million.				Percentage composition.			
	1	2	3	4	1	2	3	4
CO_3	133	276.0	51	163.0	17.05	50.15	17.00	30.15
SO_4	337	11.0	98	75.0	43.20	2.00	32.66	13.87
Cl	17	16.0	37	55.0	2.18	2.92	12.33	10.17
NO_3	Tr.	4.0	------	------	Tr.	.73	------	------
Ca	103	101.0	24	86.0	13.20	18.35	8.00	15.91
Mg	42	26.0	12	18.0	5.37	4.72	4.00	3.33
Na (K)	101	70.0	59	72.0	12.98	12.71	19.69	13.32
(Al, Fe)$_2$O$_3$	------	1.3	19	------	------	.24	6.32	------
Fe_2O_3	Tr.	------		7.6	Tr.	------		1.41
SiO_3	47	45.0		64.0	6.02	8.18		11.84
	780	550.3	300	540.6	100.00	100.00	100.00	100.00

For the main stem of Kansas River there is first, a table of analyses covering a period of two years and giving the average character of the water during that time.

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[35] According to Parker and Bailey, U. S. Geol. Survey Water-Supply Paper 273, p. 234, 1911. When the samples for analysis were taken the creek contained little else but ground water from the Tertiary.

Analyses of water from Kansas River near Holliday, Kans.

[Parts per million except as otherwise stated. Drainage area, 61,100 square miles. Analyses made in the chemical laboratories of the University of Kansas, E. H. S. Bailey, director.]

Date.		Turbidity.	Silica (SiO₂).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate (CO₃).	Bicarbonate (HCO₃).	Sulphate (SO₄).	Nitrate (NO₃).	Chlorine (Cl).	Total dissolved solids.	Mean gage height (feet).[a]	Mean discharge (cubic feet per second).	Run-off per square mile (cubic feet per second).	Suspended matter (tons per 24 hours).	Dissolved matter (tons per 24 hours).
From—	To—																	
1906. Dec. 29	1907. Jan. 7	47	56	1.0	92	26	94	[b]12	341	77	0.9	82	564	6.2	4,340	0.071	410	6,610
1907. Jan. 8	17	62	25	1.0	74	21	77	[b]3.6	319	81	1.6	80	495	6.3	4,510	.074	572	6,030
19	28	298	61	3.0	63	9.5	40	.0	216	60	3:9	28	363	6.6	5,020	.082	2,467	4,920
29	Feb. 7	18	25	2.0	94	3.1	64	.0	328	81	2.7	60	474	6.3	4,510	.074	244	5,770
Feb. 8	13	------	------	------	------	------	------	------	------	------	------	------	------	6.6	5,020	.082	[c]2,500	------
14	24	429	47	.40	52	8.8	68	[b]12	171	60	3.4	44	375	7.0	5,700	.093	5,279	5,770
25	Mar. 6	906	67	.8	62	12	68	.0	222	47	2.3	39	421	7.4	6,620	.108	10,492	7,520
Mar. 7	18	3,425	33	.40	70	15	37	.0	247	60	3.0	25	366	8.3	8,840	.145	55,207	8,740
19	30	1,672	25	2.0	82	7.9	54	.0	278	74	4.9	38	415	7.1	5,930	.097	19,517	6,640
31	Apr. 11	970	17	6.0	87	5.4	62	[b]5.0	295	80	2.9	54	455	6.6	5,020	.082	8,539	6,170
Apr. 12	23	80	17	1.8	82	8.7	74	.0	335	82	1.5	72	505	6.4	4,680	.076	1,061	6,380
24	May 3	72	18	1.5	88	12	67	.0	315	76	1.9	60	459	6.3	4,510	.074	999	5,590
May 4	13	117	19	1.3	78	6.4	58	.0	280	69	2.2	48	407	6.2	4,340	.071	1,430	4,770
14	23	125	23	1.5	71	2.3	76	.0	257	81	3.3	61	435	6.1	4,170	.068	1,700	4,900
24	June 6	765	24	2.0	66	14	57	.0	233	57	4.0	43	366	6.7	5,190	.085	11,196	5,130
June 8	19	2,940	27	3.0	55	12	40	[b]7.0	170	43	6.8	29	285	8.2	8,560	.140	45,669	6,590
20	29	2,093	35	7.0	56	13	39	.0	192	31	6.0	18	272	7.2	6,160	.101	22,220	4,520
30	July 9	2,500	29	1.2	66	14	66	.0	217	57	6.5	60	371	6.7	5,190	.085	23,639	5,200
July 10	19	3,190	39	7.0	52	14	50	[b]11	188	39	4.0	29	307	8.0	8,000	.131	51,084	6,630
20	29	2,840	55	10	44	10	38	[b]36	68	44	.6	17	278	9.4	12,400	.203	68,634	9,310
30	Aug. 8	1,800	36	5.0	54	18	40	.0	185	42	2.5	24	277	7.5	6,850	.112	21,102	5,120
Aug. 9	18	765	37	2.5	65	13	48	.0	223	48	2.8	37	334	7.0	5,700	.093	9,991	5,140
19	28	400	34	.8	69	17	56	[b]9.0	213	56	2.3	45	364	6.1	4,170	.068	3,333	4,100
29	Sept. 7	80	32	.14	79	21	84	[b]9.0	223	93	1.7	79	484	5.6	3,520	.058	722	4,600
Sept. 8	17	70	35	.05	98	19	54	.0	327	67	1.9	43	450	5.3	3,160	.052	640	3,840
18	27	55	23	.04	71	20	35	.0	265	52	Tr.	19	309	5.1	2,920	.048	434	2,440
29	Oct. 8	833	24	.14	79	18	50	.0	275	55	2.5	42	378	6.4	4,680	.076	8,011	4,780
Oct. 9	18	1,260	35	.6	58	15	76	.0	285	56	3.3	69	375	6.4	4,680	.076	8,769	4,740
19	31	52	26	.14	85	16	36	.0	345	46	1.2	27	363	5.3	3,160	.052	316	3,100
Nov. 1	Nov. 10	46	19	.12	86	14	30	.0	260	39	1.8	27	289	5.3	3,160	.052	427	2,470
11	20	41	22	.12	59	17	39	.0	370	48	.6	13	278	5.2	3,040	.05	213	2,280
21	30	37	21	.12	100	13	30	.0	320	44	.8	11	305	5.2	3,040	.05	205	2,500
Dec. 1	Dec. 7	24	19	.24	67	16	32	.0	335	56	.7	19	286	5.2	3,040	.05	230	2,350
8	17	16	20	.20	101	19	45	.0	342	59	.5	41	326	5.3	3,160	.052	213	2,780
18	27	18	20	.24	61	16	33	.0	340	48	.6	19	257	6.0	4,000	.065	173	2,780
28	1908. Jan. 6	18	24	.40	77	18	50	.0	315	61	1.2	32	329	5.6	3,520	.058	200	3,130
1908. Jan. 7	Jan. 16	30	21	.16	96	16	48	.0	318	63	.8	32	389	5.6	3,520	.058	266	3,700
17	26	12	22	.25	96	17	48	.0	340	71	.5	32	380	5.8	3,760	.062	406	3,860
27	Feb. 5	30	20	.10	110	19	71	.0	370	80	1.4	68	526	5.6	3,520	.058	124	5,000
Feb. 6	14	18	16	.14	102	16	57	.0	340	64	.6	48	440	6.0	4,000	.065	216	4,750
15	24	60	13	.13	89	14	41	.0	263	62	3.6	30	357	6.2	4,340	.071	598	4,180
25	Mar. 5	1,100	23	.16	79	15	64	.0	265	70	3.8	67	401	6.5	4,850	.079	10,856	5,250
Mar. 6	15	240	24	.10	73	15	66	.0	260	68	1.7	54	402	6.3	4,510	.074	2,034	4,900
16	25	90	16	.10	91	15	44	.0	270	61	.6	35	364	5.9	3,880	.064	419	3,810
26	Apr. 4	70	14	.10	78	14	51	.0	300	69	2.0	28	342	5.7	3,640	.06	462	3,360
Apr. 5	14	90	24	.12	48	15	46	.0	295	60	.5	34	303	5.8	3,760	.062	812	3,080
15	24	395	28	.14	62	15	59	.0	288	63	.8	45	352	6.1	4,170	.068	3,457	3,960
25	May 4	215	51	.10	93	16	62	.0	299	70	2.5	52	472	5.9	3,880	.064	1,393	4,940
May 5	14	4,120	28	.52	55	10	35	.0	158	41	8.0	18	270	10.0	14,800	.242	135,224	1,080
15	24	2,900	44	.6	56	13	42	.0	175	45	8.0	22	282	9.3	12,000	.196	83,893	9,140
25	June 3	3,850	33	1.2	49	9.9	32	[b]27	12	32	.7	9.1	250	11.6	23,600	.386	203,011	1,590
June 6	15	2,550	23	.6	49	8.0	29	.0	151	28	4.5	5.9	217	21.8	87,700	1.44	486,840	51,380
16	25	2,620	33	1.2	49	7.5	29	.0	152	30	.4	6.5	236	17.7	62,050	1.02	361,875	39,540
26	July 5	2,250	26	.44	64	13	40	[b]11	72	57	3.0	22	237	13.7	36,200	.592	197,141	23,160
July 6	15	2,280	25	.44	58	10	42	.0	185	50	4.6	24	298	11.0	20,000	.327	108,594	16,090
16	25	2,800	31	.7	51	13	41	.0	164	40	4.0	23	273	12.0	26,000	.426	191,014	19,160
26	Aug. 4	2,050	29	.4	54	9.8	39	.0	227	42	4.0	27	288	10.2	15,840	.259	70,482	12,320
Aug. 5	14	1,663	27	.7	61	13	46	.0	206	52	2.8	35	321	8.8	10,240	.168	42,744	8,880
15	24	2,000	32	.5	59	11	46	.0	184	44	3.0	36	310	10.3	16,360	.268	81,409	13,690
25	Sept. 3	2,375	31	.44	44	6.0	45	[b]7.5	121	34	3.2	28	253	10.8	18,960	.310	111,701	12,950
Sept. 4	13	430	33	.14	78	13	58	.0	274	49	1.5	53	422	7.3	6,390	.104	6,280	7,280
14	23	111	33	.14	95	15	84	.0	327	119	1.0	88	558	6.5	4,850	.079	1,571	7,310
24	Oct. 3	90	41	.06	94	32	67	[b]2.4	329	------	.75	107	410	6.1	4,170	.068	788	4,620
Oct. 4	13	70	55	.30	96	46	50	[b]11	306	106	.75	123	672	5.9	3,880	.064	503	7,040
14	23	680	23	.15	49	46	51	.0	149	71	.75	22	272	5.8	3,760	.062	14,081	2,760
24	Nov. 2	140	45	.07	85	21	------	.0	303	68	.62	45	476	6.4	4,680	.076	1,756	6,020
Nov. 3	11	150	41	.14	93	20	38	.0	312	84	.9	48	473	6.2	4,340	.071	1,465	5,540
12	21	1,040	25	.07	69	13	44	.0	251	90	1.4	35	376	5.8	3,760	.062	5,127	3,820
23	Dec. 2	613	12	.20	70	18	41	.0	278	89	.87	43	352	6.0	4,000	.065	4,266	3,800
Dec. 3	13	50	23	.15	92	24	36	.0	266	78	1.03	46	428	5.9	3,880	.064	524	4,480
14	23	50	12	.10	93	27	29	.0	295	48	.76	38	476	6.0	4,000	.065	454	5,140
24	31	36	10	.15	92	30	66	.0	388	82	.94	28	504	5.9	3,880	.064	262	5,280
Mean.......		920	29	1.05	73	16	51	.0	261	61	2.30	41	372	....	8,699	....	35,100	6,989

[a] Gaging station at Topeka, Kans.

[b] Abnormal; computed as HCO_3 in the average.

[c] Estimated.

NOTE.—Analyses from Dec. 29, 1906, to Nov. 20, 1907, by F. W. Bushong; Nov. 21, 1907, to Sept. 23, 1908, by Archie J. Weith; Sept. 24 to Dec. 31, 1908, by W. L. Sippy.

Additional analyses of water from Kansas River are as follows:

Analyses of water from Kansas River, Kans.

1. At Topeka. Mean of two analyses received from Atchison, Topeka & Santa Fe Ry.
2. At South Topeka. From Missouri Pacific Ry.
3. Above Lawrence. E. H. S. Bailey, analyst.
4. At Lawrence. From Union Pacific R. R.
5. At Holliday.
6. At Argentine. Analyses 5 and 6 received from Atchison, Topeka & Santa Fe Ry.
7. At Armourdale. From Chicago, Rock Island & Pacific Ry.

I. Parts per million.

	1	2	3	4	5	6	7
CO_3	197	107	189	177	169	150	135
SO_4	118	69	134	79	68	85	113
Cl	141	61	144	84	33	36	92
Ca	106	66	112	68	54	104	88
Mg	19	13	27	44	29	16	20
Na(K)	72	53	121	67	27	29	77
Fe_2O_3	-------	-------	5	-------	-------	-------	-------
$(Al, Fe)_2O_3$	-------	2	-------	8	Tr.	1	-------
SiO_2	33	34	30	30	32	34	3
	686	405	762	557	412	455	528

Analyses of water from Kansas River, Kans.—Continued.

II. Percentage composition of dissolved solids.

	1	2	3	4	5	6	7
CO_3	28.72	26.42	24.80	31.77	41.02	32.97	25.57
SO_4	17.20	17.04	17.59	14.18	16.51	18.68	21.40
Cl	20.55	15.06	18.90	15.08	8.01	7.91	17.42
Ca	15.45	16.29	14.70	12.21	13.11	22.86	16.67
Mg	2.77	3.21	3.54	7.90	7.03	3.52	3.79
Na(K)	10.50	13.09	15.88	12.03	6.55	6.37	14.58
Fe_2O_3	-------	-------	.66	-------	-------	-------	-------
$(Al, Fe)_2O_3$	-------	.50	-------	1.44	Tr.	.22	-------
SiO_2	4.81	8.39	3.93	5.39	7.77	7.47	.57
	100.00	100.00	100.00	100.00	100.00	100.00	100.00

East of Junction City the two principal feeders of the Kansas are Big Blue and Delaware rivers. For the Big Blue there are, first, a table of analyses made in the laboratory of the University of Kansas, and also several separate analyses from other sources. They are as follows:

Analyses of water from Big Blue River at Manhattan, Kans.

[Parts per million. Drainage area, 9,490 square miles. Analyses made in the chemical laboratories of the University of Kansas, E. H. S. Bailey, director.]

Date (1906–7).		Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate (CO_3).	Bicarbonate (HCO_3).	Sulphate (SO_4).	Nitrate (NO_3).	Chlorine (Cl).	Total dissolved solids.
From—	To—												
Dec. 19	Dec. 28	24	11	1.0	87	17	49	[a]11	326	60	0.2	33	422
29	Jan. 7	16	26	.6	72	13	41	[a]3.5	316	55	1.0	28	373
Jan. 8	17	16	26	.8	82	9.1	44	[a]8.6	313	54	2.6	7.2	386
18	27	43	54	.6	77	15	43	[a]4.8	310	61	1.9	19	398
28	Feb. 6	17	59	1.4	87	19	49	[a]22	324	58	2	23	458
Feb. 7	16	373	36	.22	74	20	79	.0	228	138	2	31	471
17	26	392	43	.8	44	4.6	29	.0	169	34	4	8.8	262
27	Mar. 8	293	45	.70	62	13	38	.0	227	43	3	16	453
Mar. 9	18	718	36	.6	54	15	39	.0	204	39	4.8	8.4	283
19	28	176	-------	6	68	4.9	43	.0	274	40	1.5	19	348
29	Apr. 8	46	22	.9	83	15	40	[a]7.4	318	53	.2	21	389
Apr. 9	18	39	31	2.6	86	20	44	[a]10	340	41	.9	26	399
19	30	22	18	1.6	86	17	45	.0	337	55	1.2	29	395
May 1	May 10	19	25	3.5	86	3.9	47	[a]8.0	312	56	.9	26	391
11	20	28	25	.50	86	12	45	[a]8.0	320	55	.8	27	398
21	30	495	26	5.5	71	10	48	.0	280	50	1.7	23	348
31	June 9	1,136	21	4	40	14	27	.0	153	27	5	10	158
June 10	19	4,180	79	6	31	9.1	29	.0	115	20	1	7	285
20	29	740	37	3.5	52	10	41	.0	188	29	4	17	254
30	July 9	666	40	4	49	20	39	.0	210	31	7	15	495
July 10	19	1,455	19	7	46	13	43	.0	175	27	5.5	18	256
20	29	2,156	50	40	33	17	30	.0	120	18	6	5	227
30	Aug. 8	620	35	2	55	18	30	.0	210	35	3	19	282
Aug. 9	18	900	30	5	63	11	34	.0	185	29	3	10	380
19	Sept. 1	158	31	.8	68	16	44	.0	240	36	2.5	23	304
Sept. 2	12	160	32	.10	63	16	46	[a]8.0	228	26	2.2	25	321
13	22	100	39	.03	80	16	48	.0	280	41	1.3	28	354
Oct. 1	Oct. 13	1,582	35	.8	44	10	34	.0	165	32	3.3	15	234
14	23	140	35	.40	60	13	47	.0	228	34	2	23	305
24	Nov. 3	57	40	.24	83	21	68	.0	270	41	1	31	354
Nov. 4	13	47	36	.20	68	15	47	.0	296	43	.6	30	361
14	23	25	32	.20	78	18	47	.0	300	46	.5	29	372
24	Dec. 3	24	33	.18	75	21	54	.0	305	46	.5	29	376
Dec. 4	20	29	24	.10	73	18	61	.0	305	46	.2	28	360
Mean		497	34	3	67	14	44	.0	258	44	2.3	21	348

[a] Abnormal; computed as HCO_3 in the average.

NOTE.—Analyses from Dec. 19, 1906, to Feb. 6, 1907, and from Mar. 19 to Dec. 3, 1907, by F. W. Bushong; from Feb. 7 to Mar. 18 and from Dec. 4 to Dec. 20, 1907, by Archie J. Weith.

Additional analyses of water from Big Blue River, Kans.

1. Big Blue River at Marysville. C. M. Belknap, analyst.
2. Big Blue River at Blue Rapids. Received from Missouri Pacific Ry.
3. Big Blue River above Manhattan. E. H. S. Bailey, analyst.
4. Big Blue River at Manhattan. Received from Union Pacific R. R. Did the sample analyzed contain sediment?
5. Mill Creek at Washington. Received from Chicago, Burlington & Quincy Ry.
6. The same. J. H. Hamilton, analyst. Analyses 1 and 6 from Kansas State Board of Health. Originally in bicarbonate form.

I. Parts per million.

	1	2	3	4	5	6
CO_3	116.1	139.8	154	92.0	359	90.0
SO_4	153.9	34.8	78	25.0	51	86.8
Cl	42.0	21.4	28	38.0	65	27.0
Ca	107.6	71.4	82	57.0	188	77.6
Mg	6.4	16.8	22	8.6	22	9.3
Na(K)	32.2	23.4	34	25.0	67	24.2
Fe_2O_3	--------	--------	7	--------	--------	--------
$(Al, Fe)_2O_3$	3.0	1.2	--------	14.4	41	2.4
SiO_2	19.8	26.2	37	66.0		6.4
	481.0	335.0	442	326.0	793	323.7

Additional analyses of water from Big Blue River, Kans.—Con.

II. Percentage composition of dissolved solids.

	1	2	3	4	5	6
CO_3	24.14	41.73	34.84	28.22	45.27	27.80
SO_4	32.00	10.39	17.66	7.67	6.43	26.81
Cl	8.73	6.39	6.33	11.66	8.20	8.34
Ca	22.37	21.32	18.55	17.48	23.70	23.97
Mg	1.33	5.01	4.98	2.64	2.80	2.87
Na(K)	6.69	6.98	7.69	7.67	8.43	7.48
Fe_2O_3	--------	--------	1.58	--------	--------	--------
$(Al, Fe)_2O_3$	.62	.36	--------	4.42	5.17	.74
SiO_2	4.12	7.82	8.37	20.24		1.99
	100.00	100.00	100.00	100.00	100.00	100.00

For Delaware River and its tributaries there are the following data:

Analyses of water from Delaware River at Perry and Valley Falls, Kans.[a]

[Parts per million. Drainage area at Perry, 1,200 square miles (estimated); at Valley Falls, 951 square miles. Analyses made in the chemical laboratories of University of Kansas, E. H. S. Bailey, director.]

[Parts per million.]

Date (1907).		Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate (CO_3).	Bicarbonate (HCO_3).	Sulphate (SO_4).	Nitrate (NO_3).	Chlorine (Cl).	Total dissolved solids.
From—	To—												
Jan. 4	Jan. 13	6	13	0.6	99	22	35	0.0	392	62	0.6	21	408
14	23	1,140	34	4.0	57	5.8	32	.0	242	43	6.0	11	280
24	Feb. 2	268	43	4.8	58	6.0	29	.0	227	36	3.3	6.0	288
Feb. 3	12	390	33	4.0	62	8.4	32	.0	256	22	.2	12	500
13	22	570	29	.6	48	8.4	27	.0	168	33	6.6	6.0	240
23	Mar. 4	498	40	.24	74	14	38	.0	261	39	4.2	6.9	329
Mar. 5	14	1,338	26	.50	60	11	41	.0	227	41	4.9	7.6	309
15	24	1,044	17	1.8	76	17	30	.0	280	41	3.6	8.8	306
25	Apr. 5	410	14	3.5	89	17	27	.0	371	43	3.3	8.4	368
Apr. 6	16	111	11	2.8	85	--------	29	.0	380	50	3.5	14	376
17	29	60	4.6	1.0	83	20	33	.0	356	48	1.8	14	368
30	May 11	47	7.6	3.6	77	16	30	.0	350	46	1.6	14	325
May 12	22	78	11	1.2	74	15	35	.0	365	49	2.1	13	334
24	June 7	90	10	1.2	93	24	35	.0	357	48	2.5	48	375
June 23	28	5,125	--------	--------	--------	--------	--------	.0	140	--------	7.5	6	--------
12	22	1,950	34	9.0	54	18	36	.0	195	35	10	10	271
22	July 12	3,400	69	40	42	20	28	.0	157	24	7.5	6	272
July 13	23	560	22	1.5	83	19	37	[b] 5.0	278	37	6.0	11	334
24	Aug. 4	425	25	6.0	68	22	33	.0	270	27	4.5	12	286
Aug. 5	15	317	20	1.5	73	17	31	.0	255	34	3.0	10	282
17	27	317	17	.09	68	18	33	.0	257	29	3.0	13	283
28	Sept. 6	200	24	.44	82	19	32	.0	232	25	3.0	13	298
Sept. 7	17	317	20	.12	50	15	30	.0	195	31	3.3	9.3	253
18	28	115	21	.06	44	17	37	[b] 7.0	170	46	.3	11	198
Oct. 13	Oct. 23	63	13	.30	73	19	22	[b] 9.0	250	68	1.7	17	337
24	Nov. 22	42	16	.14	84	19	43	.0	330	52	1.2	20	377
Nov. 23	29	23	13	.16	67	20	39	.0	315	62	.8	18	322
Mean		700	23	3.4	70	16	33	.0	270	41	3.6	13	320

[a] Valley Falls, Kans., from June 12 to November 29, 1907.

[b] Abnormal; computed as HCO_3 in the average.

NOTE.—Analyses from Jan. 4 to Feb. 12 and from Mar. 15 to Oct. 23, 1907, by F. W. Bushong; from Feb. 13 to Mar. 14 and from Oct. 24 to Nov. 29, 1907, by Archie J. Weith.

The following analyses represent waters in the Delaware basin:

Analyses of waters in the Delaware River basin, Kans.

1. Delaware River at Muscotah. Received from Missouri Pacific Ry.
2. Delaware River at Valley Falls. From Atchison, Topeka & Santa Fe Ry.
3. Delaware River at Perry. Analysis by J. E. Curry. Cited in Water-Supply Paper 273, p. 207.
4. Creek at Horton.
5. Elk Creek at Holton. Nos. 4 and 5 from Chicago, Rock Island & Pacific Ry.
6. Creek at Perry. From Union Pacific R. R. Imperfectly filtered?

I. Parts per million.

	1	2	3	4	5	6
CO_3	202. 1	148	172. 0	96. 0	177	82
SO_4	109. 6	26	44. 0	6. 6	80	77
Cl	15. 9	18	2. 3	6. 1	34	9
Ca	122. 6	80	89. 0	43. 0	102	34
Mg	27. 2	15	21. 0	16. 0	27	10
Na(K)	24. 7	16	18. 0	. 8	27	47
Fe_2O_3		1	5. 3			
$(Al, Fe)_2O_3$	1. 7			Tr.	13	14
SiO_2	13. 2	13	13. 0	2. 6		41
	517. 0	317	364. 6	171. 1	460	314

II. Percentage composition of dissolved solids.

	1	2	3	4	5	6
CO_3	39. 09	46. 70	47. 18	56. 11	38. 48	26. 11
SO_4	21. 20	8. 15	12. 07	3. 86	17. 39	24. 52
Cl	3. 08	5. 68	. 63	3. 57	7. 39	2. 87
Ca	23. 71	25. 25	24. 41	25. 13	22. 17	10. 83
Mg	5. 26	4. 74	5. 76	9. 35	5. 87	3. 18
Na(K)	4. 78	5. 05	4. 93	. 46	5. 87	14. 97
Fe_2O_3		. 32	1. 45			
$(Al, Fe)_2O_3$	. 33			Tr.	2. 83	4. 46
SiO_2	2. 55	4. 11	3. 57	1. 52		13. 06
	100. 00	100. 00	100. 00	100. 00	100. 00	100. 00

For several of the tributaries of the Kansas in the lower part of its course, the following analyses are available:

Analyses of waters from tributaries of lower Kansas River.

1. Mill Creek at Alma. From Atchison, Topeka & Santa Fe Ry.
2. Mill Creek at McFarland. From Chicago, Rock Island & Pacific Ry. This Mill Creek is not to be confused with another stream of the same name, which flows into the Big Blue.
3. Wakarusa at Wakarusa. From Atchison, Topeka & Santa Fe Ry.
4. Wakarusa Creek at Richland. From Missouri Pacific Ry.
5. Big Stranger Creek at Linwood. From Union Pacific R. R.

I. Parts per million.

	1	2	3	4	5
CO_3	186. 0	139	55. 0	142	108. 0
SO_4	53. 0	97	29. 0	53	41. C
Cl	12. 0	17	5. 7	21	16. 0
Ca	102. 0	94	39. 0	85	57. 0
Mg	27. 0	23	7. 0	17	16. 0
Na(K)	5. 5	13	3. 4	18	17. 0
Fe_2O_3	2. 4		2. 4		
$(Al,Fe)_2O_3$		5		2	. 5
SiO_2	5. 3		22. 0	12	26. 5
	393. 2	388	163. 5	350	282. 0

II. Percentage composition of dissolved solids.

	1	2	3	4	5
CO_3	47. 30	35. 83	33. 64	40. 57	38. 31
SO_4	13. 48	25. 00	17. 74	15. 14	14. 54
Cl	3. 05	4. 38	3. 49	6. 00	5. 66
Ca	25. 94	24. 23	23. 85	24. 29	20. 22
Mg	6. 87	5. 92	4. 28	4. 86	5. 66
Na(K)	1. 40	3. 35	2. 08	5. 14	6. 03
Fe_2O_3	. 61		1. 47		
$(Al,Fe)_2O_3$		1. 29		. 57	. 18
SiO_2	1. 35		13. 45	3. 43	9. 40
	100. 00	100. 00	100. 00	100. 00	100. 00

These waters are all from a comparatively small region, and apart from local differences they are of the same general type.

In the foregoing pages there are eight tables of analyses, each one giving the composition of a river water during several months or for a year or more. The final averages, restated in percentage form, appear in the next table.

Average composition of Kansas River waters.

1. Smoky Hill River at Lindsborg. 29 composite analyses.
2. Saline River at Sylvan Grove. 34 composites.
3. Solomon River at Beloit. 32 composites.
4. Republican River at Junction. 25 composites.
5. Prairie Dog Creek at Long Island. A tributary of Republican River. 30 composites.
6. Big Blue River at Manhattan. 34 composites.
7. Delaware River at Perry and Valley Falls. 27 composites.
8. Kansas River at Holliday. A two years' average. 72 composites.

	1	2	3	4	5	6	7	8
CO_3	14. 40	6. 02	26. 17	34. 36	45. 91	35. 53	39. 47	31. 78
SO_4	26. 87	18. 26	19. 50	12. 56	4. 20	12. 32	12. 17	15. 14
Cl	21. 61	38. 57	12. 09	7. 11	2. 49	5. 89	3. 85	10. 18
NO_3	. 21	. 03	. 54	. 71	1. 00	. 64	1. 07	. 57
Ca	12. 93	5. 03	16. 61	16. 35	20. 69	18. 74	20. 78	18. 12
Mg	2. 41	1. 98	2. 89	3. 32	4. 19	3. 92	4. 75	3. 98
Na (K)	18. 26	28. 97	15. 52	13. 50	10. 06	12. 32	9. 79	12. 66
Fe_2O_3	. 13	. 07	. 36	. 71	. 56	1. 12	1. 30	. 38
SiO_2	3. 18	1. 07	6. 32	11. 38	10. 90	9. 52	6. 82	7. 19
	100. 00	100. 00	100. 00	100. 00	100. 00	100 00	100. 00	100. 00
Salinity [a]	882	2, 624	554	422	358	357	337	403

[a] Parts per million.

The two westernmost of these streams flow from a semiarid region and are characterized by high salinity, which decreases as the river system is followed eastward into a rich, fertile, well-watered area. Saline River, which well deserves its name, is rich in sulphates and chlorides, derived from saliferous and gypsiferous shales. In Solomon River carbonates begin to predominate, and in the easternmost rivers of the group there is a close approximation in chemical character to some streams of the Middle West and the Atlantic slope. Kansas River itself represents a blending of all the streams that flow into it.

OSAGE RIVER BASIN.

Osage River, also known in Kansas as Marais des Cygnes, rises in eastern Kansas and flows southward to its junction with the Missouri at Osage, Mo. The area of its basin is about 15,300 square miles. Its area in Kansas is approximately 4,300 square miles, and its waters in that portion of it have been well studied by H. N. Parker and E. H. S. Bailey.[36] The composition of the water of the Osage and its tributary Marmaton River is given in the two following tables:

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[36] U. S. Geol. Survey Water-Supply Paper 273, 1911.

Analyses of water from Osage River at Boicourt, Kans.

[Parts per million. Drainage area, 2,700 square miles. Analyses made in the chemical laboratories of the University of Kansas, E. H. S. Bailey, director.]

Date (1906-7).		Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate (CO_3).	Bicarbonate (HCO_3).	Sulphate (SO_4).	Nitrate (NO_3).	Chlorine (Cl).	Total dissolved solids.
From—	To—												
Nov. 29	Dec. 8	220	22.0	[a] 2.4	68	6.0	41	0.0	232	43	3.7	10	293
Dec. 9	18	70	....	3.0	58	8.7	34	.0	202	46	3.6	9.0	269
19	28	44	19	1.6	70	18	29	.0	236	51	4.0	8.8	276
30	Jan. 8	83	19	1.4	75	4.8	33	.0	260	43	4.8	12	295
Jan. 9	18	64	21	.30	41	1.9	25	[b] 12	241	35	4.4	10	293
19	28	1,016	39	4.0	43	7.2	22	.0	138	37	8.0	3.9	220
29	Feb. 7	55	45	1.8	87	6.8	27	[b] 11	278	40	5.7	8.3	352
Feb. 8	17	247	27	.24	77	12	36	.0	249	49	3.6	6.9	310
19	28	67	42	.30	105	5.6	31	.0	248	46	6.2	8.4	327
Mar. 1	Mar. 11	1,007	29	.50	69	8.7	26	.0	204	50	4.0	6.9	298
12	21	810	19	3.4	68	2.6	20	.0	192	44	4.8	4.1	259
22	31	516	20	5	70	3.1	24	[b] 3.1	260	43	2.2	8.2	298
Apr. 1	Apr. 10	297	12	1.5	73	3.7	20	.0	240	39	2.3	7.6	275
11	21	45	7.2	1.0	84	2.0	22	.0	275	44	1.2	11	292
22	May 2	286	9.0	2.0	74	11	26	.0	247	39	1.7	12	277
May 3	13	473	19	5	65	2.0	23	.0	195	40	6.0	6.0	249
14	23	700	17	1.2	73	11	20	.0	232	42	6.5	6.0	277
24	June 4	100	21	.8	90	3.6	18	.0	273	42	4.0	9.0	303
June 5	14	1,850	20	6	57	9.9	22	.0	185	33	6.0	7.0	239
15	24	1,140	23	5	57	19	28	.0	187	31	7.0	4.0	232
25	July 10	1,200	....	3.5	48	13	21	.0	170	31	6.0	5.0	180
July 11	21	84	32	2	78	16	35	[b] 10	238	33	3.5	12.0	310
22	Aug. 1	139	23	2	64	8.8	23	[b] 9.0	125	32	.6	4.0	228
Aug. 2	11	210	58	12	32	12	25	[b] 17	152	21	3.8	5	234
12	21	282	36	3.6	65	15	39	.0	188	24	3.2	11	245
22	Sept. 3	284	23	.7	47	11	19	.0	145	20	3.0	5	185
Sept. 4	17	80	45	.22	49	11	27	.0	190	19	1.9	8	237
18	29	75	19	.20	65	12	27	.0	198	22	.6	10	215
30	Oct. 14	80	15	.16	58	12	26	[b] 5.0	205	25	.3	13	233
Oct. 15	24	55	15	.14	72	35	34	.0	245	27	.5	22	279
25	Nov. 4	42	17	.15	70	14	22	.0	248	32	1.2	26	293
Nov. 5	17	36	12	.36	74	11	42	.0	280	34	.9	43	333
18	30	85	13	.12	83	13	43	.0	250	32	.8	26	290
Mean........		356	24	2.2	67	12	28	.0	222	36	3.5	10	270

[a] Al=1.8.

[b] Abnormal; computed as HCO_3 in the average.

NOTE.—Analyses from Nov. 29, 1906, to Feb. 7, 1907, and from Mar. 12 to Nov. 17, 1907, by F. W. Bushong; from Feb. 8 to Mar. 11 and from Nov. 18 to 30, 1907, by Archie J. Weith.

Analyses of water from Marmaton River at Fort Scott, Kans.

[Parts per million. Drainage area 360 (estimated) square miles. Analyses made in the chemical laboratories of the University of Kansas, E. H. S. Bailey, director.]

Date (1907-8).		Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate (CO_3).	Bicarbonate (HCO_3).	Sulphate (SO_4).	Nitrate (NO_3).	Chlorine (Cl).	Total dissolved solids.
From—	To—												
Feb. 1	Feb. 10	15	16	3.2	84	3.3	21	0.0	257	38	6.0	10	277
11	20	7	16	.24	89	7.6	21	.0	283	41	3.5	4.0	297
21	Mar. 2	8	70	.10	91	5.5	30	[a] 8.0	256	45	2.3	4.2	366
Mar. 3	12	11	48	.36	88	7.5	29	[a] 6.7	246	44	.7	4.1	344
13	22	7	4	1.0	85	8.3	17	.0	250	43	.2	4.1	268
23	Apr. 1	9	1.5	.6	83	1.6	23	.0	229	43	.1	4.6	280
Apr. 2	11	15	8.0	1.5	77	9.3	18	.0	240	46	.6	2.3	268
12	21	12	5.4	1.2	96	1.3	16	.0	287	47	.4	6.0	294
22	May 1	12	2.6	1.4	94	1.3	20	.0	280	45	.7	7.5	291
May 2	11	58	8.4	5.0	67	2.9	20	.0	181	38	5.5	3.5	224
12	21	54	15	3.5	67	6.9	14	.0	205	33	4.5	4.0	238
23	June 3	14	10	1.5	86	3.7	25	.0	285	36	3.2	5.5	274
June 4	13	23	13	1.0	89	8.5	21	.0	280	34	1.9	6.0	270
14	25	80	18	2.0	65	23	36	.0	172	34	7.2	2.0	296
26	July 5	44	18	5	59	8.6	18	.0	178	24	4.0	2.5	205
July 6	15	22	12	3	73	19	23	.0	235	27	2.6	2.0	226
16	29	20	14	1.5	58	12	19	[a] 14	240	28	1.8	5.5	196
30	Aug. 9	22	9.0	1.0	80	11	23	.0	280	28	1.0	4.0	257
Aug. 10	26	15	12	.8	79	11	37	.0	260	26	.7	5.0	251
27	Sept. 6	13	9.0	.11	84	11	19	[a] 3.0	260	21	.7	4.0	242
Sept. 8	19	12	10	.04	79	9.7	18	.0	258	20	.9	5.4	247
20	Oct. 5	17	10	.04	83	14	28	.0	290	34	.0	5.5	289
Oct. 7	20	17	5.2	.02	83	12	20	.0	270	25	1.5	6.5	257
21	31	10	14	.10	89	11	20	.0	285	24	.6	7.0	279
Nov. 1	Nov. 10	14	11	.13	86	9.8	21	.0	278	29	1.0	7.0	273
11	20	11	11	.14	88	10	15	.0	265	21	.5	7.0	266
21	Dec. 3	12	9.0	.12	79	10	24	.0	255	24	.5	6.5	265
Dec. 4	15	13	11	.06	94	9.2	26	.0	275	21	.5	7.0	258
17	26	14	9.0	.14	76	8.7	25	.0	250	32	.6	6.0	259
17	Jan. 7	36	18	.40	78	7.8	23	.0	213	37	3.0	5.5	236
Jan. 8	17	42	18	.6	74	6.8	25	.0	218	51	2.0	4.5	252
18	27	45	14	.25	89	7.8	20	.0	220	48	2.0	5.0	264
28	Feb. 9	12	11	.40	82	8.0	30	.0	250	52	2.1	5.9	289
Feb. 10	19	32	14	.18	81	7.5	24	.0	245	48	1.7	6.0	277
Mean........		22	14	1.1	81	8.7	23	.0	251	35	1.9	5.2	267

[a] Abnormal; computed as HCO_3 in the average.

NOTE.—Analyses from Feb. 11 to Mar. 12, 1907, and from Dec. 4, 1907, to Feb. 19, 1908, by Archie J. Weith; from Mar. 13 to Dec. 3, 1907, by F. W. Bushong.

Reduced to standard form and in percentages, the averages of the two preceding tables compare as follows:

Reduced analyses of Osage and Marmaton rivers.

	Osage.	Marmaton.
CO_3	37.26	42.01
SO_4	12.31	11.89
Cl	3.41	1.77
NO_3	1.20	.65
Ca	22.90	27.58
Mg	4.10	2.96
Na(K)	9.56	7.81
Fe_2O_3	1.06	.55
SiO_2	8.20	4.78
	100.00	100.00
Salinity, parts per million	293	294

Additional analyses of water from Osage River are given in the next table.

Analyses of water from Osage River.

1. At Reading, Kans.
2. At Quenemo, Kans.
3. At Ottawa, Kans. Analyses 1 to 3 received from Atchison, Topeka & Santa Fe Ry.
4. At Ottawa, Kans.
5. At Ossawatomie, Kans.
6. At Bagnell, Mo.
7. At Osage, Mo. Analyses 4 to 7 from Missouri Pacific Ry.

I. Parts per million.

	1	2	3	4	5	6	7
CO_3	151.1	164.0	90	91.0	150	79.8	100.7
SO_4	59.0	45.0	40	31.0	36	40.8	13.3
Cl	16.0	9.0	18	8.7	11	4.2	4.4
Ca	92.0	100.0	62	59.0	87	42.5	47.9
Mg	21.1	17.0	8	9.3	12	16.0	14.8
Na(K)	9.8	6.3	15	5.7	16	4.0	2.8
$(Al, Fe)_2O_3$	17.0	1.0	1	4.4	1	1.7	2.7
SiO_2	18.0	18.0	16	22.7	16	2.4	17.4
	384.0	360.3	250	231.8	329	191.4	204.0

II. Percentage composition of dissolved solids.

	1	2	3	4	5	6	7
CO_3	39.35	45.52	36.00	39.26	45.59	41.69	49.36
SO_4	15.37	12.46	16.00	13.37	10.94	21.32	6.52
Cl	4.17	2.50	7.20	3.75	3.35	2.19	2.16
Ca	23.96	27.76	24.80	25.45	26.44	22.21	23.48
Mg	5.49	4.72	3.20	4.02	3.65	8.36	7.26
Na(K)	2.55	1.75	6.00	2.46	4.86	2.09	1.37
$(Al, Fe)_2O_3$	4.42	.29	.40	1.90	.31	.89	1.32
SiO_2	4.69	5.00	6.40	9.79	4.86	1.25	8.53
	100.00	100.00	100.00	100.00	100.00	100.00	100.00

The analyses in the following table relate to tributaries of the Osage. All the localities cited are in Kansas.

Analyses of water from tributaries of the Osage.

1. Elm Creek at Miller.
2. Salt Creek at Lyndon. W. A. Burton, analyst
3. Salt Creek at Lomax.
4. Dragoon Creek, at Harveyville.
5. Dragoon Creek at Burlingame. W. F. Standiford, analyst.
6. North Pottawatamie Creek at Glenlock.
7. Cedar Creek at Garnett. A. H. Wieters, analyst.
8. Sugar Creek at Sugar Creek.
9. Little Osage River at Harding.
10. Bull Creek at Paola.

Analyses 1, 3, 6, 8, 9, and 10 received from the Missouri Pacific Ry.; No. 4 from Atchison, Topeka & Santa Fe Ry.; Nos. 2, 5, and 7 from Kansas State Board of Health.

I. Parts per million.

	1	2	3	4	5	6	7	8	9	10
CO_3	114.0	82.7	112.0	190.0	74.4	152.0	46.8	97.0	87.0	69.1
SO_4	58.0	116.4	52.0	47.0	88.5	44.0	90.1	19.0	51.0	25.4
Cl	6.7	10.0	28.0	12.0	8.0	7.9	9.0	2.8	6.7	6.2
Ca	65.0	74.0	71.0	104.0	56.4	84.0	52.4	60.0	50.0	40.8
Mg	14.0	13.1	12.0	20.0	12.8	16.0	5.1	7.8	12.0	8.0
Na(K)	16.0	18.9	25.0	17.0	19.1	17.0	13.3	1.8	16.0	6.9
$(Al, Fe)_2O_3$	.2	5.4	2.4	13.6	6.0	7.5	4.8	3.2	2.6	1.2
SiO_2	14.4	5.0	27.0	4.8	9.2	10.5	10.2	22.9	13.0	11.4
	288.3	325.5	329.4	408.4	274.4	338.9	231.7	214.5	238.3	169.0

II. Percentage composition of dissolved solids.

	1	2	3	4	5	6	7	8	9	10
CO_3	39.54	25.38	34.00	46.52	27.11	44.85	20.20	45.22	36.51	40.89
SO_4	20.12	35.76	15.79	11.51	32.25	12.98	38.89	8.86	31.40	15.03
Cl	2.33	3.08	8.50	2.94	2.92	2.34	3.88	1.31	2.81	3.67
Ca	22.55	22.74	21.55	25.46	20.55	24.79	22.62	27.97	20.98	24.14
Mg	4.84	4.03	3.64	4.90	4.66	4.72	2.20	3.64	5.04	4.73
Na(K)	5.55	5.81	7.59	4.16	6.96	5.01	5.74	.84	6.71	4.08
$(Al, Fe)_2O_3$	.07	1.66	.73	3.33	2.19	2.21	2.07	1.49	1.09	.71
SiO_2	5.00	1.54	8.20	1.18	3.36	3.10	4.40	10.67	5.46	6.75
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

MINOR TRIBUTARIES OF THE MISSOURI.

Between Kansas River and the mouth of the Missouri there are several streams for which analyses have been received from the Missouri Pacific Railway. For convenience, two analyses of water from Meramec River have been included with this group, although this river flows into the Mississippi south of St. Louis. Its waters, however, belong in the same general region as the others, even though it is not an affluent of the Missouri.

Analyses of waters from tributaries of the Missouri, etc.

1. Big Blue River at Mastin, Kans. Not to be confused with the tributary of Kansas River of the same name.
2. Little Blue River at Little Blue, Mo.
3. Davis Creek at Sweet Springs, Mo.
4. Stephens Fork at Speed, Mo.
5. La Mine River at Otterville, Mo.
6. South Moreau Creek at South Moreau, Mo.
7. Berger Creek at Etlah, Mo. Imperfectly filtered?
8. Gasconade River at Gasconade, Mo.
9. Meramec River at Pacific, Mo.
10. Meramec River at Valley Park, Mo.

I. Parts per million.

	1	2	3	4	5	6	7	8	9	10
CO_3	146.0	100.9	37.1	83.4	49.5	54.7	56.6	67.7	84.7	104.2
SO_4	29.0	28.1	64.9	20.1	25.5	137.0	8.9	8.6	18.8	56.7
Cl	5.3	7.4	24.2	6.9	4.1	4.0	3.3	1.8	3.1	7.4
Ca	95.0	62.5	36.3	44.8	22.6	45.8	26.4	25.6	33.9	58.9
Mg	7.7	8.9	9.3	10.7	10.6	13.5	9.0	13.8	18.2	20.5
Na(K)	4.4	6.7	15.7	6.2	6.7	31.6	2.2	1.1	2.0	4.8
$(Al, Fe)_2O_3$	2.0	2.7	5.5	1.9	7.0	5.8	11.6	1.5	2.0	.2
SiO_2	17.0	27.4	36.0	19.0	27.0	29.1	35.7	9.9	13.3	13.8
	306.4	244.6	229.0	193.0	153.0	321.5	153.7	130.0	176.0	266.5

II. Percentage composition of dissolved solids.

	1	2	3	4	5	6	7	8	9	10
CO_3	47.65	41.21	16.20	43.21	32.35	17.01	36.82	52.08	48.12	39.10
SO_4	9.47	11.49	28.34	10.41	16.67	42.61	5.79	6.63	10.68	21.27
Cl	1.73	3.03	10.57	3.58	2.68	1.24	2.15	1.38	1.76	2.78
Ca	31.00	25.56	15.85	23.21	14.77	14.25	17.18	19.69	19.26	22.10
Mg	2.51	3.65	4.06	5.54	6.93	4.20	5.85	10.61	10.34	7.69
Na(K)	1.44	2.74	6.86	3.21	4.38	9.83	1.43	.85	1.14	1.80
$(Al,Fe)_2O_3$	.65	1.11	2.40	.99	4.57	1.81	7.55	1.15	1.14	.08
SiO_2	5.55	11.21	15.72	9.85	17.65	9.05	23.23	7.61	7.56	5.18
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

ARKANSAS RIVER BASIN.

MAIN STREAM.

The sources of Arkansas River are in the mountains of Colorado near Leadville. It emerges from the deep canyon known as the Royal Gorge at Canon City, Colo., traverses parts of Oklahoma and Kansas, and joins the Mississippi in eastern Arkansas. Its drainage area is about 188,000 square miles.

For the composition of its waters there are abundant data. A few analyses are of samples from points in Colorado, and many more are given in Water-Supply Paper 273, of water from localities in Kansas. For its course in Arkansas only a few analyses have been found.[37]

First in order are four tables of analyses of water from the main stream, made by or for the water-resources branch of the United States Geological Survey. They are as follows:

Analyses of water from Arkansas River near Deerfield, Kans.

[Parts per million. Drainage area, 25,860 square miles (estimated). Analyses made in the chemical laboratories of the University of Kansas, E. H. S. Bailey, director.]

Date (1906-7).		Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate (CO_3).	Bicarbonate (HCO_3).	Sulphate (SO_4).	Nitrate (NO_3).	Chlorine (Cl).	Total dissolved solids.
From—	To—												
Dec. 11	Dec. 20	730	16	1.2	239	86	280	0.0	283	1,171	2.2	104	2,167
21	31	1,900	19	1.0	223	76	250	.0	296	781	4.0	83	1,911
Jan. 2	Jan. 13	1,020	26	1.2	229	70	289	.0	144	1,201	4.0	84	2,109
14	24	1,460	42	1.0	233	74	301	.0	280	1,174	3.5	94	2,144
25	Feb. 7	422	45	1.2	217	79	282	.0	215	1,127	2.0	85	2,031
Feb. 10	19	3,360	56	.10	97	12	29	.0	288	65	4.9	76	410
24	Mar. 7	607	68	.30	256	88	298	.0	263	1,163	1.2	95	2,179
Mar. 8	18	20	25	.80	217	67	243	.0	242	992	.5	75	1,808
19	28	21	22	1.6	194	73	246	.0	236	953	1.2	82	1,764
29	Apr. 9	14	25	3.0	180	62	222	[a] 7.0	241	855	3.5	75	1,640
Apr. 10	25	12	20	1.4	156	71	198	.0	245	818	3.5	78	1,580
26	May 5	14	22	1.0	187	70	229	.0	245	876	2.8	82	1,647
May 6	15	13	26	1.0	191	64	242	.0	247	900	1.9	76	1,666
16	25	117	26	1.5	182	42	228	.0	220	854	2.8	76	1,583
26	June 5	3,247	24	1.2	147	74	224	.0	232	841	5.5	76	1,612
June 6	15	21,240	27	5	185	51	178	.0	258	746	10	53	1,421
16	25	320	26	3.5	179	76	219	.0	222	842	3	73	1,572
27	July 11	6,000	34	4	136	49	153	.0	203	565	5	48	1,116
July 12	21	4,425	28	10	141	51	151	.0	178	541	3.5	46	1,114
22	Aug. 1	26,200	27	3.5	157	51	146	.0	210	568	5.5	42	1,132
Aug. 2	12	15,620	32	5	167	47	144	.0	190	600	6.5	39	1,156
13	24	296	23	.8	178	62	194	.0	220	759	1.2	62	1,402
25	Oct. 16	21	30	.04	169	65	195	.0	200	751	.9	64	1,371
Oct. 17	Nov. 2	46	22	.24	227	68	209	.0	210	756	.8	66	1,418
Nov. 3	16	116	16	.14	155	37	186	.0	190	725	1.1	67	1,346
19	Dec. 2	100	19	.12	189	55	258	.0	245	840	1.2	74	1,552
Mean		3,359	29	1.9	186	62	215	.0	231	826	3.2	72	1,571

[a] Abnormal; computed as HCO_3 in the average.

NOTE.—Analyses from Dec. 11, 1906, to Nov. 16, 1907, by F. W. Bushong; from Nov. 19 to Dec. 2, 1907, by Archie J. Weith.

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[37] A large number of partial analyses of waters in Oklahoma are given in Water-Supply Paper 148, but they are not complete enough to be available for present purposes.

Analyses of water from Arkansas River near Great Bend, Kans.

[Parts per million. Drainage area, 34,600 square miles (estimated). Analyses made in the chemical laboratories of the University of Kansas, E. H. S. Bailey, director]

Date (1906-7).		Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate (CO_3).	Bicarbonate (HCO_3).	Sulphate (SO_4).	Nitrate (NO_3).	Chlorine (Cl).	Total dissolved solids.
From—	To—												
Nov. 26	Dec. 5	210	2.3	0.8	99	24	124	0.0	208	377	2.8	52	793
Dec. 6	15	58		1.2	139	16	158	.0	245	557	.9	69	1,135
16	27	28	24	.6	163	40	132	[a] 6.7	281	508	2.7	98	1,330
28	Jan. 7	1,330	27	1.2	177	49	173	.0	295	612	4.6	90	1,336
Jan. 8	20	494	27	4.0	173	45	174	3.6	266	651	2.5	92	1,355
21	31	163	50	2.0	153	56	199	.0	187	719	1.1	93	1,385
Feb. 1	Feb. 13	770	21	.40	157	42	157	.0	266	535	.6	78	1,131
14	24	3,730	76	.30	192	54	227	.0	264	859	2.3	77	1,654
25	Mar. 4	499	83	.30	187	45	49	[a] 2.8	259	696	1.5	85	1,495
Mar. 8	17	340	56	.52	327	48	195	.0	243	652	.7	88	1,304
19	28	51	18	.8	148	43	191	.0	228	608	.2	104	1,264
29	Apr. 8	19	22	.9	148	34	191	.0	219	565	.2	121	1,230
Apr. 9	18	15	18	3.3	149	36	196	8.0	230	536	.7	128	1,218
19	30	15	12	1.0	132	41	181	.0	230	506	1.1	134	1,179
May 1	May 11	44	17	2.5	162	7.2	190	.0	225	624	.6	106	1,265
12	21	20	20	.6	155	33	191	.0	210	574	.6	121	1,239
22	June 8	15	16	1.2	147	41	186	.0	218	518	.6	133	1,168
June 10	19	19,200	49	3.2	164	50	211	.0	245	671	7.0	125	1,400
21	30	2,736	26	2	113	36	135	.0	178	407	3.5	76	902
July 1	July 10	9,480	30	1.5	137	47	192	.0	235	522	3.5	127	1,169
11	20	14,530	31	4	96	32	117	.0	178	347	6.0	49	756
21	31	14,160	26	3	117	46	152	.0	225	464	.9	87	972
Aug. 1	Aug. 11	18,720	29	2.0	145	40	120	.0	192	487	7.5	32	960
12	22	20,000	32	1.8	147	41	138	.0	193	490	4.5	40	968
23	Sept. 3	315	31	.20	142	46	158	[a] 5.0	205	511	1.5	84	1,079
Sept. 4	16	40	29	.05	135	44	171	.0	210	502	.7	122	1,109
17	28	16	30	.08	124	44	171	.0	230	461	.5	125	1,033
30	Oct. 9	168	12	.06	115	34	180	.0	200	391	.5	108	913
Oct. 10	20	38	21	.12	135	44	179	.0	223	437	.5	140	1,061
21	31	26	20	.11	142	43	137	.0	217	450	.6	130	1,069
Nov. 1	Nov. 10	22	20	.26	145	42	168	.0	238	476	.5	124	1,107
11	21	28	17	.20	153	42	170	.0	255	474	.6	128	1,120
22	Dec. 7	38	20	.11	105	43	195	.0	242	502	.6	114	1,128
Mean		3,252	28	1.2	149	40	167	.0	230	536	1,9	99	1,158

[a] Abnormal; computed as HCO_3 in the average.

NOTE.—Analyses from Nov. 26, 1906, to Nov. 21, 1907, by F. W. Bushong; from Nov. 22 to Dec. 7, 1907, by Archie J. Weith.

Analyses of water from Arkansas River at Arkansas City,[a] Kans.

[Parts per million. Drainage area, 44,500 square miles. Analyses made in the chemical laboratories of the University of Kansas, E. H. S. Bailey, director.]

Date (1906-7).		Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate (CO_3).	Bicarbonate (HCO_3).	Sulphate (SO_4).	Nitrate (NO_3).	Chlorine (Cl).	Total dissolved solids.
From—	To—												
Dec. 7	Jan. 8	1,700	24	0.8	108	32	267	0.0	295	300	3.6	278	1,132
Jan. 12	21	872	41	3.0	92	7.2	193	.0	276	201	3.5	221	882
22	Feb. 7	415	40	.20	74	21	162	[b] 12	238	135	3.0	180	707
Feb. 8	17	1,480	84	.52	120	28	217	.0	310	270	2.3	229	1,309
18	Mar. 10	480	54	.6	109	26	274	.0	310	57	1.2	330	1,177
Mar. 15	24	132	31	2.8	109	26	253	[b] 5.5	288	196	1.2	317	1,060
Apr. 8	Apr. 18	14	14	1.2	103	14	252	.0	282	179	.7	330	1,024
19	27	18	17	1.8	85	24	241	.0	261	169	1.0	328	1,011
28	May 7	70	15	3.0	88	19	216	.0	255	147	2.0	264	857
May 10	19	180	34	2.5	88	13	233	.0	252	165	1.8	292	938
25	June 3	30	19	.7	86	25	236	.0	254	162	1.1	312	960
June 6	15	42	35	2	83	29	250	.0	240	159	1.5	292	987
28	July 7	885	42	6	76	21	241	.0	235	126	2.5	280	862
July 8	17	112	43	1.5	86	24	262	[b] 12	230	152	1.0	328	995
18	27	3,000	39	12	64	19		.0	223	100	2.8	192	662
28	Aug. 6	27,500	36	1.5	123	40	184	.0	275	363	1.9	164	1,028
Aug. 7	16	18,360	22	1.0	128	34	166	.0	200	415	6.0	125	976
17	26	3,320	24	.18	103	30	170	.0	200	270	2.8	170	837
27	Sept. 5	250	32	.07	97	30	254	.0	210	230	1.1	314	1,067
Sept. 6	15	95	41	.05	90	30	279	.0	230	210	.5	364	1,105
16	25	80	24	.05	93	28	237	.0	263	167	2.3	310	956
26	Oct. 5	562	16	.10	86	21	219	.0	172	115	1.5	306	813
Oct. 6	15	238	31	.20	92	21	270	.0	250	146	1.8	349	994
16	25	130	18	.12	97	23	305	.0	225	157	.6	440	1,141
26	Nov. 4	65	24	.30	96	18	396	.0	275	152	.5	430	1,155
Nov. 1	14	68	21	.24	97	20	273	.0	280	148	.8	386	1,078
Dec. 5	Dec. 10	39	17	1.6	93	27	270	.0	255	313	.8	368	1,029
Mean		2,227	31	1.6	95	24	243	.0	253	193	1.8	292	990

[a] The sampling station was located on the canal of the Land & Power Co., the head of which is above the mouth of Walnut River.
[b] Abnormal; computed as HCO_3 in the average.

NOTE.—Analyses from Dec. 7, 1906, to Jan. 21, 1907, and from Mar. 15 to Dec. 10, 1907, by F. W. Bushong; from Jan. 22 to Mar. 10, 1907, by Archie J. Weith.

Analyses of water from Arkansas River near Little Rock, Ark.[a]

[Parts per million.]

Date (1906-7).		Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total dissolved solids.	Mean gage height (feet).
From—	To—													
Nov. 1	Nov. 10	270	31	0.30	84	18	351	0.0	230	136	1.8	535	1,285	3.5
11	20	140	20	.30	86	22	381	.0	221	149	Tr.	568	1,339	3.6
21	Dec. 2	140	24	.9	39	11	123	.0	115	72	.5	186	519	5.2
Dec. 3	19	1,000	47	2.4	53	14	180	.0	142	95	.4	276	752	8.0
20	Jan. 11	320	31	1.2	25	8.9	60	.0	76	57	1.5	80	304	10.4
14	31	1,320	----------	----------	40	13	62	.0	106	----------	2.4	87	451	15.2
Feb. 2	Feb. 20	275	20	.40	57	12	83	.0	155	63	3.8	107	433	8.6
21	Mar. 7	220	16	.25	54	13	----------	.0	144	74	3.4	----------	460	8.1
Mar. 8	28	450	25	1.8	42	9.5	67	.0	131	61	1.2	82	366	9.5
29	Apr. 12	235	19	.8	45	11	80	.0	140	67	1.5	103	412	6.8
Apr. 13	22	290	20	.9	32	8.7	49	.0	106	42	1.2	65	287	7.3
23	May 2	285	22	1.2	42	11	74	.0	102	56	2.0	102	377	7.0
May 3	13	1,500	54	1.8	27	6.9	33	.0	86	32	3.6	37	279	18.0
14	23	860	56	2.2	32	5.6	41	.0	92	43	6.3	40	305	17.4
24	June 2	450	40	1.0	31	2.7	31	0	100	34	1.8	34	271	11.4
June 20	July 18	2,800	20	.30	49	13	80	.0	181	72	2.8	87	414	10.6
July 19	Aug. 5	270	18	.10	66	17	157	.0	196	103	1.1	213	695	5.3
Aug. 8	17	1,000	29	.15	96	20	415	.0	181	211	1.5	610	1,500	5.3
18	29	600	13	.06	95	23	261	.0	195	212	4.4	347	1,093	4.0
30	Sept. 8	3,000	36	.12	71	20	155	.0	189	153	1.3	181	736	5.0
Sept. 9	Oct. 6	280	26	.33	72	17	179	[b] 8.4	184	117	.3	265	806	2.8
Oct. 7	24	900	26	.8	72	16	155	[b] Tr.	157	98	.2	262	774	3.3
Mean		755	28	.82	55	13	144	.0	148	93	2.0	203	630	----------

[a] Analyses Nov. 1, 1906, to Jan. 31, 1907, by W. M. Barr; Feb. 2 to 20, 1907, by Henry S. Spaulding; Feb. 21 to Sept. 8, 1907, by Walton Van Winkle; Sept. 9 to Oct. 24, 1907, by R. B. Dole, Chase Palmer, and W. D. Collins.

[b] Abnormal; computed as HCO_3 in the average.

The averages of the foregoing tables, reduced to percentage form, are as follows:

Reduced analyses of water from Arkansas River.

1. At Deerfield, Kans. 26 composite analyses.
2. Near Great Bend, Kans. 33 composites.
3. At Arkansas City, Kans. 27 composites. Nos. 1, 2, and 3 are from Water-Supply Paper 273.
4. At Little Rock, Ark. 22 composites. From Water-Supply Paper 236.

	1	2	3	4
CO_3	7.55	9.95	12.33	11.89
SO_4	54.70	47.19	19.18	15.19
Cl	4.77	8.72	29.03	33.17
NO_3	.21	.17	.18	.33
Ca	12.31	13.13	9.44	8.99
Mg	4.11	3.52	2.39	2.13
Na(K)	14.24	14.71	24.15	23.53
Fe_2O_3	.19	.15	.22	.20
SiO_2	1.92	2.46	3.08	4.57
	100.00	100.00	100.00	100.00
Salinity, parts per million	1,510	1,136	1,006	630

These analyses, which are arranged in order going downstream, show noteworthy regularities. The salinity diminishes from point to point, and the sulphates also decrease in amount, while the chlorides increase. The alkalies also increase, but the calcium and magnesium decrease. Carbonates are low in all the analyses but are highest in the more eastern parts of the Arkansas basin.

Additional analyses of water from the main stem of Arkansas River appear in the following table. The stations are arranged in order downstream.

Analyses of water from Arkansas River.

1. At Canon City, Colo. Analysis by W. P. Headden. Colorado Agr. Exper. Sta. Bull. 82, 1903.
2. At Pueblo, Colo. From Atchison, Topeka & Santa Fe Ry.
3. The same. From Denver & Rio Grande Western R. R.
4. At Ordway, Colo. City water, piped from the river. From Missouri Pacific Ry.
5. At Rocky Ford, Colo. Analysis by Headden, loc. cit.
6. At Sterling, Kans. Analysis by A. J. Weith. U. S. Geol. Survey Water-Supply Paper 273, p. 281, 1911.

Analyses of water from Arkansas River—Continued.

7. At Wichita, Kans. From Kennicott Water Softener Co.
8. At Arkansas City, Kans. From Atchison, Topeka & Santa Fe Ry.
9. At Little Rock, Ark. High water, Dec. 20, 1888.
10. The same. Low water, Aug. 22, 1888. Analyses 9 and 10 by R. N. Brackett. Arkansas Geol. Survey Ann. Rept. for 1891, vol. 2, pp. 159, 160, 1892. According to J. C. Branner (idem, p. 164), the river carries in solution past Little Rock 6,828,350 tons of solids annually.

I. Parts per million.

	1	2	3	4	5	6	7	8	9	10
CO_3	55.5	92	48	95	56.6	131.8	117	112	22.8	85.7
SO_4	21.6	201	60	349	1295.0	481.0	60	58	8.9	100.2
Cl	5.6	21	12	15	104.3	422.0	36	13	24.2	306.2
Ca	29.9	81	32	108	272.7	141.0	68	75	7.8	60.1
Mg	7.6	21	8	34	80.8	45.0	12	11	1.9	13.3
Na	14.2	47	25	62	309.4	382.0	40	10	21.6	205.9
K	1.0				6.0				4.0	5.9
Al_2O_3	[a] .5	17	2	5	------	------	4	------	13.1	1.9
Fe_2O_3					------	.1		------	.7	.5
SiO_2	12.1	15	17	19	9.6	26.0	19	15	4.0	14.3
	148.0	495	204	687	2134.4	1628.9	356	294	109.0	794.0

[a] Includes a little manganic oxide.

II. Percentage composition of dissolved solids.

	1	2	3	4	5	6	7	8	9	10
CO_3	37.55	18.58	23.53	13.87	2.65	8.09	32.87	38.10	20.92	10.80
SO_4	14.62	40.61	29.41	50.80	60.69	29.53	16.85	19.73	8.15	12.61
Cl	3.77	4.24	5.88	2.13	4.89	25.91	10.11	4.42	22.21	38.55
Ca	20.24	16.37	15.69	15.72	12.78	8.66	19.10	25.51	7.20	7.60
Mg	5.13	4.24	3.92	4.95	3.76	2.76	3.37	3.74	1.75	1.67
Na	9.57	9.49	12.26	9.03	14.50	23.45	11.24	3.40	19.83	25.92
K	.60				.28				3.68	.74
Al_2O_3	[a] .33	3.43	.98	.73	------	------	1.12	------	.61	.24
Fe_2O_3					------	.01		------	3.65	.06
SiO_2	8.19	3.04	8.33	2.77	.45	1.59	5.34	5.10	12.00	1.81
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

[a] Includes a little manganic oxide.

These analyses, notwithstanding their irregularities, are instructive, especially the two pairs made by Headden and by Brackett. Headden's analyses, Nos. 1 and 5, are like those of water from Cache la Poudre River, a tributary of the Platte. At Canon City the Arkansas has just issued from a mountain region, in which its dissolved solids have been derived mainly, from igneous rocks. It has then the character of a mountain water; but at Rocky Ford, a hundred miles below, saline matter has been received from a semiarid soil and partly through the return to the river of water from irrigation ditches. Brackett's analyses show the differences between high and low water, both as to salinity or concentration and as to composition. When a large amount of flood water, in great part surface run-off, enters a stream, the composition of the stream is necessarily altered. The lack of agreement between the two analyses of water taken at Pueblo may be due to differences in the stage of the river when the sample was collected.

WALNUT RIVER.

Walnut River, which enters the Arkansas at Arkansas City, Kans., drains an area of about 2,020 miles, entirely within the State of Kansas. For the composition of its water there is, first, the following table, from Water-Supply Paper 273:

Analyses of water from Walnut River at Winfield, Kans.

[Parts per million. Drainage area 1,870 square miles. Analyses made in the chemical laboratories of the University of Kansas, E. H. S. Bailey, director.]

Date (1906-7).		Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate (CO_3).	Bicarbonate (HCO_3).	Sulphate (SO_4).	Nitrate (NO_3).	Chlorine (Cl).	Total dissolved solids.
From—	To—												
Dec. 2	Dec. 11	165	22	1.4	76	10	29	0.0	222	52	4.2	12	286
12	21	20	21	.8	92	16	31	.0	323	55	3.0	12	368
22	31	12	26	.4	101	22	33	.0	360	58	3.7	15	388
Jan. 1	Jan. 10	11	19	.7	107	18	24	.0	372	70	4.2	18	544
11	20	613	39	4.0	58	7.9	33	[a] 9.6	230	47	7.0	14	316
21	30	270											
31	Feb. 11	11	21	.8	98	7.6	28	.0	366	68	6.2	12	387
Feb. 12	22	8	72	.24	121	21	46	.0	410	89	4.8	17	547
23	Mar. 4	54	57	.18	82	17	33	.0	330	86	4.4	16	415
Mar. 5	14	49	27	.40	86	15	33	.0	256	71	2.5	8.4	367
15	24	44	15	2.4	92	19	25	[a] 8.2	276	73	3.3	9.6	367
26	Apr. 4	61	16	1.2	98	13	30	.0	323	77	4.9	7.3	406
Apr. 5	15	40	14	1.0	105	15	30	.0	374	96	.7	13	437
16	26	47	7.2	.8	101	18	27	.0	317	106	1.5	15	530
27	May 7	297	13	3.0	88	8.2	33	.0	275	86	4.2	15	371
May 8	18	201	21	3.0	78	3.7	23	.0	247	59	4.5	9	306
19	30	63	20	1.2	99	14	31	.0	345	73	6.0	14	400
June 1	June 10	58	17	1.2	111	23	31	.0	367	97	6.7	15	452
11	22	130	20	1.4	77	19	33	.0	295	87	5.3	16	375
23	July 5	142	29	3.0	68	19	28	.0	235	60	6.5	10	316
July 7	17	56	30	1.2	76	16	36	.0	282	50	7.5	11	331
18	29	28	28	2.0	74	21	34	[a] 5.0	277	73	4.5	14	344
30	Aug. 8	20	20	1.0	77	28	33	.0	216	93	2.8	15	357
Aug. 9	22	29	19	3.2	97	24	43	.0	270	73	2.7	12	361
24	Sept. 2	42	19	.18	.80	20	31	.0	243	91	4.0	17	340
Sept. 3	15	20	22	.06	97	25	35	.0	240	144	2.5	18	445
16	28	25	13	.14	78	29	38	.0	178	137	Tr.	20	382
29	Oct. 10	28	16	.04	87	23	35	.0	260	115	2.0	17	408
Oct. 14	23	18	8.6	.10	77	20	34	.0	225	114	Tr.	16	364
24	Nov. 5	26	21	.16	106	26	33	.0	288	141	1.8	21	478
Nov. 6	16	28	16	.20	112	23	38	.0	300	175	1.8	29	539
17	26	24						.0	315		2.2	23	
Mean		82	23	1.2	90	18	32	.0	292	87	3.7	15	398

[a] Abnormal; computed as HCO_3 in the average.

NOTE.—Analyses from Dec. 2, 1906, to Feb. 11, 1907, and from Mar. 15, to Nov. 26, 1907, by F. W. Bushong; from Feb. 22 to Mar. 14, 1907, by Archie J. Weith.

The following analyses relate to tributaries of the Arkansas above Walnut River.

Analyses of waters tributary to the Arkansas.

1. Purgatory River at Trinidad, Colo. From Atchison, Topeka & Santa Fe Ry.
2. Walnut Creek at Great Bend, Kans. Analysis by F. W. Bushong, U. S. Geol. Survey Water-Supply Paper 273, p. 281, 1911.
3. Cow Creek at Hutchinson, Kans. From Kennicott Water Softener Co.
4. Little Arkansas River at Little River, Kans.
5. Ninnescah River at Pratt, Kans. Nos. 4 and 5 from Atchison, Topeka & Santa Fe Ry.
6. Ninnescah River at Belle Plaine, Kans. Analysis by Bushong, op. cit.
7. Slate Creek at Wellington, Kans. From Atchison, Topeka & Santa Fe Ry.

I. Parts per million.

	1	2	3	4	5	6	7
CO_3	121.6	184.2	114	209.0	84.0	140.1	122.0
SO_4	22.9	101.0	88	25.0	41.0	59.0	24.0
Cl	41.5	90.0	240	21.0	76.0	202.0	24.0
Ca	76.0	108.0	80	109.0	63.0	79.0	57.0
Mg	8.8	20.0	16	25.0	7.8	17.0	19.0
Na(K)	26.9	97.0	114	14.0	45.0	160.0	20.0
Al_2O_3				2.4	1.7		1.7
Fe_2O_3		.1				.1	
SiO_2	39.3	30.0	11	23.0	20.0	39.0	5.0
	337.0	630.3	663	428.4	338.5	696.2	272.7

Analyses of waters tributary to the Arkansas—Continued.

II. Percentage composition of dissolved solids.

	1	2	3	4	5	6	7
CO_3	36.09	29.22	17.20	48.79	24.81	20.12	44.73
SO_4	6.80	16.02	13.27	5.83	12.11	8.47	8.80
Cl	12.31	14.28	36.20	4.90	22.45	29.02	8.80
Ca	22.55	17.13	12.06	25.45	18.62	11.35	20.90
Mg	2.61	3.17	2.41	5.83	2.31	2.44	6.96
Na(K)	7.98	15.39	17.20	3.27	13.29	22.98	7.37
Al_2O_3				.56	.50		.61
Fe_2O_3		.03				.02	
SiO_2	11.66	4.76	1.66	5.37	5.91	5.60	1.83
	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Six of the analyses in the next table are of waters in the Walnut River basin, and two relate to Grouse Creek, which joins the Arkansas below the Walnut.

Analyses of waters from Walnut River and Grouse Creek, Kans.

1. West Branch of of Walnut River at De Graff.
2. Walnut River at Winfield.
3. Walnut River at South Winfield.
4. Walnut River at Arkansas City. Analyses 1, 2, 3, and 4 received from Atchison, Topeka & Santa Fe Ry.
5. West Whitewater River at Whitewater.
6. Creek at Whitewater. Analyses 5 and 6 received from Chicago, Rock Island & Pacific Ry.
7. Grouse Creek at Cambridge. From Atchison, Topeka & Santa Fe Ry.
8. Grouse Creek at Dexter. From Missouri Pacific Ry.

I. Parts per million.

	1	2	3	4	5	6	7	8
CO_3	116.0	53.0	71	160.0	207	170	128.0	108.0
SO_4	5.1	12.0	76	82.5	1,017	613	14.0	8.5
Cl	12.0	12.0	6	14.5	54	281	12.0	5.5
Ca	52.0	30.0	30	107.0	413	292	69.0	54.0
Mg	5.4	5.3	16	18.5	83	40	13.0	12.0
Na(K)	29.0	8.9	30	14.0	51	172	9.8	6.6
$(Al, Fe)_2O_3$	1.1	2.6	1	--------	18	5	.9	4.8
SiO_2	13.0	28.0	28	13.0	52		18.0	13.6
	233.6	151.8	258	409.5	1,895	1,573	264.7	213.0

Analyses of waters from Walnut River and Grouse Creek, Kans.—Continued.

II. Percentage composition of dissolved solids.

	1	2	3	4	5	6	7	8
CO_3	49.66	34.92	27.52	39.07	10.92	10.81	48.36	50.70
SO_4	2.18	7.90	29.46	20.14	53.67	38.97	5.29	4.00
Cl	5.14	7.90	2.33	3.55	2.85	17.86	4.53	2.58
Ca	22.26	19.76	11.63	26.13	21.79	18.56	26.06	25.36
Mg	2.31	3.49	6.20	4.52	4.38	2.55	4.91	5.63
Na(K)	12.41	5.87	11.63	3.42	2.69	10.93	3.70	3.10
$(Al, Fe)_2O_3$	.47	1.71	.38	--------	.95	.32	.35	2.25
SiO_2	5.57	18.45	10.85	3.17	2.75		6.80	6.38
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

MEDICINE LODGE AND CHIKASKIA RIVERS

Medicine Lodge and Chikaskia rivers are tributaries of the Salt Fork of the Arkansas. For these two rivers there are the following tables of analyses from Water-Supply Paper 273.

Analyses of water from Medicine Lodge River at Kiowa, Kans.

[Parts per million. Drainage area, 940 square miles. Analyses made by F. W. Bushong in the chemical laboratories of the University of Kansas, E. H. S. Bailey, director.]

Date (1906-7).		Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate (CO_3).	Bicarbonate (HCO_3).	Sulphate (SO_4).	Nitrate (NO_3).	Chlorine (Cl).	Total dissolved solids.
From—	To—												
Jan. 21	Feb. 1	152	39	1.8	218	47	90	0.0	280	512	3.5	84	1,266
Feb. 2	12	162	26	.20	192	37	105	.0	288	495	.6	92	1,081
13	23	134	87	.40	177	36	94	.0	266	443	.7	69	1,048
24	Mar. 26	115	24	2.0	164	36	89	.0	230	438	1.2	74	953
Mar. 27	Apr. 5	49	18	.6	152	44	104	.0	203	457	.3	100	1,014
Apr. 6	15	41	27	3.0	148	30	86	.0	222	376	.6	75	880
16	26	24	20	1.8	151	40	115	.0	309	343	28.0	98	1,072
27	May 7	75	22	1.2	158	35	85	.0	265	401	1.9	73	907
May 8	17	54	13	.8	193	59	134	.0	222	633	1.6	141	1,346
18	26	41	22	1.2	167	37	122	.0	187	522	1.6	116	1,146
28	June 6	46	18	.6	202	47	132	.0	243	602	1.5	127	1,371
June 7	16	20	5.4	.7	218	76	168	.0	268	730	1.5	178	1,654
17	26	20	15	1.2	218	109	212	.0	212	867	1.7	206	1,825
27	July 6	140	28	4.0	99	45	93	.0	167	330	2.1	82	773
July 7	17	130	31	1.5	122	32	57	.0	238	252	2.4	43	645
18	27	766	35	8.0	126	19	61	.0	215	248	5.0	42	638
28	Aug. 9	296	30	2.2	98	19	46	.0	150	215	3.0	30	506
Aug. 10	19	67	32	.8	152	43	103	.0	213	423	3.5	94	958
20	30	40	27	.50	168	62	133	.0	225	510	6.0	132	1,176
31	Sept. 11	62	16	.09	132	34	92	.0	185	316	3.5	111	815
Sept. 12	14	36	----------	----------	----------	----------	----------	.0	170	----------	.4	91	----------
Mean		118	27	1.6	163	44	106	.0	226	455	3.4	98	1,054

Analyses of water from Chikaskia River at Argonia, Kans.

[Parts per million. Drainage area, 520 square miles. Analyses made in the chemical laboratories of the University of Kansas, E. H. S. Bailey, director.]

Date (1906-7).		Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate (CO_3).	Bicarbonate (HCO_3).	Sulphate (SO_4).	Nitrate (NO_3).	Chlorine (Cl).	Total dissolved solids.
From—	To—												
Nov. 30	Dec. 10	60	31	0.30	51	11	36	0.0	278	26	0.2	14	299
Dec. 11	23	12	21	.9	71	16	40	[a] 5.0	304	37	.8	19	325
24	Jan. 3	12	29	.40	69	15	43	[a] 4.8	302	35	.9	19	315
Jan. 4	13	13	25	.8	68	22	39	.0	300	34	4.0	20	307
14	24	417	43	2.0	56	6.2	46	[a] 9.6	260	25	3.3	11	310
25	Feb. 5	35	46	1.6	72	6.5	41	[a] 15	284	45	1.9	15	354
Feb. 7	16	30	35	.18	71	16	35	[a] 6	262	41	.4	13	350
18	27	17	48	.20	74	16	47	[a] 4	280	62	1.2	15	383
28	Mar. 10	25	32	.32	65	16	43	[a] 4.8	275	34	1.2	15	323
Mar. 11	21	14	17	.25	64	12	27	.0	281	38	.5	14	306
22	31	16	19	1.8	60	10	39	[a] 8.9	262	29	.3	13	297
Apr. 1	Apr. 10	15	20	1.0	68	4.3	36	[a] 6.2	263	40	.2	12	305
11	21	12	14	.8	63	3.5	33	[a] 4.0	264	34	.4	15	282
22	May 1	14	16	2.0	64	15	36	.0	522	32	.5	13	281
May 2	12	31	26	3.2	63	1.7	39	.0	275	27	.8	15	291
13	22	17	24	1.0	63	9	38	.0	275	35	.9	23	298
24	June 2	19	22	.40	62	15	38	.0	260	30	.3	15	279
June 3	13	30	18	.6	61	13	40	[a] 7.0	245	30	.8	14	282
14	24	60	30	3.0	54	18	40	[a] 9.6	223	31	1.0	13	272
25	July 5	220	44	6.0	51	15	34	.0	235	24	1.9	12	285
Mean		53	28	1.3	64	12	38	.0	278	34	1.1	15	307

[a] Abnormal; computed as HCO_3 in the average.

NOTE.—Analyses from Nov. 30, 1906, to Feb. 5, 1907, and from Mar. 22 to July 5, 1907, by F. W. Bushong; from Feb. 7 to Mar. 21, 1907, by Archie J. Weith.

Additional analyses of waters in the basins of Medicine Lodge and Chikaskia rivers are as follows. All the localities cited are in Kansas

Analyses of waters from the Medicine Lodge and Chikaskia basins.

1. Elm Creek at Medicine Lodge. A tributary of Medicine Lodge River.
2. Chikaskia River at Argonia.
3. Bluff Creek at Anthony. A tributary of Chikaskia River. Analyses 1, 2, and 3 received from Atchison, Topeka & Santa Fe Ry.
4. Bluff Creek at Anthony.
5. Bluff Creek at Caldwell. Analyses 4 and 5 received from Chicago, Rock Island & Pacific Ry.

I. Parts per million.

	1	2	3	4	5
CO_3	68.0	102	98	152.0	157
SO_4	37.0	57	95	83.0	131
Cl	20.0	32	24	44.0	76
Ca	32.0	55	58	71.0	79
Mg	8.3	13	18	25.0	34
Na(K)	27.0	44	35	61.0	76
$(Al, Fe)_2O_3$	4.0	--------	2	3.4	13
SiO_2	26.0	18	12	21.0	
	222.3	321	342	460.4	566

Analyses of waters from the Medicine Lodge and Chikaskia basins—Continued.

II. Percentage composition of dissolved solids.

	1	2	3	4	5
CO_3	30.59	31.77	28.66	33.01	27.74
SO_4	16.65	17.76	27.78	18.02	23.15
Cl	9.00	9.99	7.00	9.57	13.42
Ca	14.40	17.13	16.96	15.42	13.96
Mg	3.73	4.05	5.27	5.43	6.01
Na(K)	12.14	13.70	10.23	13.25	13.42
$(Al, Fe)_2O_3$	1.80	--------	.59	.74	2.30
SiO_2	11.69	5.60	3.51	4.56	
	100.00	100.00	100.00	100.00	100.00

CIMARRON RIVER.

Cimarron River rises in the Raton Mountains, N. Mex., and joins the Arkansas at Keystone, Okla. Its length is about 450 miles, and the area of its basin is approximately 6,800 square miles. For this river we have only the single table of analyses published in Water-Supply Paper 273, as follows:

Analyses of water from Cimarron River at Englewood, Kans.

[Drainage area, 6,800 square miles. Parts per million. Analyses made in the chemical laboratories of the University of Kansas, E. H. S. Bailey, director.]

Date (1906-7).		Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate (CO_3).	Bicarbonate (HCO_3).	Sulphate (SO_4).	Nitrate (NO_3).	Chlorine (Cl).	Total dissolved solids
From—	To—												
Nov. 30	Dec. 9	268	38	1.4	89	30	320	[a] 14	297	150	1.1	500	1,336
Dec. 11	20	90	33	.6	88	30	289	[a] 13	327	135	1.4	368	1,080
21	30	78	41	1.2	80	28	123	[a] 14	296	118	.9	307	928
31	Jan, 9	83	58	2.4	67	30	292	[a] 4.8	309	137	3.5	382	1,120
Jan. 14	23	93	57	2.2	83	33	319	[a] 6.2	320	149	.8	453	1,230
24	Feb. 4	85	35	.24	105	46	510	.0	428	187	2.3	744	1,827
Feb. 5	14	40	42	.24	98	36	305	.0	422	122	1.6	388	1,380
15	24	142	45	.40	86	29	266	[a] 2.6	357	125	1.8	320	1,031
25	Mar. 6	95	52	.28	87	31	331	[a] 5.2	308	165	.7	448	1,246
Mar. 7	16	293	38	.20	72	26	212	.0	334	128	.8	256	858
17	27	40	26	1.5	77	22	183	[a] 5.0	351	124	.2	185	783
28	Apr. 6	111	32	1.4	87	32	327	.0	351	160	.3	435	1,217
Apr. 7	17	131	29	2.5	90	28	441	.0	295	179	1.6	640	1,766
18	30	99	26	2.0	90	39	451	.0	285	178	.3	651	1,560
May 1	May 10	247	30	2.0	87	32	403	.0	292	179	1.9	560	1,423
11	31	103	28	1.5	84	35	446	.0	275	181	1.4	632	1,545
June 11	June 20	250	40	1.2	81	43	520	[a] 5.0	238	196	1.6	744	1,723
21	30	462	41	5	75	37	378	[a] 7.0	257	155	.7	526	1,333
July 1	July 12	1,170	48	3.5	84	38	383	[a] 10	225	183	1.3	528	1,392
13	22	1,390	43	3	73	31	369	[a] 12	220	158	.5	528	1,308
23	Aug. 1	785	29	1.5	79	35	332	.0	263	149	7.0	472	1,208
Aug. 2	12	3,680	40	3	75	28	235	.0	270	115	4.7	314	942
13	24	1,350	40	1.5	90	38	359	.0	315	151	3.0	500	1,317
25	Sept. 9	240	34	.09	84	40	438	.0	280	182	1.4	622	1,537
Sept. 10	20	9,700	24	.20	91	46	411	.0	285	189	1.1	568	1,425
21	Oct. 8	1,920	39	.36	85	40	424	[a] 7.0	255	177	2.7	618	1,498
Oct. 13	22	316	28	.30	94	38	389	.0	290	160	1.0	550	1,389
23	Nov. 1	470	39	.25	89	33	379	.0	289	155	1.3	520	1,373
Nov. 4	13	283	37	.30	95	38	400	[a] 3.0	295	147	1.5	582	1,452
21	30	328	33	.16	90	37	440	.0	292	171	2.5	616	1,503
Mean		811	38	1.4	85	34	356	.0	308	157	1.7	498	1,324

[a] Abnormal; computed as HCO_3 in the average.

NOTE.—Analyses from Nov. 30, 1906, to Jan. 23, 1907, and from Mar. 17 to Nov. 13, 1907, by F. W. Bushong; from Jan. 24 to Mar. 16, and from Nov. 21 to 30, 1907, by Archie J. Weith.

VERDIGRIS RIVER.

For Verdigris River there are first, two tables of analyses from Water-Supply Paper 273—one of the river itself and one of its tributary Fall River. These tables are as follows:

Analyses of water from Verdigris River at Coffeyville, Kans.

[Drainage area 3,250 square miles. Parts per million. Analyses made in the chemical laboratories of the University of Kansas, E. H. S. Bailey, director.]

Date (1906-7).		Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate (CO_3).	Bicarbonate (HCO_3).	Sulphate (SO_4).	Nitrate (NO_3).	Chlorine (Cl).	Total dissolved solids.
From—	To—												
Dec. 11	Dec. 20	40	17	2.0	78	12	31	0.0	287	32	2.7	22	329
21	Jan. 2	7	23	.40	95	10.5	31	.0	367	40	3.5	32	384
Jan. 3	12	107	24	1.4	71	4.3	33	[a] 9.6	290	44	4.2	38	364
13	22	874	34	1.0	46	1.3	32	.0	164	25	7.9	10	224
23	Feb. 1	327	22	3.0	79	4.1	29	[a] 9.6	284	33	5.8	15	321
Feb. 2	11	18	23	.10	62	16	37	.0	359	41	2.5	23	291
12	21	13	76	.10	106	16	41	.0	370	46	4.1	23	481
22	Mar. 3	65	67	.20	88	16	44	.0	294	39	3.0	24	444
Mar. 4	13	380	33	.36	73	12	35	.0	248	40	3.2	14	324
14	23	211	16	5.0	79	11	33	[a] 3.1	265	30	3.0	13	317
24	Apr. 1	1,877	13	2.0	80	7.2	31	.0	288	30	4.0	19	323
Apr. 2	14	188	16	4.0	69	2.0	25	.0	237	30	2.9	18	278
15	26	103	16	1.8	78	11	31	.0	315	35	2.8	28	326
28	May 7	1,805	13	3.0	64	1.2	28	.0	210	36	5.0	25	266
May 8	19	1,307	18	3.0	70	5.5	28	.0	222	40	6.5	14	282
20	31	203	17	1.2	81	16	27	.0	318	39	3.8	22	325
June 1	June 16	900	22	9	57	11	18	.0	252	24	3.5	20	398
17	26	2,700	21	1.4	68	12	27	.0	220	27	7	16	259
July 8	July 17	165	30	1.5	65	16	44	[a] 7.0	273	33	4	19	304
18	29	58	27	1.5	68	13	34	.0	290	33	3.0	19	246
30	Aug. 10	60	29	1.3	72	14	34	.0	268	31	2.0	21	267
Aug. 11	23	95	18	.7	73	18	37	.0	273	32	.5	28	309
24	Sept. 5	266	20	.05	57	14	37	.0	210	21	3.5	18	233
Sept. 6	15	50	20	.03	57	13	34	.0	210	16	3.1	20	235
16	25	42	23	.12	62	16	33	.0	208	23	.9	25	250
26	Oct. 9	35	16	.12	66	14	33	.0	210	20	1.2	36	262
Oct. 10	20	23	23	.13	67	14	36	.0	242	27	.6	35	293
21	31	14	19	.14	65	16	38	.0	238	22	.8	40	291
Nov. 1	Nov. 10	22	17	.20	63	12	32	.0	215	21	1.1	31	255
11	20	22	15	.30	51	12	33	.0	200	19	.9	21	226
21	Dec. 10	56	17	.20	83	11	34	.0	213	24	1.0	24	253
Mean		388	24	1.4	71	11	33	.0	261	31	3.2	23	302

[a] Abnormal; computed as HCO_3 in the average.

Analyses of water from Fall River at Neodesha, Kans.

[Parts per million. Drainage area, 848 square miles. Analyses made in the chemical laboratory of the University of Kansas, E. H. S. Bailey, director.]

Date (1907-8).		Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate (CO_3).	Bicarbonate (HCO_3).	Sulphate (SO_4).	Nitrate (NO_3).	Chlorine (Cl).	Total dissolved solids.
From—	To—												
July 1	July 12	93	33	6	71	19	25	0.0	240	25	3.8	9	244
13	27	15	28	1.6	62	18	28	.0	300	30	3.0	15	269
28	Aug. 8	13	22	.7	64	22	28	.0	292	27	1.1	14	286
Aug. 9	18	10	34	.30	59	17	27	.0	285	24	1.2	17	271
20	31	684	16	.24	51	12	24	.0	180	18	2.0	10	195
Sept. 1	Sept. 11	85	23	.22	48	8.8	24	.0	165	14	2.5	8.5	194
12	23	45	17	.04	60	9.9	24	.0	182	15	.5	10	190
24	Oct. 26	20	19	.12	64	11	25	.0	215	16	.9	12	424
Oct. 27	Nov. 8	16	23	.08	61	17	29	.0	265	17	.8	17	253
Nov. 9	Dec. 13	11	18	.12	74	17	32	.0	290	21	.6	25	304
Dec. 14	24	95	23	.30	75	14	33	.0	270	29	1.5	14	283
Jan. 16	Jan. 28	50	35	.16	81	15	34	.0	290	41	2.2	14	340
29	Feb. 14	36	33	.12	85	16	36	.0	312	41	2.0	14	357
Feb. 15	17	18						.0	276			14	
Mar. 10	Mar. 20	50	20	.18	79	13	33	.0	270	62	3.5	11	322
21	31	16	21	.12	73	16	40	.0	300	42	2.5	13	303
Apr. 5	Apr. 14	180	28	.14	68	11	31	[a] 8.9	211	32	3.1	10	279
15	24	295	39	.20	63	11	32	[a] 16	177	34	3.7	13	282
25	May 5	70	28	.06	79	14	36	.0	200	34	1.0	10	344
May 5	14	50	41	.20	55	14	35	.0	228	34	.5	9.9	283
15	24	824	48	1.40	55	12	34	.0	241	27	2.8	7.6	282
25	June 10[b]	2,100	31	.14	69	11	28	[a] 8.8	69	26	.5	9.3	283
Mean		217	28	.59	66	14	30	.0	242	29	1.9	13	285

[a] Abnormal; computed as HCO_3 in the average.

[b] About June 10; 13 samples.

NOTE.—Analyses from July 1, 1907, to Feb. 17, 1908, by F. W. Bushong; from Mar. 10 to June 10, 1908; by Archie J. Weith.

Additional analyses of water from Verdigris River are as follows: All the localities cited are in Kansas.

Analyses of water from Verdigris River.

1. At Madison.
2. At Toronto.
3. At Benedict.
4. At Guilford.
5. At Independence.
6. At Independence. J. C. Gordon, analyst. Received from Kansas State Board of Health.
7. At Coffeyville.

Analyses 4 and 7 received from Missouri Pacific Ry.; Nos. 1, 2, 3, and 5 from Atchison, Topeka & Santa Fe Ry.

I. Parts per million.

	1	2	3	4	5	6	7
CO_3	241	94.0	79.0	126.0	56.0	90.0	81.0
SO_4	70	32.0	26.0	43.0	10.0	35.4	27.0
Cl	18	6.0	9.1	16.0	15.0	34.0	13.0
Ca	135	53.0	50.0	77.0	32.0	57.6	50.0
Mg	32	6.2	10.0	13.0	6.4	10.1	8.8
Na(K)	16	19.0	1.5	14.0	8.7	22.5	8.8
$(Al, Fe)_2O_3$		3.1	2.1	2.1	.2	14.2	2.0
SiO_2	10	14.0	18.0	8.7	29.0	15.0	11.6
	522	227.3	195.7	299.8	157.3	278.8	202.2

II. Percentage composition of dissolved solids.

	1	2	3	4	5	6	7
CO_3	46.17	41.35	40.37	42.03	35.60	32.28	40.06
SO_4	13.41	14.08	13.28	14.34	6.36	12.70	13.35
Cl	3.45	2.64	4.65	5.34	9.54	12.20	6.43
Ca	25.86	23.32	25.54	25.68	20.34	20.66	24.73
Mg	6.13	2.73	5.11	4.34	4.07	3.62	4.35
Na(K)	3.06	8.36	.76	4.67	5.53	8.07	4.35
$(Al, Fe)_2O_3$		1.36	1.10	.70	.13	5.09	.99
SiO_2	1.92	6.16	9.19	2.90	18.43	5.38	5.74
	100.00	100.00	100.00	100.00	100.00	100.00	100.00

The next group of analyses represents waters from Fall and Elk rivers, both tributaries of the Arkansas. Rock Creek is a tributary of Elk River. All the localities cited are in Kansas.

Analyses of waters from Fall and Elk rivers.

1. Fall River at Fredonia. From Atchison, Topeka & Santa Fe Ry.
2. The same. W. A. Burton, analyst.
3. Fall River at Neodesha. Burton, analyst. Analyses 2 and 3 received from Kansas State Board of Health.
4. The same. From Missouri Pacific Ry.
5. Elk River at Elk. From Missouri Pacific Ry.
6. Elk River at Independence. F. W. Bushong, analyst. From U. S. Geol. Survey Water-Supply Paper 273, p. 316, 1911.
7. Rock Creek at Howard. From Kennicott Water Softener Co.

I. Parts per million.

	1	2	3	4	5	6	7
CO_3	169	108.2	113.0	137.0	77.0	133.8	92.0
SO_4	44	58.0	64.6	22.0	15.0	42.0	34.0
Cl	19	17.0	21.0	16.0	11.0	13.0	12.0
NO_3						3.0	
Ca	91	83.6	91.2	76.0	44.0	86.0	54.0
Mg	23	13.9	12.7	12.0	8.2	14.0	11.0
Na(K)	13	2.8	8.5	15.0	7.6	27.0	11.0
$(Al, Fe)_2O_3$	Tr.	4.5	4.6	.3	8.5		.1
Fe_2O_3						.2	
SiO_2	10	16.0	4.6	12.7	25.0	20.0	21.0
	369	304.0	320.2	291.0	196.3	339.0	235.1

Analyses of waters from Fall and Elk rivers—Continued.

II. Percentage composition of dissolved solids.

	1	2	3	4	5	6	7
CO_3	45.80	35.59	35.29	47.07	39.23	39.47	39.13
SO_4	11.92	19.08	20.17	7.55	7.64	12.36	14.46
Cl	5.15	5.59	6.56	5.49	5.60	3.84	5.10
NO_3						.59	
Ca	24.66	27.50	28.48	26.17	22.42	25.37	22.97
Mg	6.24	4.57	3.97	4.12	4.18	4.15	4.68
Na(K)	3.52	.92	2.65	5.14	3.88	7.97	4.68
$(Al, Fe)_2O_3$	Tr.	1.48	1.44	.10	4.33		.05
Fe_2O_3						.06	
SiO_2	2.71	5.27	1.44	4.36	12.72	5.91	8.93
	100.00	100.00	100.00	100.00	100.00	100.00	100.00

For Caney River, a tributary of the Verdigris, and its affluent, Caney Creek, the following analyses are available.

Analyses of waters from Caney River and Caney Creek.

1. Caney River at Cedarvale, Kans. From Kennicott Water Softener Co.
2. The same. Analysis by W. A. Burton. From Kansas State Board of Health.
3. The same. From Missouri Pacific Ry.
4. Caney River at Elgin, Kans.
5. Caney River at Bartlesville, Okla. Analyses 4 and 5 from Atchison, Topeka & Santa Fe Ry.
6. Caney Creek at Caney, Kans. From Missouri Pacific Ry.
7. The same. Analysis by A. J. Weith. From U. S. Geol. Survey Water-Supply Paper 273, p. 316, 1911.

I. Parts per million.

	1	2	3	4	5	6	7
CO_3	169.0	117.2	168.0	109.0	73.0	119.0	78.7
SO_4	16.0	58.4	48.0	40.0	17.0	21.0	38.0
Cl	15.0	15.0	7.7	9.0	19.0	18.0	24.0
NO_3							3.0
Ca	96.0	86.0	88.0	62.0	42.0	68.0	50.0
Mg	17.0	15.1	24.0	9.9	6.5	9.9	9.6
Na(K)	5.6	.7	8.2	18.0	15.0	16.0	36.0
$(Al,Fe)_2O_3$		7.8	2.7	2.0	1.5	2.0	
Fe_2O_3							.5
SiO_2	11.0	18.0	7.0	17.0	29.0	12.0	13.0
	329.6	318.2	353.6	266.9	203.0	265.9	252.8

II. Percentage composition of dissolved solids.

	1	2	2	4	5	6	7
CO_3	51.27	36.83	47.51	40.84	35.96	44.75	31.13
SO_4	4.85	18.35	13.58	14.99	8.38	7.90	15.03
Cl	4.56	4.71	2.18	3.37	9.36	6.77	9.49
NO_3							1.20
Ca	29.12	27.02	24.89	23.23	20.69	25.57	19.78
Mg	5.16	4.73	6.78	3.71	3.20	3.72	3.80
Na(K)	1.70	.23	2.32	6.74	7.39	6.02	14.24
$(Al,Fe)_2O_3$		2.45	.76	.75	.74	.75	
Fe_2O_3							.19
SiO_2	2.34	5.66	1.98	6.37	14.28	4.52	5.14
	100.00	100.00	100.00	100.00	100.00	100.00	100.00

NEOSHO RIVER.

Neosho River rises in Morris County, Kans., and joins the Arkansas below the mouth of Verdigris River and west of Fort Gibson, Okla. It drains an area of 12,660 square miles. In Water-Supply Paper 273 two tables are given for the Neosho, and one each for its principal tributaries, Cottonwood River and Spring River. They are reproduced as follows:

Analyses of water from Neosho River at Emporia, Kans.

[Parts per million. Drainage area, 740 square miles (estimated). Analyses made in the chemical laboratories of the University of Kansas, E. H. S. Bailey, director.]

Date (1906-7).		Turbidity.	Silica (SiO$_2$)	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate (CO$_3$).	Bicarbonate (HCO$_3$).	Sulphate (SO$_4$).	Nitrate (NO$_3$).	Chlorine (Cl).	Total dissolved solids.
From—	To—												
Dec. 5	Dec. 14	40	21	1.4	79	13	25	0.0	324	27	0.3	12	315
15	24	14	17	.30	86	13	35	.0	344	23	.2	12	317
25	Jan. 4	14	28	1.4	88	12	22	[a]11	326	31	4.0	10	332
Jan. 5	14	9.5	18	1.6	67	11	32	.0	356	27	2.6	14	262
15	24	700	43	3.6	62	4.8	29	.0	259	31	4.4	6.8	278
25	Feb. 4	20	39	1.2	82	8.5	33	[a]6.7	304	36	5.3	6.3	346
Feb. 5	14	273	21	.40	64	12	25	.0	245	36	5.9	6.1	284
15	24	65	41	.24	70	8.4	19	.0	244	27	4.6	5.5	300
25	Mar. 6	907	57	.68	64	9.0	28	.0	226	25	4.9	4.5	319
Mar. 7	16	870	16	.20	64	11	38	.0	213	44	4.8	4.2	238
17	26	37	19	1.2	99	16	24	.0	347	30	4.8	5.4	350
27	Apr. 5	47	6.0	.50	76	11	24	.0	287	33	1.4	4.8	283
Apr. 6	15	52	3.6	2.5	72	7.5	24	.0	290	34	1.5	8.2	270
16	26	31	3.8	3.5	69	17	22	.0	289	35	2.3	9	285
27	May 6	40	7.6	1.4	78	20	26	.0	297	36	1.5	11	291
May 7	16	35	16	1.2	75	----------	22	.0	310	37	1.7	9	295
17	26	45	16	1.4	74	16	28	.0	295	32	3.1	9	296
27	June 6	50	20	1.2	84	14	25	.0	300	32	4.5	9	322
June 7	16	1,075	32	10	55	12	22	.0	220	23	10	7	259
17	26	660	24	5	56	15	23	[a]7.0	230	24	8.0	6.5	266
27	July 7	610	29	6	46	13	28	.0	187	16	7.5	5.0	246
July 8	17	63	30	2.5	74	14	27	.0	268	25	6.5	7.0	272
18	27	23	32	2	70	16	23	.0	263	24	3.8	7.0	287
28	Aug. 6	340	42	10	49	13	24	.0	175	21	3.5	6.0	240
Aug. 7	16	53	19	1.0	56	9.2	23	.0	169	18	4.8	5.0	184
17	26	46	24	.7	49	12	26	[a]8.0	212	19	2.0	4.0	228
27	Sept. 6	40	26	.14	61	14	23	.0	220	24	1.8	5.0	230
Sept. 7	18	21	24	.03	58	13	25	.0	220	24	1.0	7.2	235
20	30	27	18	.08	58	15	25	.0	225	21	.4	5.7	222
Oct. 1	Oct. 11	74	19	.40	50	14	21	.0	185	22	1.9	6.5	199
12	21	38	11	.10	62	14	27	.0	250	26	1.8	6.5	232
28	Nov. 6	48	16	.24	51	14	18	.0	182	20	6.0	6.0	196
Nov. 7	16	32	18	.10	66	12	17	.0	193	21	1.8	8.5	198
17	25	15	18	.14	54	14	23	.0	195	24	1.2	6.5	213
26	Dec. 5	11	17	.18	60	14	32	.0	210	28	1.3	8.5	241
Mean		184	44	1.79	66	13	25	.0	255	34	3.5	7.2	267

[a] Abnormal; computed as HCO$_3$ in the average.

NOTE.—Analyses from Dec. 5, 1906, to Feb. 4, 1907, and from Mar. 17 to Nov. 25, 1907, by F. W. Bushong; from Feb. 5 to Mar. 16, 1907, and from Nov. 26 to Dec. 5, 1907, by Archie J. Weith.

Analyses of water from Neosho River at Oswego, Kans.

[Parts per million. Drainage area, 5,230 square miles. Analyses made in the chemical laboratories of the University of Kansas, E. H. S. Bailey, director.]

Date (1906-7).		Turbidity.	Silica (SiO$_2$).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate (CO$_3$).	Bicarbonate (HCO$_3$).	Sulphate (SO$_4$).	Nitrate (NO$_3$).	Chlorine (Cl).	Total dissolved solids.	Mean gage height (feet).
From—	To—													
Dec. 11	Dec. 20	75	19	2.4	59	11	27	0.0	190	65	3.1	11	282	0.8
21	31	13	17	.40	103	21	24	.0	324	129	3.8	14	453	.6
Jan. 1	Jan. 16	108	17	2.4	86	16	24	.0	235	98	4.6	16	372	1.3
17	26	730	38	4.0	30	1.5	29	.0	80	27	7.9	3.8	165	18.1
27	Feb. 5	373	39	3.0	67	3.9	22	.0	202	45	5.3	7.2	280	2.7
Feb. 6	15	31	16	.12	83	15	30	.0	326	62	3.1	10	333	1.5
16	25	84	56	.10	97	12	29	.0	332	65	3.5	8.8	410	1.3
26	Mar. 7	618	28	.32	82	13	28	[a]3.3	227	74	3.2	8.2	348	2.7
Mar. 8	19	1,073	18	.08	56	12	45	.0	180	46	3.7	4.6	245	4.0
22	Apr. 2	368	16	4.0	70	12	24	.0	253	47	2.2	7.6	303	1.7
Apr. 3	13	170	17	5.0	70	13	24	.0	238	52	2.1	8.5	293	1.1
14	23	36	2.0	.7	81	14	23	.0	275	77	.6	12	328	.7
25	May 4	315	7.2	2.4	65	18	23	.0	209	67	3.0	11	281	2.8
May 5	June 1	404	21	5	61	3.2	26	.0	172	56	5.5	8	257	----------
June 2	12	289	10	2.0	89	15	25	.0	295	67	2.6	10	359	1.3
13	22	140	21	3	71	20	27	[a]12	230	57	4	9	303	1.1
24	July 5	835	22	3.5	43	9.2	25	.0	145	32	6.0	6.0	205	7.3
July 8	17	73	28	1.8	67	18	25	.0	242	42	5.5	8	273	1.1
18	31	33	20	1.5	72	18	26	[a]14	115	52	.6	8	281	.6
Aug. 1	Sept. 2	20	20	.04	80	19	26	.0	263	55	1.7	9	310	----------
Sept. 3	15	27	----------	.05	68	18	26	.0	232	52	1.4	10	287	.3
18	Oct. 2	29	13	.10	68	27	42	.0	185	117	Tr.	13	334	.0
Oct. 3	19	15	15	.03	83	24	29	.0	255	88	.6	11	346	.5
20	Nov. 5	45	14	.14	78	21	28	.0	220	106	.5	13	360	.6
Nov. 7	18	37	15	.02	57	13	23	.0	192	50	1.5	11	240	.7
19	28	66	10	.20	58	15	27	.0	198	62	1.1	9.5	247	.9
Dec. 2	Dec. 9	70	----------	----------	----------	----------	----------	.0	160	----------	.9	13	----------	.3
Mean		225	20	1.63	71	15	27	.0	223	65	2.9	9.7	304	----------

[a] Abnormal; computed as HCO$_3$ in the average.

NOTE.—Analyses from Dec. 11, 1906, to Feb. 5, 1907, and from Mar. 22 to Dec. 9, 1907, by F. W. Boshong; from Feb. 15 to Mar. 19, 1907, by Archie J. Weith.

Analyses of water from Cottonwood River at Emporia, Kans.

[Parts per million. Drainage area 1,880 square miles (estimated). Analyses made in the chemical laboratories of the University of Kansas, E. H. S. Bailey, director.]

Date (1906–7).		Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate (CO_3).	Bicarbonate (HCO_3).	Sulphate (SO_4).	Nitrate (NO_3).	Chlorine (Cl).	Total dissolved solids.
From—	To—												
Dec. 4	Dec. 13	35	18	0.40	144	28	31	0.0	387	203	1.1	14	625
14	23	16	13	.50	133	30	29	.0	395	199	1.8	15	602
24	Jan. 4	8	27	.8	123	31	27	.0	353	157	4.0	16	540
Jan. 5	17	17	36	1.0	100	28	32	.0	263	162	2.1	16	503
18	30	864	40	2.4	70	6.1	28	[a] 7.4	236	61	4.4	6.9	328
Feb. 1	Feb. 13	58	55	.12	104	21	28	.0	370	93	2.1	7.6	446
14	23	25	34	.20	120	22	28	4.0	365	139	3.7	11	528
24	Mar. 5	405	31	.18	103	22	35	.0	296	101	4.0	8.4	441
Mar. 6	15	644	19	.18	75	15	21	.0	226	73	4.6	6.1	321
16	25	68	19	2.4	100	19	27	.0	327	65	1.1	6.8	386
28	Apr. 6	50	14	1.0	112	25	25	.0	364	111	3.8	7.2	462
Apr. 7	16	45	9.2	3.2	99	21	24	.0	298	128	1.1	11	457
17	26	37	5.8	.8	102	29	28	.0	317	148	1.3	11	482
27	May 6	92	12	1.8	98	15	28	.0	315	133	1.3	10	446
May 7	17	117	13	1.4	93	5.5	22	.0	302	100	3.8	9	384
18	28	34	19	.8	93	11	28	.0	365	123	3.0	11	433
29	June 7	69	14	1.0	100	27	27	.0	355	120	1.9	10	444
June 8	18	54	12	.6	112	28	28	.0	345	133	10	12	285
19	28	930	21	1.5	85	21	26	.0	252	95	5.5	8	368
29	July 8	120	25	3	90	25	29	[a] 9.5	278	93	6.5	9	391
July 9	20	63	24	1.0	109	27	29	[a] 7.0	320	111	4.5	9.5	421
22	31	43	24	1.0	102	31	29	.0	337	122	2.5	11	448
Aug. 1	Aug. 11	30	23	.8	119	30	37	.0	322	160	3.0	11	506
12	21	87	23	.50	91	27	29	.0	310	122	2.0	10	411
22	Sept. 2	100	14	.16	87	23	23	.0	250	98	3.0	9.0	364
Sept. 3	14	39	18	.12	108	36	35	.0	318	178	2.4	10	508
16	27	43	17	1.4	96	36	33	.0	285	189	1.1	13	471
28	Oct. 8	64	20	.28	110	32	29	.0	260	190	2.7	11	504
Oct. 9	18	86	18	.35	81	22	29	.0	222	95	3.2	15	352
19	28	66	19	.13	94	26	26	.0	250	126	2.0	10	416
30	Nov. 8	70	20	.16	91	24	24	.0	256	106	2.3	12	389
Nov. 9	20	41	19	.26	118	34	28	.0	350	222	1.1	14	563
21	Dec. 3	32	20	.12	100	30	33	.0	360	167	1.0	13	452
Mean		135	21	.90	102	24	28	.0	312	131	3.0	11	445

[a] Abnormal; computed as HCO_3 in the average.

NOTE.—Analyses from Dec. 4, 1906, to Jan. 30, 1907, and from Mar. 16 to Nov. 20, 1907, by F. W. Bushong; from Feb. 1 to Mar. 15, 1907, and from Nov. 21 to Dec. 3, 1907, by Archie J. Weith.

Analyses of water from Spring River at Baxter Springs, Kans.

[Parts per million. Drainage area, 1,890 square miles. Analyses made in the chemical laboratories of the University of Kansas, E. H. S. Bailey, director.]

Date (1906–7).		Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate (CO_3).	Bicarbonate (HCO_3).	Sulphate (SO_4).	Nitrate (NO_3).	Chlorine (Cl).	Total dissolved solids.
From—	To—												
Dec. 1	Dec. 10	20	6.4	0.40	81	5.3	32	0.0	157	130	3.5	11	319
11	20	11	8.0	.50	69	5.7	24	[a] 2.4	171	80	2.9	7.6	268
21	31	10	8.0	.6	64	12	20	.0	170	88	3.9	7.2	282
Jan. 1	Jan. 10	15	18	1.2	77	16	20	.0	149	132	4.6	12	330
11	20	187	13	2.0	48	4.8	32	.0	103	88	6.0	8.0	234
21	30	72											
31	Beb. 9	16	10	1.0	57	1.5	15	.0	130	54	10	4.9	200
Feb. 10	19	9	29	.10	66	8.1	19	.0	188	60	4.9	6.9	276
20	Mar. 3	11	51	.24	65	5.2	29	.0	147	74	4.8	4.2	301
Mar. 4	13	26	65	.30	63	3.5	30	.0	147	74	4.0	6.6	325
14	24	31	7	.8	55	9.7	22	.0	149	61	4.8	6.2	235
25	Apr. 4	43	7	.8	65	1.6	25	.0	154	77	4.6	5.8	260
Apr. 5	15	19	3.2	3.0	68	2.1	18	.0	157	72	4.5	7.5	250
16	26	18	0.0	1.5	63	3.2	18	.0	156	72	5.0	6.5	246
27	May 6	130	7.6	4.0	56	9.8	21	.0	97	89	6.0	7.0	229
May 7	16	274	17	7.5	38	4.6	17	.0	80	43	7.5	7.0	164
17	26	88	29	1.6	49	2.0	18	.0	112	45	8.0	8.0	182
27	June 6	27	6.2	.9	64	9.5	19	.0	142	70	7.5	8.0	241
June 7	18	63	5.6	.6	66	6.6	21	.0	133	86	7.2	9.0	251
19	30	178	12	1.5	52	7.7	20	.0	98	80	7	5.5	210
July 1	July 10	110	16	1.5	50	15	17	.0	110	54	6	6.0	181
11	20	66	16	1.0	66	7.1	25	.0	138	61	6.5	6.0	215
21	Aug. 1	59	15	1.0	63	9.3	22	.0	145	62	6.0	6.5	196
Aug. 2	11	23	6.8	1.0	74	12	18	.0	163	69	5	5	240
12	22	24	6.4	2.0	87	14	31	.0	165	77	4.5	5.5	256
23	Sept. 3	36	9.0	.05	64	9.6	19	.0	140	71	4.5	6.0	232
Sept. 4	15	26	6.6	.05	72	7.9	18	.0	142	71	6.0	6.0	241
16	25	27	9.4	.02	85	7.5	22	.0	160	83	5.0	6.3	269
26	Oct. 9	32	9.4	.08	63	11	21	.0	125	92	4.0	6.8	246
Oct. 10	21	28	6.0	.06	69	8.4	20	.0	132	90	5.0	6.5	250
22	31	15	12	.18	92	11	29	.0	140	116	5.0	7.0	303
Nov. 1	Nov. 10	21	4.0	.10	70	12	21	.0	117	150	5.0	8.5	317
11	20	17	8.4	.10	77	16	43	.0	145	160	3.2	20	377
21	30	19	11	.14	68	11	22	.0	133	133	4.0	7.5	302
Mean		52	13	1.1	66	8.2	23	.0	139	84	5.3	7.3	255

[a] Abnormal; computed as HCO_3 in the average.

NOTE.—Analyses from Dec. 1, 1906, to Feb. 9, 1907, and from Mar. 14 to Nov. 30, 1907, by F. W. Bushong; from Feb. 10 to Mar. 13, 1907, by Archie J. Weith.

Additional analyses of water from the main stem of Neosho River are as follows:

Analyses of water from Neosho River, Kans.

1. At Council Grove. From Missouri Pacific Ry.
2. At Emporia. From Kennicott Water Softener Co.
3. The same. Analysis by W. A. Burton, Kansas State Board of Health.
4. At Neosho Rapids. From Atchison, Topeka & Santa Fe Ry.
5. At Burlington. From Kansas State Board of Health.
6. The same. From Atchison, Topeka & Santa Fe Ry.
7. At Leroy. From Missouri Pacific Ry.
8. At Neosho Falls. Kennicott.
9. At Iola. Kennicott.
10. At Chanute. Analysis by C. Pratt, Kansas State Board of Health.

I. Parts per million.

	1	2	3	4	5	.6	7	8	9	10
CO_3	138.0	184.0	129.9	152.0	125.0	105.0	126.0	61.0	98.0	121.2
SO_4	40.0	34.0	49.8	54.0	56.0	26.0	40.0	19.0	28.0	71.2
Cl	9.0	12.0	7.0	15.0	10.0	9.1	8.3	15.0	12.0	9.0
Ca	80.0	113.0	80.0	93.0	68.4	62.0	68.0	27.0	63.0	84.0
Mg	14.0	15.0	14.0	18.0	14.9	12.0	15.0	6.6	11.0	14.1
Na(K)	18.0	6.1	10.1	11.0	25.3	4.6	14.0	11.0	3.9	12.7
$(Al,Fe)_2O_3$	1.9	.2	2.4	1.7	4.0	1.3	5.5	1.4	2.7	8.0
SiO_2	13.4	21.0	6.2	24.0	7.8	24.0	17.6	20.0	18.0	14.4
	314.3	385.3	299.4	368.7	311.4	244.0	294.4	161.0	236.6	334.6

II. Percentage composition of dissolved solids.

	1	2	3	4	5	6	7	8	9	10
CO_3	43.91	47.76	43.38	41.23	40.15	43.03	42.79	37.89	41.42	36.22
SO_4	12.72	8.82	16.63	14.65	17.98	10.66	13.59	11.80	11.83	21.28
Cl	2.87	3.12	2.34	4.07	3.21	3.73	2.82	9.32	5.07	2.69
Ca	25.45	29.33	26.72	25.22	21.97	25.41	23.10	16.77	26.63	25.09
Mg	4.46	3.89	4.68	4.88	4.78	4.91	5.10	4.10	4.65	4.22
Na(K)	5.73	1.58	3.37	2.98	8.12	1.89	4.75	6.83	1.65	3.80
$(Al,Fe)_2O_3$	.60	.05	.80	.46	1.28	.53	1.87	.87	1.14	2.39
SiO_2	4.26	5.45	2.08	6.51	2.51	9.84	5.98	12.42	7.61	4.31
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Four additional analyses of water in the Neosho basin in Kansas are given in the next table.

Analyses of water from tributaries of Neosho River, Kans.

1. Cottonwood River at Marion. From Chicago, Rock Island & Pacific Ry.
2. Cottonwood River at Clements.
3. Cottonwood River at Strong City. Analyses 2 and 3 from Atchison, Topeka & Santa Fe Ry.
4. Coal Creek at Humboldt. From Kennicott Water Softener Co.

	Parts per million.				Percentage composition.			
	1	2	3	4	1	2	3	4
CO_3	157	77	128.0	111	35.20	27.70	34.71	38.54
SO_4	107	77	87.0	53	23.99	27.70	23.58	18.40
Cl	22	12	12.0	12	4.93	4.31	3.25	4.17
Ca	101	62	100.0	79	22.75	22.30	27.11	27.43
Mg	20	11	12.0	13	4.48	3.96	3.25	4.52
Na(K)	14	13	7.9	3	3.14	4.68	2.14	1.04
$(Al, Fe)_2O_3$	9	2	2.0	3	2.01	.72	.54	1.04
SiO_2	16	24	20.0	14	3.50	8.63	5.42	4.86
	446	278	368.9	288	100.00	100.00	100.00	100.00

Spring River below Baxter Springs is contaminated by the drainage from zinc mines and smelters and contains very notable quantities of zinc. This is shown in a series of analyses by E. H. S. Bailey [38] of waters from the river and some of its tributaries. The extreme case is that of Short Creek, in which the water contained 732 parts per million of zinc, or 19.10 per cent of the total impurity. This sort of contamination, however, is not always due to human agency. The water of a spring near Shoal Creek, another tributary of Spring River, analyzed by W. F. Hillebrand,[39] with a salinity of 540 parts per million, contained 22.31 per cent of zinc, 0.10 per cent of cadmium, and 0.04 per cent of copper in its dissolved solids. These impurities were doubtless derived from the oxidation of underground ore bodies and are therefore to be regarded as natural.

SUMMARY FOR ARKANSAS RIVER BASIN.

In the foregoing pages fourteen tables of analyses of water from the Arkansas and its tributaries have been reproduced from Water-Supply Papers 236 and 273. Four of these tables, relating to the Arkansas itself, have already been compared and discussed. The ten others of waters from tributaries of the Arkansas now follow, the averages being reduced to standard form and stated in percentages.

Reduced analyses of waters in Arkansas River basin, Kans.

1. Walnut River at Winfield. 32 composite analyses.
2. Medicine Lodge River at Kiowa. 21 composites.
3. Chikaskia River at Argonia. 20 composites.
4. Cimarron River at Englewood. 30 composites.
5. Verdigris River at Coffeyville. 31 composites.
6. Fall River at Neodesha. 22 composites.
7. Neosho River at Emporia. 35 composites.
8. Neosho River at Oswego. 27 composites.
9. Cottonwood River at Emporia. 33 composites.
10. Spring River at Baxter Springs. 34 composites.

	1	2	3	4	5	6	7	8	9	10
CO_3	34.56	11.01	41.40	11.42	39.30	39.44	39.02	33.98	32.33	24.69
SO_4	21.05	45.05	10.28	11.87	9.49	9.61	10.61	20.08	27.59	30.36
Cl	3.63	9.70	4.53	37.65	7.04	4.31	2.25	3.00	2.32	2.64
NO_3	.90	.34	.33	.13	.98	.63	1.09	.90	.63	1.92
Ca	21.78	16.14	19.30	6.43	21.75	21.88	20.60	22.05	21.48	23.85
Mg	4.36	4.36	3.63	2.57	3.37	4.64	4.05	4.64	5.05	2.96
Na(K)	7.74	10.49	11.48	26.91	10.11	9.94	7.80	8.36	5.89	8.31
Fe_2O_3	.41	.24	.58	.15	.61	.27	.81	.80	.28	.58
SiO_2	5.57	2.47	8.47	2.87	7.35	9.28	13.77	6.19	4.43	4.69
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Salinity [a]	398	1,054	307	1,323	302	285	320	305	445	255

[a] Parts per million.

These tributaries of the Arkansas show no such gradation in composition as appears in the water of the main stream. They are affected by local conditions, which the waters plainly reflect. Medicine Lodge River, for example, flows through a region rich in gypsum, and Cottonwood and Spring rivers show the same influence in less degree. Cimarron River in much of its course traverses saline plains, its water is rich in common salt, and its salinity is extremely high. In general, the eastern streams of the Arkansas basin flow in a humid region, have moderate salinity, and show all the characteristics of waters derived from areas of sedimentary rocks, with abundant limestones.

It will be noticed that nearly all the analytical data concerning the Arkansas relate to localities in Kansas. With very few exceptions analyses of waters in Arkansas and Oklahoma are lacking. Its tributaries in those States, expecially the larger

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[38] U. S. Geol. Survey Water-Supply Paper 273, p. 351, 1911.

[39] U. S. Geol. Survey Bull. 113, p. 49, 1893.

streams such as Cimarron and Canadian rivers, need to be studied before the chemistry of the Arkansas basin can be properly discussed.

RED RIVER.

Red River, the southernmost of the large tributaries of the Mississippi, joins that stream in about latitude 31°. It rises in the Staked Plain of northwestern Texas, and its drainage basin has an area of about 90,000 square miles. For Red River we have only the table of analyses by Dole and his colleagues, published in Water-Supply Paper 236.

Analyses of water from Red River near Shreveport, La.[a]

[Parts per million.]

Date (1907–8).		Turbidity.	Suspended matter.	Coefficient of fineness.	Total iron (Fe).	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total dissolved solids.	Mean gage height (feet).
From—	To—																
Mar. 19	Mar. 28	820	780	0.95	--------	40	3.6	57	11	--------	0.0	98	99	1.0	42	350	10.8
29	Apr. 7	1,050	910	.87	--------	34	3.2	38	19	--------	.0	122	67	.1	45	324	6.0
Apr. 8	17	600	555	.92	--------	31	1.2	45	--------	48	.0	134	62	.5	58	348	6.0
18	28	750	--------	--------	--------	28	3.4	38	--------	--------	.0	117	76	.4	42	318	3.9
29	May 8	900	784	.87	--------	25	3.0	39	--------	27	.0	119	71	.5	40	298	10.6
May 9	18	1,100	1,284	1.16	40	55	1.9	35	6.7	21	7.2	117	24	1.2	13	257	17.0
23	June 3	880	960	1.09	27	36	.88	36	5.8	30	2.4	110	39	1.0	26	236	18.0
June 4	13	1,160	1,589	1.37	38	57	.82	45	6.4	38	14	122	44	1.2	34	311	23.8
14	23	800	582	.73	22	28	.19	47	7.7	38	Tr.	130	52	.5	41	286	24.7
24	July 4	1,400	1,314	.94	35	25	.14	73	13	74	.0	150	128	.4	103	491	14.8
July 5	16	1,500	1,800	1.20	42	38	.56	78	15	74	9.6	74	165	Tr.	117	584	11.1
17	27	1,600	1,850	1.15	40	38	1.8	57	10	42	4.8	102	88	.5	76	377	10.8
28	Aug. 7	1,100	1,750	1.59	25	47	.52	91	19	90	8.4	165	162	.3	110	636	4.0
Aug. 8	17	290	300	1.04	5.3	30	.22	120	28	101	14	176	240	.2	132	797	2.6
19	28	300	420	1.40	13	26	.58	122	30	125	6.0	190	247	.3	188	877	1.2
29	Sept. 8	170	184	1.08	2.9	39	.24	152	39	172	8.4	278	300	Tr.	252	1,131	.2
Sept. 9	18	125	134	1.07	2.7	40	.14	140	39	148	.0	305	271	.2	216	1,035	—.5
19	28	40	80	2.00	1.3	33	Tr.	221	55	436	.0	232	561	Tr.	700	2,198	—1.2
30	Oct. 10	350	438	1.25	13	24	.10	154	47	230	Tr.	288	320	.3	339	1,311	—.4
Oct. 11	22	2,800	3,925	1.40	160	9.2	.5	97	22	134	4.8	80	217	Tr.	205	761	6.3
23	Nov. 2	1,600	1,200	.75	49	20	.14	135	32	194	Tr.	156	320	.5	292	1,087	1.0
Nov. 3	12	300	254	.85	12	20	Tr.	125	26	131	12	212	228	.2	188	851	.2
13	23	1,600	1,550	.97	100	23	.15	126	30	197	7.2	152	282	.5	292	1,057	1.3
25	Dec. 4	425	508	1.19	27	13	.52	42	8.3	40	12	85	62	Tr.	55	276	6.8
Dec. 5	15	325	263	.81	15	18	.52	50	12	52	19	51	86	Tr.	71	346	4.9
16	25	400	447	1.12	13	20	.52	49	13	58	Tr.	111	86	.2	78	357	6.8
26	Jan. 4	1,300	1,400	1.08	50	35	3.5	38	4.4	25	Tr.	112	38	.8	24	240	12.6
Jan. 5	15	425	616	1.45	21	25	1.2	42	6.3	47	.0	93	71	.5	65	315	10.8
16	25	300	377	1.26	8.4	35	1.3	31	4.3	36	4.8	83	41	.0	42	248	9.6
26	Feb. 4	200	194	.97	8.9	20	.47	46	5.6	53	Tr.	88	82	.4	82	350	6.0
Feb. 5	15	240	279	1.16	8.2	15	.6	39	6.5	43	14	61	64	Tr.	55	273	7.6
16	29	960	1,065	1.11	12	38	2.8	34	4.9	25	7.2	93	39	.5	24	234	13.0
Mar. 1	Mar. 10	240	260	1.08	7.7	28	1.5	34	5.6	31	.0	95	52	.3	35	237	9.9
11	19	800	660	.82	16	33	2.4	37	5.9	32	Tr.	98	59	.2	38	277	8.9
Mean		790	870	1.11	--------	30	1.1	74	17	90	4.6	135	140	.4	121	561	--------

[a] Analyses Mar. 19 to May 8, 1907, by James R. Evans; May 9 to Mar. 19, 1907, by R. B. Dole, Chase Palmer, and W. D. Collins.

Reduced to percentages, and with the alkalies corrected by Palmer's later determinations of potassium, the average of 34 composite analyses for Red River is as follows:

CO_3	13.01
SO_4	25.65
Cl	22.16
NO_3	.07
Ca	13.56
Mg	3.12
Na	15.74
K	.91
Fe_2O_3	.29
SiO_2	5.49
	100.00
Salinity, parts per million	561

These figures show clearly the influence of the semiarid plains on the upper waters of the river. The low calcium and carbonates and the high sodium, chlorides, and sulphates are characteristic of such regions.

GENERAL SUMMARY FOR MISSISSIPPI BASIN.

From the great mass of data relative to the composition of the river that enter the Mississippi, it is easy to select those which are most significant—namely, those which represent streams that drain into it directly—and to omit the data on tributaries of tributaries. For thirteen of the streams that may be called primary affluents of the Mississippi the following tables have been constructed in order to compare the eastern accessions with those coming from the west. The first table gives the drainage area of the several river basins, and also the annual "run-off" in terms of dissolved solids. These data are taken from Water-Supply Paper 234, as given by R. B. Dole and H. Stabler.

Drainage areas and run-off of 13 rivers in Mississippi basin.

River.	Drainage area (square miles).	Annual run-off (tons of solids per square mile).
Chippewa	9,750	116
Wisconsin	12,280	140
Rock	10,970	200
Illinois	27,900	218
Kaskaskia	5,880	180
Muddy	2,370	170
Ohio	214,000	190
Minnesota	16,100	88
Iowa	12,400	145
Des Moines	14,700	169
Missouri	526,000	50
Arkansas	189,000	120
Red	90,000	160

The sum of the drainage areas given in this table is 1,131,350 square miles. The total area of the Mississippi basin is 1,265,000 square miles. The thirteen tributaries, therefore, represent about nine-tenths of the total, and it is fair to assume that, at least in general character, the waters of the remaining tenth will average much like those cited in the tables.

A comparison between the eastern and western groups of waters reveals an apparent anomaly. The seven eastern tributaries occupy a drainage area of 283,150 square miles. That of the six western rivers aggregates 848,200 square miles. The western rivers, moreover, as will appear in subsequent tables, are higher in salinity than the others. The run-off, however, in the chemical sense of the term, shows reverse conditions. The aggregate run-off of the eastern streams is 1,214 tons of dissolved solids per square mile per annum; that of the western group is only 732 tons. The Missouri, for instance, drains 526,000 square miles of territory, and its average salinity is 346 parts per million. The Ohio drains only 214,000 square miles, and its salinity is 175 parts. The run-off of the Ohio is 190 tons per square mile, while that of the Missouri is only 50 tons. This extraordinary inversion of conditions is climatic in origin. The Ohio basin occupies a humid region, with abundant rainfall, whereas much of the Missouri basin is in semiarid territory. The discharge or flow of the Ohio is 270,000 second-feet; that of the Missouri is only 94,000. In other words, the Ohio carries nearly three times as much water as the Missouri and so contributes more saline matter to the Mississippi. Because of these differences in humidity the eastern waters carry 62 per cent of the dissolved solids, and the western group only 38 per cent.

In the detailed discussion below of the river basins tributary to the Mississippi, a table of analyses giving the average composition of the water of each stream has been reproduced from previous publications of the United States Geological Survey.[40] These averages reflect the climatic conditions of each basin very clearly. To some extent, obviously, the two groups of waters overlap, for the two rivers of Iowa are like those of the eastern streams. The lower courses of Missouri, Arkansas, and Red rivers are also in humid regions. These three rivers, however, derive a great part of their dissolved solids from the saline or alkaline plains east of the Rocky Mountains, and their compositon is correspondingly modified. The two following tables give the average composition of the waters of the two groups of rivers, and a weighted average for the whole group ends each table. That average is obtained, as in the case of the Ohio (p. 91), by multiplying each preceding column by its corresponding run-off in tons of dissolved solids per square mile per annum, adding the products together, and dividing the sum by the aggregate run-off.

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[40] Water-Supply Paper 236, 239, and 273.

Average composition of tributaries of the Mississippi.

I. Eastern tributaries.

1. Chippewa River at Eau Claire, Wis.
2. Wisconsin River at Portage, Wis.
3. Rock River at Sterling, Ill.
4. Illinois River at Kampsville, Ill.
5. Kaskaska River at Carlyle, Ill.
6. Muddy River at Murphysboro, Ill.
7. Ohio River. Computed average. (See p. 91.)
8. Weighted mean of columns 1 to 7.

	1	2	3	4	5	6	7	8
CO_3	30. 49	31. 43	48. 56	38. 42	42. 13	17. 15	30. 29	34. 83
SO_4	18. 09	18. 74	9. 34	16. 30	13. 64	34. 88	16. 97	17. 91
Cl	1. 42	2. 31	2. 06	5. 82	2. 77	6. 30	7. 17	4. 21
NO_3	. 78	. 99	1. 42	1. 67	1. 92	. 97	1. 64	1. 40
Ca	16. 80	15. 44	18. 30	18. 24	18. 86	12. 11	18. 25	17. 04
Mg	6. 07	7. 50	10. 09	7. 76	8. 02	5. 82	4. 70	6. 97
Na+K	10. 46	8. 93	4. 48	6. 98	5. 62	9. 69	8. 10	7. 47
Fe_2O_3	. 39	. 33	. 15	. 16	. 20	1. 45	. 43	. 44
SiO_2	15. 50	14. 33	5. 60	4. 65	6. 84	11. 63	12. 45	9. 73
	100. 00	100. 00	100. 00	100. 00	100. 00	100. 00	100. 00	100. 00
Salinity [a]	90	98	267	267	248	206	175	193

II. Western tributaries.

1. Minnesota River at Shakopee, Minn.
2. Iowa River at Iowa City, Iowa.
3. Des Moines River at Keosauqua, Iowa.
4. Missouri River at Ruegg, Mo.
5. Arkansas River at Little Rock, Ark.
6. Red River at Shreveport, La.
7. Weighted mean of columns 1 to 6.

	1	2	3	4	5	6	7
CO_3	31. 59	42. 17	34. 96	25. 63	11. 89	13. 01	26. 02
SO_4	31. 26	14. 70	23. 37	30. 44	15. 19	25. 65	22. 65
Cl	1. 02	1. 47	1. 58	3. 52	33. 17	22. 16	12. 16
NO_3	. 43	1. 15	1. 09	. 85	. 33	. 07	. 64
Ca	17. 81	20. 00	19. 09	15. 22	8. 99	13. 56	15. 70
Mg	7. 61	6. 94	6. 91	4. 68	2. 13	3. 12	5. 08
Na+K	5. 27	5. 67	5. 59	10. 97	23. 53	16. 65	11. 50
Fe_2O_3	. 02	. 14	. 17	. 20	. 20	. 29	. 17
SiO_2	4. 99	7. 76	7. 24	8. 49	4. 87	5. 49	6. 08
	100. 00	100. 00	100. 00	100. 00	100. 00	100. 00	100. 00
Salinity [a]	460	247	312	346	630	561	436

[a] Parts per million.

A comparison of the two averages that end the foregoing tables shows very clearly the difference between the eastern and western drainage of the Mississippi basin. In the eastern waters carbonates predominate over sulphates and chlorides, and the alkalies are relatively low. In the western group this condition is reversed. The two groups, however, can not be so combined as to show the composition of the Mississippi as a whole. The reason for this statement is obvious. Many minor tributaries are as yet unstudied, and their tendency is all in one direction. On the east side of the Mississippi, for example, there are St. Croix, Big Black, and Yazoo rivers, with many smaller streams for which no analyses have been found. On the west side, in Iowa, Missouri, Arkansas, and Louisiana, there are also many minor streams and the same lack of data. All these waters flow through fertile regions, mainly agricultural, and are unaffected by the peculiarities of the western plains. They are of the eastern type, and the analyses of the Mississippi itself (pp. 50–54) show that their influence can not be left out of account.

RED RIVER.

Red River, formerly known as Red River of the North, is formed by the union of two branches, Ottertail River, which flows from a small lake in Minnesota, and Bois des Sioux River, the outlet of Lake Traverse, on the boundary line between Minnesota and North Dakota. The two streams unite at Breckenridge, Minn., and from that point Red River flows northward and enters Lake Winnipeg in Canada.[41] Its drainage area in the United States is about 50,000 square miles. Lake Winnipeg belongs to the Saskatchewan River system, which drains into Hudson Bay. The analyses given in the following pages are, with three exceptions, taken from Water-Supply Paper 193, by R. B. Dole and F. F. Wesbrook. They are arranged here in order going downstream from the headwaters of Red River.

Analyses of water from Red River basin.

1. Lake at Graceville, Minn. From Chicago, Milwaukee & St. Paul Ry.
2. Ottertail River at Fergus Falls, Minn. From Kennicott Water Softener Co
3. The same. Analysis by W. A. Noyes, Minnesota Geol. Nat. Hist. Survey, Eleventh Ann. Rept., p. 173, 1882.
4. Ottertail River at Wahpeton, N. Dak. Kennicott.
5. Red River at Fargo, N. Dak. From Chicago, Milwaukee & St. Paul Ry.
6. The same. Kennicott.
7. Red River at Drayton, N. Dak. Kennicott.
8. Red River at St. Vincent, Minn. Analysis by Noyes, op. cit., p. 172.

I. Parts per million.

	1	2	3	4	5	6	7	8
CO_3	185.8	118.1	116.2	113	175.0	158.0	108	117.0
SO_4	185.6	5.0	3.1	14	29.1	26.0	26	44.6
Cl	9.0	6.0	1.4	6	2.8	6.1	18	13.8
NO_3								.8
PO_4								.5
Ca	58.0	35.0	40.0	34	82.0	67.0	56	50.0
Mg	59.0	23.0	20.0	25	18.0	37.0	20	23.3
Na	58.6	1.9	4.0	11	22.0	1.9	11	16.0
K			2.4					3.9
Li								.1
(Al, Fe)$_2$O$_3$	49.2	Tr.	1.2	Tr.	11.1	2.5	1	1.0
SiO_2		9.9	14.2	20		8.9	14	13.0
	605.2	198.9	202.5	223	340.0	307.4	264	284.0

II. Percentage composition of dissolved solids.

	1	2	3	4	5	6	7	8
CO_3	30.70	59.38	57.38	50.68	51.48	51.40	44.70	41.20
SO_4	30.67	2.51	1.53	6.28	8.53	8.46	9.85	15.71
Cl	1.49	3.02	.69	2.69	.83	1.98	6.82	4.89
NO_3								.28
PO_4								.19
Ca	9.58	17.60	19.76	15.22	24.12	21.80	21.21	17.55
Mg	9.75	11.56	9.88	11.21	5.29	12.04	7.58	8.23
Na	9.68	.95	1.98	4.94	6.48	.62	4.16	5.64
K			1.18					1.37
Li								.02
(Al, Fe)$_2$O$_3$	8.13	Tr.	.59	Tr.	3.27	.81	.38	.35
SiO_2		4.98	7.01	8.98		2.89	5.30	4.57
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

In the foregoing table the analysis of water from the lake at Graceville is anomalous and doubtless owes its peculiarities to local condition. The other analyses, from the Ottertail at Fergus Falls to St. Vincent, near the Canadian boundary, show a certain amount of regularity. In going downstream the proportion of carbonates steadily diminishes, while the sulphates increase. The alkalies are comparatively low, and from that fact we infer that the sulphates mainly represent the solution of gypsum. The high proportion of magnesium in some of the analyses is unusual. The following analyses relate to tributaries of Red River. Ottertail River is to be regarded as part of the main stream.

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[41] For some analyses of Canadian waters belonging to this river system see U. S. Geol. Survey Bull. 695, p. 88, 1920.

Analyses of waters tributary to Red River.

1. Wild Rice River at Wild Rice, N. Dak. From Chicago, Milwaukee & St. Paul Ry. Another river of the same name enters Red River from the east.
2. Sheyenne River at Valley City, N. Dak.
3. Sheyenne River at Lisbon, N. Dak.
4. Sheyenne River at Eastedge, N. Dak.
5. Maple River at Mapleton, N. Dak.
6. Hill Creek at Hannaford, N. Dak. Maple River and Hill Creek are tributaries of the Sheyenne.
7. Buffalo River at Stockwood, Minn.
8. Buffalo River at Winnepeg Junction, Minn.
9. Red Lake River at Crookston, Minn.
10. Red Lake River at East Grand Forks, Minn
11. Turtle River at Mekinock, N. Dak.
12. Forest River at Forest River, N. Dak.
13. Pembina River at Pembina, N. Dak.
14. Tongue River at Bathgate, N. Dak. A tributary of the Pembina. Analyses 2 to 14 from Kennicott Water Softener Co.

I. Parts per million.

	1	2	3	4	5	6	7
CO_3	203	259.0	237.0	130	390	203	192
SO_4	219	188.0	295.0	141	547	188	68
Cl	41	30.0	36.0	18	73	18	12
Ca	78	91.0	103.0	70	233	128	88
Mg	42	52.3	56.0	29	114	38	36
Na	117	105.0	124.0	43	124	37	17
K							
$(Al, Fe)_2O_3$	10	7.5	3.4	Tr.	6	Tr.	2
SiO_2		15.0	14.0	18	27	5	24
	710	747.8	868.4	449	1,514	617	439

	8	9	10	11	12	13	14
CO_3	157.0	110.9	102.9	186	208	130.0	212.0
SO_4	51.0	15.0	12.0	158	118	36.0	31.0
Cl	6.0	5.9	4.2	42	12	18.0	12.0
Ca	71.0	56.0	50.0	120	116	60.0	100.0
Mg	33.0	17.0	14.0	34	35	20.0	25.0
Na	5.4	2.3	1.3	46	25	21.0	23.0
K							
$(Al, Fe)_2O_3$	Tr.	2.5	3.9	2	16	1.5	3.4
SiO_2	12.0	4.4	3.7	28	11	7.0	29.0
	335.4	214.0	192.0	616	541	293.5	435.4

II. Percentage composition of dissolved solids.

	1	2	3	4	5	6	7
CO_3	28.59	34.63	27.29	28.95	25.76	32.91	43.74
SO_4	30.84	25.14	33.97	31.40	36.13	30.46	15.49
Cl	5.78	4.00	4.14	4.01	4.82	2.92	2.74
Ca	10.98	12.17	11.86	15.59	15.39	20.75	20.04
Mg	5.91	6.99	6.45	6.46	7.53	6.16	8.20
Na	16.48	14.04	14.28	9.58	8.19	5.99	3.87
K							
$(Al, Fe)_2O_3$	1.42	1.03	.39	Tr.	.40	Tr.	.45
SiO_2		2.00	1.62	4.01	1.78	.81	5.47
	100.00	100.00	100.00	100.00	100.00	100.00	100.00

	8	9	10	11	12	13	14
CO_3	46.80	51.82	53.59	30.19	38.45	44.29	48.70
SO_4	15.21	7.01	6.25	25.65	21.27	12.27	7.12
Cl	1.79	2.76	2.19	6.82	2.22	6.13	2.76
Ca	21.17	26.17	26.04	19.48	21.44	20.44	22.97
Mg	9.84	7.95	7.29	5.52	6.47	6.81	5.75
Na	1.61	1.07	.68	7.47	4.62	7.16	5.28
K							
$(Al, Fe)_2O_3$	Tr.	1.16	2.03	.33	2.96	.51	.75
SiO_2	3.58	2.06	1.93	4.54	2.03	2.39	6.67
	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Red Lake River and Buffalo River enter Red River from the east, and their saline matter is like that of the main stream. The other rivers belong to the western drainage and with the exception of the Pembina are very different from the eastern group. They are much higher in sulphates, which is reflected in the analyses of Red River below Fargo. The alkalies of Wild Rice and Sheyenne rivers show a similar increase in their proportion in Red River. Sodium sulphate has evidently been dissolved by the waters of the western streams.

DEVILS LAKE.

Devils Lake is an isolated, highly saline body of water in North Dakota, north of Sheyenne River. It belongs in the general area of the drainage basin of Red River. For the water of this lake, the largest in the State, there is the following analysis by H. W. Daudt. It is here reduced to standard form and percentages of total dissolved solids.

Analysis of water from Devils Lake.

CO_3	4.24
SO_4	54.07
Cl	10.45
Ca	[a] Tr.
Mg	5.36
Na	25.88
$(Al, Fe)_2O_3$	[a] Tr.
SiO_2	[a] Tr.
	100.00
Salinity, parts per million	11,278

RIVERS OF TEXAS.

The largest rivers of Texas are the Brazos, the Colorado, and the Rio Grande, and their drainage areas are respectively 48,800, 39,000, and 248,000 square miles. The basins of the Brazos and Colorado are wholly in Texas; the Rio Grande forms the boundary between Texas and Mexico. All three rivers drain into the Gulf of Mexico. For each of these streams a table of analyses giving the average composition of its waters during almost an entire year appears in Water-Supply Paper 236.

BRAZOS AND COLORADO RIVERS.

First to be considered are the Brazos and Colorado, together with some individual analyses relative to the Colorado and the streams between it and the Rio Grande.

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[a] Ca, 0.4 part per million; SiO_2, 12.2 parts; $(Al, Fe)_2O_3$, 4 parts.

Analyses of water from Brazos River near Waco, Tex.[a]

[Parts per million.]

Date (1906–7).		Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4)	Nitrate radicle (NO_3).	Chlorine (Cl).	Total dissolved solids.	Mean gage height (feet).
From—	To—													
Dec. 14	Dec. 25	675	23	Tr.	113	14	247	0.0	159	222	1.7	382	1,113	4.9
26	Jan. 5	110	15	0.5	126	20	313	.0	198	241	1.8	533	1,430	3.9
Jan. 6	15	30	12	.5	102	18	190	.0	197	181	3.5	315	952	3.8
16	25	30	12	Tr.	107	20	258	.0	182	231	1.7	392	1,128	3.6
27	Feb. 6	10	14	Tr.	129	27	373	.0	195	266	.8	575	1,513	3.6
Feb. 7	16	10	16	Tr.	103	24	265	.0	204	197	1.1	354	1,114	3.5
17	26	20	11	.05	131	30	376	.0	190	276	4.4	564	1,532	3.4
27	Mar. 10	20	12	.03	77	19	257	.0	242	222	1.7	293	1,004	3.3
Mar. 11	20	45	12	.05	86	21	193	.0	190	175	.7	283	890	3.0
21	30	40	14	.05	93	20	267	.0	196	242	Tr.	328	1,068	3.7
31	Apr. 9	30	11	.10	81	19	182	.0	166	188	Tr.	253	808	3.3
Apr. 11	21	75	15	.20	88	22	184	.0	171	216	4.2	253	892	2.8
22	May 1	20	12	.02	70	22	163	.0	163	202	1.1	228	826	2.6
May 2	11	3,100	65	.9	71	19	94	.0	149	139	3.2	124	648	4.7
13	22	6,100	60	1.1	70	7.8	82	.0	140	90	4.2	121	547	6.0
23	June 1	4,000	11	.02	60	6.3	69	.0	118	84	5.6	119	420	7.0
June 2	11	6,800	19	.15	104	13	----------	.0	127	193	4.1	----------	908	6.6
12	21	2,100	9.6	.02	131	16	182	.0	110	320	5.1	297	1,077	4.8
22	July 1	6,400	31	.5	218	26	346	.0	119	555	1.5	533	1,848	6.4
July 2	11	2,000	26	.6	105	13	155	.0	136	260	2.2	201	848	4.4
12	22	5,400	20	.07	136	23	201	.0	123	390	6.0	270	1,161	7.9
24	Aug. 2	1,650	16	.16	99	16	108	.0	127	212	2.6	133	696	4.4
Aug. 3	12	262	27	.01	149	21	215	.0	133	324	.5	295	1,186	4.0
13	22	300	26	.09	194	26	344	.0	134	494	.4	470	1,677	3.9
23	Sept. 1	10	23	.09	178	27	308	.0	147	450	.4	451	1,618	3.5
Sept. 2	10	5	18	.10	182	28	326	.0	164	451	Tr.	468	1,638	3.0
11	20	8	59	.7	150	20	300	[b] 6.2	129	377	----------	418	1,442	2.9
21	30	18	31	.26	162	15	306	[b] 3.6	140	402	----------	427	1,458	3.0
Oct. 1	Oct. 10	2,200	21	.8	118	13	181	[b] 3.6	146	247	----------	253	937	5.6
Nov. 11	Nov. 19	2,400	29	.9	206	7.8	314	[b] 6.0	98	523	----------	482	1,695	5.0
Mean -------		1,462	22	.26	121	19	234	.0	158	279	2.2	338	1,136	----------

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[a] Analyses Dec. 14, 1906, to Feb. 6, 1907, by W. M. Barr; Feb. 7 to Feb. 26, 1907, by H. S. Spaulding; Feb. 27, to Sept. 10, 1907, by Walton Van Winkle; Sept. 11 to Nov. 19, 1907, by R. B. Dole, Chase Palmer, and W. D. Collins.

[b] Abnormal; computed as HCO_3 in the average.

Analyses of water from Colorado River at Austin, Tex.[a]

[Parts per million.]

Date (1905–6.)		Silica (SiO_2).	Oxides of iron and aluminum ($Fe_2O_3+Al_2O_3$).	Calcium (Ca).	Magnesium (Mg).	Sodium (Na).	Potassium (K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Chlorine (Cl).	Total dissolved solids.	Mean gage height (feet)
From—	To—												
Aug. 1	Aug. 10	19	3.6	53	7.9	30	1.8	0.0	177	41	34	300	2.5
11	20	23	4.0	58	12	42	3.6	.0	199	52	37	322	1.4
21	30	28	1.4	53	15	45	5.3	.0	171	38	47	316	.9
31	Sept. 9	26	2.8	69	16	58	3.6	.0	220	39	44	296	.9
Sept. 10	18	27	1.4	56	14	48	7.5	.0	212	45	53	326	1.3
22	29	25	2.6	57	15	103	7.0	.0	156	110	137	498	1.7
30	Oct. 9	30	1.0	73	15	52	4.3	.0	187	60	98	432	1.4
Oct. 10	19	20	1.8	49	10	72	11	.0	175	34	32	244	1.7
20	29	27	2.0	52	10	49	8.3	.0	161	37	40	248	1.8
31	Nov. 8	21	2.4	47	9.1	----------	----------	.0	174	29	32	226	1.0
Nov. 10	19	22	1.8	54	13	----------	----------	.0	173	33	38	252	1.9
20	29	19	2.4	47	12	----------	----------	.0	173	34	41	246	1.1
30	Dec. 9	17	3.2	46	15	30	3.6	.0	197	24	49	268	1.0
Dec. 10	19	14	1.8	47	17	31	4.4	.0	201	21	44	280	1.1
20	29	15	1.2	47	19	27	1.2	.0	223	18	48	294	1.1
30	Jan. 8	10	2.0	53	20	32	4.3	.0	238	26	56	366	1.1
Jan. 9	18	8.8	4.6	54	21	34	3.8	.0	238	28	53	330	.9
19	28	9.0	2.8	49	21	34	4.0	.0	228	29	60	324	1.0
29	Feb. 7	10	3.2	48	21	38	3.5	.0	220	24	55	298	.9
Feb. 8	17	14	3.4	51	22	35	3.4	.0	219	29	48	290	1.1
18	27	12	3.6	47	22	34	3.6	.0	214	25	51	306	1.1
28	Mar. 9	9.0	1.2	48	24	35	4.0	.0	218	42	66	324	.9
Mar. 10	19	----------	1.6	48	23	19	4.0	.0	221	39	59	320	.9
20	29	8.8	1.8	49	24	----------	----------	.0	223	35	86	336	1.2
30	Apr. 8	14	2.4	52	21	39	----------	.0	239	35	56	338	1.4
Apr. 9	18	11	2.6	59	25	44	----------	.0	217	46	75	320	1.4
19	28	14	3.0	48	24	64	----------	.0	204	80	79	402	2.7
29	May 8	14	6.4	56	24	53	3.5	.0	205	89	75	426	1.4
May 9	18	18	6.8	68	24	77	4.9	.0	180	112	113	536	1.2
19	28	14	3.6	45	21	90	4.4	.0	184	102	134	550	2.6
29	June 7	19	4.8	57	8.7	51	4.3	.0	154	37	67	294	3.3
June 8	17	35	7.0	62	17	36	4.2	[b] 18	151	30	55	270	3.7
18	27	21	2.8	41	13	51	9.9	.0	166	43	57	308	1.8
28	July 7	17	4.4	40	6.8	25	8.9	.0	160	18	26	220	2.5
July 8	17	13	4.6	45	10	31	6.9	.0	177	28	52	268	4.9
18	27	21	4.4	40	6.5	11	9.2	.0	133	14	24	178	5.3
Mean --------		18	3.1	52	17	44	5.1	.0	195	42	59	321	----------

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[a] Analyses by W. H. Heileman.

[b] Abnormal; computed as HCO_3 in the average.

Reduced to percentages and with the carbonates normal, the two average analyses of water from the Brazos and the Colorado assume the form given below. The alkalies in the Brazos water are corrected by the later determinations of potassium by Palmer.

Reduced analyses of Brazos and Colorado waters.

	Brazos.	Colorado.
CO_3	7.09	28.60
SO_4	25.49	12.48
Cl	30.87	17.52
NO_3	.20	
Ca	11.06	15.45
Mg	1.74	5.14
Na	20.83	13.07
K	.67	1.50
Al_2O_3		.92
Fe_2O_3	.04	
SiO_2	2.01	5.32
	100.00	100.00
Salinity, parts per million	1,136	321

The analysis of the water of the Brazos shows clearly the influence of the semiarid plains in the northern part of Texas.

The following analyses are all reduced to standard form from data published by the Southern Pacific Co., H. Stillman, analyst.

Analyses of waters from Texas rivers.

1. Colorado River at La Grange.
2. Colorado River at Glidden.
3. Eagle Lake at Eagle Lake station, near Colorado River.
4. San Marcos River at Luling. A tributary of the Guadalupe.
5. Guadalupe River at Seguin.
6. Guadalupe River at Gonzales.
7. Medina River at Idlewiid. Basin of San Antonio River.
8. Sabinal River at Sabinal. Drains through Rio Frio into the Nueces.

I. Parts per million.

	1	2	3	4	5	6	7	8
CO_3	93.3	115.8	71.9	108.3	108.0	99.4	94.5	111.6
SO_4	29.5	34.4	56.3	30.0	25.6	27.9	58.3	7.9
Cl	47.1	34.0	225.5	32.5	19.1	24.4	11.5	7.2
NO_3			25.4					
Ca	48.6	56.8	109.7	57.0	57.5	50.7	63.0	52.6
Mg	14.0	19.1	12.6	17.6	15.8	16.8	14.6	9.0
Na(K)	33.4	28.0	87.1	19.9	10.9	15.4	7.5	4.7
$(Al, Fe)_2O_3$	1.1	2.9	6.0	2.1	1.2	2.0	2.0	2.0
SiO_2	12.0	14.0	27.9	12.0	9.9	11.9	10.9	14.0
	279.0	305.0	622.4	279.4	248.0	248.5	262.3	219.0

Analyses of waters from Texas rivers—Continued.

II. Percentage composition of dissolved solids.

	1	2	3	4	5	6	7	8
CO_3	33.44	37.97	11.55	38.76	43.55	40.00	36.03	50.96
SO_4	10.57	11.28	9.05	10.74	10.32	11.23	22.23	3.61
Cl	16.88	11.15	36.23	11.63	7.70	9.82	4.38	3.28
NO_3			4.08					
Ca	17.42	18.62	17.62	20.40	23.19	20.40	24.02	28.58
Mg	5.02	6.28	2.03	6.30	6.37	6.76	5.56	4.11
Na(K)	11.97	9.18	13.99	7.12	4.39	6.20	2.86	2.15
$(Al, Fe)_2O_3$	.40	.95	.97	.75	.48	.80	.77	.92
SiO_2	4.30	4.59	4.48	4.30	4.00	4.79	4.15	6.39
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

These analyses are too few for any elaborate discussion. Colorado River, which must not be confused with the larger river of the same name in Colorado, Utah, and Arizona, shows in its high proportion of chlorine and alkalies the influence of saline plains at its headwaters. The water of Eagle Lake is quite different from the others, and owes its peculiarities to local conditions. The other waters are such as characterize agricultural regions and draw their salinity from alluvium.

RIO GRANDE BASIN.

The Rio Grande rises in the San Juan Mountains in southwestern Colorado, traverses New Mexico, and enter the Gulf of Mexico near Brownsville, Tex., after a course of about 1,800 miles. For the composition of its water we have, first, the table given in Water-Supply Paper 236.

Analyses of water from Rio Grande at Laredo, Tex.[a]

Date (1905-6). From—	Date (1905-6). To—	Silica (SiO_2).	Oxides of iron and aluminum (Fe_2O_3+Al_2O_3).	Calcium (Ca).	Magnesium (Mg).	Sodium (Na).	Potassium (K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Chlorine (Cl).	Total dissolved solids.	Mean gage height (feet).
Aug. 1	Aug. 10	35	5.0	137	18	104	9.5	0.0	164	446	128	772	6.7
11	20	40	3.4	204	25	102	9.9	.0	159	267	143	1,090	7.1
21	30	33	3.0	117	14	118	7.2	.0	166	202	111	664	5.7
31	Sept. 9	32	3.8	98	20	96	5.2	.0	178	185	144	676	4.8
Sept. 10	20	31	2.4	104	19	65	4.9	.0	185	202	152	746	6.5
21	30	33	2.2	87	14	64	3.6	.0	165	164	77	540	6.6
Oct. 1	Oct. 10	33	2.6	67	10	51	5.2	.0	161	88	71	436	6.9
11	20	39	3.0	97	17	--------	6.5	.0	178	138	134	600	5.3
21	30	36	4.6	98	20	104	9.6	.0	195	192	134	684	4.2
31	Nov. 9	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	836	3.8
Nov. 10	19	22	2.4	110	25	--------	--------	.0	190	233	203	864	4.6
20	29	27	3.2	76	15	--------	--------	.0	153	155	139	612	5.2
30	Dec. 9	27	2.6	108	26	122	4.9	.0	176	252	182	904	4.9
Dec. 11	19	28	2.0	107	23	98	12	.0	165	243	144	812	4.7
20	29	23	2.6	87	18	72	4.7	.0	--------	191	113	612	5.4
30	Jan. 8	24	3.2	92	20	97	4.5	.0	--------	192	149	720	4.6
Jan. 9	18	26	4.4	112	31	122	5.9	.0	212	268	201	956	4.0
19	28	30	3.6	149	35	153	6.0	.0	245	298	240	1,080	3.6
29	Feb. 7	29	4.0	142	35	142	3.7	.0	185	330	241	1,112	3.5
Feb. 8	17	17	4.6	130	34	118	3.1	.0	188	322	241	1,072	4.2
18	27	23	2.6	82	19	141	11	.0	126	192	82	668	5.1
28	Mar. 9	25	1.0	83	22	103	5.4	.0	160	193	120	690	4.4
Mar. 10	19	34	1.8	104	29	143	3.9	.0	--------	254	--------	916	3.6
20	29	33	4.0	112	34	147	--------	[b] 6.3	175	294	227	1,004	3.1
30	Apr. 8	25	4.0	105	28	145	--------	.0	169	297	265	1,054	2.9
Apr. 9	18	35	4.0	107	38	190	--------	.0	166	319	304	1,040	3.2
19	28	27	3.4	103	36	162	--------	.0	159	310	292	1,072	3.0
29	May 8	26	10.2	131	38	205	8.9	.0	255	309	346	1,304	4.3
May 9	18	31	6.2	151	31	131	5.9	.0	225	368	275	1,094	4.9
19	28	22	5.8	83	27	81	5.1	.0	204	168	121	580	5.0
29	June 7	35	3.2	85	20	89	4.4	.0	170	210	154	752	5.4
June 8	17	29	7.0	89	25	86	5.7	.0	172	193	115	654	4.6
18	22	26	3.4	97	20	137	10	.0	172	236	166	782	4.2
28	July 7	19	1.6	64	18	78	8.8	.0	157	146	105	524	4.8
July 8	17	21	2.4	68	12	65	6.8	.0	171	112	103	480	7.3
18	27	35	2.4	72	11	82	7.4	[b] 13	150	116	74	466	8.4
28	Aug. 2	32	2 2	69	10	72	6.3	[b] 6.3	147	118	50	410	9.5
Mean		29	3.6	104	23	112	6.6	.0	178	228	164	791	--------

[a] Analyses by W. H. Heileman.

[b] Abnormal; computed as HCO_3 in the average.

Additional analyses of water from the Rio Grande are as follows. The averages from the preceding table are included in this.

Analyses of water from the Rio Grande.

1. Near Creede, Colo.
2. At Del Norte, Colo.
3. At Monte Vista, Colo.
4. At Alamosa, Colo.
5. At Stewart's Place, Colo.
6. At State Bridge, Colo. Analyses 1 to 6, by W. P. Headden, Colorado Agr. Exper. Sta. Bull. 230, 1917.
7. At Mesilla, N. Mex. Mean of 12 samples taken monthly between June, 1893, and June, 1894. The average composition for a year. Analyses by Arthur Goss and assistants, New Mexico Agr. Exper. Sta. Bull. 34, 1900.
8. At Laredo, Tex. The Survey table; 37 composite analyses.

I. Parts per million.

	1	2	3	4	5	6	7	8
CO_3	14.5	17.4	20.4	28.2	29.5	32.0	68.9	87.5
SO_4	6.3	8.1	8.4	13.4	16.3	19.1	125.0	228.0
Cl	.7	1.3	1.4	2.6	3.1	4.4	54.0	164.0
PO_4	.3	--------	Tr.	--------	Tr.	Tr.	--------	--------
Ca	11.4	12.1	13.8	19.7	23.4	21.4	59.0	104.0
Mg	1.8	1.8	1.9	2.9	1.5	3.6	8.2	23.0
Na	4.0	5.4	6.1	9.1	10.0	10.8	57.6	112.0
K	1.9	2.1	2.2	2.9	2.8	3.2	7.8	6.6
Mn_2O_3	.5	1.0	.1	.1	.8	.1	--------	--------
Al_2O_3	--------	.4	.2	.7	.8	.8	18.5	3.6
Fe_2O_3	.5	.6	.5	.7	.9	.8		
SiO_2	34.7	27.9	29.1	35.8	31.0	30.8		29.0
	76.6	78.1	84.1	116.1	120.1	127.0	399.0	757.7

Analyses of water from the Rio Grande—Continued.

II. Percentage composition of dissolved solids.

	1	2	3	4	5	6	7	8
CO_3	19.00	22.32	24.24	24.31	24.53	25.26	17.28	11.55
SO_4	8.19	10.37	10.00	11.52	13.57	15.06	31.33	30.10
Cl	.95	1.68	1.70	2.23	2.67	3.47	13.55	21.65
PO_4	.32	--------	Tr.	--------	Tr.	Tr.	--------	--------
Ca	14.78	15.37	16.31	16.94	19.48	16.85	14.78	13.73
Mg	2.38	2.29	2.30	2.55	1.30	2.87	2.05	3.03
Na	5.23	6.99	7.25	7.83	8.40	8.52	14.43	14.78
K	2.55	2.67	2.64	2.48	2.35	2.48	1.95	.85
Mn_2O_3	.69	1.34	.10	.10	.52	.06	--------	--------
Al_2O_3	--------	.45	.28	.63	.52	.59	4.63	.48
Fe_2O_3	.64	.80	.62	.61	.76	.56		
SiO_2	45.27	35.72	34.56	30.80	25.90	24.28		3.83
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

The foregoing table shows some remarkable regularities. The first six analyses, by Headden, cover a reach of about 100 miles and show progressive changes. At Creede the water is low in salinity and is of what might be called the mountain type. Its saline matter is derived from igneous rocks. Passing from Creede to State Bridge the river enters a broad valley and its salinity steadily increases. The proportion of silica, very high at first, diminishes regularly, while carbonates, sulphates, chlorides, and bases as regularly increase. At Mesilla, in southern New Mexico, the character of the water is completely changed, and at Laredo, Tex., the change is even greater. The effect of saline and alkaline soils and of tributaries like the Pecos is clearly apparent.

Headden's analyses as recalculated here differ from the original statements. In three of them small amounts of carbon are reported, and in five of them figures are given for loss on ignition. These unessential details have been rejected in the reduction of the analyses. Headden also regards a part of the silica as combined in the form of silicates, but that policy has not been followed in this work. The change possibly introduces a small error into the recalculation, but one so small as to be negligible. Retention of the original usage would complicate the comparison of the data.

Analyses of waters tributary to the Rio Grande.

1. Santa Fe River at Santa Fe, N. Mex.
2. Rio Bonito at Fort Stanton, N. Mex.
3. Pecos River at Carlsbad, N. Mex. Mean of five analyses.
4. Pecos River at Toyahvale, Tex. Nos. 1 to 4 by Goss and his assistants, op. cit.
5. Devils River at Devils River Station, Tex.
6. Las Moras Creek near Spofford, Tex. Analyses 5 and 6 from Southern Pacific Co.

I. Parts per million.

	1	2	3	4	5	6
CO_3	19.4	89.8	31.1	84.0	89.6	107.2
SO_4	2.1	198.6	1,206.3	1,400.9	4.9	6.2
Cl	3.1	29.4	578.4	944.1	15.5	10.2
NO_3						7.9
Ca	9.6	100.2	469.9	437.6	47.6	65.5
Mg	2.1	2.8	89.6	166.9	9.8	6.6
Na	4.0	59.2	459.3	571.0	7.6	6.8
K	2.8	6.2	19.3	35.5		
$(Al,Fe)_2O_3$	9.3	2.8	8.7	12.0	1.0	1.0
SiO_2					14.0	12.0
	52.4	489.0	2,862.6	3,652.0	190.0	223.4

II. Percentage composition of dissolved solids.

	1	2	3	4	5	6
CO_3	37.02	18.36	1.09	2.30	47.16	47.98
SO_4	4.01	40.61	42.14	38.36	2.58	2.77
Cl	5.92	6.02	20.22	25.85	8.16	4.57
NC_3						3.54
Ca	18.32	20.49	16.41	11.98	25.05	29.32
Mg	4.01	.57	3.13	4.57	5.16	2.95
Na	7.64	12.11	16.04	15.65	4.00	3.04
K	5.35	1.27	.67	.97		
$(Al,Fe)_2O_3$	17.73	.57	.30	.32	.52	.45
SiO_2					7.37	5.38
	100.0	100.00	100.0	100.00	100.00	100.00

The great salinity of the Pecos, its deficiency in carbonates, and its high proportions of chlorides, sulphates, and alkalies show that its course is largely in an arid region, with the characteristic saline soils. It is the largest tributary of the Rio Grande, and its influence upon that stream appears in the composition of the water at Laredo, which is below the mouth of the Pecos. Rio Bonito is a mountain stream, which joins the Pecos. Its water is of an intermediate character, being derived partly from igneous rocks, partly from saline plains lower in its course.

COLORADO RIVER BASIN.

Colorado River, sometimes called Colorado River of the West, to distinguish it from the Texan river of the same name, rises in the mountains of western Colorado. Its main tributary is the Green, which has its source in southern Wyoming. The drainage basin of the Colorado is estimated at about 230,000 square miles. For nearly 300 miles of its course it flows through the deep gorge known as the Grand Canyon. After traversing Arizona it enters Mexican territory and empties into the Gulf of California.

Analyses of waters in the Colorado River basin.

1. Colorado River at Yuma, Ariz., 1893.
2. The same, 1898. Analyses 1 and 2 received from Southern Pacific Co.
3. The same, average of seven composite samples covering collections made between January 10, 1900, and January 24, 1901. R. H. Forbes and W. W. Skinner, analysts. Arizona Univ. Agr. Exper. Sta. Bull. 44, 1902. The mean composition of the water for a year.
4. Animas River at Aztec, N. Mex. Enters San Juan River, an upper tributary of the Colorado. Analysis by Arthur Goss, New Mexico Agr. Exper. Sta. Bull. 34, 1900.
5. Gila River at head of Florence canal, below The Buttes, Ariz. Average of four analyses by Forbes and Skinner representing 21 weekly composite samples taken between November 28, 1899, and November 5, 1900.
6. Salt River at Mesa, Ariz. Average of 40 weekly composites of water taken between August 1, 1899, and August 4, 1900. Forbes and Skinner, analysts. Salt River and the Gila are tributaries of the Colorado. In the original statement of the analyses silica is reported as the silicate radicle SiO_3. This is reduced to SiO_2 in the table.

I. Parts per million.

	1	2	3	4	5	6
CO_3	86.9	91.8	91.4	66.8	123.7	118.5
SO_4	230.9	242.0	200.8	175.9	164.3	102.3
Cl	183.3	197.3	139.8	49.0	305.0	513.0
Ca	66.1	89.4	72.7	76.0	82.1	88.2
Mg	13.2	28.1	22.0	16.3	25.8	33.2
Na	194.4	157.4	138.6	35.5	250.9	325.5
K			15.3	6.8	23.5	17.0
Al_2O_3	39.8	7.0	--------	.0	--------	--------
Fe_2O_3			--------		--------	--------
SiO_2	18.9	--------	21.4		47.7	36.3
	833.0	813.0	702.0	426.3	1,023.0	1,234.0

II. Percentage composition of dissolved solids.

	1	2	3	4	5	6
CO_3	10.43	11.27	13.02	15.67	12.10	9.61
SO_4	27.66	29.77	28.61	41.26	16.07	8.29
Cl	22.00	24.27	19.92	11.49	29.78	41.56
Ca	7.94	10.99	10.35	17.83	8.03	7.15
Mg	1.58	3.46	3.14	3.82	2.52	2.69
Na	23.35	19.36	19.75	8.33	24.53	26.38
K			2.17	1.60	2.31	1.38
Al_2O_3	4.78	.86	--------	.0	--------	--------
Fe_2O_3			--------		--------	--------
SiO_2	2.26	--------	3.04		4.66	2.94
	100.00	100.00	100.00	100.00	100.00	100.00

The Colorado is a typical water of the kind which draws its dissolved solids from an arid region. It is therefore worth while to compare it with waters of the other two types, and these for present purposes are well represented by the St. Lawrence and the Mississippi. In the following table the three waters are compared. Each column gives in percentage form the average composition of the corresponding water for an entire year. The figures for the St. Lawrence and Mississippi have been discussed in previous sections of this memoir.

Comparative table for three typical waters.

1. St. Lawrence River at Ogdensburg, N. Y.
2. Mississippi River at New Orleans, La.
3. Colorado River of Arizona at Yuma, Ariz.

	1	2	3
CO_3	45.70	34.98	13.02
SO_4	9.15	15.37	28.61
Cl	5.87	6.21	19.92
NO_3	.23	1.60	---------
Ca	23.66	20.50	10.35
Mg	5.49	5.38	3.14
Na	4.81	8.33	19.75
K			2.17
SiO_2	5.03	7.05	3.04
Al_2O_3	---------	.45	---------
Fe_2O_3	.06	.13	---------
	100.00	100.00	100.00
Salinity, parts per million	134	166	702

The St. Lawrence is a typical river of the Temperate Zone, in which, in winter and early spring, alternations of freezing and thawing disintegrate the rocks and render them more attackable by percolating waters. There is also abundant rainfall and rich vegetation, and the water, therefore, is a carbonate water. The Colorado, on the other hand, drains an arid region, with scanty rainfall and vegetation, and such soluble decomposition products as there are accumulate in the soil. As for the Mississippi, it is an intermediate water, fed by waters from humid regions on the east and by tributaries from the semiarid plains of western Kansas and Arkansas on the west. It represents a blending of all types of river water. The transition from one extreme type to the other is very striking.

INTERIOR BASIN OF CALIFORNIA.

The interior basin of California comprises that portion of the State which lies east of the Sierra Nevada. The southern part of it is arid and includes the great Mohave Desert. North of this area there are two large alkaline lakes, which deserve first attention.

OWENS AND MONO LAKES.

First, there are two tables of analyses from Owens River, the principal feeder of Owens Lake, as given by Van Winkle and Eaton in Water-Supply Paper 237.

Analyses of water from Owens River near Round Valley, Calif.

[Parts per million unless otherwise stated.]

Date (1907-8).		Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle NO_3).	Chlorine (Cl).	Total solids.	Mean discharge.	
From—	To—													Acre-feet per day.	Cubic feet per second.
Dec. 31	Jan. 9	15	48	0.05	17	4.5	53	0.0	144	35	1.2	23	270	494.1	249.2
Jan. 10	19	10	50	.05	17	4.1	63	3.8	159	34	1.3	27	277	432.8	218.2
20	29	5	49	.05	23	5.7	58	.0	155	37	1.1	26	264	469.1	236.5
30	Feb. 8	8	53	.55	18	4.5	68	.0	155	30	.66	28	268	445.5	224.6
Feb. 9	18	5	29	.07	11	2.6	21	.0	63	21	.43	4.4	107	418.5	211
Apr. 9	Apr. 18	5	49	.15	16	5.2	56	.0	134	45	2.1	23	240	459.0	231.4
19	28	10	55	.15	13	3.8	47	.0	131	41	1.8	21	240	530.0	267.2
29	May 4	4	53	.14	16	3.0	47	.0	124	30	1.9	22	216	560.7	282.7
May 9	18	4	48	.36	17	2.1	44	.0	131	31	----------	23	216	516.7	260.5
19	28	4	44	.18	16	3.1	46	.0	126	38	2.3	20	224	553.7	279.2
29	June 7	8	43	.15	14	4.0	41	.0	115	30	1.8	18	202	581.9	293.4
June 18	27	30	33	.95	15	4.4	35	.0	94	29	2.0	14	170	619.7	312.5
28	July 7	10	28	.30	14	7.3	20	.0	68	38	.34	8.5	135	593.2	299.1
July 8	17	Tr.	30	.08	14	4.2	29	.0	85	19	2.8	15	152	608.3	306.7
18	27	6	29	.19	15	4.5	24	.0	79	23	1.6	9.5	137	526.6	265.5
28	Aug. 6	20	32	.32	16	3.1	31	.0	93	19	.4	12	151	604.3	304.7
Aug. 7	16	10	26	.28	13	3.1	15	.0	75	14	1.7	9.0	117	554.7	279.7
17	26	Tr.	25	.13	11	1.7	12	.0	59	15	----------	6.5	95	469.1	236.5
27	Sept. 5	8	36	.40	18	2.3	21	.0	84	26	.2	7.7	142	458.2	231
Sept. 6	15	10	32	.32	13	2.3	17	.0	78	18	----------	6.8	123	469.1	236.5
26	Oct. 5	10	38	.16	12	4.0	31	.0	95	29	1.1	9.9	125	393.9	198.6
Oct. 6	15	Tr.	35	.04	12	3.3	38	.0	92	38	.96	16	158	379.0	191.1
27	Nov. 14	Tr.	23	.26	12	3.0	20	.0	62	23	.50	6.0	99	373.5	188.3
Nov. 16	24	Tr.	23	.14	8.8	5.1	19	.0	73	12	1.0	2.0	116	362.8	182.9
25	Dec. 4	Tr.	53	.08	15	5.7	64	.0	161	33	.88	29	271	362.8	182.9
Dec. 5	14	Tr.	53	.04	14	8.7	66	.0	154	41	.40	28	264	368.2	185.7
15	24	Tr.	54	.06	15	10	54	.0	139	42	.42	22	236	353.0	178.0
25	31	8	45	.04	18	5.9	77	.0	164	40	.48	29	278	361.0	182.0
Mean		7	40	.20	15	4.3	40	.0	111	30	1.2	17	189	476	240

[a] Abnormal; computed as HCO_3 in the average.

Analyses of water from Owens River at Charlies Butte, near Tinemaha, Calif.

[Parts per million unless otherwise stated.]

Date (1907-8).		Turbidity.	Silica (SiO₂).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO₃).	Bicarbonate radicle (HCO₃).	Sulphate radicle (SO₄).	Nitrate radicle NO₃).	Chlorine (Cl).	Total solids.	Mean discharge.	
From—	To—													Acre-feet per day.	Cubic feet per second.
Dec. 31	Jan. 9	10	44	0.15	28	7.4	66	0.0	171	46	1.0	27	290	1,017.5	513
Jan. 0	19	20	44	.15	32	5.8	63	.0	167	49	1.4	29	288	1,035.5	522.1
:0	29	20	45	.15	33	8.6	67	.0	199	63	1.7	36	362	1,127.2	568.3
30	Feb. 8	30	43	.21	33	8.3	102	.0	233	73	1.4	49	407	1,288.4	649.6
Feb. 9	18	20	42	.12	26	8.6	95	.0	212	65	1.5	43	366	1,106.2	557.7
19	28	30	42	.17	31	8.5	87	.0	216	63	5.7	41	374	1,095.8	552.5
29	Mar. 9	18	43	.17	26	7.2	84	.0	211	50	2.5	39	344	989.2	498.7
Mar. 10	19	25	47	.33	25	5.6	84	.0	205	51	3.2	39	353	1,108.9	559.1
20	29	35	43	.15	28	6.2	77	.0	218	45	3.0	34	338	878.3	442.8
30	Apr. 8	10	48	.13	28	12	62	[a] 4.8	193	55	2.0	30	329	464.7	234.3
Apr. 19	28	Tr.	45	.04	37	18	64	.0	272	63	.75	40	412	180.7	91.1
29	May 8	5	42	1.0	41	22	79	.0	290	68	2.5	45	432	120.0	60.5
May 9	18	Tr.	43	.18	41	21	74	[a] 31	203	73	1.4	35	431	114.0	57.5
19	28	Tr.	41	.45	39	19	72	.0	266	67	2.1	40	296	115.0	58.0
29	June 7	Tr.	40	.15	38	19	70	.0	254	61	2.2	38	374	119.0	60.0
June 8	17	8	42	.13	39	20	72	.0	261	56	3.0	42	391	90.2	45.5
18	27	10	31	.18	37	14	68	.0	240	60	1.4	31	364	122.2	61.6
28	July 7	20	47	.33	32	20	79	[a] 2.4	249	53	.92	40	380	222.7	112.3
July 8	17	Tr.	41	.40	27	11	59	.0	188	41	.44	27	295	521.8	263.1
18	27	12	47	.13	32	16	55	[a] 6.0	212	45	1.1	30	331	323.8	163.3
28	Aug. (	40	43	.08	26	11	51	.0	181	46	1.8	23	293	564.3	284.5
Aug. 7	16	40	39	.30	28	8.5	49	.0	161	44	1.6	19	252	808.3	407.5
17	26	----------	47	.55	32	11	51	[a] Tr.	195	43	1.0	14	302	320.5	161.6
27	Sept. 5	8	39	.20	44	12	55	.0	210	48	2.0	27	317	213.2	107.5
Sept. 6	15	50	40	.25	33	12	73	.0	222	49	1.8	37	351	272.3	137.3
16	25	20	41	.20	30	10	56	.0	196	45	----------	29	379	398.4	209
26	Oct. 5	10	30	.04	30	10	58	.0	202	43	.54	27	307	494.1	249.1
Oct. 6	15	20	40	.05	27	7.7	62	.0	195	39	.78	25	284	507.0	255.6
16	25	25	49	.13	25	9.0	64	.0	188	52	.74	25	303	632.9	319.1
26	Nov. 4	15	41	.26	26	7.9	57	.0	171	42	.70	24	273	768.6	387.5
Nov. 5	14	20	43	.07	27	8.4	60	.0	173	41	.20	24	278	788.8	397.7
15	24	8	55	.34	28	8.8	70	.0	188	56	1.1	26	314	786.6	396.6
25	Dec. 4	14	42	.08	29	9.1	76	.0	188	69	3.3	35	334	808.3	407.5
Dec. 5	14	14	46	.36	30	11	81	.0	185	67	1.6	36	344	865.2	436.2
15	24	Tr.	45	.34	28	9.9	64	.0	189	48	3.8	30	310	748.7	377.5
25	31	10	46	.08	27	9.8	86	.0	190	79	.70	34	312	799.2	402.9
Mean........		16	43	.22	31	12	69	.0	211	54	1.7	33	339	606	306

[a] Abnormal; computed as HCO_3 in the average.

The averages of the foregoing tables, reduced to percentage form, appear in the next table together with analyses of the lake waters.

Analyses of water from Owens and Mono lakes, Calif.

1. Owens River at Round Valley; 28 composite analyses.
2. Owens River at Charlies Butte; 36 composites.
3. Owens Lake. Analysis by T. M. Chatard, U. S. Geol. Survey Bull. 60, p. 58, 1890.
4. The same. Analysis by C. H. Stone, cited by W. T. Lee in Water Supply Paper 181, p. 22, 1906. Sample taken in August, 1905.
5. The same. Analysis by W. B. Hicks in chemical laboratory of U. S. Geol. Survey.
6. The same. Analysis by J. G. Smith, U. S. Dept. Agr. Bull. 61, p. 80, 1914.
7. Mono Lake. Analysis by Chatard, op. cit., p. 53.

	1	2	3	4	5	6	7
CO_3	26.97	29.84	23.51	24.55	22.70	26.06	23.42
SO_4	14.83	15.52	9.95	9.93	9.89	7.62	12.86
Cl	8.40	9.49	25.67	24.82	25.40	25.39	23.34
NO_3	.60	.49	--------	.45	--------	Tr.	--------
PO_4	--------	--------	--------	.11	--------	.27	--------
B_4O_7	--------	--------	.48	.14	1.89	Tr.	.32
As_2O_3	--------	--------	--------	.05	--------	--------	--------
Ca	7.40	8.92	.02	.02	--------	1.47	.04
Mg	2.13	3.45	.01	.01	--------	.03	.10
Li	--------	--------	--------	.03	--------	--------	--------
Na	19.76	19.84	37.83	38.09	37.83	37.42	37.93
K			2.18	1.62	2.09	1.74	1.85
Rb, Cs	--------	--------	--------	Tr.	--------	--------	--------
Al_2O_3	--------	--------	.04	.04	--------	--------	Tr.
Fe_2O_3	.15	.09	.02		--------	--------	Tr.
SiO_2	19.76	12.36	.29	.14	.20	--------	.14
	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Salinity, parts per million	202.4	347.8	72,700	213,700	118,830	15,900	51,170
Specific gravity	--------	--------	1.062	--------	--------	--------	1.045

Early analyses of Owens Lake and Black Lake by Oscar Loew are too incomplete to be available for use here. The salinity assigned to Owens Lake in column 6 is evidently too low. The apparent error is probably due to a misprint, either a misplaced comma or a transposal of the figures 1 and 5. The variations in the salinity of the lake may be partly the result of differences between high and low water in Owens River.

The saline residue from Owens Lake is very uniform in composition, as shown in the four analyses given in the table. On evaporation the water deposits trona, $Na_2CO_3.NaHCO_3.2H_2O$. At ordinary temperatures the water contains the bicarbonate radicle, but upon ignition at a red heat the sodium bicarbonate would be reduced to the normal salt, and the anhydrous residue from the water would then have the composition shown in the analyses as stated here.

The water of Owens Lake is used commercially for the recovery of the soda, a subject which was thoroughly studied by Chatard in his classical paper upon "natural soda."[42]

For three waters south of Owens Lake the following analyses are available:

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[42] U. S. Geol. Survey Bull. 60, 1890.

Analyses of waters south of Owens Lake, Calif.

1. Haiwee Creek at Haiwee.
2. Snow Creek at Whitewater. Analyses 1 and 2 received from Southern Pacific Co.
3. Mohave River at Victorville. Analysis by Walton Van Winkle. U. S. Geol. Survey. Water-Supply Paper 237, p. 125, 1910. Reduced to normal carbonates.

	Parts per million.			Percentage composition.		
	1	2	3	1	2	3
CO_3	150	57.7	40.9	38.66	37.65	36.08
SO_4	46	24.3	7.9	11.85	15.85	6.98
Cl	42	5.3	6.0	10.83	3.46	5.29
NO_3	--------	--------	.4	--------	--------	.38
Ca	73	28.1	15.0	18.81	18.33	13.23
Mg	18	6.2	2.9	4.64	4.04	2.51
Na, K	45	15.2	15.0	11.60	9.91	13.21
Fe_2O_3	--------	--------	.3	--------	--------	.27
SiO_2	--------	--------	25.0	--------	--------	22.05
Oxides [a]	14	16.5	--------	3.61	10.76	--------
	388	153.3	113.4	100.00	100.00	100.00

[a] Silica plus sesquioxides.

SALTON SEA.

Salton Sea is a body of water of variable area, which occupies a depression at the head of Imperial Valley in California. It was originally formed by overflows from Colorado River, but these have been checked, and now Salton Sea receives additions of water only from seepage and from several small streams. Two analyses of the water are cited by Van Winkle and Eaton.[43] Reduced to percentages and with all the carbonates normal they are as follows:

Analyses of water from Salton Sea.

1. Sample taken Nov. 12, 1907. Analysis by W. Van Winkle.
2. Sample taken Feb. 28, 1908. Analysis by J. A. Bailey and A. M. McAfee.

	1	2
CO_3	2.06	2.15
SO_4	14.21	13.54
Cl	46.44	46.33
NO_3	.01	--------
Ca	2.72	3.42
Mg	1.72	1.85
Na	28.54	28.65
K	3.81	3.73
Fe_2O_3	.01	.01
Al_2O_3	--------	.23
SiO_2	.48	.09
	100.00	100.00
Salinity, parts per million	3,934	4,154

SOUTH PACIFIC SLOPE.

The rivers of the south Pacific slope are those which drain into the Pacific Ocean south of San Francisco Bay. For convenience they may be divided into three groups—first, the drainage of Monterey Bay; second, those which reach the Pacific between Monterey Bay and the Santa Monica Mountains; and third, those of the valley of southern California between Los Angeles and the Mexican boundary.

MONTEREY BAY SYSTEM.

The three principal affluents of Monterey Bay are San Lorenzo, Pajaro, and Salinas rivers. For these streams Van Winkle and Eaton[44] furnish tables giving their average composition, the Pajaro, however, being represented by its chief tributary, San Benito River. They also give similar tables for four of the principal tributaries of the Salinas and data relative to other less noteworthy streams. A few other analyses have been received from the Southern Pacific Co., and all these minor data are interpolated in their proper places between the larger and more significant tables. Beginning with the northernmost of the rivers the analyses are as follows.

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[43] U. S. Geol. Survey Water-Supply Paper 237, p. 125, 1910.

[44] All the tables of analysis by Van Winkle at Eaton are from Water-Supply Paper 237, 1910.

Analyses of water from San Lorenzo River at Big Trees, Calif.

[Parts per million.]

Date (1906).		Turbidity.	Silica (SiO_2).	Fe_2O_3+ Al_2O_3.	Calcium (Ca).	Magnesium (Mg).	Sodium (Na).	Potassium (K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Chlorine (Cl).	Total solids.
From—	To—												
Jan. 6	Jan. 10	....	33	1.0	41	11.0	61	0.5	0.0	144	37	26	230
11	20	....	29	1.8	31	6.3	16	3.8	.0	79	30	17	198
21	30	....	28	.8	31	7.1	26	1.7	.0	100	41	18	152
31	Feb. 9	....	24	.8	36	....	19	1.7	.0	118	34	22	238
Feb. 10	19	....	21	1.4	27	8.0	13	.3	.0	109	39	24	208
20	Mar. 1	....	23	2.2	32	7.5	15	3.0	.0	99	39	17	170
Mar. 2	11	....	23	3.6	33	8.4	18	5.4	.0	102	39	16	186
12	21	....	20	3.6	19	8.2	18	1.5	.0	87	39	30	216
22	31	....	20	5.8	26	6.9	13	1.8	.0	82	34	12	204
Apr. 1	Apr. 10	....	23	2.4	34	8.3	11	1.8	.0	99	36	14	202
11	20	....	21	4.4	41	10	19	3.6	.0	121	40	18	208
21	30	....	20	5.0	49	11	17	2.4	.0	156	48	22	276
May 1	May 10	....	25	3.2	54	12	22	3.6	.0	169	50	26	278
11	20	....	23	3.2	51	12	35	3.2	.0	170	47	29	288
21	31	....	26	3.8	42	12	21	2.2	.0	141	44	26	250
June 1	June 11	....	19	4.0	43	12	23	2.6	.0	142	45	25	254
11	20	....	22	4.4	47	12	29	1.9	.0	157	46	24	264
21	30	....	21	5.4	39	12	27	2.0	.0	162	47	32	260
				Fe.									
July 1	July 10	....	27	.10	48	11	16		.0	164	52	28	280
11	20	....	27	.10	56	14	27		[a] 5.5	162	58	31	280
21	31	....	25	.07	46	10	34		.0	167	53	34	286
Aug. 1	Aug. 10	....	31	.05	54	11	27		[a] 7.0	154	43	35	296
11	19	....	28	.10	59	11	42		.0	176	43	35	310
21	31	....	21	.10	52	9.9	30		.0	166	40	36	274
Sept. 1	Sept. 10	....	25	.15	47	11	38		.0	167	39	36	288
11	20	....	26	.20	51	11	37		.0	164	38	38	284
21	30	....	24	.20	54	0.3	43		.0	163	37	40	288
Oct. 1	Oct. 10	....	21	.10	68	10	24		.0	189	39	41	260
11	20	....	17	.05	48	9.5	44		.0	184	44	41	288
21	31	....	20	.10	44	9.7	32		.0	182	37	40	284
Nov. 1	Nov. 10	....	20	.30	46	9.8	37		.0	174	44	40	306
11	20	5	23	.70	56	11	41		.0	182	44	41	286
21	30	5	25	.50	51	12	43		.0	186	50	41	280
Dec. 1	Dec. 10	10	19	.07	48	11	46		.0	182	52	39	310
11	19	60	16	.10	40	8.9	32		.0	128	42	28	234
21	31	40	15	.20	37	9.8	32		.0	128	46	31	262
Mean........		....	23	.18	44	10	31		.0	147	43	29	255

[a] Abnormal; computed as HCO_3 in the average.

Analyses of water from San Benito River at Hollister, Calif.

[Parts per million.]

Date (1906).		Silica (SiO_2).	Fe_2O_3 + Al_2O_3.	Calcium (Ca).	Magnesium (Mg).	Sodium (Na).	Potassium (K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Chlorine (Cl).	Total solids.
From—	To—											
Jan. 1..................	Jan. 10..................	25	1.4	65	92	234	2.0	27	356	383	184	1,136
11..................	20..................	26	1.4	58	35	80	4.7	0.0	229	140	68	516
21..................	30..................	25	3.2	92	....	126	5.4	.0	375	246	118	856
31..................	Feb. 9..................	15	3.4	62	59	165	5.4	6.5	384	270	147	950
Feb. 10..................	19..................	16	1.6	52	60	119	2.4	16	363	208	99	728
20..................	Mar. 1..................	27	3.0	38	36	44	3.0	.0	....	109	....	502
Mar. 2..................	11..................	25	3.4	54	40	58	2.4	.0	273	144	60	522
12..................	21..................	24	4.0	35	27	36	....	4.9	191	80	32	356
Apr. 1..................	Apr. 9..................	26	2.0	49	39	42	5.4	.0	271	88	40	508
11..................	17..................	23	3.8	47	53	67	3.3	5.0	322	130	59	576
May 13..................	May 20..................	26	4.0	64	58	110	5.3	2.7	331	197	96	718
21..................	30..................	28	3.0	57	62	105	3.8	8.8	318	217	98	776
31..................	June 10..................	24	3.8	53	70	91	1.8	11	362	187	76	740
June 11..................	20..................	26	5.8	53	67	90	3.6	.0	359	235	106	824
21..................	30..................	24	6.6	62	72	123	5.1	3.0	362	272	130	936
			Fe.									
Dec. 1..................	Dec. 10..................	32	.10	68	80	180		8.0	456	310	141	1,000
11..................	20..................	21	.10	84	56	122		6.0	375	212	74	706
21..................	30..................	20	.07	57	66	144		12	372	254	93	836
Mean....................................		24	.09	58	57	110		6.2	335	204	95	732

Two other analyses of water in the San Benito basin are reported by Van Winkle. With them we tabulate one analysis representing a creek that enters the Pacific at Davenport, a short distance north of Monterey Bay.

Analyses of water from San Benito River and two creeks.

1. San Benito River near Hollister.
2. Pescadero Creek, the water supply of Hollister. Analyses 1 and 2 by W. Van Winkle.
3. San Vicente Creek at Davenport. Analysis received from Southern Pacific Co.

	Parts per million.			Percentage composition.		
	1	2	3	1	2	3
CO_3	216.2	52.6	31.1	28.78	30.71	26.40
SO_4	214.0	13.0	10.8	28.48	7.59	9.17
Cl	69.0	19.0	15.8	9.18	11.10	13.42
Ca	50.0	30.0	17.2	6.66	17.52	14.60
Mg	78.0	7.6	3.6	10.38	4.44	3.06
Na(K)	107.0	21.0	15.4	14.21	12.26	13.07
Fe_2O_3	.2	.1	23.9	.05	.06	20.28
SiO_2	17.0	28.0		2.26	16.32	
	751.4	171.3	117.8	100.00	100.00	100.00

Analyses of water from Salinas River at Paso Robles, Calif.

[Parts per million.]

Date (1907-8.)		Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K)	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total solids.
From—	To—												
Dec. 31	Jan. 9	Tr.	27	0.53	83	27	37	2.4	246	99	0.5	25	415
Jan. 10	19	Tr.	24	.02	65	27	33	1.2	249	103	1.8	25	423
20	29	175	25	.50	55	20	16	.0	183	80	1.2	17	307
30	Feb. 8	50	34	.25	45	19	26	.0	168	72	.6	15	292
Feb. 9	18	65	29	.35	44	21	30	2.4	173	74	1.3	14	296
19	28	50	28	.07	53	24	29	9.6	188	87	.81	18	334
29	Mar. 9	60	26	.20	45	22	25	.0	185	83	.94	16	315
Mar. 10	19	10	30	.30	55	25	28	7.2	215	96	.88	21	352
20	29	Tr.	26	.30	57	24	33	1.2	222	97	1.5	22	380
30	Apr. 8	Tr.	27	.16	61	28	34	11	221	101	1.2	22	387
Apr. 9	18	5	25	.08	60	26	33	.0	246	106	1.0	23	388
19	28	5	25	.18	61	27	32	12	229	98	.80	23	391
29	May 8	Tr.	30	.05	60	28	32	12	229	99	1.0	24	391
May 9	18	Tr.	32	.03	61	33	35	17	222	98	.60	25	408
19	28	Tr.	30	.15	65	30	41	31	198	103	1.5	29	428
29	June 7	5	27	.05	64	28	51	9.1	255	100	.80	33	426
June 8	17	Tr.	24	.20	54	23	53	19	245	87	.62	37	427
18	27	Tr.	28	.05	63	30	66	2.6	305	97	1.2	51	466
28	July 7	Tr.	30	.19	61	29	83	4.3	312	95	.48	56	475
July 8	17	3	37	.10	65	30	79	1.2	339	116	.34	65	537
Oct. [a] 1	Oct. 5	Tr.	36	.02	57	31	88	2.4	326	103	.5	65	530
6	15	Tr.	42	.07	62	36	103	4.8	349	106	.4	63	544
16	25	Tr.	46	.04	60	32	99	6.0	344	99	.48	64	545
26	Nov. 4	Tr.	35	.05	63	32	108	3.6	353	95	.30	63	540
Nov. 5	14	5	35	.05	64	32	84	2.4	351	94	.24	62	544
15	24	6	33	.04	65	32	90	.0	354	98	.18	60	537
25	Dec. 4	5	29	.08	64	34	93	.0	354	111	.18	60	555
Dec. 5	14	Tr.	33	.12	66	32	89	4.8	332	106	.40	56	615
15	24	Tr.	35	.06	65	31	92	.0	354	104	.40	57	540
24	31	35	36	.08	63	36	126	.0	400	110	.18	64	648
Mean		16	31	.15	60	28	59	5.6	272	97	.74	39	448

[a] River dry July 18 to Oct. 1.

Two additional analyses of water from Salinas River are reported by Van Winkle, and two more have been received from the Southern Pacific Co. The figures, reduced to standard form, are as follows.

Analyses of water from Salinas River, Calif.

1. At Templeton.
2. At Kings City. Analyses 1 and 2 from Southern Pacific Co.
3. Above Salinas City, Aug. 28, 1908.
4. The same, Apr. 6, 1908. Analyses 3 and 4 by Van Winkle.

	Parts per million.				Percentage composition.			
	1	2	3	4	1	2	3	4
CO_3	112.6	76.0	131.0	110.0	31.02	30.53	19.20	22.61
SO_4	97.5	55.9	253.0	150.0	26.86	22.45	37.08	30.83
Cl	19.9	19.9	80.0	49.0	5.48	8.00	11.73	10.08
NO_3			1.0	1.3			.15	.27
Ca	63.5	39.9	72.0	66.0	17.49	16.03	10.55	13.57
Mg	25.0	15.5	50.0	31.0	6.89	6.22	7.32	6.37
Na, K	24.5	21.9	70.0	51.0	6.75	8.80	10.26	10.48
Fe_2O_3			.3	.2			.04	.03
(Al, Fe_2) O_3	2.0	2.0			.55	.80		
SiO_2	18.0	17.9	25.0	28.0	4.96	7.17	3.67	5.76
	363.0	249.0	682.3	486.5	100.00	100.00	100.00	100.00

The four following tables relate to tributaries of Salinas River:

Analyses of water from Estrella River near San Miguel, Calif.

[Parts per million.]

Date (1907-8).		Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total solids.
From—	To—												
Dec. 31	Jan. 9	30	35	0.08	86	49	221	4.8	278	336	0.4	185	1,094
Jan. 10	19	50	20	.30	80	47	202	4.8	273	345	.44	180	1,084
20	29	1,800	38	.30	94	47	155	0	232	299	2.0	145	926
30	Feb. 8	950	28	.12	95	35	173	0	212	350	.26	146	955
Feb. 9	18	1,200	24	.28	90	36	147	0	206	304	1.3	112	925
19	28	550	28	.08	90	48	189	0	240	394	1.0	160	1,039
29	Mar. 9	750	26	.22	90	40	150	0	292	341	4.0	121	889
Mar. 10	19	85	31	.32	86	47	195	5.0	266	391	.80	157	1,060
20	29	5.	33	.05	86	49	208	14.0	264	403	.92	171	1,117
30	Apr. 8	5	37	.15	86	54	212	19	257	408	.95	185	1,140
Apr. 9	18	5	31	.05	80	55	216	17	254	408	.65	193	1,167
19	28	20	33	.33	80	55	219	17	261	408	.90	195	1,162
29	May 8	Tr.	29	.08	79	56	223	17	261	393	.65	199	1,176
May 9	18	Tr.	36	.15	77	58	229	8.4	276	422	1.4	214	1,229
19	28	Tr.	40	.35	71	60	247	16	254	444	1.5	223	1,281
29	June 7	15	26	.08	83	62	259	0	408	383	.34	216	1,233
June 8	17	10	38	.29	98	75	276	0	394	480	1.6	252	1,433
18	27	Tr.	32	.14	68	54	230	18	230	387	.80	174	1,099
28	July 7	5	52	.18	69	56	243	19	229	406	.36	206	1,149
July 8	17	Tr.	42	.15	71	54	250	20	232	418	.34	217	1,182
18	27	5	37	.45	70	60	266	22	245	427	1.4	228	1,254
28	Aug. 6	Tr.	38	.08	74	59	254	19	259	404	.44	224	1,210
Aug. 7	16	6	38	.35	64	60	298	19	243	425	1.6	252	1,345
17	26	5	34	.15	66	62	266	17	246	426	.50	234	1,243
27	Sept. 5	15	38	.28	64	59	275	19	236	417	1.1	241	1,211
Sept. 6	15	Tr.	36	.08	65	57	250	11	246	418	1.3	223	1,189
16	25	30	37	.15	73	55	235	0	289	455	.18	206	1,198
26	Oct. 5	60	39	.08	80	55	235	8.4	304	397	.02	195	1,200
Oct. 6	15	50	40	.18	76	57	218	9.6	310	371	.60	197	1,156
16	25	45	38	.11	80	54	244	7.2	327	381	.70	200	1,180
26	Nov. 4	30	34	.45	79	56	239	11	315	359	.70	192	1,119
Nov. 5	14	70	43	.12	81	53	223	9.6	310	356	.40	188	1,131
15	24	30	45	.08	75	51	218	11	292	334	.60	181	1,079
25	Dec. 4	40	31	.14	69	52	210	2.4	298	348	.92	177	1,039
Dec. 5	14	70	32	.36	78	46	211	4.8	283	336	.88	177	1,009
15	24	25	29	.13	77	44	195	0	293	324	.60	167	961
25	31	9	32	.10	80	52	216	4.8	276	334	.60	167	978
Mean		161	35	.19	79	53	224	9.6	273	385	.88	192	1,131

Analyses of water from Nacimiento River near San Miguel, Calif.

[Parts per million.]

Date (1907-8).		Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total solids.
From—	To—												
Jan. 10	Jan. 19	5	25	0.10	38	19	16	0.0	157	55	0.56	10	238
20	29	45	22	.25	30	16	18	.0	131	49	.52	7.5	194
30	Feb. 8	50	23	.18	30	13	12	.0	127	42	1.4	6.5	178
Feb. 9	18	10	24	.18	36	17	16	.0	159	63	2.0	10	235
19	28	5	22	.15	35	18	16	.0	159	53	.44	8.5	220
29	Mar. 9	4	27	.23	36	19	16	6.0	153	66	.56	9.1	249
Mar. 20	29	Tr.	20	.14	45	21	23	.0	173	73	1.6	12	266
30	Apr. 8	5	25	.18	39	19	20	.0	174	68	2.2	10	257
Apr. 10	19	5	24	.35	42	22	26	2.4	173	75	2.2	11	278
29	May 8	Tr.	19	.28	45	22	19	9.6	151	79	1.7	13	274
May 9	18	Tr.	14	.26	42	22	20	11	149	70	1.4	12	268
19	28	Tr.	17	.18	36	21	20	2.4	144	75	1.5	13	258
29	June 7	Tr.	20	.12	34	21	21	9.8	122	70	1.8	15	244
June 8	17	Tr.	26	.18	34	21	24	8.4	122	72	.20	14	251
18	27	Tr.	28	.21	40	21	22	3.6	148	73	2.0	15	278
28	July 7	5	30	.15	42	20	20	.0	168	74	2.0	16	300
July 8	17	[a]50	29	.15	52	26	28	.0	222	66	4.0	19	340
18	27	Tr.	33	.11	45	24	33	.0	290	54	2.5	23	376
28	Aug. 6	[a]325	34	.25	46	25	46	.0	244	69	2.0	20	380
Aug. 7	16	[a]450	35	.15	58	29	27	.0	218	95	40	18	383
17	26	....	43	.38	60	26	33	.0	199	102	8.0	17	403
27	Sept. 5	Tr.	16	.39	53	25	29	.0	195	97	20	16	361
Sept. 6	15	9	28	.21	44	22	23	.0	185	72	3.2	13	295
16	25	[a]60	27	.02	42	20	21	.0	171	77	2.5	14	285
26	Oct. 5	....	27	.09	42	23	21	.0	162	80	14	15	304
Oct. 6	15	Tr.	20	.03	35	17	22	.0	159	64	7.7	10	227
16	25	20	25	.53	41	21	21	.0	156	81	6.5	14	301
26	Nov. 4	8	25	.24	39	21	30	.0	154	73	2.1	15	278
Nov. 5	14	25	30	.12	37	21	28	.0	156	68	1.2	15	265
15	24	55	26	.12	39	21	25	.0	151	72	3.6	13	274
25	Dec. 4	8	27	.18	44	24	28	.0	176	81	4.0	18	313
Dec. 5	14	12	24	.06	44	25	33	.0	193	79	4.0	18	314
15	24	Tr.	20	.16	46	26	32	.0	198	82	1.2	20	327
25	31	Tr.	21	.12	43	27	34	4.8	173	83	.32	22	310
Mean		36	25	.19	42	22	24	1.7	171	72	4.4	14	286

Analyses of water from San Antonio River near Bradley, Calif.

[Parts per million.]

Date (1907-8).		Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total solids.
From—	To—												
Dec. 21	Jan. 9	5	32	0.9	56	15	21	0.0	171	85	1.5	14	314
Jan. 10	19	5	32	.04	64	16	25	.0	181	81	1.4	15	316
20	29	122	31	.03	50	13	20	.0	149	52	1.2	11	260
30	Feb. 8	50	32	.08	45	11	27	.0	146	60	.34	9.2	242
Feb. 9	18	120	31	.25	46	13	25	.0	153	61	1.7	9.8	245
19	28	8	37	.14	52	17	24	6.0	157	70	.70	12	280
29	Mar. 9	10	28	.05	42	12	19	6.0	154	62	.74	11	253
Mar. 10	19	5	32	.18	47	15	25	.0	173	69	1.2	11	278
20	29	Tr.	34	.03	48	16	22	12.0	156	77	.78	11	291
30	Apr. 8	5	30	.48	51	17	23	7.2	168	80	1.1	13	295
Apr. 9	18	5	35	.06	54	16	26	.0	189	86	2.0	17	321
19	28	Tr.	53	.09	53	17	24	7.2	166	82	1.2	14	327
29	May 8	Tr.	30	.19	53	20	23	8.4	162	82	1.9	14	310
May 9	18	5	34	.05	53	18	24	.0	185	85	2.0	15	318
19	28	Tr.	36	.12	57	18	24	3.6	184	88	1.6	17	336
29	June 7	Tr.	36	.18	67	21	21	2.4	214	108	.7	24	401
June 8	17	Tr.	41	.19	75	24	44	2.4	249	131	1.1	32	476
18	27	Tr.	41	.13	88	30	58	Tr.	298	161	.80	43	562
28	July 7	10	41	.15	120	39	87	.0	368	226	.68	63	746
July 8	17	Tr.	39	.21	108	35	78	17	320	195	1.6	56	691
18	27	5	55	.03	103	36	70	1.2	356	180	1.0	54	683
28	Aug. 6	Tr.	47	.18	55	19	32	.0	246	58	1.2	19	352
Aug. 7	16	Tr.	40	.18	55	18	38	.0	238	58	2.0	19	335
17	26	Tr.	43	.29	54	18	33	.0	242	60	1.4	19	334
27	Sept. 5	Tr.	43	.15	54	17	33	3.6	232	59	1.0	29	336
Sept. 6	15	9	43	.42	55	18	35	7.2	231	55	1.3	20	339
16	25	8	24	.05	53	17	37	.0	242	54	1.3	21	338
26	Oct. 5	Tr.	36	.13	55	19	29	8.4	231	56	.1	20	344
Oct. 6	15	5	37	.06	54	20	43	.0	257	52	1.3	21	333
16	25	Tr.	38	.18	53	19	41	.0	267	55	.62	21	349
26	Nov. 4	Tr.	35	.03	81	32	76	.0	261	154	1.1	48	575
Nov. 5	14	Tr.	35	.05	82	30	60	.0	311	142	.8	41	550
15	24	Tr.	35	.05	77	35	63	.0	297	137	0	37	502
25	Dec. 4	Tr.	41	.08	74	28	52	.0	288	117	.24	31	477
Dec. 5	14	Tr.	33	.06	66	23	43	.0	220	107	.50	26	394
15	24	Tr.	52	.08	62	22	42	.0	222	103	.34	25	392
25	31	Tr.	33	.28	66	20	43	.0	222	106	.30	27	406
Mean		10	37	.16	63	21	38	2.5	224	94	1.0	24	387

Analyses of water from Arroyo Seco at Soledad, Calif.

[Parts per million unless otherwise stated.]

Date (1906).		Turbidity.	Silica (SiO_2).	Fe_2O_3+ Al_2O_3.	Calcium (Ca).	Magnesium (Mg).	Sodium (Na).	Potassium (K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Chlorine (Cl).	Total solids.	Mean discharge.	
From—	To—													Acre-feet per day.	Cubic feet per second.
Jan. 1	Jan. 9	----------	29	4.0	53	14	29	3.1	0.0	176	70	11	304	254	128
11	20	----------	23	1.0	29	7.4	18	2.7	.0	95	40	8.8	140	2,367	1,194
21	30	----------	26	1.6	32	7.6	29	3.6	.0	111	37	7.4	158	764	385
31	Feb. 9	----------	26	1.4	25	5.4	14	1.6	.0	134	21	14	226	281	142
Feb. 10	18	----------	21	1.6	35	8.5	7.1	1.7	.0	118	40	11	156	625	315
25	Mar. 1	----------	23	2.0	35	10	7.2	2.7	.0	114	37	9.5	132	807	407
Mar. 2	10	----------	26	2.8	33	9.1	12	1.7	.0	111	38	14	176	1,186	598
12	21	----------	18	2.8	28	7.5	8.0	1.3	.0	93	32	15	178	3,764	1,898
Apr. 1	Apr. 10	----------	19	4.2	35	8.4	16	3.1	.0	107	17	11	180	1,850	933
11	20	----------	25	4.6	40	11	13	2.4	.0	126	43	7.8	200	823	415
21	27	----------	30	2.0	42	11	15	1.7	.0	134	51	9.8	234	676	341
May 4	May 10	----------	27	4.0	48	12	16	2.4	.0	154	62	12	238	419	211
11	20	----------	28	2.0	51	13	21	2.2	.0	155	59	11	254	355	179
21	31	----------	20	3.2	40	13	12	1.9	.0	131	52	12	230	1,024	516
June 1	June 10	----------	26	5.0	41	11	20	2.2	.0	137	46	9.0	246	510	257
11	20	----------	32	3.6	53	14	18	1.8	.0	154	60	12	262	319	161
21	30	----------	27	5.6	51	19	26	4.6	.0	161	65	14	264	230	116
				Fe.											
July 1	July 10	----------	22	.7	45	16	25		.0	158	68	13	276	380	192
11	20	----------	25	.10	72	15	26		.0	184	75	13	320	910	459
21	31	----------	24	.10	59	16	31		.0	193	87	16	320	649	327
Aug. 1	Aug. 10	----------	34	.13	65	17	48		.0	207	102	14	270	48	24
11	20	----------	33	.10	75	18	49		.0	214	104	15	384	32	16
21	31	----------	29	.15	61	18	40		.0	211	105	11	370	24.6	12.3
Sept. 1	Sept. 10	----------	29	.20	63	19	24		.0	217	110	17	402	2.58	1.3
11	20	----------	29	.10	71	19	50		^{a}5.0	210	114	19	414	8.93	4.5
21	30	----------	28	.10	74	19	48		.0	255	120	11	408	40.7	20.5
Oct. 1	Oct. 10	----------	30	.10	66	20	54		.0	244	127	19	440	21.2	10.7
11	20	----------	27	.05	68	19	48		.0	258	117	20	424	24.8	12.5
21	31	0	23	.15	68	20	52		.0	258	119	18	420	36.7	18.5
Nov. 11	Nov. 20	2	28	.7	61	17	42		.0	238	107	16	386	47.6	24.0
21	30	2	26	.15	68	18	40		.0	238	107	18	362	63.5	32.0
Dec. 1	Dec. 10	2	24	.10	66	18	43		.0	225	103	18	366	77.5	39.0
11	20	10	18	.30	40	9.1	32		.0	128	47	10	214	2,050	1,034
21	30	30	20	.07	32	9.4	22		.0	113	54	10	196	8,184	4,126
Mean		----------	26	.20	51	14	29		.0	170	72	13	284	849	428

[a] Abnormal; computed as HCO_3 in the average.

For six other tributaries of Salinas River there are analyses by Van Winkle. (See Water-Supply Paper 237, p. 71.) His figures, reduced to standard form, are as follows:

Analyses of water from tributaries of Salinas River, Calif.

1. Huer Huero Creek near Paso Robles, Apr. 9, 1908.
2. San Juan Creek at Shandon, Aug. 24, 1908.
3. The same, Apr. 9, 1908.
4. Cholame Creek at Shandon, Aug. 24, 1908.
5. The same, Apr. 9, 1908. Cholame and San Juan creeks unite to form Estrella River.
6. Indian Valley Creek at Douglas ranch, Aug. 25, 1908.
7. The same, Apr. 8, 1908.
8. San Lorenzo River at Matthews dam, Aug. 25, 1908.
9. The same, Apr. 7, 1908.
10. Gaviota Creek 1 mile above San Ardo, Apr. 7, 1908.

I. Parts per million.

	1	2	3	4	5	6	7	8	9	10
CO_3	152.2	61.0	106.2	98.2	159.0	215.0	139.4	145.0	165.4	92.6
SO_4	55.0	272.0	403.0	891.0	836.0	611.0	644.0	1,728.0	1,793.0	1,848.0
Cl	71.0	131.0	236.0	533.0	508.0	74.0	63.0	506.0	432.0	161.0
NO_3	1.0	1.0	.3	.7	.4	2.0	------	.8	39.0	1.0
Ca	59.0	59.0	94.0	73.0	110.0	145.0	126.0	159.0	167.0	286.0
Mg	21.0	24.0	35.0	101.0	100.0	86.0	81.0	174.0	181.0	152.0
Na	82.0	112.0	163.0	486.0	487.0	164.0	106.0	725.0	617.0	402.0
K		31.0	45.0	55.0	56.0		72.0	46.0	39.0	17.0
Fe_2O_3	.3	.2	1.5	.3	.2	.2	.3	.2	.4	.5
SiO_2	35.0	41.0	31.0	27.0	14.0	43.0	28.0	24.0	23.0	102.0
	476.5	732.2	1,115.0	2,265.2	2,270.6	1,340.2	1,259.7	2,508.0	3,456.8	3,062.1

II. Percentage composition of dissolved solids.

	1	2	3	4	5	6	7	8	9	10
CO_3	31.94	8.33	9.53	4.34	7.02	16.05	11.07	4.13	4.78	3.02
SO_4	11.54	37.15	36.14	39.33	36.82	45.59	51.12	49.26	51.87	60.35
Cl	14.90	17.89	21.17	23.53	22.37	5.52	5.00	14.42	12.50	5.25
NO_3	.21	.13	.03	.03	.02	.15	------	.03	1.12	.03
Ca	12.38	8.06	8.43	3.22	4.84	10.82	10.00	4.53	4.83	9.34
Mg	4.41	3.28	3.14	4.46	4.40	6.42	6.43	4.96	5.24	4.95
Na	17.21	15.30	14.61	21.45	21.44	12.23	8.42	20.67	17.85	13.13
K		4.23	4.04	2.43	2.47		5.72	1.31	1.12	.56
Fe_2O_3	.06	.03	.13	.02	.01	.01	.02	.01	.02	.02
SiO_2	7.35	5.60	2.78	1.19	.61	3.21	2.22	.68	.67	3.35
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

In the foregoing pages there are seven tables of analyses by Van Winkle and Eaton, giving the average composition of the waters of as many streams that empty into Monterey Bay. These averages, reduced to percentages with all the carbonates normal, appear in the next table. They are arranged in order from the south going northward.

Reduced analyses of waters entering Monterey Bay, Calif.

1. Salinas River at Paso Robles. 30 composite analyses.
2. Estrella River near San Miguel. 36 composites.
3. Nacimiento River near San Miguel. 34 composites.
4. San Antonio River near Bradley. 37 composites.
5. Arroyo Seco at Soledad. 34 composites.
6. San Benito River at Hollister. 18 composites.
7. San Lorenzo River at Big Trees. 36 composites.

	1	2	3	4	5	6	7
CO_3	30.69	12.93	29.74	28.79	28.92	23.77	28.74
SO_4	21.34	34.58	24.87	24.06	24.90	28.36	17.14
Cl	8.58	17.25	4.83	6.15	4.50	13.20	11.56
NO_3	.20	.09	1.50	.25	--------	--------	--------
Ca	13.20	7.10	14.51	16.12	17.64	8.06	17.55
Mg	6.16	4.76	7.60	5.38	4.85	7.92	4.00
Na	12.97	20.12	8.29	9.73	8.73	12.96	10.65
K					1.38	2.36	1.07
Fe_2O_3	.04	.03	.01	.05	.11	.01	.12
SiO_2	6.82	3.14	8.65	9.47	8.97	3.36	9.17
	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Salinity, parts per million	448	1,131	281	387	284	732	255

MIDDLE DIVISION.

In the middle division of the south Pacific slope there are several streams for which analytical data are available. They are Carmel River, Santa Maria River, Santa Ynez River, Ventura River, Santa Clara River, Malibu Creek, and five other creeks of minor importance. The analyses are arranged in order from north to south.

Carmel River is a relatively small stream which enters Carmel Bay, south of Monterey Bay. Its total drainage area is 275 square miles. Three analyses of its waters are available, as follows:

Analyses of water of Carmel River, Calif.

1. Two miles above its mouth, Aug. 29, 1908.
2. The same, Apr. 10, 1908. Analyses 1 and 2 by Van Winkle. See Water-Supply Paper 237, p. 89.
3. Near Pacific Grove. Analysis received from Southern Pacific Co., 1899.

	Parts per million.			Percentage composition		
	1	2	3	1	2	3
CO_3	81.5	66.0	50.4	23.53	25.87	30.09
SO_4	79.0	56.0	33.7	22.80	21.95	20.12
Cl	47.0	25.0	14.5	13.57	9.80	8.65
NO_3	.8	.4	--------	.23	.16	--------
Ca	50.0	38.0	26.3	14.43	14.90	15.70
Mg	18.0	12.0	10.1	5.20	4.71	6.03
Na,K	43.0	33.0	14.6	12.40	12.93	8.72
Fe_2O_3	.2	.7	--------	.05	.27	--------
$(Al,Fe)_2O_3$	--------	--------	1.0	--------	--------	.60
SiO_2	27.0	24.0	16.9	7.79	9.41	10.09
	346.5	255.1	167.5	100.00	100.00	100.00

For Santa Maria and Santa Ynez rivers Van Winkle and Eaton give the following tables:

Analyses of water from Santa Maria River at Santa Maria, Calif.

[Parts per million.]

Date (1906).		Turbidity.	Silica (SiO_2).	Fe_2O_3+ Al_2O_3.	Calcium (Ca).	Magnesium (Mg).	Sodium (Na).	Potassium (K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Chlorine (Cl).	Total solids.
From—	To—												
Jan. 2	Jan. 10	------	22	5.6	342	164	247	6.1	0.0	228	1,617	127	------
11	20	------	24	1.8	287	149	278	8.3	.0	200	1,492	127	2,776
21	30	------	68	5.0	314	164	------	------	.0	243	912	122	2,992
31	Feb. 9	------	20	8.6	462	162	351	12	.0	429	1,684	137	3,252
Feb. 10	19	------	18	6.6	406	152	170	6.7	.0	244	1,614	116	2,948
20	25	------	30	7.2	322	142	230	6.3	.0	248	1,458	115	2,540
Mar. 1	Mar. 8	------	20	2.8	346	162	181	7.2	.0	228	1,561	124	3,004
18	21	------	19	8.4	253	69	86	4.5	.0	190	768	54	1,516
22	31	------	18	4.6	190	60	78	4.5	[a] 9.8	224	556	48	1,200
Apr. 1	Apr. 10	------	20	3.2	206	82	83	3.5	.0	276	699	67	1,512
11	20	------	22	2.8	279	113	159	8.5	.0	269	977	87	1,926
21	28	------	20	3.0	264	124	186	7.2	.0	264	1,122	103	2,274
May 4	May 9	------	17	5.0	258	123	197	11.0	.0	253	1,110	100	2,152
10	20	------	------	5.6	273	134	181	5.6	.0	257	1,215	118	2,372
21	30	------	22	6.6	270	121	116	4.7	.0	254	1,080	87	2,126
June 1	June 10	------	26	7.0	272	131	163	5.4	.0	243	1,175	100	2,330
11	20	------	27	7.4	274	145	134	8.2	.0	232	1,335	110	2,507
21	30	------	30	6.8	348	145	136	4.6	.0	222	1,287	110	2,480
				Fe									
July 1	July 10	------	27	.10	233	125	226		[a] 4.0	212	1,123	94	2,218
11	19	------	20	.10	169	93	154		.0	301	734	84	1,564
20	31	------	24	.20	312	158	207		.0	291	1,557	127	2,910
Aug. 1	Aug. 10	------	30	.30	324	143	223		[a] 4.0	242	1,370	103	2,624
11	20	------	22	.10	321	146	192		.0	224	1,427	105	2,654
21	31	------	20	.20	359	143	225		.0	227	1,357	101	2,526
Sept. 1	Sept. 10	------	17	.10	288	136	223		.0	219	1,261	00	2,386
11	20	------	19	.20	258	122	159		[a] 5.0	226	1,068	91	2,084
21	30	------	20	.20	231	106	197		.0	290	957	81	1,878
Oct. 1	Oct. 10	------	26	.05	203	93	191		.0	320	769	75	1,638
11	20	------	24	.10	274	122	244		.0	293	1,083	97	2,178
21	31	------	22	.10	299	141	282		.0	264	1,381	121	2,592
Nov. 1	Nov. 10	5	26	.30	334	158	102		[a] 7.0	224	1,503	127	2,824
11	20	5	35	.15	330	160	290		.0	247	1,560	130	2,832
21	30	400	26	.10	374	169	300		.0	282	1,700	140	3,014
Dec. 1	Dec. 10	400	20	.02	335	154	------		.0	243	1,461	130	2,974
11	20	4,000	18	.10	456	149	264		.0	278	1,648	131	2,946
21	31	7,000	21	.02	406	128	229		.0	210	1,473	105	2,656
Mean		------	24	[b] .14	302	133	200		.0	254	1,253	105	2,412

[a] Abnormal; computed as HCO_3 in the average.

[b] Mean of Fe values after July 1.

Analyses of water from Santa Ynez River near Santa Barbara, Calif.

[Parts per million unless otheswise stated.]

Date.		Turbidity.	Silica (SiO_2).	Fe_2O_3+ Al_2O_3.	Calcium (Ca).	Magnesium (Mg).	Sodium (Na).	Potassium (K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_2).	Chlorine (Cl).	Total solids.	Mean discharge.	
From—	To—													Acre feet per day.	Cubic feet per second.
1906.	1906.														
Jan. 1	Jan. 8	------	27	1.0	80	39	45	2.6	0.0	309	224	26	686	7.58	3.8
12	20	------	23	2.0	90	40	21	3.2	.0	244	283	22	680	56.2	28.1
21	30	------	25	2.6	82	47	59	2.1	.0	289	334	27	806	30.8	15.4
31	Feb. 9	------	29	2.6	87	48	63	2.3	.0	286	312	43	776	17.4	8.7
Feb. 10	19	------	20	4.2	113	44	36	2.4	.0	255	317	33	758	111	56.1
20	28	------	21	3.6	116	49	37	3.9	.0	272	339	27	792	47.6	23.8
Mar. 2	Mar. 10	------	19	2.6	106	48	56	1.2	.0	233	309	26	754	69.2	35.1
13	20	------	18	3.6	104	40	32	3.1	.0	241	264	18	664	2,572	1,297
31	Apr. 10	------	18	2.6	121	51	53	2.9	.0	270	326	18	800	597	301
Apr. 11	20	------	24	3.2	111	53	36	2.2	.0	264	341	17	818	238	120
21	25	------	23	4.4	121	55	------	5.8	6.6	254	364	22	776	161	81.2
May 8	May 10	------	------	------	------	------	------	------	.0	273	------	22	------	83	42
11	20	------	27	5.0	122	55	69	3.5	.0	276	360	22	838	64.8	32.9
21	31	------	26	6.0	109	45	45	2.2	.0	251	302	19	736	234	118
June 1	June 10	------	24	------	111	51	73	------	.0	256	331	22	782	73.2	37.1
11	20	------	23	2.8	107	50	65	6.4	14	217	352	20	782	40	20.0
21	30	------	33	9.2	127	48	56	------	.0	217	330	24	730	28.8	14.5
				Fe.											
July 1	July 10	------	22	.10	102	45	57		5.0	259	275	21	690	17.4	8.7
11	20	------	22	.05	95	44	59		12	235	275	28	690	10.2	5.8
21	30	------	30	.07	112	43	73		.0	264	263	21	654	6.40	3.2
Aug. 1	Aug. 10	------	29	.15	98	43	69		8.0	249	254	24	664	4.16	2.1
11	16	------	26	.20	103	43	70		8.5	232	258	24	696	2.78	1.4
Sept 2	Sept. 10	------	28	.05	100	40	61		11	270	238	26	662	1.98	1
11	20	------	21	.05	88	44	72		5.5	273	254	24	646	1.98	1
21	30	------	23	.20	93	44	58		.0	290	251	27	670	1.98	1
Oct. 1	Oct. 10	5	29	.27	105	45	64		5.0	282	254	31	656	1.98	1
11	20	2	32	.10	86	51	67		.0	308	259	28	664	1.98	1
21	31	------	29	.10	92	41	74		5.5	304	290	28	664	1.98	1
Nov. 13	Nov. 20	2	25	.10	105	43	74		5.0	324	214	26	648	2.98	1.5
21	30	------	21	.07	74	43	51		.0	203	227	24	664	3.17	1.6
Dec. 3	Dec. 10	------	14	.15	61	40	51		.0	324	244	25	610	5.16	2.6
11	20	60	19	.02	114	42	62		.0	272	313	24	764	152	76.8
21	31	40	18	.05	105	35	58		.0	258	220	20	636	149	75.2
Mean		------	24	[a] .11	101	45	58		2.6	265	287	25	714	145	73

Analyses of water from Santa Ynez River near Santa Barbara, Calif.—Continued.

Date.		Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total solids.
From—	To—												
1907. Dec. 31	1908. Jan. 9	5	20	0.10	138	51	60	4.8	253	421	0.12	17	864
1908. Jan. 10	19	5	24	.08	64	57	132	4.8	268	419	.28	15	805
20	29	50	17	.15	136	45	49	4.8	244	336	Trace.	11	715
30	Feb. 8	70	23	.18	99	47	54	0	264	357	1.1	15	794
Feb. 9	18	60	29	.25	114	45	55	0	271	353	.33	12	769
29	Mar. 9	Trace.	19	.12	103	53	47	0	250	350	.90	11	764
Mean		32	22	.15	109	49	66	2.4	258	373	.46	14	785

[a] Mean of Fe values after July 1.

Two additional analyses of water from Santa Ynez River have been collected, with figures for Mono Creek, its chief tributary, and five other creeks which enter the Pacific south of the river itself. They are given in standard form in the next table.

Analyses of water from Santa Ynez River and adjacent creeks.

1. Santa Ynez River at Gibraltar, north of Santa Barbars. Analysis by J. A. Dodge. Water-Supply Paper 116, 1904.
2. Santa Ynez River near mouth of river. Received from Southern Pacific Co.
3. Mono Creek. Mean of three analyses by Dodge.
4. Jalama Creek at Jalama. Mean of two analyses.
5. Mission Creek near Santa Barbara. Analyses 4 and 5 from Southern Pacific Co.
6. The same. Analysis by Dodge.
7. Cold Spring Creek near Santa Barbara. Analysis by Dodge.
8. Creek at Gaviota. Not to be confused with Gaviota Creek, in the Salinas basin.
9. Dos Pueblos Creek at Naples. Mean of two analyses. Nos. 8 and 9 from Southern Pacific Co.

I. Parts per million.

	1	2	3	4	5	6	7	8	9
CO_3	214.5	170	188.8	230	226	113.5	144.2	142	216
SO_4	321.0	324	458.7	253	159	170.7	197.3	338	339
Cl	22.0	279	36.1	134	89	13.3	11.0	224	133
NO_3	Tr.				(?)				
Ca	151.8	104	148.8	136	102	78.9	96.4	146	161
Mg	51.6	73	54.3	75	74	20.5	33.0	47	53
Na	53.9	208	108.9	86	48	47.1	40.1	158	127
K	5.8		Tr.			Tr.	Tr.		
Li	Tr.								
Fe_2O_3	Tr.	2	3.4	33	2	Tr.	Tr.	2	1
Al_2O_3	Tr.		2.6			Tr.	Tr.		
SiO_2	Tr.	24	2.4		39	Tr.	Tr.	13	15
	822.6	1,184	1,004.0	947	739	444.0	522.0	1,070	1,045

Analyses of water from Santa Ynez River and adjacent creeks—Continued.

II. Percentage composition of dissolved solids.

	1	2	3	4	5	6	7	8	9
CO_3	26.13	14.36	18.80	24.28	30.58	25.55	27.67	13.27	2 .67
SO_4	39.10	27.37	45.68	26.72	21.52	38.45	37.89	31.59	32.44
Cl	2.69	23.62	3.60	14.15	12.04	3.01	2.10	20.94	12.73
NO_3	Tr.				(?)				
Ca	18.49	8.79	14.83	14.36	13.80	17.76	18.50	13.65	15.41
Mg	6.29	6.18	5.41	7.92	10.01	4.62	6.15	4.39	5.07
Na	6.57	17.58	10.85	9.08	6.50	10.61	7.69	14.76	12.15
K	.73		Tr.			Tr.	Tr.		
Li	Tr.								
Fe_2O_3	Tr.	.17	.34	3.49	.27	Tr.	Tr.	.20	.10
Al_2O_3	Tr.		.25			Tr.	Tr.		
SiO_2	Tr.	2.03	.24		5.28	Tr.	Tr.	1.20	1.43
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

For Ventura River there is the following table of analyses by Van Winkle and Eaton.

Analyses of water from Ventura River near Ventura, Calif.

[Parts per million; drainage area, 210 square miles.]

Date (1907-8).		Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total solids.
From—	To—												
Dec. 31	Jan. 9	5	23	0.09	132	29	49	2.4	222	268	0.56	22	620
Jan. 10	19	5	25	.10	118	32	43	1.2	226	252	.46	23	619
20	29	40	21	.16	101	27	48	.0	199	225	1.1	17	546
30	Feb. 8	35	20	.10	101	26	52	3.6	194	225	.32	9.9	522
Feb. 9	18	20	24	.08	107	27	38	4.8	195	249	1.2	12	557
19	28	7	24	.35	93	27	40	7.2	191	242	.50	13	563
29	Mar. 9	Tr.	22	.03	95	28	42	6.0	187	249	.64	14	568
Mar. 10	19	Tr.	21	.03	98	29	36	5.0	195	250	.84	16	563
20	29	Tr.	22	.08	98	29	38	9.6	198	250	6.0	16	574
30	Apr. 8	Tr.	29	.04	100	30	40	12	193	252	1.8	16	596
Apr. 9	18	Tr.	25	.07	99	28	46	.0	211	254	.90	17	582
19	28	Tr.	23	.05	101	28	43	9.6	198	259	.68	16	581
29	May 8	Tr.	14	.05	100	29	40	3.6	212	251	.75	19	600
May 9	18	Tr.	18	.43	99	29	44	7.2	198	266	.46	18	600
19	28	Tr.	21	.15	101	29	45	4.8	212	253	.34	21	598
29	June 7	Tr.	23	.05	103	30	43	.0	223	252	.10	20	606
June 8	17	Tr.	27	.30	109	28	44	Tr.	239	261	.68	19	628
18	27	Tr.	11	.13	108	27	46	9.6	226	248	.70	20	595
28	July 7	Tr.	23	.12	103	32	43	16	200	250	1.2	21	513
July 8	17	Tr.	24	.08	101	30	42	4.8	221	252	.66	20	591
18	27	Tr.	26	.08	103	30	47	4.8	223	247	1.2	20	606
28	Aug. 6	Tr.	23	.18	106	31	44	7.2	230	251	.65	21	598
Aug. 7	16	Tr.	24	.23	108	30	40	.0	246	262	.50	22	610
17	26	Tr.	28	.17	108	32	45	2.4	237	256	Tr.	22	632
27	Sept. 5	Tr.	23	.17	104	29	48	7.2	220	251	.10	20	611
Sept. 6	15	Tr.	24	.05	114	30	42	.0	255	255	.18	21	688
16	25	5	23	.15	107	28	41	6.0	244	252	.20	21	622
26	Oct. 5	5	22	.12	107	30	45	.0	262	253	.50	22	639
Oct 6	15	5	23	.12	105	31	45	2.4	254	249	.76	22	623
16	25	Tr.	25	.04	105	30	65	.0	266	250	.24	23	637
26	Nov. 4	Tr.	23	.07	109	31	58	.0	262	253	.26	23	655
Nov. 5	14	Tr.	25	.15	108	31	61	.0	244	246	----------	23	631
15	24	Tr.	28	.34	107	32	55	.0	249	252	.30	22	640
25	Dec. 4	Tr.	23	.05	111	32	56	.0	259	249	.20	25	637
Dec. 5	14	Tr.	24	.07	111	30	51	2.4	257	256	.64	24	635
15	24	Tr.	25	.28	111	31	56	.0	257	249	.40	27	651
25	31	Tr.	23	.35	112	35	74	4.8	259	263	.74	26	650
Mean		3	23	.14	106	30	47	3.9	226	251	.72	20	605

One other analysis of water from Ventura River is included in the next table with data relative to Santa Clara River. The Santa Clara enters the Pacific a short distance south of the Ventura. The three other streams cited in the table are tributaries of the Santa Clara. All these analyses were received from the Southern Pacific Co.

Analyses of water from Ventura and Santa Clara rivers, Calif.

1. Ventura River at San Buenaventura.
2. Santa Clara River at Lang. Mean of two analyses.
3. Santa Clara Creek at Lang.
4. Piru River at Piru.
5. Santa Paula Creek at Santa Paula.

I. Parts per million.

	1	2	3	4	5
CO_3	137	163	161	182	104
SO_4	246	70	205	1,101	181
Cl	30	38	31	65	21
Ca	117	75	97	212	82
Mg	30	23	24	108	21
Na, K	50	48	83	258	45
$(Al, Fe)_2O_3$	3	29	2	3	3
SiO_2	23		23	41	19
	636	446	626	1,970	476

Analyses of water from Ventura and Santa Clara rivers, Calif.—Continued.

II. Percentage composition of dissolved solids.

	1	2	3	4	5
CO_3	21,54	36.54	25.71	9.24	21.83
SO_4	38.68	15.70	32.75	55.89	38.03
Cl	4.72	8.52	4.95	3.30	4.41
Ca	18.40	16.81	15.49	10.76	17.22
Mg	4.72	5.16	3.84	5.48	4.41
Na, K	7.86	10.77	13.26	13.10	9.47
$(Al, Fe)_2O_3$	.47	6.50	.32	.15	.63
SiO_2	3.61		3.68	2.08	4.00
	100.00	100.00	100.00	100.00	100.00

One more table of analyses by Van Winkle and Eaton, that for Malibu Creek, belongs in this division of the south Pacific slope.

Analyses of water from Malibu Creek near Calabasas, Calif.

[Parts per million unless otherwise stated.]

Date (1906).		Turbidity.	Silica (SiO₂).	Fe_2O_3+ Al_2O_3.	Calcium (Ca).	Magnesium (Mg).	Sodium (Na).	Potassium (K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Chlorine (Cl).	Total solids.	Mean discharge.	
From—	To—													Acre-feet per day.	Cubic feet per second.
Jan. 1	Jan. 10	....	33	3.0	160	78	104	4.1	0.0	344	566	66	1,266	1.59	0.8
11	20	....	42	2.0	143	70	98	....	.0	327	499	58	1,140	1.86	.94
21	30	....	37	3.8	110	61	69	2.0	.0	304	367	53	930	4.64	2.34
31	Feb. 9	....	31	1.6	126	56	79	2.8	.0	289	331	69	842	1.82	.92
Feb. 10	18	....	31	2.0	66	31	34	1.7	8.1	218	138	33	448	5.10	2.57
19	Mar. 1	....	35	4.0	102	50	50	3.1	.0	287	256	42	680	4.50	2.27
Mar. 2	11	....	33	5.2	105	57	60	1.3	3.3	277	359	58	966	5.99	3.02
22	31	....	25	4.4	43	26	35	2.7	.0	199	90	27	400	11.17	5.63
Apr. 1	Apr. 10	....	34	3.8	64	38	38	1.6	.0	251	159	28	536	73.4	37
11	20	....	30	....	79	46	55	3.6	.0	256	172	27	576	37.3	18.8
21	30	....	36	5.0	82	48	53	4.7	.0	312	204	31	636	12.75	6.43
May 1	May 10	....	34	4.2	78	45	54	2.8	.0	272	200	35	604	19.8	10.0
11	20	....	32	3.8	83	46	61	5.4	.0	287	236	36	670	15.8	7.96
21	31	....	31	5.4	94	46	58	4.4	2.9	267	312	36	624	18.6	9.36
June 1	June 9	....	39	4.4	91	43	58	2.1	7.0	258	198	31	570	14.1	7.1
10	19	....	35	5.2	85	40	44	2.0	6.0	253	186	29	582	14.1	7.1
24	30	....	31	3.6	73	43	59	3.8	11	247	187	30	592	14.1	7.1
				Fe.											
July 1	July 10	....	44	.30	78	42	53		8.0	257	217	30	578	10.9	5.49
11	20	....	34	.10	72	40	44		.0	273	181	30	594	8.73	4.40
21	30	....	40	.08	198	100	195		.0	378	830	81	1,766	8.73	4.40
Aug. 1	Aug. 9	....	48	.07	95	42	65		.0	283	188	31	598	8.73	4.40
11	20	....	42	.20	86	41	48		5.0	275	191	32	584	8.73	4.40
21	31	....	34	.10	85	32	....		.0	278	184	31	592	8.73	4.40
Sept. 1	Sept. 8	....	39	.20	89	42	34		9.0	261	186	30	596	8.73	4.40
22	30	....	41	.10	123	60	106		.0	324	399	50	976	5.02	2.53
Oct. 1	Oct. 10	....	39	.05	104	45	69		.0	322	238	41	708	8.73	4.40
11	20	....	37	.10	94	43	70		.0	319	198	36	614	8.73	4.40
Nov. 11	Nov. 20	5	43	.15	117	62	131		6.0	340	400	54	960	8.73	4.40
21	30	....	40	.15	138	70	111		.0	374	462	59	1,070	8.73	4.40
Dec. 1	Dec. 10	....	30	.06	149	70	112		5.2	305	443	56	....	9.26	4.67
11	20	15	30	.05	124	62	94		.0	345	410	61	932	11	5.54
21	29	400	31	.01	104	42	76		.0	245	233	40	656	7.62	38.4
Mean		....	36	[a].11	101	50	73		2.2	288	285	42	751	47	24

[a] Mean of Fe values after July 1.

Reduced to standard form and expressed in percentages, the four tables given by Van Winkle and Eaton yield the following averages:

Reduced analyses of water in middle division of south Pacific slope.

1. Malibu Creek at Calabasas, 32 composite analyses.
2. Ventura River at Ventura. 37 composites.
3. Santa Ynez River near Santa Barbara, 39 composites.
4. Santa Maria River at Santa Maria, 36 composites.

	1	2	3	4
CO_3	19.66	19.39	19.30	5.85
SO_4	38.99	42.34	43.81	58.67
Cl	5.74	3.37	3.41	4.91
NO_3	....	.12	.07	....
Ca	13.81	17.88	14.90	14.14
Mg	6.85	5.06	6.71	6.23
Na	9.61	7.93	7.96	8.7
K	.41		.45	.34
Fe_2O_3	.01	.03	.03	.01
SiO_2	4.92	3.88	3.36	1.11
	100.00	100.00	100.00	100.00
Salinity, parts per million	731	593	685	2,136

SOUTHERN DIVISION.

In the southern division of the south Pacific slope, between Los Angeles and the Mexican boundary, the waters of six streams have been studied by Van Winkle and Eaton. The data, nearly all in the form of long series of analyses, are as follows:

Analyses of water from San Gabriel River near Azusa, Calif.

[Parts per million unless otherwise stated.]

Date (1907-8).		Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl.)	Total solids.	Mean discharge.		Run-off per square mile (cubic feet per second).
From—	To—													Acre-feet per day.	Cubic feet per second.	
Dec. 31	Jan. 9	Tr.	24	0.20	60	12	19	2.4	190	40	0.40	3.7	240	103.5	52.2	0.2351
Jan. 10	19	Tr.	21	.10	57	12	21	.0	196	41	.76	5.2	238	117.6	59.3	.2671
20	29	10	21	.15	52	11	17	.0	161	33	1.2	5.1	204	493.3	248.7	1.1203
30	Feb. 8	5	22	.05	40	8.7	21	.0	160	27	.28	4.4	190	686.6	346.2	1.5595
Feb. 9	18	Tr.	25	.10	41	12	25	2.4	159	34	.48	3.5	196	487.9	246.0	1.1080
19	28	Tr.	22	.12	44	12	14	6.0	164	29	.85	4.0	198	379.8	191.5	.8626
29	Mar. 9	Tr.	22	.08	44	11	16	.0	171	27	.38	4.0	195	377.6	190.4	.8552
Mar. 10	19	5	20	.05	42	11	19	3.6	167	27	.34	4.0	193	393.5	198.4	.8937
20	29	Tr.	18	.03	41	11	11	2.4	161	29	.78	3.1	184	463.9	233.9	1.0536
30	Apr. 8	Tr.	19	.29	43	11	13	7.2	159	32	2.0	3.1	195	278.2	190.7	.8590
Apr. 9	18	Tr.	22	.04	44	10	13	.0	175	32	1.8	3.0	200	291.9	147.2	.6630
19	28	5	19	.20	43	11	11	4.8	161	29	.40	4.0	191	279.6	141.0	.6351
29	May 8	Tr.	19	.05	42	12	9.9	13	143	29	1.0	2.6	187	314.7	158.7	.7149
May 9	18	Tr.	20	.21	44	13	16	7.2	160	38	1.2	3.0	198	249.3	125.7	.5662
19	28	Tr.	20	.08	46	12	12	7.2	163	36	1.0	2.5	192	182.9	92.2	.4153
29	June 7	Tr.	18	.17	41	11	17	4.8	167	28	.75	4.0	201	161.1	81.2	.3658
June 8	17	Tr.	18	.15	45	11	13	3.6	172	27	2.0	3.5	195	154.3	77.8	.3505
18	27	Tr.	18	.08	44	11	13	4.8	172	29	.15	3.5	196	133.1	67.1	.3022
28	July 7	5	21	.13	46	11	14	.0	171	42	1.1	3.7	211	92.2	46.5	.2095
July 8	17	5	21	.23	46	13	14	7.2	171	31	.30	14.0	206	81.5	41.1	.1851
18	27	Tr.	25	.15	43	13	18	1.2	178	29	1.3	6.0	212	73.4	37.0	.1666
28	Aug. 6	[a] 260	25	.50	44	14	15	1.2	179	32	---------	4.0	218	91.4	46.1	.2077
Aug. 7	16	90	20	.32	43	11	25	3.6	171	32	.70	3.4	202	76.6	38.6	.1739
17	26	10	24	.35	47	14	15	7.2	166	39	.76	5.5	220	63.1	31.8	.1387
27	Sept. 5	6	18	.38	45	12	24	4.8	171	33	1.0	4.8	204	56.3	28.4	.1279
Sept. 6	15	300	27	.50	40	13	13	.0	163	35	17.0	3.3	222	55.1	27.8	.1252
16	25	90	21	.18	42	13	17	6.0	168	32	Tr.	4.2	204	65.8	33.2	.1495
26	Oct. 5	40	18	.10	39	13	23	11	166	30	---------	3.7	208	67.6	31.0	.1536
Oct. 6	15	10	21	.05	40	14	20	.0	196	35	Tr.	4.0	211	61.5	34.1	.1396
16	25	5	17	.04	48	12	18	2.4	200	30	Tr.	3.0	213	73.0	36.8	.1657
26	Nov. 4	Tr.	19	.28	50	13	22	2.4	198	33	.28	5.0	228	63.7	32.1	.1446
Nov. 5	14	Tr.	18	.05	50	16	15	4.8	196	22	.12	4.5	221	64.1	32.3	.1455
15	24	Tr.	19	.14	50	16	24	.0	201	24	.10	5.0	223	65.4	33.0	.1495
25	Dec. 4	18	20	.08	47	14	27	.0	204	30	.20	3.7	223	92.4	46.6	.2099
Dec. 5	14	4	18	.08	49	14	20	.0	195	37	.50	5.5	220	102.1	51.5	.2319
15	24	Tr.	21	.11	49	13	16	.0	205	34	.44	4.2	226	80.3	40.5	.1824
25	31	Tr.	20	.08	50	14	29	.0	209	29	.28	4.7	239	78.1	39.4	.1775
Mean		23	21	.16	45	12	18	3.3	176	32	1.1	4.3	208	190.5	96	.43

[a] Cloudburst July 31. Turbidities as follows: July 31, 775; Aug. 1, 725; Aug. 2, 380; Aug. 3, 400; Aug. 4, 340; Aug. 5, 335. "River rose 4 to 6 feet July 31, 1908" (J. W. Moon).

Analyses of water from San Gabriel River near Rivera, Calif.

[Parts per million.]

Date (1907-8).		Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total solids.
From—	To—												
Dec. 31	Jan. 9	8	25	0.15	68	11	17	0.0	218	40	15	6.9	262
Jan. 10	19	5	24	.01	76	9.8	19	.0	217	34	.16	7.0	266
20	29	100	22	.11	63	8.5	19	.0	185	37	1.4	7.9	231
30	Feb. 8	20	20	.07	50	9.8	19	.0	185	31	1.2	7.2	223
Feb. 9	18	5	22	.07	58	11	24	.0	200	38	1.1	5.0	236
19	28	5	22	.08	60	11	24	.0	214	34	1.9	9.0	244
29	Mar. 9	Tr.	22	.05	58	13	21	2.4	207	33	1.8	7.4	241
Mar. 10	19	5	25	.05	52	10	23	7.2	203	28	2.1	7.5	249
20	29	Tr.	30	.05	40	13	19	.0	213	26	3.0	7.9	237
30	Apr. 8	5	24	.05	52	12	20	.0	211	36	4.0	8.5	248
Apr. 9	18	5	25	.10	53	12	19	16	186	36	1.5	6.5	253
19	28	5	24	.18	52	9.8	22	.0	215	35	2.0	6.5	247
29	May 8	Tr.	26	.03	54	13	18	.0	214	30	4.0	7.0	248
May 9	18	Tr.	26	.10	54	12	19	4.8	209	29	.84	6.5	251
19	28	Tr.	26	.18	57	12	22	.0	220	37	2.0	12	258
29	June 7	6	22	.04	55	11	23	6.0	203	33	1.8	7.7	244
June 8	17	Tr.	21	.08	54	12	18	.0	210	30	.56	8.9	238
18	27	Tr.	21	.15	54	11	18	.0	221	36	.82	15	251
28	July 7	Tr.	24	.08	53	11	18	9.6	193	29	1.6	8	240
July 8	17	Tr.	23	.00	55	10	20	7.2	200	28	.86	7.7	237
18	27	Tr.	19	.29	52	12	25	.0	212	30	1.2	7.5	243
28	Aug. 6	Tr.	23	.16	53	12	19	.0	212	30	-----------	8.5	240
Aug. 7	16	3	20	.04	54	12	23	6.0	207	30	-----------	9.0	239
17	26	Tr.	22	.19	55	12	20	7.2	203	29	1.4	8.0	245
27	Sept. 5	3	26	.12	62	13	26	9.6	201	32	1.6	17	268
Sept. 6	15	Tr.	33	.22	55	11	20	Tr.	222	29	1.2	7.5	255
16	25	Tr.	20	.07	54	12	19	.0	224	29	1.3	8.5	246
26	Oct. 5	Tr.	23	.08	52	12	18	2.4	217	30	-----------	7.5	230
Oct. 6	15	5	26	.07	55	12	23	.0	237	34	1.8	8.3	258
16	25	Tr.	25	.13	53	11	38	.0	226	40	1.5	7.5	250
26	Nov. 4	Tr.	21	.12	54	11	20	2.4	221	30	1.2	9.5	248
Nov. 5	14	6	21	.08	52	11	20	.0	222	27	.98	8.0	246
15	24	Tr.	21	.08	52	12	32	.0	217	30	.96	7.5	250
25	Dec. 4	Tr.	20	.15	50	13	24	.0	220	30	1.1	9.0	247
Dec. 5	14	Tr.	22	.34	42	12	37	.0	212	46	1.0	9.0	246
15	24	6	25	.24	54	13	27	.0	220	38	.94	8.5	253
25	31	Tr.	23	.04	53	16	35	.0	222	38	1.6	8.5	249
Mean		5	23	.11	55	12	22	2.2	211	33	1.9	8.4	246

Van Winkle's analysis of water from Rio Hondo, reduced to standard form, is as follows:

Analysis of water from Rio Hondo, Calif.

	Parts per million.	Percentages.
CO_3	115.0	42.86
SO_4	21.0	7.83
Cl	16.0	5.96
NO_3	1.2	.45
Ca	50.0	11.64
Mg	13.0	4.84
Na (K)	26.0	9.69
Fe_2O_3	.1	.04
SiO_2	26.0	9.69
	268.3	100.00

Analyses of water from Santa Ana River above Mentone, Calif.

[Parts per million unless otherwise stated.]

Date (1906).		Turbidity.	Silica (SiO_2).	Fe_2O_3+Al_2O_3.	Calcium (Ca).	Magnesium (Mg).	Sodium (Na).	Potassium (K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Chlorine (Cl).	Total solids.	Mean discharge including canal.		Mean discharge without canal.	
From—	To—													Acre-feet per day.	Cubic feet per second.	Acre-feet per day.	Cubic feet per second.
Jan. 1	Jan. 10	....	32	1.2	23	5.6	27	0.3	0.0	113	14	6.1	140	69.2	34.9	1.98	31.0
11	20	....	24	.8	31	4.4	16	2.4	.0	111	13	5.9	176	124	62.3	43.2	21.8
21	30	....	26	1.2	25	4.8	29	3.1	.0	119	16	6.9	132	88.3	44.5	11.5	5.8
31	Feb. 9	....	26	1.8	37	10	14	1.8	.0	116	51	6.9	136	69.8	35.2	1.98	1.0
Feb. 11	18	....	17	2.2	29	5.0	14	1.3	.0	112	9.9	11	156	113	57.0	1.98	1.0
20	28	....	21	2.8	25	4.8	18	1.2	.0	111	12	7.5	160	198	100	93.4	47.1
Mar. 2	Mar. 11	....	16	4.2	30	7.1	15	2.4	.0	117	15	8.8	156	124	62.4	25.8	13.0
12	19	....	13	2.4	19	4.1	9.1	1.5	.0	78	10	11	150	1,551	782	1,489	75.1
23	31	....	19	2.8	21	4.6	13	2.0	.0	82	7.4	6.9	160	1,926	971	1,846	93.1
Apr. 1	Apr. 10	....	18	4.0	33	7.2	16	3.8	.0	92	13	6.9	144	502	253	392	198
11	20	....	16	3.6	27	7.0	15	2.8	.0	96	15	5.9	124	384	194	246	124
21	30	....	14	4.4	24	6.8	13	2.4	.0	88	10	5.9	114	746	376	605	305
May 2	May 10	....	16	3.2	26	7.7	21	3.0	.0	94	10	6.2	138	530	267	388	196
11	20	....	16	1.8	20	5.2	12	1.1	.0	94	8.6	7.8	122	390	197	258	130
21	31	....	10	3.6	23	5.3	10	1.3	.0	90	11	5.9	128	544	274	423	113
June 1	June 10	....	16	3.4	23	5.7	12	2.0	.0	88	16	7.6	104	394	199	256	129
11	20	....	15	5.8	24	6.8	8.4	1.3	.0	89	12	5.9	142	329	166	190	95.8
21	30	....	....	....	....	....	....	....	....	....	....	....	....	297	150	159	80.2
				Fe.													
July 1	July 10	....	13	.10	21	6.7	14		.0	88	16	6.3	142	263	133	123	62.3
11	20	....	22	.05	19	4.7	15		[a] 3.0	89	12	8.2	132	242	122	101	50.9
21	30	....	11	.08	28	5.0	14		.0	98	12	5.8	120	210	106	68.6	34.6
Aug. 5	Aug. 10	....	19	.07	32	5.8	22		.0	112	12	7.5	150	150	75.4	9.92	5.0
12	20	....	13	.17	33	5.3	18		.0	102	13	5.8	148	181	91.7	52.0	26.2
21	31	....	22	.40	23	5.8	18		.0	112	15	4.9	146	143	72.3	5.77	2.91
Sept. 1	Sept. 10	....	10	.20	18	4.5	22		.0	70	11	22	128	127	64.2	3.77	1.9
11	20	....	18	.30	29	6.3	12		.0	98	12	5.1	122	122	61.5	3.37	1.7
21	29	....	....	....	....	....	....		....	....	....	....	854	130	65.6	19.0	9.56
Oct. 1	Oct. 10	....	13	.10	25	4.6	22		.0	113	12	7.1	130	145	72.9	20.8	10.5
11	20	....	12	.10	26	6.4	20		.0	118	12	7.6	134	143	72.2	20.8	10.5
21	31	....	11	.10	25	5.6	18		.0	116	12	6.1	138	136	69.3	4.96	2.5
Nov. 1	Nov. 10	0	13	.5	26	5.1	18		.0	118	12	6.1	136	128	64.6	4.96	2.5
11	20	....	16	.15	26	5.9	17		.0	117	22	7.1	144	117	58.8	4.96	2.5
22	30	2	14	.10	25	4.8	19		.0	104	17	7.1	134	114	57.7	4.96	2.5
Dec. 1	Dec. 10	2	10	.10	28	6.2	18		.0	118	14	6.1	130	146	73.6	14.7	7.4
11	20	20	15	.05	28	5.0	16		.0	120	12	7.1	156	323	163	192	96.8
21	31	30	13	.05	....	4.6	15		.0	86	15	5.6	120	212	107	79.3	40.0
Mean		....	16	[b] .15	26	5.7	18		.0	102	14.	7.3	158	313	160	....	....

[a] Abnormal; computed as HCO_3 in the average.

[b] Mean of Fe values after July 1.

Analyses of water from Santa Ana River above Mentone, Calif.—Continued.

Date. (1907-8)		Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).[c]	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total solids.	Mean discharge.		Run-off per square mile (cubic feet per second).
From—	To—													Acre-feet per day.	Cubic feet per second.	
Dec. 31	Jan. 9	Tr.	27	0.02	33	4.9	13	2.4	110	28	--------	3.6	150	106.9	53.9	2,960
Jan. 10	19	Tr.	22	.11	29	4.5	19	.0	111	19	1.2	3.7	148	115.8	58.4	3,208
20	29	25	25	.05	27	4.5	20	.0	99	21	.66	3.4	143	245.1	123.6	6,791
30	Feb. 8	10	23	.13	29	6.0	18	.0	106	21	.44	3.9	141	252.8	127.5	7,005
Feb. 9	18	5	20	.05	26	5.7	21	.0	109	20	.32	3.2	138	230.6	116.3	6,390
19	28	5	22	.18	29	6.4	15	Tr.	120	20	1.1	3.7	141	290.3	146.4	8,044
29	Mar. 9	Tr.	20	.15	31	6.5	16	.0	118	16	.10	3.0	141	332.6	167.7	9,214
Mar. 10	19	Tr.	24	.15	24	5.4	22	.0	118	20	.54	4.9	141	189.0	95.3	5,236
20	29	Tr.	26	.02	23	5.2	14	.0	117	18	.80	3.0	139	233.4	117.7	6,466
30	Apr. 8	5	25	.11	26	5.5	15	.0	116	24	1.0	3.5	142	234.0	118.0	6,483
Apr. 9	18	5	23	.05	25	5.3	14	.0	109	23	6.0	3.0	134	175.6	88.5	4,862
19	28	5	22	.08	25	3.9	14	.0	107	23	2.0	3.5	162	201.9	101.8	5,593
29	May 8	Tr.	25	.08	24	6.7	15	.0	104	18	1.0	3.0	130	186.6	94.1	5,170
May 9	18	5	28	.10	24	7.1	15	.0	112	16	.80	3.5	142	150.3	75.8	4,109
19	28	5	29	.12	21	4.8	14	.0	100	20	1.3	3.5	137	129.7	65.4	3,593
29	June 7	Tr.	27	.18	25	5.3	16	.0	112	23	.70	2.6	149	129.7	65.4	3,593
June 8	17	Tr.	19	.18	31	7.4	14	.0	109	30	.20	4.0	128	121.8	61.4	3,373
18	27	Tr.	22	.08	24	5.5	16	.0	110	20	1.9	3.0	135	117.0	59.0	3,242
28	July 7	5	23	.20	25	4.6	18	.0	115	17	.34	4.0	136	121.4	61.2	3,362
July 8	17	Tr.	28	.25	25	7.8	13	.0	116	16	.38	4.0	140	132.3	66.7	3,664
18	27	Tr.	23	.23	24	7.4	17	.0	110	13	.90	4.0	138	125.1	63.1	3,466
28	Aug. 6	5	20	.14	25	9.1	15	.0	117	28	.35	4.5	139	129.7	65.4	3,563
Aug. 7	16	130	23	.35	21	7.9	17	.0	120	15	--------	2.8	146	130.9	66.0	3,626
17	26	Tr.	17	.37	23	8.1	15	.0	106	14	.70	3.5	122	125.0	63.0	3,461
27	Sept. 5	5	23	.20	28	10	15	1.2	118	29	.70	3.5	178	122.8	61.9	3,401
Sept. 6	15	8	17	.15	27	7.2	13	.0	121	14	.80	3.0	134	121.0	61.0	3,351
16	25	70	23	.33	24	7.1	14	.0	122	14	.20	3.5	142	122.0	61.5	3,379
26	Oct. 5	Tr.	23	.20	21	6.6	11	.0	121	17	Tr.	3.1	145	106.7	53.8	2,956
Oct. 6	15	Tr.	24	.44	23	7.6	14	.0	127	19	Tr.	3.2	146	117.2	59.1	3,247
16	25	Tr.	27	.10	24	6.2	17	.0	121	14	.34	3.0	146	109.5	55.2	3,033
26	Nov. 4	Tr.	20	.15	24	1.8	17	.0	115	16	Tr.	4.0	137	109.1	55.0	3,022
Nov. 5	14	4	78	.24	23	5.7	39	45	80	25	Tr.	6.0	256	82.1	41.4	2,274
15	24	15	36	.08	24	6.4	32	.0	121	22	Tr.	4.5	162	81.9	41.3	2,269
25	Dec. 4	Tr.	29	.12	24	6.9	23	.0	115	22	1.8	4.1	144	88.9	44.8	2,461
Dec. 5	14	Tr.	22	.18	25	6.7	31	.0	115	20	.70	7.0	142	89.3	45.0	2,472
15	24	Tr.	24	.08	25	6.1	17	.0	117	18	.36	4.9	141	81.7	41.2	2,263
25	31	4	21	.10	25	8.9	29	.0	120	22	.26	5.0	144	80.7	40.7	2,236
Mean		8	25	.16	25	6.3	18	.0	116	20	.75	3.8	145	149.2	75.22	4,131

[c] The values given for CO_3 are abnormal and are computed as HCO_3 in the average.

Analyses of water from Santa Ana River near Corona, Calif.

[Parts per million.]

Date (1906-7).		Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total solids.
From—	To—												
Dec. 31	Jan. 9	15	30	0.08	79	12	39	0.0	244	51	2.0	41	362
Jan. 10	19	135	27	.12	75	12	52	.0	249	55	2.1	41	366
20	29	680	28	.21	60	12	46	.0	212	53	2.7	34	329
30	Feb. 8	675	30	.38	66	12	45	.0	206	54	.9	30	317
Feb. 9	18	450	27	.37	55	12	50	.0	201	52	1.6	29	313
19	28	50	25	.15	66	12	36	.0	210	49	2.9	25	292
29	Mar. 9	55	23	.15	61	11	36	.0	205	45	2.1	24	285
Mar. 10	19	20	28	.45	53	7.8	40	.0	227	46	3.5	28	312
20	29	10	39	.24	60	12	41	4.8	239	17	3.0	38	344
30	Apr. 8	20	29	.17	61	13	49	1.2	232	48	Tr.	38	342
Apr. 9	18	Tr.	31	.05	62	12	47	9.4	230	56	3.0	45	363
19	28	10	31	.05	63	12	51	.0	251	39	3.0	46	362
29	May 8	Tr.	26	.20	62	18	47	.0	246	35	4.0	45	347
May 9	18	Tr.	28	.14	59	12	46	.0	240	40	2.0	41	342
19	28	4	32	.17	64	13	50	11	222	42	3.8	43	359
29	June 7	Tr.	29	.18	62	9.3	50	4.8	237	43	2.0	47	352
June 8	17	Tr.	35	.23	60	13	48	18	210	47	2.5	35	361
18	27	Tr.	29	.07	60	12	52	7.2	229	35	1.6	45	336
28	July 7	5	30	.18	59	13	44	9.6	218	36	1.6	43	336
July 8	17	Tr.	33	.70	59	13	49	9.6	218	41	1.6	43	356
18	27	6	32	.18	57	13	52	7.2	223	35	2.2	44	341
28	Aug. 6	5	38	.12	57	12	47	4.8	232	33	1.5	41	341
Aug. 7	16	7	39	.08	58	12	59	.0	243	32	1.3	43	342
17	26	Tr.	41	.29	57	15	51	4.8	222	40	3.0	41	349
27	Sept. 5	Tr.	34	.18	56	12	48	20	195	36	2.0	34	317
Sept. 6	15	Tr.	38	.15	59	13	48	12	226	38	1.9	45	350
16	25	[a] 150	30	.15	60	14	47	1.2	245	43	2.0	49	364
26	Oct. 5	60	33	.20	61	13	48	4.8	250	42	--------	50	368
Oct. 6	15	8	33	.11	61	14	49	2.4	246	38	2.2	44	344
16	25	10	35	.05	71	17	58	.0	256	55	1.9	47	418
26	Nov. 4	Tr.	30	.22	60	11	48	.0	249	50	2.4	44	348
Nov. 5	14	6	30	.08	61	13	49	.0	256	36	1.9	48	356
15	24	7	31	.08	61	14	52	.0	249	35	2.2	44	352
25	Dec. 4	4	31	.25	62	14	55	2.4	248	38	2.5	49	370
Dec. 5	14	12	29	.15	61	14	48	.0	254	44	3.6	49	362
15	24	4	32	.08	63	14	64	.0	259	37	3.8	47	361
25	31	Tr.	27	.04	63	15	66	2.4	246	50	4.0	48	366
Mean		65	31	.18	61	13	49	3.7	233	42	2.3	41	347

[a] September 25, turbidity 1,500, suspended matter, 3,200.

Analyses of water from San Luis Rey River at Pala, Calif.

[Parts per million unless otherwise stated.]

Date (1906).		Turbidity.	Silica (SiO₂).	Al₂O₃+Fe₂O₃.	Calcium (Ca).	Magnesium (Mg).	Sodium (Na).	Potassium (K).	Carbonate radicle (CO₃).	Bicarbonate radicle (HCO₃).	Sulphate radicle (SO₄).	Chlorine (Cl).	Total solids.	Mean discharge.	
From—	To—													Acre-feet per day.	Cubic feet per second.
Jan. 1	Jan. 10		41	1.2	44	14	92	0.1	0.0	178	63	47	336	23.4	11.8
11	20		35	1.8	40	12	86	6.8	.0	56	54	7.7	346	69.8	35.2
21	30		35	.8	41	14	48	4.5	.0	166	64	47	294	36.1	18.2
31	Feb. 9		37	1.8	46	14	41	3.8	.0	176	69	48	354	21.8	11.0
Feb. 10	19		33	3.4	37	13	30	4.5			11		346	86.9	43.8
20	Mar. 1		29	3.2	39	14	34	3.5	.0	168	63	46	320	57.5	29.0
Mar. 3	10		37	2.2	41	14	37	3.1	.0	168	60	47	340	61.3	30.9
22	31		27	3.8	20	6.3	18	3.2	.0	89	20	17	224	5,284	2,664
Apr. 1	Apr. 9		28	8.4	28	12	20	1.6	.0	111	34	27	260	952	480
11	20		23	5.2	30	9.5	20	3.3	.0	127	36	26		538	271
21	30		29	2.4	35	9.8	33	3.8	.0	131	34	28	262	315	159
May 1	May 10		29	3.8	29	9.6	17	4.5	.0	132	35	29	252	317	160
11	20		29	3.4	31	11	25	3.7	.0	138	41	30	266	315	159
21	31		27	4.0	33	11	24	3.1	.0	136	37	30	276	309	156
June 1	June 10		29	3.4	44	13	34	4.1	.0	144	48	32	276	224	113
11	20		34	5.0	44	12	27	2.2	[a]13	132	47	35	312	104	52.7
21	30		40	4.4	44	12	42	3.3	.0	160	46	34	292	62.1	31.3
July 2	July 9								[a]2.5	166		41	242	37.7	19.0
				Fe.											
11	20		31	.06	39	12	42		.0	169	52	39	314	37.7	19.0
21	30		27	.08	45	14	44		.0	175	54	39	342	37.7	19.0
Aug. 1	Aug. 10		33	.10	58	14	50		.0	167	59	38	338	27.6	13.9
11	20		29	.05	43	13	45		.0	171	56	40	338	25.2	12.7
21	31		36	.13	48	14	51		.0	182	58	44	348	10.6	5.36
Sept. 1	Sept. 10		42	.20	46	14	26		.0	176	60	42	348	5.95	3.0
11	20		36	.10	46	14	50		.0	174	63	41	342	10.1	5.10
21	30		33	.20	48	13	60		.0	196	54	41	338	5.95	3.0
Oct. 1	Oct. 10		23	.20	56	18	58		.0	197	61	46	346	5.95	3.0
11	20		28	.15	48	14	36		.0	197	68	44	346	5.95	3.0
21	31	20	27	.25	48	14	50		.0	200	60	46	354	5.95	3.0
Nov. 1	Nov. 10	5	30	.15	46	15	49		.0	198	84	46	354	5.95	3.0
11	20	2	31	.05	48	14	62		.0	203	67	48	358	5.95	3.0
21	30	10	31	.10	50	16	53		.0	201	65	52	352	37.5	18.9
Dec. 1	Dec. 10	10	31	.04	46	24	50		.0	206	64	54	368	32.1	16 2
11	12								[a]24	114		50		556	280
26	31	60	22	.01	40	13			.0	170		60	400	335	169
Mean			31	[b].12	42	13	44		.0	163	53	39	321	285	143

[a] Abnormal; computed as HCO_3 in the average.

[b] Mean of Fe values after July 1.

Analyses of water from Santa Ysabel Creek at San Pasqual, near Escondido, Calif.

[Parts per million unless otherwise stated.]

Date (1907-8).		Turbidity.	Silica (SiO₂).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO₃).	Bicarbonate radicle (HCO₃).	Sulphate radicle (SO₄).	Nitrate radicle (NO₃).	Chlorine (Cl).	Total solids.	Mean discharge.		Run-off per square mile (cubic feet per second).
From—	To—													Acre-feet per day.	Cubic feet per second.	
Dec. 31	Jan. 9	5	40	0.11	37	16	43	0	158	33	2.0	40	277	21.8	11	0.0859
Jan. 10	19	5	37	.17	35	14	42	0	156	36	.76	39	270	21.6	10.9	.0851
20	29	90	39	.25	29	12	37	0	137	31	.48	33	236	99.0	49.9	.3898
30	Feb. 8	30	40	.35	28	11	40	0	122	33	.16	29	232	117.4	59.2	.4624
Feb. 9	18	40	38	.21	27	10	35	0	116	26	.48	28	209	120.6	60.8	.4750
19	28	8	44	.18	25	8.2	33	2.4	134	32	.68	31	237	81.3	41	.3203
29	Mar. 9	19	41	.18	22	12	33	0	133	28	1.1	28	214	112.3	56.6	.4422
Mar. 10	19	5	47	.08	26	11	32	0	138	32	4.0	32	243	67.2	33.9	.2648
20	29	15	47	.04	26	13	34	4.3	135	27	1.9	31	234	51.4	25.9	.2023
30	Apr. 8	5	23	.49	26	12	32	0	144	31	1.9	31	241	46.8	23.6	.1843
Apr. 9	18	10	32	.30	27	10	37	7.4	136	35	.40	33	261	30.3	15.3	.1117
19	28	10	38	.20	26	12	33	0	144	28	.50	31	244	51.2	25.8	.2015
29	May 8	10	45	.13	26	12	35	0	148	24	2.1	32	241	35.1	17.7	.1383
May 9	18	Tr	43	.18	27	9.6	33	7.2	132	25	1.2	32	238	32.5	16.4	.1281
19	28	Tr.	47	.09	26	12	35	4.8	138	27	.96	33	247	19.0	9.6	.0750
29	June 7	5	51	.21	27	12	36	0	154	26	1.2	34	250	15.0	7.54	.0589
June 8	17	Tr.	47	.06	28	13	37	0	159	24	Tr.	37	254	10.0	5.07	.0396
18	27	Tr.	50	.06	28	14	42	7.2	154	29	.48	40	273	7.54	3.8	.0297
28	July 7	Tr.	49	.13	32	13	48	0	179	25	.72	48	293	2.10	1.06	.0083
July 8	10	10														
Sept. 26	Oct. 5	60	54	.02	33	18	54	1.2	206	43	.02	58	349	.56	.28	.0018
Oct. 6	15	Tr.	54	.24	33	18	46	0	206	31	.86	60	348	.46	.23	.0018
16	25	45	49	.05	30	16	54	0	185	30	.68	44	302	2.08	1.05	.0082
26	Nov. 4	Tr.	49	.10	30	13	48	0	190	29	.08	45	317	1.69	.85	.0066
Nov. 5	14	6	48	.28	30	15	61	2.4	181	32	Tr.	48	299	3.29	1.66	.0129
15	24	4	42	.16	32	17	55	0	181	30	Tr.	46	289	6.64	3.35	.0261
25	Dec. 4	40	40	.18	30	14	52	0	167	33	.30	42	282	12.9	6.5	.0508
Dec. 5	14	10	47	.05	30	15	52	0	176	29	.72	43	289	10.3	5.2	.0406
15	24	Tr.	49	.18	30	15	58	0	172	28	.44	43	286	9.60	4.84	.0378
25	31	6	47	.28	34	16	54	0	173	30	.24	44	292	10.7	5.4	.0422
Mean		14	44	.17	29	13	42	1.3	160	30	.84	38	260	34	17	.135

Analyses of water from Cottonwood Creek at Barrett dam, San Diego County, Calif.

[Parts per million unless otherwise stated.]

Date (1907-8).		Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total solids.	Mean discharge.	
From—	To—													Acre-feet per day.	Cubic feet per second.
Dec. 31	Jan. 9	5	42	0.05	77	20	75	0.0	164	55	0.5	59	423	20.19	10.18
Jan. 10	19	15	39	.18	56	20	66	2.4	261	62	1.0	61	431	25.98	13.10
20	29	105	38	.12	61	14	42	.0	237	57	.8	53	402	93.28	47.03
30	Feb. 8	160	39	.28	47	18	59	.0	205	55	.26	48	361	127.73	64.4
Feb. 9	18	45	40	.48	42	18	60	.0	199	55	1.2	42	341	140.18	70.7
19	28	30	43	.09	31	15	64	4.8	200	53	.69	49	356	788.94	39.8
29	Mar. 9	50	39	.38	37	11	50	14	168	47	1.3	45	328	104.13	52.5
Mar. 10	19	15	43	.30	44	16	54	3.6	217	52	1.4	53	380	55.34	27.9
20	29	12	43	.27	48	18	63	.0	242	53	2.0	54	384	49.12	24.77
30	Apr. 8	10	53	.05	45	17	61	9.6	220	38	2.1	54	341	35.20	17.75
Apr. 19	28	15	59	.04	47	19	62	.0	215	50	2.0	63	353	24.93	12.57
29	May 8	Tr.	42	.15	50	24	60	.0	253	55	.9	56	410	25.03	12.62
May 9	18	5	42	.02	50	23	68	2.4	251	52	1.0	60	416	19.22	9.69
19	28	Tr.	46	.35	52	21	68	8.4	245	55	1.5	64	431	14.53	7.33
29	June 7	Tr.	43	.18	49	19	70	7.2	242	50	.56	66	417	12.81	6.46
June 8	17	Tr.	48	.08	53	22	64	6.0	268	43	.82	66	423	7.44	3.75
18	27	Tr.	49	.18	54	22	75	9.6	278	54	Tr.	70	455	3.93	1.98
28	July 7	5	51	.13	56	24	82	.0	317	41	3.5	78	482	1.21	.61
July 8	9	Tr.													
Nov. 6[a]	Nov. 15	Tr.	46	.12	55	23	91	4.8	298	39	Tr.	86	467	8.41	4.24
16	25	Tr.	46	.16	54	23	85	2.4	286	43	Tr.	73	465	8.52	4.30
26	Dec. 4	Tr.	42	.14	54	26	84	2.4	273	61	1.3	73	455	10.95	5.52
Dec. 5	14	Tr.	44	.14	55	23	91	4.8	264	61	.80	74	454	10.33	5.21
15	24	10	51	.26	56	24	91	2.4	295	58	.74	73	479	13.47	6.79
25	31	Tr.	42	.32	57	27	78	6.0	300	65	.32	73	474	13.15	6.63
Mean		19	44	.18	51	20	69	3.7	246	52	1.0	62	413	37.66	19

In the following table the averages of the seven foregoing tables are compared in percentage form.

Reduced analyses of waters in southern division of south Pacific slope.

1. Cottonwood Creek at Barrett dam, about 35 miles east of San Diego. 25 composite analyses.
2. Santa Ysabel Creek at San Pasqual. 30 composites.
3. San Luis Rey River at Pala. 35 composites.
4. Santa Ana River above Mentone. Average for two years. 73 composites.
5. Santa Ana River at Corona. 37 composites.
6. San Gabriel River at Azuza. 37 composites.
7. San Gabriel River at Rivera. 37 composites.

	1	2	3	4	5	6	7
CO_3	29.41	28.87	26.23	36.56	33.06	40.23	40.54
SO_4	12.26	10.83	12.34	11.60	11.74	14.32	12.62
Cl	14.62	13.72	12.79	3.75	11.46	1.92	3.22
NO_3	.24	.29		.54	.64	.49	.72
Ca	12.03	10.46	13.74	17.40	17.04	20.13	21.02
Mg	4.72	4.69	4.25	4.10	3.63	5.37	4.59
Na K	16.27	15.16	14.30	10.91	13.69	8.05	8.42
			1.13	1.36			
Fe_2O_3	.07	.10	.08	.14	.08	.09	.08
SiO_2	10.38	15.88	10.14	13.64	8.66	9.40	8.79
	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Salinity, parts per million	424	277	306	147	358	234	262

SUMMARY FOR THE SOUTH PACIFIC SLOPE.

A careful study of the analyses of waters in the south Pacific area shows more similarities than differences. Nearly all these waters are abnormally high in sulphates, and in some of them, as in the Salinas basin, chlorides are in excess of carbonates. In some of the tributaries of the Salinas the proportion of carbonates is extremely low. In San Lorenzo Creek the proportion of magnesium exceeds that of calcium, a relation which is doubtless due to the fact that the stream rises where magnesian rocks, especially serpentine, are abundant. These waters of the Salinas basin are in several instances very high in salinity, and are in that respect characteristic of the arid or semiarid region through which they flow. Santa Maria River, in the middle division of this area, resembles the Salinas waters, both in composition and in salinity. It is probable that in some of the rivers these peculiarities have been intensified by return drainage from irrigation ditches, as has been shown by Headden in his admirable study of the upper waters of the Platte in Colorado. (See pp. 99-100.)

In the middle and southern divisions of the region the peculiarities mentioned above are less marked. The salinity, except in Santa Maria River, is moderate, and the streams show more tendency toward the normal carbonate type. Alkalies, however, are as a rule high in all three divisions and in many streams are even in excess of lime. Here again the effect of irrigation seems to be clearly shown.

MIDDLE PACIFIC SLOPE.

The rivers of the middle Pacific slope are those which drain into the ocean from San Francisco Bay northward to but not including the basin of Columbia River. They are divided for present convenience into two groups—the drainage into San Francisco Bay and western streams. In the first group data are available for Alameda Creek and San Joaquin and Sacramento Rivers, with their tributaries. Except when otherwise stated, the analyses are by Van Winkle and Eaton, taken from Water-Supply Paper 237.

Analyses of water from Alameda Creek at Niles, Calif.

[Parts per million.]

Date (1906). From—	Date (1906). To—	Silica (SiO_2).	Fe_2O_3+ Al_2O_3.	Calcium (Ca).	Magnesium (Mg).	Sodium (Na).	Potassium (K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Chlorine (Cl).	Total solids.
Jan. 1	Jan. 10	23	2.0	102	40	72	2.0	0.0	356	170	36	600
11	19	18	.6	35	12	10	2.3	.0	119	42	18	234
21	30	21	2.0	51	19	28	3.8	.0	188	56	26	332
31	Feb. 9	20	2.0	64	26	38	2.7	.0	243	86	38	400
Feb. 10	19	21	1.8	71	25	44	2.8	.0	247	80	43	406
20	Mar. 1	17	3.4	31	13	21	3.0	.0	142	30	27	228
Mar. 2	11	14	3.2	37	16	22	1.3	.0	168	38	20	250
12	21	12	2.6	32	14	17	3.1	.0	139	32	24	216
22	31	15	2.4	39	14	22	4.8	.0	151	29	23	240
Apr. 1	Apr. 10	21	3.0	39	17	23	2.3	.0	182	36	22	322
11	20	18	4.4	77	25	36	4.6	.0	232	67	29	324
21	22								240		29	
May 2	May 10	17	3.8	57	24	36	1.9	.0	255	58	33	374
11	20	18	3.0	62	24	41	1.6	3.3	256	60	35	362
21	30	17	3.8	57	25	32	3.4	3.8	251	63	39	382
31	June 10	20	4.2	56	25	37	2.5	10	242	62	39	404
June 11	20	17	4.8	58	27	50	2.7	.0	270	63	36	398
21	30	21	2.4	62	32	56	5.0	5.1	273	68	41	420
			Fe.									
July 1	July 10	19	.06	58	30	66		14	257	80	42	412
11	18	20	.05	57	29	48		10	268	68	40	428
21	31	20	.05	64	32	56		.0	296	100	37	466
Aug. 1	Aug. 10	21	.05	96	30	55		8.0	264	82	36	422
11	20	25	.20	62	30	50		.0	287	113	33	410
21	30	20	.10	79	34	82		7.0	286	126	36	480
Sept. 1	Sept. 10	20	.13	90	36	55		10	290	122	35	510
11	20	23	.10	70	34	73		12	249	124	38	502
21	30	17	.05	87	34	61		10	327	123	41	504
Oct. 1	Oct. 10	16	.10	92	40	65		9.0	339	149	39	562
11	20	19	.15	90	40	50		10	329	152	40	584
21	30	17	.40	89	42	70		16	342	174	42	610
Nov. 8	Nov. 10							.0	358		35	
11	20	19	.20	94	44	72		10	396	202	42	654
21	30	23	.15	98	42	71		4.0	420	160	37	606
Mean		19	[a] .13	66	28	49		4.4	262	91	34	421

[a] Mean of Fe values after July 1.

SAN JOAQUIN BASIN.

North of Alameda Creek the San Joaquin joins the Sacramento, and the united rivers drain into Suisun Bay. For the San Joaquin Van Winkle and Eaton give two tables, as follows:

Analyses of water from San Joaquin River at Lathrop, Calif.

[Parts per million.]

Date (1906).		Turbidity.	Silica (SiO_2).	Fe_2O_3+ Al_2O_3.	Calcium (Ca).	Magnesium (Mg).	Sodium (Na).	Potassium (K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Chlorine (Cl).	Total solids
From—	To—												
Jan. 1	Jan. 10	------------	27	3.0	32	12	55	0.6	0.0	118	59	72	260
11	20	------------	22	2.4	20	7.9	30	2.9	.0	76	46	39	186
21	30	------------	21	1.2	10	5.0	22	4.2	.0	50	17	13	88
31	Feb. 9	------------	22	2.4	9.1	8.7	38	2.7	.0	85	36	20	204
Feb. 10	19	------------	17	1.6	15	5.9	17	1.3	.0	61	18	24	140
20	Mar. 1	------------	21	3.8	14	5.9	16	1.9	.0	57	15	12	122
Mar. 2	11	------------	20	6.0	13	6.4	11	1.3	.0	63	16	14	126
12	21	------------	16	5.2	16	7.4	5.2	1.2	.0	64	22	15	138
22	31	------------	22	4.0	15	6.5	8.7	2.0	.0	51	15	13	108
Apr. 1	Apr. 10	------------	20	4.0	36	7.8	15	4.4	.0	71	15	15	186
11	20	------------	16	2.0	11	5.2	13	2.0	.0	51	9.1	9.3	84
21	27	------------	11	4.8	9.7	5.3	9.6	1.3	.0	38	11	6.9	84
May 3	May 10	------------	10	2.4	8.6	2.9	8.7	2.1	.0	36	6.6	7.8	76
11	20	------------	10	3.8	9.1	3.5	5.5	2.2	.0	26	9.1	7.9	60
21	30	------------	10	2.0	8.9	3.6	6.9	3.7	.0	30	8.7	8.8	60
31	June 10	------------	10	3.0	8.3	5.7	8.2	1.0	.0	38	9.7	9.6	68
June 11	20	------------	8.0	3.2	8.8	4.6	10	.9	.0	29	12	7.8	72
21	30	------------	14	4.8	11	6.4	6.2	.8	.0	30	14	7.8	70
				Fe.									
July 1	July 7	------------	9.4	.20	8.0	6.7	9.5		.0	33	9.2	6.8	70
11	20	------------	25	.20	8.6	2.9	6.4		.0	42	11	7.8	74
21	30	------------	11	.10	8.0	3.2	12		.0	40	6.8	7.8	80
Aug. 1	Aug. 10	------------	11	.15	16	4.6	15		.0	38	8.9	7.8	82
11	20	------------	9.8	.27	11	3.9	12		.0	38	11	8.7	72
21	30	------------	9.8	.30	11	4.5	15		.0	44	16	11	94
31	Sept. 9	------------	17	.25	19	6.8	20		.0	62	20	28	------------
Sept. 10	19	------------	13	.20	25	8.5	27		.0	72	30	40	182
21	30	------------	17	.20	29	12	37		.0	88	42	63	252
Oct. 1	Oct. 10	------------	18	.15	36	13	64		.0	102	59	83	328
11	20	------------	19	.10	41	16	68		.0	123	60	92	358
21	31	------------	17	.10	33	16	56		.0	122	60	86	324
Nov. 1	Nov. 10	------------	17	.7	32	14	52		.0	117	51	78	332
11	20	40	17	.30	28	12	52		.0	110	47	69	282
21	30	20	19	.20	30	14	48		.0	109	62	74	320
Dec. 1	Dec. 10	30	18	.25	31	13	68		.0	111	55	78	310
11	20	200	15	.40	22	8.8	25		.0	73	38	29	182
21	31	20	15	.15	21	6.4	26		.0	73	23	24	158
Mean		------------	16	[a] .23	18	8.0	27		.0	66	26	30	161

Date (1907–8).		Turbidity.	Silica SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total solids.
From—	To—												
Dec. 31	Jan. 9	45	24	0.40	19	5.8	14	0.0	61	31	0.84	13	147
Jan. 10	19	60	20	.38	16	8.7	25	.0	57	36	2.4	22	155
20	29	80	22	.17	16	7.9	25	.0	59	29	1.4	22	146
30	Feb. 8	50	23	.52	17	5.5	26	.0	59	29	1.2	22	149
Feb. 9	18	70	21	.48	15	6.7	26	.0	61	27	.80	31	145
19	28	40	23	.15	16	8.8	33	.0	73	34	.88	31	172
29	Mar. 9	65	21	.25	14	9.8	21	.0	66	28	.50	23	138
Mar. 10	19	60	25	.39	14	6.3	24	.0	63	26	.34	17	124
20	29	40	23	.55	8.4	3.1	14	.0	42	17	1.4	9.0	94
30	Apr. 8	50	20	.38	14	6.4	17	.0	37	27	1.1	19	112
Apr. 9	18	30	13	.18	10	3.3	15	.0	37	25	1.2	13	84
19	28	65	14	.35	6.8	2.3	8.2	.0	29	16	1.2	6.0	62
29	May 8	100	12	.45	6.6	3.1	6.1	.0	22	19	Tr.	4.0	52
May 9	18	35	14	.30	5.5	2.0	6.5	.0	26	14	1.7	5.0	58
19	28	40	17	.30	8.6	3.1	5.5	.0	32	14	.78	6.0	63
29	June 7	35	13	.25	6.0	2.4	8.0	.0	27	15	1.3	4.5	58
June 8	17	30	12	.32	6.8	2.8	6.2	.0	29	13	.92	6.1	56
18	27	25	11	.21	7.8	2.9	12	.0	32	15	.52	11	66
28	July 7	30	16	.20	20	7.2	17	.0	55	24	1.4	16	131
July 8	17	6	15	.20	17	4.4	21	.0	53	21	.35	28	125
18	27	30	23	.33	21	11	34	.0	76	30	.36	49	203
28	Aug. 6	15	15	.15	29	15	52	.0	98	51	2.0	77	286
Aug. 7	16	7	16	.08	25	16	68	.0	107	58	------------	103	357
17	26	12	16	.28	33	18	70	.0	116	59	2.0	98	347
27	Sept. 5	22	19	.20	39	20	72	.0	128	70	1.0	108	396
Sept. 6	15	6	25	.20	40	21	77	.0	139	73	.64	116	416
16	25	30	20	.29	37	20	70	.0	126	72	.36	119	391
26	Oct. 5	25	19	.10	34	18	58	.0	123	67	Tr.	87	364
Oct. 6	15	10	24	.15	37	19	68	.0	124	67	.94	103	373
16	25	40	19	.12	25	14	43	.0	98	61	.86	73	297
26	Nov. 4	35	18	.10	25	14	49	.0	95	52	.68	69	268
Nov. 5	14	9	17	.18	29	15	56	.0	104	53	.70	80	302
15	24	Tr.	19	.75	31	18	73	.0	107	70	1.4	97	372
25	Dec. 4	5	20	.28	28	15	60	.0	105	57	1.0	79	324
Dec. 5	14	26	17	.38	25	15	49	.0	85	55	2.1	59	256
15	24	18	27	.50	21	13	46	.0	90	44	1.7	54	234
25	31	25	20	.50	23	14	49	.0	90	44	1.5	58	247
Mean		34	19	.30	20	10	36	.0	74	39	1.0	47	205

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[a] Mean of Fe values after July, 1906.

Additional analyses of water from the San Joaquin are as follows:

Analyses of water of San Joaquin River, Calif.

1. At Sycamore Station, Fresno County. Analysis by H. G. Kelsey, California Univ. Coll. Agr. Rept., 1882.
2. At Mendota, Firebaugh, and Los Banos, three *identical* analyses. Received from the Southern Pacific Co.

	Parts per million.		Percentage composition.	
	1	2	1	2
CO_3	16.2	25.7	24.07	18.44
SO_4	4.3	33.8	6.39	24.25
Cl	9.4	7.9	13.97	5.66
Ca	6.7	12.0	9.95	8.60
Mg	.7	3.1	1.04	2.23
Na	10.3	21.0	15.31	15.07
K	2.0		2.97	
$(Fe, Mn)_2O_3$	.1	35.9	.15	25.75
Al_2O_3	----------		----------	
SiO_2	17.6		26.15	
	67.3	139.4	100.00	100.00

For important tributaries of the San Joaquin Van Winkle and Eaton give the following tables. They are arranged in order following the course of the river downstream.

Analyses of water from Kern River at Bakersfield, Calif.

[Parts per million unless otherwise stated.]

Date (1906).		Silica (SiO_2).	Fe_2O_3+ Al_2O_3.	Calcium (Ca).	Magnesium (Mg).	Sodium (Na).	Potassium (K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Chlorine (Cl).	Total solids.	Mean discharge.	
From—	To—												Acre-feet per day.	Cubic feet per second.
Jan. 1	Jan. 10	44	2.2	23	5.3	40	0.4	0.0	107	24	13	170	492	248
11	19	29	.8	23	5.4	25	2.1	.0	92	41	12	210	1,874	945
21	30	24	2.4	19	3.2	24	2.4	.0	89	25	13	158	1,467	740
31	Feb. 9	22	.8	39	6.1	105	2.6	.0	110	71	14	270	1,083	546
Feb. 10	19	26	1.6	26	3.9	19	1.3	.0	96	37	15	200	1,220	615
20	Mar. 1	22	1.8	22	3.3	59	2.2	.0	97	24	12	162	2,669	1,346
Mar. 2	11	18	3.4	21	5.4	25	2.9	.0	90	33	14	134	1,597	805
12	21	25	5.4	19	3.8	14	3.8	.0	71	18	12	152	5,185	2,614
23	31	23	6.0	17	4.6	12	2.8	.0	74	16	17	142	5,963	3,006
Apr. 1	Apr. 9	23	5.2	16	4.0	16	3.1	.0	69	18	7.6	128	4,258	2,298
11	20	21	4.6	21	9.4	15	2.7	.0	90	22	9.8	190	5,405	2,725
21	30	11	----------	19	8.9	13	1.8	.0	54	15	6.9	88	7,351	3,706
May 2	May 9	19	3.2	18	5.3	9.8	1.2	.0	53	11	6.9	112	8,263	4,166
11	20	18	3.2	9.4	3.2	11	.6	.0	46	6.8	6.4	84	12,429	6,266
21	31	12	4.2	13	4.3	10	1.3	.0	40	14	5.4	94	13,706	6,910
June 1	June 10	16	3.6	12	3.6	9.3	1.0	.0	43	16	6.9	82	11,602	5,849
12	20	11	4.6	8.3	3.5	10	.9	.0	33	9.1	4.5	70	17,742	8,945
21	30	12	5.0	10	2.6	12		.0	30	9.4	4.4	56	32,811	16,542
			Fe.											
July 1	July 10	12	.23	7.4	2.8	16		.0	36	12	4.6	68	15,623	7,876
11	20	7.4	.10	4.9	1.4	9.5		.0	32	10	5.3	60	28,779	14,509
21	31	9.4	.10	8.6	1.6	9		.0	30	5.8	5.8	56	10,189	5,137
Aug. 1	Aug. 10	12	.10	15	2.5	12		.0	38	13	5.8	78	5,991	3,020
11	19	12	.13	9.4	3.1	14		.0	44	10	5.3	80	4,616	2,327
23	30	20	.18	13	3.3	18		.0	57	14	6.4	118	3,011	1,518
Sept. 1	Sept. 10	11	.13	17	3.8	19		.0	60	18	6.8	102	2,471	1,246
11	20	23	.25	16	3.5	13		.0	63	17	7.6	114	1,803	909
21	30	15	.10	18	3.9	26		.0	72	16	8.1	118	1,517	765
Oct. 1	Oct. 10	14	.10	15	3.0	20		.0	80	18	7.1	114	1,319	665
11	20	15	.10	25	5.5	23		.0	89	23	9.1	148	1,202	606
21	31	14	.10	22	3.5	22		.0	97	27	10	146	1,113	661
Nov. 1	Nov. 10	14	.50	21	4.2	22		.0	95	26	10	146	1,091	550
11	17	20	.10	24	5.0	26		.0	100	30	11	148	1,004	506
22	30	17	.15	26	5.5	25		.0	105	27	10	150	930	569
Dec. 1	Dec. 10	16	.10	22	4.3	26		.0	89	26	14	162	1,101	456
11	12	----------	----------	----------	----------	----------		.0	107	----------	10	----------	1,319	555
Mean		18	[a] .15	18	4.2	22		.0	71	21	9.1	127	6,234	3,147

[a] Mean of Fe values after July 1.

Analyses of water from Merced River at Merced Falls, Calif.

[Parts per million unless otherwise stated.]

Date (1906).		Silica (SiO_2).	Fe_2O_3+ Al_2O_3.	Calcium (Ca).	Magnesium (Mg).	Sodium (Na).	Potassium (K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Chlorine (Cl).	Total solids.	Mean discharge.[a]	
From—	To—												Acre-feet per day.	Cubic feet per second.
Jan. 1	Jan. 10	24	1.2	21	5.6	15	0.3	0.0	77	19	9.4	116	206	104
11	20	27	1.4	8.3	4.0	11	2.9	.0	41	13	4.4	68	9,211	4,644
21	30	17	1.6	9.1	4.6	16	2.0	.0	40	42	4.9	----------	1,837	926
31	Feb. 9	18	3.0	9.4	3.9	6.9	1.9	.0	43	15	5.9	68	928	468
Feb. 10	19	20	1.2	7.4	3.1	7.2	1.3	.0	43	11	8.3	86	1,475	744
20	Mar. 1	18	3.2	13	5.1	6.5	1.4	.0	51	7.9	6.9	86	3,897	1,965
Mar. 2	11	13	1.2	15	5.3	5.5	.5	.0	49	11	8.0	88	3,290	1,659
12	21	15	4.6	7.7	4.8	8.0	1.3	.0	62	7.6	6.9	82	11,584	5,840
Apr. 1	Apr. 10	13	3.0	10	4.9	7.7	2.1	.0	47	10	5.5	74	6,794	3,425
11	20	12	2.6	9.7	5.0	6.6	2.5	.0	31	12	4.9	68	6,024	3,037
21	27	16	3.0	8.3	6.3	5.5	1.3	.0	28	5.4	3.9	42	8,136	4,102
May 2	May 10	9.4	2.8	10	2.4	4.9	1.7	.0	30	7.4	4.9	54	11,465	5,780
11	20	10	2.0	7.7	2.6	8.0	2.0	.0	20	4.3	4.9	68	13,350	6,731
21	30	6.8	2.6	5.7	3.1	4.7	1.3	.0	21	9.2	5.9	40	14,785	7,454
31	June 10	15	3.4	9.1	2.0	7.9	----------	.0	25	8.6	4.9	62	11,858	5,978
June 11	20	6.4	3.6	4.8	3.9	6.8	.6	.0	16	8.6	3.4	54	20,262	10,215
21	30	6.4	4.6	6.9	1.7	8.2		.0	17	7.6	4.9	50	18,913	9,535
July 1	July 10	15	1.0	8.0	4.2	13		.0	17	7.3	3.9	40	18,718	9,437
			Fe.											
11	20	6.2	.10	4.0	1.5	6.5		.0	17	5.6	4.7	46	12,665	6,385
21	31	16	.10	6.9	1.3	6.3		.0	18	3.3	4.5	48	6,467	3,260
Mean........		14	[b].10	9.1	3.8	9.3		.0	35	11	5.6	65	9,093	4,584

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[a] For data regarding gage heights and stream flow see U. S. Geol. Survey Water-Supply Papers 134, 177, and 213.
[b] Mean of Fe values after July 1.

Analyses of water from Tuolumne River at Lagrange, Calif.

[Parts per millon unless otherwise stated.]

Date (1906).		Silica (SiO_2).	Fe_2O_3+ Al_2O_3.	Calcium (Ca).	Magnesium (Mg).	Sodium (Na).	Potassium (K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Chlorine (Cl).	Total solids.	Mean discharge, including canals.		Mean discharge, without canals.	
From—	To—												Acre-feet per day.	Cubic feet per second.	Acre-feet per day.	Cubic feet per second.
Jan. 1	Jan. 10	26	1.4	15	4.4	24	0.3	0.0	81	10	14	100	248	125	171	86.2
11	20	20	3.4	5.7	3.9	13	1.5	.0	41	14	5.9	----------	13,456	6,784	13,135	6,622
21	30	18	2.2	11	4.4	19	2.2	.0	43	14	6.0	52	3,673	1,852	3,233	1,630
31	Feb. 9	14	2.2	5.4	2.9	----------	1.3	.0	38	19	5.4	72	2,298	1,159	1,180	595
Feb. 10	19	15	1.8	9.1	4.7	8.4	1.2	.0	41	7.6	19	82	3,649	1,845	2,885	1,455
20	Mar. 1	15	2.8	10	5.3	7.9	2.1	.0	51	9.8	6.1	100	6,875	3,466	6,292	3,172
Mar. 2	11	15	2.6	9.4	5.1	8.0	1.5	.0	47	13	6.7	76	5,543	2,795	5,345	2,695
12	21	12	4.0	9.4	5.6	4.1	1.3	.0	46	9.2	5.9	70	15,547	7,838	15,257	7,692
Apr. 1	Apr. 10	16	4.8	11	5.1	14	3.8	.0	36	16	5.9	76	11,572	5,834	11,312	5,703
11	20	8.6	2.4	6.3	5.4	8.8	1.3	.0	26	4.8	3.9	48	12,522	6,313	11,608	5,852
21	30	7.2	3.0	7.7	4.6	5.8	1.2	.0	27	7.9	4.9	56	14,611	7,366	13,442	6,777
May 1	May 9	8.6	2.4	6.6	1.9	3.8	1.4	.0	25	4.8	4.5	58	19,776	9,970	18,054	9,102
11	20	10	2.8	5.1	1.7	6.9	1.9	.0	19	4.4	4.9	62	23,516	11,856	20,672	10,422
21	30	11	2.4	6.5	3.0	7.7	1.3	.0	20	9.2	4.1	42	22,215	11,200	20,896	10,535
31	June 10	7.6	4.0	9.7	3.9	6.6	2.6	.0	21	21	4.7	60	20,533	10,352	18,995	9,576
June 11	20	6.6	3.4	5.7	3.2	6.9	.6	.0	16	6.9	3.9	42	33,525	16,902	31,618	15,941
21	30	6	3.0	3.7	2.0	8.5	.8	.0	15	7.7	4.9	40	28,727	14,483	26,727	13,475
			Fe.													
July 1	July 10	5.4	.10	5.1	4.0	5.4		.0	13	6.3	3.9	42	31,893	16,079	29,891	15,070
11	20	8.4	.05	5.1	1.9	7.9		.0	17	7.1	4.7	54	22,795	11,493	20,829	10,501
21	31	5.2	.10	4.9	1.4	9.0		.0	15	3.8	4.9	42	15,346	7,737	13,372	6,742
Aug. 1	Aug. 10	11	.07	7.9	2.1	11		.0	21	11	4.8	42	6,635	3,345	4,689	2,364
11	20	4.8	.18	7.4	3.0	8.0		4.0	14	5.8	5.8	46	4,300	2,168	3,040	1,533
22	29	6.6	.23	11	3.6	6.3		.0	30	7.9	4.9	46	2,560	1,291	1,418	715
Sept. 1	Sept. 9	6.6	.18	8.0	5.0	17		.0	52	8.1	10	74	132	66.4	48.4	24.4
11	20	9.8	.20	7.2	4.7	18		.0	52	9.1	8.1	82	86.7	43.7	0	0
21	30	16	.10	12	5.4	24		.0	59	15	8.1	112	629	317	0	0
Oct. 1	Oct. 10	8.8	.10	16	5.4	12		.0	73	13	6.1	92	550	277	69.4	35.0
11	20	11	.20	16	7.5	13		.0	65	18	7.6	104	457	230	181	91.5
21	31	11	.10	18	6.4	13		.0	72	17	7.1	134	289	146	289	146
Nov. 1	Nov. 9	14	.7	21	6.7	19		.0	77	15	8.1	116	536	270	536	270
11	20	8.8	.25	12	5.1	14		.0	53	28	7.6	100	577	291	577	291
22	30	9.8	.10	17	5.1	15		.0	64	10	7.1	88	321	162	321	162
Dec. 1	Dec. 10	16	.10	18	5.3	12		.0	65	15	7.1	122	457	230	457	230
11	20	8.4	.5	17	6.8	14		.0	72	21	7.1	94	3,456	1,743	3,456	1,743
21	31	7.4	.20	10	4.8	13		.0	39	13	5.6	74	4,647	2,343	4,647	2,343
Mean........		11	[a].19	10	4.3	12		.0	41	12	6.6	74	9,542	4,811	----------	----------

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[a] Mean of Fe values after July1.

Analyses of water from Stanislaus River at Knights Ferry, Calif.

[Parts per million unless otherwise stated.]

Date (1906).		Silica (SiO_2).	Fe_2O_3+ Al_2O_3.	Calcium (Ca).	Magnesium (Mg).	Sodium (Na).	Potassium (K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Chlorine (Cl).	Total solids.	Mean discharge including canal.		Mean discharge without canal.	
From—	To—												Acre-feet per day.	Cubic feet per second.	Acre-feet per day.	Cubic feet per second.
Jan. 1	Jan. 10	9.6	0.6	23	8.4	15	0.1	0.0	106	22	16	138	831	419	754	380
11	20	25	1.2	16	4.7	12	--------	.0	63	14	5.4	116	10,872	5,481	10,774	5,432
21	30	20	1.4	14	4.7	37	2.7	.0	61	8.6	4.4	76	3,278	1,653	3,254	1,641
31	Feb. 9	22	1.4	11	14	14	1.9	.0	61	15	5.9	126	2,294	1,157	2,169	1,094
Feb. 10	19	18	2.2	17	5.7	6.8	.4	.0	61	14	6.2	118	3,526	1,778	3,383	1,706
20	Mar. 1	19	1.8	16	5.8	4.3	1.3	--------	--------	8.4	--------	98	6,409	3,231	6,328	3,190
Mar. 2	11	16	3.6	--------	5.7	6.5	1.3	.0	64	11	5.3	114	5,138	2,590	4,048	2,545
12	20	17	3.8	13	5.3	4.8	3.4	.0	60	11	9.8	114	9,387	4,733	10,317	5,201
22	31	20	3.4	12	5.5	9.0	1.4	.0	55	8.1	5.4	120	17,106	8,624	17,058	8,600
Apr. 1	Apr. 10	13	3.2	11	5.2	10	1.9	.0	55	6.4	3.9	76	9,814	4,948	9,755	4,918
11	20	10	2.4	8.6	5.0	3.6	1.1	.0	38	6.4	4.2	68	10,420	5,253	10,245	5,165
21	28	7.0	3.8	--------	4.9	11	2.6	.0	34	6.4	3.7	54	12,164	6,133	11,949	6,024
May 2	May 10	11	3.2	7.1	3.1	5.8	1.0	.0	30	17	3.9	58	18,602	9,378	18,376	9,264
11	20	13	2.0	5.7	3.3	8.8	1.3	.0	30	23.4	4.5	58	16,884	8,512	16,649	8,394
21	30	11	2.4	6.0	3.6	8.8	1.2	.0	34	9.6	5.4	68	14,026	7,071	13,779	6,947
31	June 10	7.6	3.0	8.0	4.6	7.3	--------	.0	28	8.2	4.4	66	15,178	7,652	14,909	7,516
June 11	20	8.8	2.8	7.1	3.5	7.4	.8	.0	25	9.2	4.9	44	23,405	11,800	23,147	11,670
21	30	8.8	3.8	8.1	3.1	9.0	.6	.0	28	8.2	4.9	48	16,560	8,349	16,376	8,256
			Fe.													
July 1	July 10	7.0	.20	8.3	4.6	9.4		.0	26	9.4	3.9	46	15,989	8,061	15,716	7,923
11	20	11	.10	7.1	3.0	7.4		.0	33	6.8	4.1	68	9,506	4,793	9,304	4,691
21	31	13	.30	9.7	3.2	9.1		.0	38	6.8	4.9	74	5,955	3,002	5,721	2,884
Mean		14	[a].20	11	5.0	11		.0	46	11	5.6	83	10,826	5,453	--------	--------

[a] Mean of Fe values after July 1.

Analyses of water from Mokelumne River at Clements, Calif.

[Parts per million unless otherwise stated.]

Date (1906).		Silica (SiO_2).	Fe_2O_3+ Al_2O_3.	Calcium (Ca).	Magnesium (Mg).	Sodium (Na).	Potassium (K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Chlorine (Cl).	Total solids.	Mean discharge.	
From—	To—												Acre-feet per day.	Cubic feet per second.
Jan. 1	Jan. 10	25	1.6	25	6.7	23	0.0	0.0	84	24	19	126	122	61.5
11	20	22	5.0	23	3.4	16	2.3	.0	45	19	7.6	70	4,580	2,309
21	30	19	2.6	12	3.1	--------	2.3	.0	40	10	7.4	--------	1,345	678
31	Feb. 9	22	2.2	13	4.0	7.6	1.0	.0	40	17	8.8	86	742	374
Feb. 10	19	17	2.0	10	3.0	13	2.0	.0	47	11	9.8	84	1,333	672
20	Mar. 1	16	2.4	9.1	3.2	9.9	.9	.0	41	11	7.5	86	2,713	1,368
Mar. 2	11	16	2.2	9.1	2.7	5.2	2.4	.0	40	8.7	8.7	--------	2,050	1,034
12	21	17	3.0	9.4	3.8	6.9	2.6	.0	43	14	8.8	86	4,562	2,300
22	31	11	6.0	11	3.8	7.9	2.5	.0	36	8.7	7.8	74	8,678	4,375
Apr. 1	Apr. 10	15	3.0	7.1	3.2	9.6	1.5	.0	35	6.4	4.9	70	5,725	2,886
11	20	7.6	3.8	7.7	4.4	5.7	1.7	.0	28	4.6	3.9	52	5,500	2,773
21	30	13	8.4	17	7.2	6.9	1.2	.0	24	11	5.9	46	6,276	3,164
May 1	May 10	11	2.6	6.6	1.8	6.0	1.7	.0	24	7.9	3.9	54	10,747	5,418
11	20	11	2.4	7.2	2.7	5.8	2.0	.0	24	5.3	5.9	42	9,320	4,699
21	30	7.2	2.0	6.0	2.7	5.5	.9	.0	22	8.4	5.1	46	8,192	4,130
31	June 10	8.8	2.6	7.4	4.0	6.8	1.3	.0	25	12	4.1	52	9,892	4,987
June 11	19	9.0	4.6	6.0	5.3	5.4	1.0	.0	17	8.1	4.4	46	14,457	7,288
21	30	11	4.0	6.3	1.8	9.0	--------	.0	17	5.8	3.9	30	11,275	5,684
			Fe.											
July 2	July 10	17	.10	8.0	4.2	14		.0	22	4.9	4.8	56	12,081	6,091
11	20	20	.10	9.7	3.7	18		.0	39	8.6	6.7	56	6,835	3,446
21	30	8.4	.10	6.9	2.0	8.0		.0	25	4.8	5.8	44	2,923	1,474
Aug. 1	Aug. 10	11	.10	22	4.4	19		.0	43	14	5.8	78	1,111	562
11	20	13	.10	14	4.0	14		.0	40	12	5.8	78	653	329
22	30	12	.15	13	3.8	10		.0	44	14	7.7	76	392	198
Sept. 1	Sept. 10	9.4	.10	15	3.9	9.8		.0	47	13	6.3	74	378	191
13	20	19	.23	19	5.9	13		.0	62	18	12	118	394	199
21	30	11	.20	13	4.1	39		.0	46	13	8.1	90	384	194
Oct. 1	Oct. 8	12	.10	17	3.9	18		.0	63	10	9.1	97	351	177
11	20	9.2	.10	16	2.0	10		.0	49	11	7.6	70	382	193
21	31	9.6	.13	15	3.6	14		.0	49	16	6.6	78	384	194
Nov. 1	Nov. 10	13	.30	11	3.2	14		.0	65	12	6.6	84	603	304
11	20	16	1.00	14	5.2	13		.0	63	13	8.6	112	447	225
21	30	9.6	.07	17	4.9	14		.0	62	17	8.6	98	429	216
Dec. 1	Dec. 10	11.2	.20	21	4.1	13		.0	58	15	7.6	96	425	214
11	20	16	.15	15	4.5	14		.0	48	13	9.7	118	2,256	1,138
21	31	12	.05	11	4.0	15		.0	38	14	8.2	86	2,457	1,239
Mean		14	[a].18	12	3.8	13		.0	42	12	7.3	75	3,900	1,883

[a] Mean of Fe values after July 1.

Reduced to percentages and with all carbonates normal the averages of the eight tables of analyses by Van Winkle and Eaton assume the following form. The figures for Alameda Creek are included with those for the San Joaquin.

Reduced analyses of waters from the San Joaquin basin and Alameda Creek, Calif.

1. Alameda Creek at Niles. 33 composite analyses.
2. Kern River at Bakersfield. 35 composites.
3. Merced River at Merced Falls. 20 composites.
4. Tuolumne River at Lagrange. 35 composites.
5. Stanislaus River at Knights Ferry. 21 composites.
6. Mokelumne River at Clements. 36 composites.
7. San Joaquin River at Lathrop, 1906. 36 composites.
8. The same, 1908. 37 composites.

	1	2	3	4	5	6	7	8
CO_2	31.42	27.21	24.57	26.52	28.02	24.97	20.73	17.44
SO_4	21.76	16.33	15.71	15.75	13.67	14.47	16.58	18.68
Cl	8.13	7.08	8.00	8.66	6.97	8.81	19.14	22.52
NO_3	----	----	----	----	----	----	----	.48
Ca	15.79	14.00	13.00	13.12	13.67	14.47	11.48	9.58
Mg	6.69	3.27	5.43	5.64	6.22	4.58	5.10	4.79
Na	10.93	16.48	11.00	13.52	11.80	13.52	15.30	17.25
K	.69	1.48	2.14	1.97	1.87	1.93	1.27	
Fe_2O_3	.05	.15	.15	.39	.38	.36	.19	.14
SiO_2	4.54	14.00	20.00	14.43	17.90	16.89	10.21	9.12
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Salinity[a]	418.2	128.6	70	76.2	80.5	82.9	156.8	208.7

[a] Parts per million.

The following table gives three additional analyses of waters in the San Joaquin basin.

Analyses of waters in San Joaquin basin, Calif.

1. Kern River at Oil City. Analysis received from Southern Pacific Co.
2. Merced River at Snellings.
3. Mokelumne River at Woodbridge. Analysis by H. G. Kelsey, loc. cit.

	Parts per million.			Percentage composition.		
	1	2	3	1	2	3
CO_3	60.2	32.4	32.0	38.98	32.40	28.32
SO_4	13.5	10.8	14.0	8.75	10.75	12.39
Cl	10.3	4.9	9.5	6.67	4.87	8.41
Ca	22.7	11.5	16.7	14.71	11.51	14.78
Mg	2.5	6.9	4.6	1.62	6.93	4.07
Na	28.3	5.0	7.4	18.33	5.00	6.55
K		2.3	2.5		2.30	2.21
$(Fe, Mn)_2O_3$	.6	.6	.7		.60	.62
$(Al, Fe)_2O_3$	16.9	----	----	10.94	----	----
SiO_2		25.6	25.6		25.64	22.65
	154.4	100	113	100.00	100.00	100.00

The waters of the San Joaquin basin are easily interpreted. The Merced, Tuolumne, Stanislaus, and Mokelumne flow first through granitic canyons, which give to the waters their low salinity and high proportion of silica. In their lower courses they become mingled with valley waters, which contribute notable amounts of sulphates and chlorides. Kern River is essentially a valley water and quite unlike the others. The San Joaquin at Lathrop is clearly a blend of both hydrochemical types.

In relation to the San Joaquin, one lake near its upper waters needs to be considered. Tulare Lake is a shallow body of water, which is sometimes of small area and nearly dry and sometimes covers a relatively large surface. Ordinarily it has no outlet, but in times of flood it drains into Kings River, a tributary of the San Joaquin. For the water of this lake there are three available analyses, as follows:

Analyses of water from Tulare Lake, Calif.

1. In 1880. Analysis reported by E. W. Hilgard, California Univ. Exper. Sta. Rept., 1890, Appendix, p. 42.
2. In 1882. Analysis by H. G. Kelsey, California Univ. Coll. Agr. Rept., 1882.
3. In 1890. Reported by Hilgard, loc. cit.

	Parts per million.			Percentage composition.		
	1	2	3	1	2	3
CO_3	345	372	958	26.55	32.98	19.55
SO_4	220	84	1,018	16.91	7.45	20.77
Cl	226	210	992	17.38	18.62	20.26
Ca	20	17	14	1.50	1.51	.28
Mg	23	21	12	1.78	1.86	.26
Na	435	407	1,754	33.51	36.08	35.79
K	24	----	120	1.82	----	2.44
Al_2O_3	----	5	----	----	.44	----
SiO_2	7	12	32	.55	1,06	.65
	1,300	1,128	4,900	100.00	100.00	100.00

These analyses evidently represent different stages of water. No. 2 is evidently of water taken in time of flood, when large contributions, possibly from an overflow of Kings River, modified its composition. No. 3 shows much greater salinity, and the sample analyzed must have been taken when the water was low. In the analysis as originally published small quantities of organic matter are reported, which are left out of consideration here.

SACRAMENTO BASIN.

Sacramento River, the largest stream in California, rises south of Mount Shasta and joins the San Joaquin at Suisun Bay, an arm of San Francisco Bay. Its drainage basin occupies the area between the Sierra Nevada on the east and the Coast Range on the west. For the Sacramento itself Van Winkle and Eaton give the following analyses:

Analyses of water from Sacramento River above Sacramento, Calif.

[Parts per million.]

Date (1906). From—	Date (1906). To—	Turbidity.	Silica (SiO_2).	Fe_2O_3+ Al_2O_3.	Calcium (Ca).	Magnesium (Mg).	Sodium (Na).	Potassium (K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Chlorine (Cl).	Total solids.
Jan. 1	Jan. 10	------	31	2.4	14	6.5	18	3.0	0.0	89	8.4	6.9	144
11	20	------	27	2.8	11	5.1	21	2.8	.0	121	18	18	118
21	30	------	20	.8	15	6.2	18	.8	.0	46	19	5.9	56
Feb. 4	Feb. 9	------	28	5.4	11	6.1	12	.9	.0	73	10	8.2	176
10	17	------	24	2.4	13	5.9	9.5	2.5	.0	73	10	7.6	106
22	Mar. 1	------	16	4.2	11	6.0	8.5	1.1	.0	59	14	9.0	66
Mar. 2	11	------	18	5.8	15	9.5	11	2.3	.0	58	25	7.4	130
12	21	------	16	6.0	12	4.8	7.1	4.2	.0	60	8.4	8.3	212
Apr. 1	Apr. 4	------	10	4.0	13	8.4	12	1.8	.0	49	14	5.1	104
12	20	------	16	6.8	14	6.2	11	2.3	.0	57	9.7	4.9	102
21	30	------	13	4.4	12	6.0	8.7	1.9	.0	58	8.2	4.9	112
May 1	May 9	------	9.2	4.8	13	6.1	6.3	1.3	.0	58	8.2	5.9	98
10	20	------	15	3.6	14	5.9	7.4	1.2	.0	53	8.7	6.4	80
21	30	------	10	2.8	11	5.5	6.0	.9	.0	54	13	6.2	88
31	June 10	------	20	4.2	13	5.2	9.6	2.1	.0	50	16	6.2	100
June 11	20	------	15	4.0	12	10	10	1.7	.0	51	16	6.7	94
21	30	------	12	4.8	13	4.9	12	------	.0	53	7.1	6.8	80
				Fe.									
July 1	July 10	------	16	.20	14	6.8	16		.0	66	13	5.8	106
11	20	------	32	.50	16	5.9	10		.0	73	16	7.8	126
21	31	------	19	.10	16	5.9	15		.0	81	12	7.2	130
Aug. 1	Aug. 10	------	36	.08	21	9.3	21		.0	102	17	13	176
11	20	------	23	.15	17	9.0	19		.0	102	16	14	162
21	31	------	15	.13	17	8.1	18		.0	98	15	16	142
Sept. 1	Sept. 10	------	22	.25	15	8.1	19		.0	100	15	13	136
11	20	------	21	.30	19	9.5	16		[a] 2.0	96	14	13	148
21	30	------	24	.20	17	8.5	19		.0	97	16	12	154
Oct. 1	Oct. 10	------	18	.25	19	7.8	19		.0	90	12	12	138
11	20	------	26	.35	18	9.3	19		.0	104	14	9.1	150
21	31	------	25	.17	14	7.7	13		.0	98	8.2	8.1	134
Nov. 1	Nov. 10	100	17	.75	15	6.3	18		.0	88	13	8.1	120
11	20	20	21	.25	16	7.1	14		.0	102	13	8.6	146
21	30	20	18	.35	14	6.9	27		.0	90	16	8.6	156
Dec. 1	Dec. 10	15	22	.20	17	7.9	15		.0	93	8.7	8.1	118
11	20	100	18	.20	15	5.0	13		.0	55	16	7.7	118
21	31	100	6.0	.8	14	5.9	26		.0	55	14	9.2	100
Mean		------	19	[b].29	15	7.0	15		.0	76	13	8.7	124

Date (1907-8). From—	Date (1907-8). To—	Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total solids.
Dec. 31	Jan. 9	230	26	1.0	13	5.1	10	0.0	54	21	1.0	4.3	104
Jan. 10	19	115	24	.51	16	7.0	5.2	.0	56	25	1.4	4.9	114
20	29	85	24	.40	13	2.0	11	.0	49	16	1.1	4.1	104
30	Feb. 8	75	27	.51	12	3.1	15	.0	50	24	.80	4.0	105
Feb. 9	18	100	36	.80	11	5.9	11	.0	51	23	1.6	4.4	105
19	28	85	28	.30	13	6.4	10	.0	68	18	.37	6.0	107
29	Mar. 9	50	27	.48	15	4.8	17	.0	71	25	.34	5.1	111
Mar. 10	19	85	30	.75	13	6.1	13	.0	71	13	1.0	5.1	113
20	29	95	27	.50	13	4.0	9.5	.0	61	26	.48	3.6	107
30	Apr. 8	20	27	.50	13	5.7	15	.0	63	21	Tr.	4.1	102
Apr. 9	18	110	21	.85	10	5.2	10	.0	59	20	.70	4.0	85
19	28	135	26	.55	11	4.4	8.8	.0	55	16	1.0	3.4	94
29	May 8	108	22	.28	9.7	4.4	8.8	.0	52	17	.68	4.0	88
May 9	18	40	19	.23	10	8.1	7.1	.0	56	13	.74	2.5	86
19	28	95	18	.30	9.7	3.8	5.8	.0	54	9.9	------	2.5	80
29	June 7	50	19	.38	12	4.7	8.5	.0	56	13	.48	3.4	81
June 8	17	50	22	.25	12	3.7	9.0	.0	59	11	1.0	4.2	89
18	27	45	26	.38	12	6.7	12	.0	71	18	.22	7.0	112
28	July 7	55	33	1.0	12	7.3	13	.0	73	13	.70	7.0	132
July 8	17	50	28	.38	15	9.4	11	.0	84	18	.92	6.5	124
18	27	60	24	.18	14	7.9	13	.0	87	12	1.2	6.0	118
28	Aug. 6	50	27	.31	16	10	14	.0	89	16	------	7.5	122
Aug. 7	16	40	29	.25	16	8.7	16	[a]1.2	99	16	.40	7.2	131
17	26	45	32	.20	15	9.3	17	.0	95	16	.56	8.0	131
27	Sept. 5	30	29	.60	16	9.4	16	.0	95	16	.78	8.0	134
Sept. 6	15	30	34	.38	17	7.9	15	.0	96	16	.10	7.2	132
16	25	25	24	.21	15	8.0	14	.0	92	16	.30	6.5	120
26	Oct. 5	45	29	.04	14	8.9	11	.0	96	13	.54	5.5	120
Oct. 6	15	50	33	.13	14	8.3	14	.0	93	21	.40	6.5	126
16	25	85	31	.55	13	7.8	15	.0	82	18	.50	6.6	123
26	Nov. 4	65	31	.18	12	7.9	17	.0	85	13	.32	5.9	114
Nov. 11	14	40	28	.18	12	7.1	19	.0	87	12	.20	4.0	117
15	24	45	34	.40	12	8.7	16	.0	85	14	.30	5.6	128
25	Dec. 4	45	28	.40	15	7.9	15	.0	77	17	.44	6.0	114
Dec. 5	14	50	43	.50	14	7.3	13	.0	81	15	.70	6.2	138
15	24	50	31	.45	14	7.2	19	.0	83	13	.48	6.2	128
25	31	30	40	.60	15	9.8	23	.0	87	16	.54	7.0	140
Mean		66	28	.43	13	6.7	13	.0	74	17	.64	5.4	113

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[a] Abnormal; computed as HCO_3 in the average.

[b] Mean of Fe values after July 1.

One more analysis of water from Sacramento River at Sacramento was received from the Southern Pacific Co. The figures, reduced to standard form, are as follows:

Analysis of water from Sacramento River.

	Parts per million.	Percentage composition.
CO_3	24.4	28.95
SO_4	6.0	7.12
Cl	4.9	5.81
Ca	10.0	11.86
Mg	4.1	4.86
Na, K	5.5	6.52
SiO_2	25.5	30.25
$(Al, Fe)_2O_3$	3.9	4.63
	84.3	100.00

This analysis differs materially from the averages given in the preceding tables. The sample analyzed was, however, taken in April, 1899, when it may have been diluted by flood waters from the mountains around the sources of the river. The high proportion of silica is what might be expected in a mountain water.

In its upper reaches the Sacramento receives many minor tributaries, and for seven of them analyses are available. These analyses were received from the Southern Pacific Co. and are here arranged in order following the course of the river downward.

Analyses of water from seven creeks in upper Sacramento basin, Calif.

1. Creek at Cantara.
2. Bear Creek at Dunsmuir.
3. Castle Creek at Castella.
4. Mears Creek at Sims.
5. Little Dog Creek at Delta.
6. Adler Creek at Morley.
7. Motion Creek at Motion.

I. Parts per million.

	1	2	3	4	5	6	7
CO_3	40.5	10.2	16.6	32.1	12.3	14.7	24.0
SO_4	....	....	2.5	....	8.4	11.7	16.6
Cl	13.9	4.6	7.9	4.8	9.0	7.9	4.9
Ca	7.2	5.0	4.0	7.2	7.9	8.9	8.4
Mg	5.1	2.2	4.2	8.5	2.3	2.3	6.3
Na, K	22.0	.8	6.5	3.1	5.8	7.4	7.7
Oxides [a]	52.8	10.9	13.0	14.0	10.1	16.9	16.9
	141.5	33.7	54.7	69.7	55.8	69.8	84.8

[a] Silica plus sesquioxides.

II. Percentage composition of dissolved solids.

	1	2	3	4	5	6	7
CO_3	28.63	30.27	30.35	46.06	22.05	21.06	28.30
SO_4	....	....	4.57	....	15.06	16.76	19.58
Cl	9.83	13.65	14.44	6.89	16.13	11.32	5.78
Ca	5.09	14.84	7.32	10.33	14.16	12.75	9.90
Mg	3.61	6.52	7.68	12.19	4.13	3.29	7.42
Na, K	15.52	2.37	11.88	4.45	10.36	10.60	9.08
Oxides [a]	37.32	32.35	23.76	20.08	18.11	24.22	19.94
	100.00	100.00	100.00	100.00	100.00	100.00	100.00

[a] Silica plus sesquioxides.

For Pit River, the largest tributary of the Sacramento, no analyses have been found; but for Feather River, its chief affluent, Yuba River, and American River, Van Winkle and Eaton give the following tables of analyses:

Analyses of water from Feather River at Oroville, Calif.

[Parts per million unless otherwise stated.]

Date (1906).		Turbidity.	Silica (SiO_2).	Fe_2O_3+ Al_2O_3.	Calcium (Ca).	Magnesium (Mg).	Sodium (Na).	Potassium (K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Chlorine (Cl).	Total dissolved solids.	Mean discharge.	
From—	To—													Acre-feet per day.	Cubic feet per second.
Jan. 1	Jan. 9	....	....	....	17	7.0	....	....	0.0	87	12	5.9	138	2.560	1,291
12	20	....	16	2.6	7.4	4.1	14	2.1	.0	45	12	4.4	96	72,463	36,534
22	29	....	21	1.2	12	4.1	26	1.0	.0	63	13	5.9	104	17,645	8,896
31	Feb. 9	....	27	1.4	8.6	....	....	.9	.0	61	10	6.9	88	10,505	5,296
Feb. 10	17	....	16	2.2	12	3.9	13	.4	.0	56	8.1	8.8	100	17,383	8,764
20	Mar. 1	....	17	3.8	9.7	3.9	5.5	2.3	.0	48	5.9	5.7	92	34,534	17,411
Mar. 2	11	....	18	1.8	9.7	5.1	4.1	1.8	.0	62	5.6	4.9	94	22,076	11,130
13	29	....	20	7.6	12	6.0	7.6	1.2	.0	51	15	6.9	92	51,315	25,871
Apr. 1	Apr. 10	....	15	4.2	13	7.2	11	2.8	.0	64	6.4	6.4	98	43,848	22,107
11	17	....	12	4.6	13	7.9	7.6	2.8	.0	68	8.6	5.9	84	45,399	17,847
18	May 10	....	10	2.8	8.6	4.4	13	2.0	.0	48	6.9	7.8	78	37,430	18,871
May 11	20	....	10	5.0	9.7	4.9	6.0	2.0	.0	37	5.8	4.5	72	31,215	15,738
21	31	....	19	4.4	13	7.4	8.2	3.7	.0	42	17	4.9	84	32,502	16,386
June 1	June 10	....	12	3.6	11	5.4	5.8	.7	.0	39	7.4	5.7	66	34,506	17,397
11	20	....	9.8	3.6	11	4.9	8.7	.7	.0	41	7.4	4.9	70	29,050	14,646
21	30	....	10	4.0	14	3.8	16	1.9	.0	40	6.8	5.1	72	18,606	9,380
				Fe.											
July 1	July 10	....	13	.30	9.4	7.2	6.5		.0	48	14	5.6	90	13,432	6,772
11	20	....	14	.05	12	4.6	9.6		.0	59	7.1	4.8	84	10,680	5,384
21	25	....	16	.10	19	3.5	8.8		.0	69	4.8	4.8	84	8,037	4,556
Sept. 5	Sept. 10	....	34	.30	11	2.6	21		.0	84	22	6.1	108	3,923	1,978
11	20	....	23	.15	11	6.9	7.5		.0	76	63	6.9	116	3,919	1,976
21	29	....	16	.23	18	7.3	18		.0	81	10	5.1	122	3,816	1,924
Oct. 1	Oct. 10	....	15	.15	15	7.0	17		.0	86	7.1	5.1	132	3,808	1,920
11	20	....	20	.10	17	6.3	19		.0	105	12	5.0	138	3,808	1,920
21	31	....	15	.10	20	9.0	14		.0	96	16	6.6	120	3,808	1,920
Nov. 1	Nov. 10	....	19	.15	15	5.8	13		.0	78	16	5.6	112	6,224	3,138
11	20	20	12	.30	16	6.2	15		.0	86	23	7.0	116	4,086	2,060
21	29	10	17	.10	16	5.9	16		.0	84	15	6.1	108	4,078	2,050
Dec. 2	Dec. 10	30	22	.20	22	7.7	29		.0	81	....	6.1	122	5,963	3,006
11	20	10	19	.20	20	6.8	17		.0	67	8.3	5.1	94	10,482	5,284
21	31	20	8.0	.12	14	4.4	12		.0	48	8.3	5.6	96	24,726	12,466
Mean		....	16	[a].17	13	5.7	14		0.0	64	11	5.8	99	19,736	9,804

[a] Mean of Fe values after July 1.

Analyses of water from Yuba River at Smartsville, Calif.

[Parts per million unless otherwise stated.]

Date (1906).		Silica (SiO_2).	Fe_2O_3+ Al_2O_3.	Calcium (Ca).	Magnesium (Mg).	Sodium (Na).	Potassium (K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Chlorine (Cl).	Total solids.	Mean discharge.	
From—	To—												Acre-feet per day.	Cubic feet per second.
Jan. 1	Jan. 10	18	2.4	11	4.6	26	3.2	0.0	63	18	6.4	110	1,111	560
11	20	27	1.8	25	4.7	13	2.7	.0	69	23	8.6	106	35,958	18,129
21	30	17	.8	9.4	3.3	11	2.9	.0	46	20	3.9	62	8,946	4,510
31	Feb. 9	18	3.0	14	4.8	6.6	.7	.0	44	23	4.9	106	4,471	2,254
Feb. 10	19	13	2.6	10	3.4	5.2	1.9	.0	41	9.7	5.9	94	8,923	4,499
20	28	15	2.4	5.7	3.3	3.5	2.7	.0	36	7.1	6.3	56	16,287	8,211
Mar. 2	Mar. 11	13	3.0	8.3	4.4	5.2	1.0	.0	41	13	5.9	90	10,899	5,495
12	21	15	5.2	7.7	4.0	3.3	.4	.0	43	9.9	6.4	74	19,127	9,643
Apr. 1	Apr. 10	12	3.4	8.9	3.9	6.8	1.7	.0	33	8.7	3.9	64	20,559	10,365
11	20	7.2	4.0	7.7	4.5	8.7	2.2	.0	21	7.1	3.9	56	16,354	8,245
21	29	11	2.4	8.0	2.8	6.1	1.5	.0	33	7.9	4.9	70	15,273	7,700
May 3	May 10	15	3.0	8.9	3.4	6.6	1.3	.0	27	11	5.4	50	25,117	12,663
11	20	14	1.8	5.7	2.9	7.4	.7	.0	26	6.8	4.9	50	17,415	8,785
21	31	12	2.0	7.7	4.2	6.6	.6	.0	28	3.1	4.9	62	22,504	11,346
June 1	June 9	12	3.6	7.7	4.7	7.4		.0	28	9.7	4.9	62	24,850	12,528
11	19	12	4.8	8.9	6.3	6.6	1.7	.0	23	7.1	5.1	54	22,494	11,341
20	30	11	4.6	10	5.7	11	.5	.0	31	12	5.8	68	12,556	6,330
			Fe.											
July 2	July 10	12	.30	7.7	3.8	8.4		.0	35	11	4.9	74	10,605	5,397
11	20	16	.15	6.9	2.8	7.3		.0	36	8.4	4.9	70	6,413	3,233
21	31	14	.10	11	3.1	9.1		.0	45	8.6	5.4	80	3,221	1,624
Aug. 1	Aug. 10	13	.15	18	5.0	11		.0	59	12	4.9	88	1,730	872
11	20	20	.20	23	5.1	10		.0	72	12	4.9	114	3,161	1,594
21	30	15	.20	18	4.5	12		.0	60	13	4.4	88	1,283	647
Sept. 1	Sept. 10	13	.13	23	4.7	13		.0	63	10	4.4	98	1,099	554
11	20	14	.30	20	5.4	14		.0	64	13	5.1	104	1,016	512
21	30	11	.15	17	4.9	12		.0	62	17	4.6	100	979	494
Oct. 1	Oct. 10	10	.05	23	3.8	9.6		.0	80	12	6.1	94	813	410
11	20	8.4	.10	21	5.2	10		.0	76	15	5.6	100	801	404
21	31	9.6	.25	18	4.6	12		.0	73	13	5.0	118	785	396
Nov. 1	Nov. 10	13	.75	12	4.9	16		.0	58	19	6.6	110	2,284	1,152
11	20	14	.25	15	4.9	10		.0	63	23	7.1	106	1,103	556
21	30	13	.10	20	5.4	14		.0	67	22	7.1	112	1,099	554
Dec. 1	Dec. 10	12	.07	18	4.5	8.0		.0	59	15	6.1	100	1,756	885
11	20	10	.30	11	3.9	8.7		.0	46	19	6.1	84	8,966	4,520
21	31	11	.25	8.6	3.5	10		.0	33	10	6.1	70	13,542	6,827
Mean		14	[a].21	13	4.3	10		.0	48	13	5.5	84	9,814	4,950

[a] Mean of Fe values after July 1.

Analyses of water from American River at Fairoaks, Calif.

[Parts per million unless otherwise stated.]

Date (1906).		Silica (SiO_2).	Fe_2O_3+ Al_2O_3.	Calcium (Ca).	Magnesium (Mg).	Sodium (Na).	Potassium (K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Chlorine (Cl).	Total solids.	Mean discharge.	
From—	To—												Acre-feet per day.	Cubic feet per second.
Jan. 1	Jan. 10	25	1.4	17	6.3	17	1.0	0.0	86	9.4	11	102	714	360
11	20	29	.2	8.6	3.7	12	.0	.0	45	12	4.4	64	33,361	16,819
21	29	21	.4	9.7	6.0	11	2.8	.0	38	23	6.4	136	9,041	4,558
31	Feb. 9	20	1.2	8.3	2.5	8.2	.6	.0	40	12	8.8	108	4,539	2,288
Feb. 10	19	17	2.6	8.0	3.3	4.2	.4	.0	35	6.8	6.9		10,102	5,093
20	Mar. 1	17	2.4	6.3	3.2	8.5	1.8	.0	42	7.7	6.7	82	19,881	10,023
Mar. 2	11	14	3.4	11	5.1	5.7	1.0	.0	64	14	8.6	86	15,547	7,838
12	21	17	3.8	8.6	3.4	5.5		.0	34	11	7.8	74	28,864	14,552
22	31	17	3.0	8.0	4.6	11	2.7	.0	33	6.8	7.8	92	39,467	19,898
Apr. 1	Apr. 10	16	4.0	8.3	4.2	8.8	1.8	.0	31	7.1	3.9	62	25,165	12,687
16	17							.0	29		4.4		24,000	12,100
May 1	May 10	11	3.0	6.9	4.0	9.3	1.2	.0	25	8.6	3.9	48	33,452	16,865
11	18	9.4	3.0	6.0	2.8	6.2	1.3	.0	20	8.4	3.9	56	27,161	13,694
21	28	19	3.6	5.9	6.1	8.5	1.4	.0	21	3.3	4.4	58	28,088	14,161
29	June 10	10	4.8	8.3	2.8	8.2	.6	.0	24	7.4	4.2	62	33,551	16,915
June 11	20	12	5.0	9.1	6.0	4.7	1.3	.0	25	7.3	4.9	66	34,886	17,588
21	30	14	4.0	6.9	2.1	11		.0	19	6.8	3.7	56	26,850	13,537
July 1	July 10								26		3.4	54	21,110	10,643
			Fe.											
23	30	15	.30	7.4	2.7	7.4		.0	30	9.2	5.6	72	5,558	2,802
Aug. 1	Aug. 9	21	.10	12	4.4	9.9		.0	40	13	4.8	74	3,165	1,596
12	20	19	.40	8.5	3.7	11		.0	37	11	4.8	74	1,823	919
21	30	14	.40	14	4.5	10		.0	43	15	4.9	80	1,285	648
Sept. 2	Sept. 10	13	.30	13	4.7	9.4		.0	44	13	5.8	80	998	503
11	20	15	.40	16	4.6	15		.0	53	12	7.1	104	864	436
21	30	14	.30	12	4.1	13		.0	48	12	7.1	92	702	354
Oct. 1	Oct. 10	14	.30	15	4.6	20		.0	61	13	8.1	96	686	346
11	20	17	.30	14	5.4	21		.0	59	13	7.6	98	627	316
21	31	18	.35	13	5.4	13		.0	58	13	7.1	114	696	351
Nov. 1	Nov. 10	19	.70	16	5.3			.0	50	14	9.1	96	1,515	764
11	20	24	.80	11	4.8	14		.0	48	22	8.1	100	966	487
21	30	16	.40	17	5.3	9.7		.0	55	24	7.1	98	892	450
Dec. 1	Dec. 10	18	.7	11	4.9	10		.0	47	13	6.6	100	1,202	606
11	20	11	.30	12	5.1	10		.0	46	22	10	98	8,569	4.320
21	31	15	.20	10	4.6	17		.0	37	12	5.6	80	12,921	6,514
Mean		17	[a].39	11	4.4	11		.0	41	12	6.3	83	13,478	6,795

[a] Mean of Fe values after July 1.

A few other analyses of waters from the basins of Feather and American rivers have been collected and are given in the next table. All except the first were received from the Southern Pacific Co. Three of the analyses are from waters around the sources of the south branch of Yuba River.

Analyses of waters in the Sacramento basin, Calif.

1. Feather River at Gridley. Analysis reported by E. W. Hilgard, California Univ. Agr. Exper. Sta. Rept. for 1898 to 1901.
2. Lower Cascade Creek at Troy.
3. Crystal Lake at Crystal Lake Station.
4. Canyon Creek at Towle.
5. American River at Folsom.

I. Parts per million.

	1	2	3	4	5
CO_3	21.3	5.37	5.67	8.5	20.5
SO_4	15.4	--------	.69	.7	10.6
Cl	8.4	1.74	1.25	5.4	4.4
Ca	4.7	3.97	2.39	5.2	12.1
Mg	--------	--------	.83	.3	4.2
Na	23.7	.89	1.14	3.8	2.8
K	--------				
$(Al,Fe)_2O_3$	--------	3.93	7.01	10.9	11.1
SiO_2	47.5				
	121.0	15.90	18.98	34.8	65.7

II. Percentage composition of dissolved solids.

	1	2	3	4	5
CO_3	17.62	33.78	29.88	24.43	31.21
SO_4	12.72	--------	3.63	2.01	16.13
Cl	6.93	10.95	6.59	15.52	6.69
Ca	3.89	24.96	12.59	14.94	18.42
Mg	--------	--------	4.37	.86	6.39
Na	19.58	5.59	6.01	10.92	4.26
K	--------				
$(Al,Fe)_2O_3$	--------	24.72	36.93	31.32	16.90
SiO_2	39.26				
	100.00	100.00	100.00	100.00	100.00

In analyses Nos. 2 and 3, on account of their very low salinity, the parts per million are carried to two decimals in order to secure a closer relation to the true percentages. In No. 2, for example, an error of 1 part per million is equivalent to nearly 7 per cent. In four of the analyses the very high proportion of silica reflects the derivation of the waters from the igneous rocks, mainly granites, of the Sierra Nevada. The abnormally high percentage of chlorine may be due to cyclic salt, brought from the ocean in rain. As for the sulphates, they may be derived from several sources—from pyrite in the rocks from which the waters issue, from the debris and drainage of mines, or from smelter fumes. Contaminations of this sort are much less common in the Eastern States.

Feather and American rivers enter the Sacramento from the east. On the west, apart from the minor streams at the headwaters of the river, the most noteworthy tributary is Cache Creek, for which Van Winkle and Eaton give the following table of analyses.

Analyses of water from Cache Creek at Yolo, Calif.

[Parts per million unless otherwise stated.]

Date (1907-8).		Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total solids.	Mean discharge.		Run-off per square mile (cubic feet per second).
From—	To—													Acre-feet per day.	Cubic feet per second.	
Dec. 31	Jan. 9	145	19	0.19	35	23	44	2.4	173	35	1.5	47	290	1,448.0	730.2	0.5936
Jan. 10	19	85	26	.20	31	23	56	.0	198	34	1.08	47	298	1,102.8	556	.4520
20	29	155	22	.42	33	23	33	.0	170	29	1.6	32	241	2,155.2	1,086.8	.8826
30	Feb. 8	500	20	.25	24	18	30	.0	151	24	.66	26	210	4,711.3	2,375.3	1.9311
Feb. 9	16	230	16	.41	28	19	25	.0	160	25	.40	20	198	4,385.5	2,211	1.7975
19	28	20	15	.18	31	22	28	.0	185	30	.20	24	233	2,164.1	1,091.3	.8872
29	Mar. 9	150	17	.31	29	21	25	.0	181	31	1.3	24	224	3,453.7	1,741.7	1.4161
Mar. 10	19	18	14	.30	24	19	25	4.8	174	28	1.2	21	212	2,381.7	1,201	.9764
20	29	10	11	.05	26	22	27	7.2	172	23	.80	22	216	1,895.7	955.8	.7771
30	Apr. 8	10	14	.15	28	23	25	.0	180	35	1.5	23	225	1,575.8	794.7	.6461
Apr. 9	18	15	12	.28	28	21	30	.0	188	38	1.1	24	229	1,351.9	681.6	.5542
19	28	20	15	.13	28	20	27	.0	193	25	2.0	26	235	1,155.0	582.3	.4734
29	May 8	Tr.	9.4	.11	28	22	29	.0	195	26	1.0	27	238	859.0	433.1	.3521
May 9	18	5	11	.05	30	25	29	2.2	191	20	1.6	29	242	628.7	317	.2577
20	28	10	16	.35	31	25	35	.0	200	31	2.0	29	261	489.2	251.7	.2046
29	June 7	10	17	.09	31	24	35	9.6	194	27	--------	34	261	284.2	143.3	.1165
June 8	17	10	13	.19	33	26	37	.0	220	27	1.8	36	277	147.5	74.4	.0605
18	27	Tr.	12	.13	32	27	35	Tr.	224	22	1.5	35	272	69.6	35.1	.0285
28	July 7	10	15	.13	33	27	41	4.7	220	28	.65	37	283	19.0	9.6	.00780
July 8	17	Tr.	24	.18	35	27	36	12	209	27	2.0	36	287	8.13	4.1	.00333
18	27	10	18	.08	30	26	41	3.6	229	26	2.0	37	291	5.36	2.7	.00219
28	Aug. 2[a]	5	18	.06	37	29	41	Tr.	243	28	1.8	37	282	1.98	1.0	.00081
Mean		64	16	.19	30	23	33	2.1	193	28	1.3	31	250	1,377	649	.57

[a] Creek dry during the rest of the year.

Cache Creek rises in Clear Lake, for which one analysis has been published. There is also one of Cache Creek, received from the Southern Pacific Co. These appear in the next table.

Analyses of water from Clear Lake and Cache Creek, Calif.

1. Clear Lake. Analysis by T. Price, cited in U. S. Geol. Survey Water-Supply Paper 45, p. 33, 1901.
2. Cache Creek at Rumsey.

	Parts per million.		Percentage composition.	
	1	2	1	2
CO_3	55.9	179.4	54.80	31.18
SO_4	3.5	18.3	3.42	3.18
Cl	1.8	163.0	1.79	28.33
Ca	16.2	65.0	15.93	11.29
Mg	11.1	52.0	10.89	9.04
Na	4.6	77.7	4.49	13.50
K	1.9		1.92	
$(Al,Fe)_2O_3$	.2	20.0	.17	3.48
SiO_2	6.7		6.59	
	101.9	575.4	100.00	100.00

This analysis of water from Cache Creek is very different from any of those given by Van Winkle and Eaton. Was the sample taken at very low water and consequent concentration?

Borax Lake, which is near Clear Lake and was formerly connected with it, is a very small body of water of high salinity and noted for its content of borax. It was analyzed by W. H. Melville.[45] In addition to the constituents named below the original residue contained 4.5 per cent of organic matter. Reduced to percentage form the analysis appears as follows:

Analysis of water from Borax Lake, Calif.

CO_3	22.47
SO_4	.13
Cl	32.27
Br	.04
PO_4	.02
B_4O_7	5.05
Ca	.03
Mg	.35
Na	38.10
K	1.52
SiO_2	.01
$(Al,Fe,Mn)_2O_3$	.01
	100.00
Salinity, parts per million	76,560

One other lake is assignable to the Sacramento basin. Goose Lake, which is partly in California and partly in Oregon, formerly drained into Pit River. Even in recent years it has been known to overflow into the river, and it is possible that some of the lake water reaches the Pit by underground seepage. The following analysis by W. Van Winkle[46] is here reduced to standard form.

Analysis of water from Goose Lake, Calif.

	Parts per million.	Percentage composition.
CO_3	411.8	40.62
SO_4	45.0	4.44
Cl	100.0	9.86
NO_3	1.5	.15
PO_4	1.1	.11
Ca	18.0	1.77
Mg	2.0	.19
Na	350.0	34.53
K	34.0	3.38
Fe_2O_3	.03	.01
SiO_2	50.0	4.94
	1,013.43	100.00

The six tables of analyses by Van Winkle and Eaton, reduced to percentages, with all carbonates normal, give the following averages:

Reduced analyses of Sacramento waters.

1. Feather River at Oroville. 31 composite analyses.
2. Yuba River at Smartsville. 35 composites.
3. American River at Fairoaks. 34 composites.
4. Cache Creek at Yolo. 22 composites.
5. Sacramento River above Sacramento, 1906. 35 composites.
6. The same, 1908. 37 composites.

	1	2	3	4	5	6
CO_3	31.84	28.10	24.73	37.38	32.22	30.16
SO_4	11.07	15.48	14.69	10.79	11.20	14.08
Cl	5.84	6.55	7.71	11.95	7.49	4.47
NO_3	--------	--------	--------	.50	--------	.50
Ca	13.08	15.48	13.46	11.56	12.92	10.77
Mg	5.74	5.12	5.39	8.86	6.03	5.55
Na	14.59	10.35	11.01	12.72	11.80	10.77
K	1.72	1.90	1.47		1.64	
Fe_2O_3	.02	.36	.73	.08	.34	.50
SiO_2	16.10	16.66	20.81	6.16	16.36	23.20
	100.00	100.00	100.00	100.00	100.00	100.00
Salinity, parts per million	99.4	84	81.7	259.5	116.1	120.2

The first three of these analyses, with their high alkalies and silica and their low salinity, reflect the effect on the rivers of the granitic rocks in the Sierra Nevada. Cache Creek is distinctly different from the other streams, and Sacramento River appears as a blend of dissimilar waters but with the mountain influence predominating.

WESTERN DIVISION.

The western division of the middle Pacific slope covers the area west of Sacramento and Willamette rivers and lies partly in California and partly in Oregon. Its streams drain directly into the Pacific Ocean, and for eight of them analytical data are available for present purposes.[47]

First, for Russian River, which enters the Pacific in the southern part of Sonoma County, Calif., Van Winkle and Eaton give the following table of analyses:

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[45] U. S. Geol. Survey Mon. 13, p. 265, 1888.

[46] U. S. Geol. Survey Water-Supply Paper 363, p. 39, 1914.

[47] See Van Winkle, Walton, and Eaton, F. M., U. S. Geol. Survey Water-Supply Paper 237, 1910, and Van Winkle, Walton, Water-Supply Paper 363, 1914.

Analyses of water from Russian River near Ukiah, Calif.

[Parts per million.]

Date (1907-8). From—	Date (1907-8). To—	Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Total solids.
Dec. 31	Jan. 9	35	19	0.5	18	7.2	9.8	0.0	71	19	1.6	3.8	107
Jan. 10	19	15	18	.38	17	6.4	9.2	.0	83	18	1.8	4.1	116
20	29	60	17	.45	18	7.9	10	.0	71	13	1.4	4.0	101
30	Feb. 8	50	19	.38	16	6.3	12	.0	67	15	.80	3.2	99
Feb. 9	18	30	22	.32	14	8.2	15	.0	76	22	.77	3.0	107
19	28	5	20	.20	21	11	12	.0	102	17	2.1	4.3	126
29	Mar. 9	20	19	.43	16	8.0	14	.0	82	24	2.1	5.7	112
Mar. 10	19	5	19	.18	18	7.8	13	.0	107	17	1.1	5.1	131
20	29	Tr.	20	.07	19	9.3	10	.0	109	15	2.0	4.2	128
30	Apr. 8	5	18	.08	20	11	9.6	.0	116	23	2.0	4.5	131
Apr. 9	18	10	17	.07	21	12	12	.0	115	17	3.0	4.5	131
19	28	Tr.	16	.03	20	11	10	.0	118	14	1.1	4.5	127
29	May 8	Tr.	16	.03	21	11	12	.0	122	16	1.9	5.4	132
May 9	18	Tr.	18	.06	21	12	12	.0	120	12	2.0	4.6	130
19	28	Tr.	19	.15	24	12	15	[a]3.6	112	16	.86	5.2	141
29	June 7	Tr.	16	.15	22	12	14	.0	124	16	.96	4.6	131
June 8	17	Tr.	16	.08	22	12	11	.0	125	16	1.0	5.9	137
18	27	Tr.	15	.04	21	13	12	.0	128	12	2.0	5.5	131
28	July 7	5	19	.18	24	13	20	.0	138	17	.66	7.0	145
July 8	17	Tr.	24	.40	28	12	14	[a]9.6	120	16	.92	6.0	155
18	27	Tr.	20	.05	28	14	15	.0	140	15	.92	7.0	149
28	Aug. 6	5	16	.04	23	15	14	.0	144	12	.70	7.4	148
Aug. 7	16	Tr.	20	.37	25	15	16	.0	151	18	1.4	7.5	160
17	26	Tr.	27	.13	26	14	16	[a]4.8	146	18	----------	8.0	172
27	Sept. 5	4	28	.43	26	15	15	.0	163	17	.56	8.0	173
Sept. 6	15	5	30	.20	23	14	14	.0	150	17	.10	8.0	179
16	25	Tr.	21	.05	23	15	13	.0	149	17	.80	9.0	151
26	Oct. 5	Tr.	17	.04	26	14	14	.0	158	15	.52	8.0	150
Oct. 6	15	10	20	.04	30	17	23	.0	155	20	.40	11	192
16	25	Tr.	16	.02	29	15	23	.0	166	16	.18	14	189
26	Nov. 4	Tr.	15	.04	29	16	26	.0	166	16	.28	18	187
Nov. 5	14	Tr.	15	.10	31	16	28	.0	167	16	.66	20	192
15	24	5	17	.14	29	16	26	.0	169	19	.36	16	183
25	Dec. 4	20	15	.28	25	14	31	.0	120	22	1.5	11	158
Dec. 5	14	15	18	.38	26	13	15	.0	117	20	1.8	8.2	156
15	24	18	17	.40	24	13	15	.0	117	18	1.0	8.5	150
25	31	5	14	.30	23	11	27	.0	115	19	1.1	8.5	144
Mean		9	19	.19	23	12	16	.0	125	17	1.2	7.4	145

[a] Abnormal; computed as HCO_3 in the average.

For Noyo, Eel and Mad rivers, all in California, Van Winkle[48] gives the following analyses:

Analyses of water from Noyo, Eel, and Mad rivers, Calif.

1. Noyo River at Alpine Station.
2. Eel River at Fortuna.
3. Mad River near Blue Lake, June, 1908.
4. The same, October, 1908.

	Parts per million.				Percentage composition.			
	1	2	3	4	1	2	3	4
CO_3	53.6	49.6	38.0	62.4	38.59	40.03	39.54	42.05
SO_4	18.0	21.0	13.0	21.0	12.96	16.95	13.53	14.16
Cl	7.2	4.9	3.9	6.3	5.18	3.96	4.06	4.24
NO_3	.6	.2	.3	.8	.43	.16	.31	.54
Ca	20.0	23.0	21.0	34.0	14.40	18.56	21.85	22.91
Mg	7.2	7.0	4.3	5.7	5.18	5.05	4.47	3.84
Na, K	15.0	8.5	6.3	10.0	10.80	6.86	6.56	6.74
Fe_2O_3	.3	.3	.1	.2	.21	.24	.10	.13
SiO_2	17.0	9.4	9.2	8.0	12.25	7.59	9.58	5.39
	138.9	123.9	96.1	148.4	100.00	100.00	100.00	100.00

These waters show a general family resemblance. The difference in salinity between Nos. 3 and 4 is doubtless due to differences between high and low water.

Klamath River rises in Upper Klamath Lake, in southern Oregon, and enters the Pacific Ocean a short distance south of the California-Oregon boundary. For the main trunk of the river no analyses have been received, but for several of its tributaries there are satisfactory data. Two analyses are included in this schedule which are possibly misplaced—namely, of Lost River and Crater Lake. Lost River flows into Tule Lake, which is in the same depression as the Klamath lakes, but Tule Lake is supposed to discharge underground into Pit River. It may therefore belong in the Sacramento basin. Crater Lake occupies a closed basin, but its waters probably percolate underground to reappear as springs in the Klamath Valley.

Analyses of waters in or near the Klamath basin.

1. Williamson River at Chiloquin, Oreg. Received from Southern Pacific Co. Drains into Upper Klamath Lake.

2. Wood River near Fort Klamath, Oreg. Analysis by W. Van Winkle, U. S. Geol. Survey Water-Supply Paper 363, p. 41, 1914. Drains through Anna River into Upper Klamath Lake.

3. Lost River, Oreg. Analysis by A. L. Kniseley, cited by Van Winkle, op. cit., p. 41.

4. Creek at Edgewood, Calif. A tributary of Shasta River.

5. Cottonwood Creek at Cole, Calif. A direct tributary of the Klamath. Analyses 4 and 5 received from Southern Pacific Co.

6. Crater Lake, Oreg. Analysis by N. M. Finkbiner, cited by Van Winkle, op. cit., p. 43.

I. Parts per million.

	1	2	3	4	5	6
CO_3	21.3	13.8	115.8	36.4	17.6	16.7
SO_4	--------	7.6	7.4	2.7	4.7	11.0
Cl	6.1	.5	3.2	3.0	3.6	11.0
NO_3	--------	.1	--------	--------	--------	.4
PO_4	--------	--------	--------	--------	--------	.1
Ca	3.6	5.7	31.1	7.9	6.4	7.1
Mg	3.4	2.0	26.6	3.7	1.4	2.8
Na	9.5	7.2	6.1	14.9	8.1	11.0
K			1.7			2.2
Fe_2O_3	--------	.3	--------	--------	--------	.1
(Al, $Fe)_2O_3$	32.8	--------	5.2	50.9	22.9	--------
SiO_2		37.0	22.9			18.0
	76.7	74.2	220.0	119.5	64.7	80.4

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[48] U. S. Geol. Survey Water-Supply Paper 237, pp. 19, 21, 22, 1910.

Analyses of waters in or near the Klamath basin—Continued.

II. Percentage composition of dissolved solids.

	1	2	3	4	5	6
CO_3	27.77	18.59	52.64	30.46	27.20	20.62
SO_4	--------	10.24	3.37	2.26	7.27	13.75
Cl	7.96	.67	1.46	2.51	5.56	13.75
NO_3	--------	.13	--------	--------	--------	.47
PO_4	--------	--------	--------	--------	--------	.01
Ca	4.69	7.67	14.12	6.61	9.89	8.88
Mg	4.43	2.69	12.06	3.10	2.16	3.50
Na	12.39	9.76	2.78	12.47	12.53	13.75
K			.78			2.75
Fe_2O_3		.39	--------			.02
$(Al, Fe)_2O_3$	42.76	--------	2.37	42.59	35.39	--------
SiO_2		49.86	10.42			22.50
	100.00	100.00	100.00	100.00	100.00	100.00

In this group of analyses Lost River stands by itself. The water evidently derived its solid contents from calcareous sediments rich in magnesia. The other waters, with their low salinity and high alkalies and silica, reflect the decomposition of the feldspars of igneous rocks.

A number of partial analyses of waters in the Klamath Basin are cited by Van Winkle but are too incomplete for use here.

For three other rivers in Oregon south of the Columbia Van Winkle [49] gives the following tables of analyses, with details of much value:

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[49] U. S. Geol. Survey Water-Supply Paper 363, pp. 43-50, 1914.

Analyses of water from Rogue River near Tolo, Oreg.

[Parts per million except as otherwise designated.]

Date (1911-12).		Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Dissolved soilds.	Mean gage height (feet).	Mean discharge (second-feet).	Suspended matter (tons per day).	Dissolved matter (tons per day).
From—	To—																
Sept. 10	Sept. 19	3	31	0.02	7.5	4.0	6.6	0.0	42	5.3	0.48	2.3	78	0.90	1,250	11.5	263
20	29	3	30	.08	8.6	3.6	6.9	.0	43	6.6	.12	2.5	76	.85	1,215	8.0	249
30	Oct. 9	4	24	Tr.	5.8	5.1	11	.0	44	8.7	.36	1.9	77	.80	1,180	14.6	245
Oct. 10	19	1	26	.03	7.2	3.4	7.5	.0	44	5.4	.44	1.8	75	.80	1,180	10.2	239
20	29	1	32	.17	7.4	3.4	6.6	.0	48	5.9	.50	2.5	86	.77	1,162	--------	269
30	Nov. 8	3	25	.05	9.0	2.7	7.9	.0	44	7.4	.40	1.8	80	.73	1,141	7.8	246
Nov. 9	18	1	22	.09	9.6	2.0	5.7	.0	36	6.0	.40	2.3	73	2.32	3,071	49.7	611
19	28	Tr.	21	.07	9.9	1.5	7.9	.0	37	4.9	.40	1.5	70	1.77	2,144	10.4	405
29	Dec. 8	Tr.	26	.02	7.4	2.2	7.6	.0	44	5.3	Tr.	1.9	75	1.42	1,722	5.6	348
Dec. 9	18	1	27	.05	6.7	2.3	6.2	.0	41	3.1	.42	2.4	70	1.36	1,660	3.6	313
19	28	Tr.	24	.15	7.8	2.3	6.9	.0	41	6.7	.14	1.6	73	1.28	1,588	20.6	310
29	Jan. 7	2	26	.08	7.0	1.2	7.9	.0	41	3.1	Tr.	2.3	73	1.52	1,987	7.5	392
Jan. 8	17	40	21	.25	5.2	1.2	6.6	.0	34	2.1	.30	.40	80	5.29	9,493	1,360	2,050
18	27	10	21	.12	6.4	1.0	6.9	.0	33	3.6	.20	.85	66	4.40	7,462	177	1,322
28	Feb. 6	7	19	.01	7.8	1.6	7.6	.0	38	2.5	.08	1.3	65	3.35	4,739	84	830
Feb. 7	16	9	23	.12	5.7	1.8	4.3	.0	34	3.2	.06	.75	61	3.7	5,525	72	910
17	26	35	21	.01	6.0	1.6	6.9	.0	34	1.8	.30	1.0	61	6.4	14,134	877	2,328
27	Mar. 7	3	23	.11	6.1	.7	6.8	.0	38	1.2	.15	1.0	69	3.0	4,085	35	763
Mar. 8	17	15	22	.08	5.8	.6	6.3	.0	40	1.6	.15	1.0	70	3.2	4,529	120	856
18	27	10	21	.15	8.4	.9	6.9	.0	40	2.0	.24	1.5	76	2.9	3,926	106	806
28	Apr. 6	2	19	.04	7.2	.6	7.9	[a]4.3	29	3.1	.21	1.3	68	2.5	3,254	53	597
Apr. 7	16	30	21	.08	6.4	1.0	7.2	.0	35	3.8	.20	1.3	69	3.2	4,388	343	818
17	26	10	21	.22	7.6	.8	8.2	.0	40	1.8	.12	1.3	74	2.7	3,584	68	716
27	May 6	20	22	.09	7.6	.9	9.8	.0	42	8.6	.24	1.3	79	4.1	6,459	331	1,377
May 7	16	5	19	.04	9.0	.9	7.9	.0	38	6.6	.20	.75	66	3.9	5,849	379	1,041
17	26	5	20	.01	5.4	1.0	6.6	.0	32	1.6	.28	1.0	59	3.5	5,036	203	803
27	June 5	10	17	.02	7.0	.9	7.4	.0	33	5.8	.34	.75	64	3.7	5,362	217	924
June 6	15	13	14	.04	5.6	1.0	5.7	.0	29	3.1	.30	.40	54	3.4	4,782	271	608
16	25	5	25	.06	6.6	.8	7.2	.0	32	3.0	.56	1.0	65	2.7	3,559	85	624
26	July 5	3	30	.04	8.6	1.2	4.4	.0	33	3.1	.30	.75	71	2.2	2,762	73	530
July 6	15	5	33	.05	7.8	1.6	5.7	.0	38	2.1	.40	1.4	76	1.8	2,212	15.5	454
16	25	350	33	.04	7.8	.5	6.9	.0	42	2.8	.46	1.2	80	1.7	2,059	867	444
26	Aug. 4	8	28	Tr.	5.7	2.4	7.1	.0	38	4.4	.12	2.0	73	1.5	1,810	103	356
Aug. 5	14	12	26	.01	5.7	2.6	7.2	.0	40	3.8	.10	1.5	71	1.35	1,650	98	316
Mean		18	24	.07	7.2	1.7	[b]6.1 [b]1.3	.0	38	4.1	.26	1.4	72	--------	--------	[c]65,350	[c]251,800

[a] Abnormal; computed as HCO_3 in average.

[b] Sodium and potassium, determined on combined alkali residues

[c] Total annual denudation.

Analyses of water from Umpqua River near Elkton, Oreg.

[Parts per million except as otherwise designated.]

Date (1911-12).		Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Dissolved soilds.	Mean gage height (feet).	Mean discharge (second-feet).	Suspended matter (tons per day).	Dissolved matter (tons per day).
From—	To—																
Aug. 1	Aug. 10	1	30	0.06	7.0	1.6	12	0.0	43	7.2	0.48	3.2	86	0.37	1,123	7.3	261
11	20	4	21	.08	10	3.3	----	.0	35	7.0	----	----	68	.28	1,047	7.9	192
21	30	1	22	.05	8.9	2.8	9.1	.0	32	7.6	1.1	3.1	70	.20	980	0	185
31	Sept. 9	3	20	.05	8.3	3.5	7.6	.0	35	4.3	.28	3.3	65	.51	1,273	10.4	223
Sept. 10	19	3	20	.08	9.4	2.8	5.0	.0	38	4.9	.44	5.3	67	.56	1,303	5.6	236
20	29	2	20	.05	9.2	3.6	6.6	.0	42	7.2	.40	4.3	71	.64	1,397	16.6	268
30	Oct. 9	1	20	Tr.	7.3	3.6	7.9	.0	41	5.9	.24	4.8	74	.78	1,525	18.1	305
Oct. 10	19	1	18	.04	11	2.8	6.1	.0	39	9.0	.41	4.1	73	.86	1,613	10.5	317
20	29	2	18	.02	7.5	2.6	6.8	.0	40	7.8	.68	4.7	71	.41	1,160	10.0	223
30	Nov. 8	Tr.	18	.03	10	2.2	6.6	.0	39	8.5	.32	4.0	71	.52	1,311	8.5	251
Nov. 9	18	15	18	.23	11	2.8	6.1	.0	39	6.7	.54	3.3	75	6.4	12,798	1,560	2,585
19	28	5	14	.15	7.8	2.0	6.1	.0	31	5.6	.38	2.5	59	4.7	8,392	63.5	1,336
29	Dec. 8	5	14	.04	8.4	1.0	6.9	.0	31	3.5	.28	3.3	57	2.7	4,133	40	637
Dec. 9	31	20	16	.30	8.4	1.4	6.4	.0	35	5.3	.18	3.8	64	3.4	5,681	245	983
Jan. 1	Jan. 31	60	16	.25	6.3	1.3	4.9	.0	29	5.0	.24	2.3	59	9.6	22,614	4,575	3,595
Feb. 1	Feb. 29	15	16	.09	8.7	1.4	4.9	.0	33	3.0	.33	2.3	70	8.3	18,478	847	3,501
Mar. 1	Mar. 31	10	17	.12	7.3	1.7	6.1	[a] Tr.	35	3.9	.12	2.8	66	5.6	10,518	369	1,870
Apr. 1	Apr. 30	10	25	.05	9.0	1.9	7.1	[a] 4.8	28	4.8	.30	2.8	76	3.7	5,928	272	1,216
May 1	May 31	10	23	.15	6.3	2.0	4.4	.0	32	2.9	.22	2.3	62	5.9	11,752	282	1,963
June 1	June 30	8	14	.01	5.9	2.0	6.5	[a] 7.4	19	8.2	.34	1.8	58	4.0	6,661	234	1,041
July 1	July 31	4	18	.01	6.7	2.3	7.3	.0	40	4.0	.40	4.0	63	1.6	2,495	40	425
Aug. 1	Aug. 15	4	17	.15	8.0	3.6	8.5	.0	39	4.3	.06	2.8	67	.75	1,487	24	269
Mean		12	18	.10	7.9	2.2	[b]5.7 [b]1.6	.0	36	5.2	.30	3.0	67	----	----	[c]217,400	[c]488,500

[a] Abnormal; computed as HCO_3 in average.

[b] Sodium and potassium, determined on the combined alkali residues.

[c] Total annual denudation.

[d] Fe_2O_3.

Analyses of water from Siletz River near Siletz, Oreg.

[Parts per million except as otherwise designated.]

Date (1911-12).		Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Dissolved soilds.	Mean gage height (feet).	Mean discharge (second-feet).	Suspended matter (tons per day).	Dissolved matter (tons per day).
From—	To—																
Aug. 11	Aug. 20	2	15	0.01	1.6	1.6	6.8	0.0	24	5.7	----	3.8	49	0.83	125	0.3	17
21	30	1	12	.03	5.5	1.8	5.6	.0	22	5.3	0.40	3.5	46	.85	130	.6	16
31	Sept. 9	2	13	.04	6.2	2.0	5.8	.0	22	2.9	.60	2.8	46	.85	128	.9	16
Sept. 10	19	3	8.0	.12	4.7	1.3	6.0	.0	20	6.0	.28	3.6	42	1.22	331	3.6	38
20	29	2	8.8	.10	4.3	1.4	5.2	.0	20	4.2	.20	3.5	41	1.14	286	----	32
30	Oct. 9	2	10	.02	4.9	.8	5.9	.0	23	5.0	.40	3.4	43	.93	159	1.1	19
Oct. 10	19	3	13	.02	8.1	3.2	12	.0	50	6.6	.42	5.5	65	1.13	264	2.2	46
20	29	1	12	.05	4.7	1.3	5.4	.0	23	4.4	.32	5.3	47	1.10	240	.9	30
30	Nov. 8	1	9.7	.02	5.5	1.4	5.3	.0	18	7.6	.76	4.0	45	1.50	666	8.3	81
Nov. 9	18	5	8.4	.05	3.7	1.1	3.9	.0	13	5.8	.88	4.2	35	6.4	7,056	343	667
19	28	3	9.1	.02	5.7	1.1	5.1	.0	15	9.7	2.0	4.5	46	3.3	2,657	50	330
29	Dec. 8	1	9.6	.02	4.4	1.3	5.1	.0	13	6.5	1.8	4.3	45	----	[a] 1,200	13	149
Dec. 9	18	1	9.1	Tr.	4.5	1.0	5.8	.0	13	4.4	2.0	4.3	40	----	[a] 1,400	5	170
19	28	1	9.2	.02	5.9	.8	6.4	.0	12	4.8	1.9	5.3	43	----	[a] 3,000	43	348
29	Jan. 7	20	8.8	.06	3.6	.8	6.3	.0	13	6.3	1.8	4.5	46	----	[a] 4,500	304	559
Jan. 8	17	15	7.0	.08	2.8	.1	4.4	.0	11	2.4	.42	3.3	32	8.4	9,968	851	860
18	27	2	13	.03	3.9	.4	4.8	.0	12	4.9	.52	3.0	34	4.0	3,679	109	338
28	Feb. 6	5	9.5	.09	4.6	.8	5.6	.0	12	3.1	2.1	4.0	41	4.7	4,594	248	506
Feb. 7	16	7	8.2	.06	3.7	1.0	5.0	.0	12	4.1	1.9	4.3	36	4.9	4,957	201	482
17	26	Tr.	9.2	.01	5.6	1.2	5.2	.0	12	5.7	4.2	5.0	42	4.1	3,749	Tr.	364
27	Mar. 7	3	6.5	.02	3.5	.4	5.5	[b] 1.2	8.5	2.4	5.4	5.8	40	2.3	1,426	15.8	154
Mar. 8	17	1	8.8	.03	3.3	.4	5.4	.0	9.5	2.4	6.0	5.0	42	2.1	1,129	9.5	128
18	27	Tr.	9.0	.02	3.7	.4	8.5	.0	9.3	2.9	5.3	5.0	43	2.4	1,572	Tr.	183
28	Apr. 6	3	7.5	.02	3.7	.6	5.2	.0	11	5.3	4.2	4.8	46	1.8	867	16.8	108
Apr. 7	16	Tr.	8.3	.01	3.3	1.3	4.7	.0	14	3.9	.45	3.5	36	1.6	549	Tr.	53
17	26	Tr.	8.0	.01	3.4	.2	5.5	.0	13	2.8	.60	4.0	38	1.4	445	Tr.	46
27	May 6	1	6.6	.02	4.5	.3	6.5	.0	13	3.5	4.0	4.8	36	[a] 1.5	[a] 625	16.9	61
May 7	16	Tr.	9.0	.02	3.9	.3	6.8	.0	15	3.6	.52	3.5	36	[a] 1.6	[a] 525	Tr.	51
17	26	Tr.	7.6	.02	5.0	.5	6.0	.0	17	3.9	2.0	4.5	38	[a] 1.5	[a] 625	Tr.	64
27	June 5	Tr.	6.2	.08	4.5	.1	6.0	.0	17	3.3	.60	4.0	43	[a] 1.2	[a] 300	Tr.	35
June 6	15	Tr.	11	.04	4.8	.6	6.0	.0	16	3.3	2.8	4.8	41	[a] 1.2	[a] 300	Tr.	33
16	25	Tr.	9.9	.04	4.2	.7	4.8	.0	17	4.6	.92	4.0	40	[a] 1.4	[a] 425	Tr.	46
26	July 5	2	9.2	Tr.	3.8	.6	8.2	.0	18	2.1	1.1	4.8	42	[a] 1.2	[a] 300	3.2	34
July 6	15	3	11	.00	3.6	.8	7.9	.0	19	4.1	.90	4.0	45	[a] 1.2	[a] 300	5.5	36
16	25	Tr.	7.6	Tr.	3.8	.8	6.0	.0	19	4.4	.34	3.5	40	[a] 1.6	[a] 525	Tr.	57
26	Aug. 4	4	9.0	Tr.	4.2	1.3	6.3	.0	20	5.6	.12	4.5	42	[a] 1.5	[a] 625	9.4	77
Aug. 5	14	5	8.4	.01	3.5	1.1	7.1	.0	20	6.3	.66	4.3	40	[a] 1.5	[a] 625	11.1	67
Mean		3	9.4	.03	4.5	.9	[c] 5.5 [c].7	.0	17	4.6	1.6	4.2	42	----	----	[d] 22,400	[d] 62,100

[a] Estimated. [b] Abnormal; computed as HCO_3 in average. [c] Sodium and potassium, determined on combined alkali residues. [d] Total annual denudation. [e] Fe_2O_3.

Four other analyses of waters in southwestern Oregon have been received from the Southern Pacific Co. The creek at Pollard is in the Rogue River Basin, the other three are tributaries of Umpqua River.

Analyses of waters in Rogue and Umpqua basins, Oreg.

1. Creek at Pollard.
2. Creek at West Fork.
3. Salt Creek at Salt Creek Station.
4. Calapooya Creek at Oakland.

	Parts per million.				Percentage composition.			
	1	2	3	4	1	2	3	4
CO_3	37.9	58.0	72.5	22.2	42.73	45.82	33.50	30.87
SO_4	2.7	6.5	4.4	4.7	3.04	5.13	.65	6.54
Cl	6.5	6.0	58.4	7.9	7.32	4.74	26.99	10.98
Ca	15.6	29.7	13.7	10.0	17.59	23.46	6.33	13.90
Mg	8.3	6.3	27.4	2.8	9.36	4.97	12.64	3.89
Na, K	.8	5.2	26.0	7.4	.90	4.11	12.02	10.32
Oxides [a]	16.9	14.9	17.0	16.9	19.06	11.77	7.87	23.50
	88.7	126.6	216.4	71.9	100.00	100.00	100.00	100.00

[a] Silica plus sesquioxides.

The proportion of magnesium in Salt Creek is very remarkable.

Four tables of analyses of waters in the western division of the middle Pacific slope are here reduced to standard percentage form.

Reduced analysis of waters in middle Pacific slope.

1. Russian River near Ukiah, Calif. Van Winkle and Eaton, Water-Supply Paper 237; 37 composite analyses.
2. Rogue River at Tolo, Oreg. Van Winkle, Water-Supply Paper 363; 34 composites.
3. Umpqua River near Elkton, Oreg. Van Winkle, idem; 22 composites.
4. Siletz River near Siletz, Oreg. Van Winkle, idem; 37 composites.

	1	2	3	4
CO_3	39.07	27.92	28.92	21.25
SO_4	10.80	6.39	8.40	11.50
Cl	4.70	2.18	4.85	10.50
NO_3	.76	.46	.48	4.00
Ca	14.61	11.28	12.76	11.25
Mg	7.63	2.65	3.55	2.25
Na	10.17	9.51	9.21	13.75
K		2.03	2.59	1.75
Fe_2O_3	.19	.15	.16	.25
SiO_2	12.07	37.43	29.08	23.50
	100.00	100.00	100.00	100.00
Salinity, parts per million	157.4	64.1	61.9	40

These waters are remarkably similar to those of the south Atlantic slope.

NORTH PACIFIC SLOPE.

The waters of the north Pacific slope, with a few trifling exceptions, fall into two divisions—those of the Columbia River basin, and those which drain into Puget Sound.

COLUMBIA RIVER BASIN.

The basin of Columbia River drains an area of about 250,000 square miles, of which 38,700 square miles is in Canada. Its northern tributaries are in Washington, its southern and eastern branches are partly in Oregon, partly in Idaho and Montana, and in small degree Nevada and Wyoming. With a few exceptions, the analytical data relative to this great river system are due to Walton Van Winkle and originally appeared in Water-Supply Papers 339 (Washington) and 363 (Oregon).

COLUMBIA RIVER.

For the main or trunk stream Van Winkle gives four tables of analyses, as follows:

Analyses of water from Columbia River at Northport, Wash.

[Parts per million]

Date (1910-11).		Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Dissolved solids.	Mean gage height (feet).
From—	To—													
Feb. 1	Feb. 10	4	16	0.10	21	5.5	7.9	0.0	86	14	0.45	0.6	99	----------
11	20	5	18	.05	20	4.9	7.2	[a] Tr.	86	14	.25	.8	111	----------
21	Mar. 2	3	11	.08	19	5.6	6.0	[a] 7.2	66	13	Tr.	.2	91	----------
Mar. 3	12	6	15	.01	20	5.5	5.0	.0	83	14	.10	.2	99	−5.23
13	22	5	12	.05	20	5.5	4.7	.0	83	11	.00	.4	101	−2.94
23	Apr. 1	7	12	.02	17	5.2	4.3	.0	76	15	Tr.	.5	94	+.57
Apr. 2	11	10	16	.04	20	5.0	4.2	.0	82	9.8	Tr.	.8	98	1.00
12	21	35	7.6	.01	15	4.9	4.7	.0	66	11	.00	.8	77	3.55
22	May 1	5	16	.05	15	4.8	4.6	.0	74	10	.00	.4	77	9.45
May 2	11	5	8.4	Tr.	14	5.2	4.6	.0	62	14	.00	.4	74	16.23
12	21	4	8.0	.07	19	5.4	4.7	.0	72	13	.00	.3	81	20.86
22	31	3	9.6	.05	19	5.8	5.2	.0	72	11	.80	.6	85	21.76
June 1	June 10	4	8.4	.06	19	5.6	5.2	.0	73	14	.20	.2	85	21.17
11	20	7	9.3	.01	18	4.2	3.3	.0	68	8.5	.00	.3	80	20.49
21	30	2	13	.01	17	4.4	3.2	.0	74	9.1	.00	.2	88	18.22
July 1	July 10	4	9.4	.04	14	5.4	5.0	.0	76	11	.30	.2	87	15.06
11	20	5	7.8	.01	20	4.1	5.8	.0	72	11	.00	.2	85	13.26
21	30	3	9.4	.01	20	5.1	5.8	.0	74	9.5	1.0	.8	87	12.50
31	Aug. 9	15	7.4	Tr.	17	3.6	4.7	.0	72	12	.30	.4	81	7.64
Aug. 10	19	1	4.2	.01	18	4.2	4.7	.0	67	8.1	.00	.3	73	5.77
20	29	1	3.4	Tr.	17	4.3	3.3	.0	65	6.7	.35	.6	71	3.66
30	Sept. 8	3	6.4	.01	19	3.9	3.3	.0	68	7.4	.00	.1	74	−.25
Sept. 9	18	3	5.4	Tr.	19	3.8	3.5	.0	68	7.2	.21	.1	73	−2.74
19	28	1	2.2	.01	16	3.3	3.8	.0	68	9.4	.67	.1	81	−3.66
29	Oct. 8	1	3.4	.02	18	3.6	3.8	.0	68	8.7	.38	1.0	74	−1.97
Oct. 9	18	1	4.0	.01	20	3.5	6.1	.0	67	12	.46	1.0	75	−.97
19	28	1	5.8	.01	19	4.6	5.5	.0	70	11	.55	.3	77	−.12
29	Nov. 7	5	5.2	.01	20	3.8	3.6	.0	67	13	.05	1.4	80	−1.08
Nov. 8	27	2	7.2	.01	19	4.2	3.2	.0	71	15	.90	1.2	80	−1.58
18	2	3	5.4	.10	20	4.3	4.1	.0	71	15	.20	.5	80	−1.38
28	Dec. 7	2	17	.02	16	4.8	5.5	.0	74	12	.10	.8	99	----------
Dec. 8	17	2	6.8	.01	19	4.3	4.4	.0	73	11	.30	.8	85	----------
18	27	2	1.4	Tr.	21	5.2	4.6	.0	79	13	.30	.3	86	----------
28	Jan. 6	1	7.0	Tr.	20	5.6	4.3	.0	77	15	Tr.	.8	87	----------
Jan. 7	16	1	7.0	Tr.	20	5.2	5.0	.0	76	14	.40	.5	88	----------
17	26	2	8.2	Tr.	20	5.2	4.3	.0	79	15	Tr.	.6	89	----------
27	31	5	9.4	Tr.	15	4.4	4.4	.0	57	9.7	.30	2.5	72	----------
Mean		5	8.7	.02	18	4.7	4.7	.0	73	12	.23	.6	84	----------

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[a] Abnormal; computed as HCO_3 in average.

Analyses of water from Columbia River at Pasco, Wash.

[Parts per million unless otherwise stated.]

Date (1910-11).		Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Dissolved solids.	Mean discharge (second-feet).	Suspended matter (tons per day).	Dissolved matter (tons per day).
From—	To—															
Feb. 1	Feb. 10	40	11	0.17	17	4.2	10	0.0	82	13	0.40	1.5	95	64,440	4,340	16,500
11	20	5	11	.08	19	4.9	8.4	.0	82	14	.22	.4	97	56,850	521	14,900
21	Mar. 2	8	11	.10	19	5.7	7.1	[a] 6.7	67	15	Tr.	.6	93	57,890	874	14,500
Mar. 3	12	70	13	.32	18	5.0	7.6	.0	71	21	.00	.1	93	73,790	9,360	18,500
13	22	18	8.0	.09	16	5.4	6.3	[a] 26	18	9.5	.00	.3	81	92,400	3,760	20,100
23	Apr. 1	50	18	.08	15	4.0	8.8	.0	62	16	.15	1.3	100	145,900	13,800	39,400
Apr. 2	11	5	14	.07	16	5.7	9.0	.0	73	12	.40	.8	95	138,100	373	35,400
12	21	20	11	.50	12	7.0	8.6	.0	65	13	.00	.8	85	154,500	6,670	35,400
22	May 1	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	[b] 12,100	[b] 49,800
May 2	11	10	7.8	Tr.	16	4.6	7.7	.0	66	12	.00	.3	80	297,400	17,600	64,200
12	21	15	6.6	Tr.	15	3.9	6.6	.0	67	7.4	.00	.7	73	325,700	25,800	69,500
22	31	6	7.0	Tr.	15	4.9	7.0	.0	66	7.5	--------	.5	74	347,100	11,200	69,400
June 1	June 10	10	8.6	Tr.	17	3.8	5.3	.0	68	8.7	.10	.8	79	333,300	5,760	71,000
11	20	1	11	Tr.	19	5.9	8.5	.0	71	9.9	--------	.2	88	306,800	164	72,800
21	30	1	4.6	Tr.	17	4.9	7.2	.0	71	8.6	--------	.3	75	288,200	312	58,400
July 1	July 10	3	7.2	Tr.	17	4.5	7.0	.0	73	7.9	.30	.3	77	260,200	1,410	54,100
11	20	2	6.0	Tr.	17	4.8	5.5	.0	72	7.5	--------	.2	76	239,300	904	49,000
21	30	2	11	.01	19	4.0	5.8	.0	70	7.5	.50	.2	84	226,500	1,100	51,500
31	Aug. 9	1	3.0	.01	18	4.6	5.7	.0	73	7.2	.32	.3	74	179,300	290	35,800
Aug. 10	19	1	4.0	.01	19	4.4	6.8	.0	74	8.6	.00	.4	78	147,100	238	31,000
20	29	3	12	Tr.	18	4.1	6.6	.0	76	9.4	.00	.4	91	123,200	1,260	30,300
30	Sept. 8	4	4.6	.01	18	3.4	3.8	[a] 4.8	59	11	.10	.3	74	90,600	49	18,100
Sept. 9	18	2	3.2	.01	18	4.1	4.3	.0	71	11	Tr.	.3	74	74,560	40	14,900
19	28	3	5.2	.01	20	4.2	3.9	.0	74	10	.30	.4	82	66,880	288	14,800
29	Oct. 8	2	3.6	.03	19	3.2	5.7	.0	72	11	.15	.6	77	69,810	Tr.	14,500
Oct. 9	18	1	3.8	.05	20	3.1	6.3	.0	71	11	.13	.9	79	77,810	42	16,600
19	28	4	5.0	.02	19	3.2	4.3	.0	71	14	.40	.3	78	86,730	140	18,300
29	Nov. 7	2	6.0	.02	19	3.6	5.3	.0	67	11	.30	4.0	77	82,660	312	17,200
Nov. 8	17	2	6.4	.03	18	4.0	3.8	.0	71	11	Tr.	1.0	83	78,400	84	17,600
18	27	1	5.6	.01	18	3.8	3.5	.0	71	13	Tr.	1.5	80	85,830	Tr.	15,500
28	Dec. 7	2	5.4	Tr.	18	4.4	3.8	.0	68	13	.15	.9	81	83,720	405	18,300
Dec. 8	17	3	7.2	Tr.	19	4.4	3.3	.0	71	12	Tr.	.7	81	74,390	523	16,200
18	27	3	5.4	Tr.	19	4.6	3.6	.0	80	11	Tr.	.5	83	66,650	360	14,900
28	Jan. 6	2	7.2	Tr.	20	5.0	4.6	.0	78	10	Tr.	.5	85	61,900	267	14,200
Jan. 7	16	10	7.8	Tr.	20	4.6	5.4	.0	79	12	.30	1.3	86	58,150	313	13,500
17	26	2	8.0	.01	20	5.0	5.2	.0	81	11	.20	.8	88	54,680	88	13,000
27	31	1	7.4	.01	19	5.4	5.0	.0	78	11	Tr.	1.2	87	53,780	145	12,600
Mean		9	7.7	.04	18	4.5	6.0	.0	73	11	.14	.7	83	----------	[c] 1,208,200	[c] 11,454,000

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[a] Abnormal; computed as HCO_3 in average.

[b] Estimated.

[c] Annual denudation.

Analyses of water from Columbia River at Cascade Locks, Wash.

[Parts per million unless otherwise stated.]

Date (1910).		Turbidity.	Silica (SiO₂).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO₃).	Bicarbonate radicle (HCO₃).	Sulphate radicle (SO₄).	Nitrate radicle (NO₃).	Chlorine (Cl).	Dissolved solids.	Mean discharge (second-feet).	Dissolved matter (tons per day).	Suspended matter (tons per day).
From—	To—															
Jan. 1	Mar. 12														[a] 4,234,000	2,740,000
Mar. 13	22	70	27	0.25	17	4.2	5.3	[b] 18	32	12	0.12	2.4	108	274,700	80,200	129,500
23	Apr. 1	100	23	.18	14	4.3	7.9	.0	55	16	.22	1.8	103	373,200	103,900	185,500
Apr. 2	11	60	19	.09	14	3.9	7.9	.0	59	15	.65	2.0	93	279,200	70,100	56,600
12	21	60	17	.05	9.4	4.1	8.7	.0	57	6.6	.45	1.5	85	348,700	80,000	69,800
22	May 1	50	14	.05	12	3.1	3.1	.0	48	13	.32	2.0	80	477,900	103,100	99,400
May 2	11	30	10	.04	14	1.9	6.5	.0	60	9.9	.27	1.2	77	521,700	108,000	114,000
12	21	30	14	.04	15	2.4	7.9	.0	57	10	.60	.8	[c] 82	613,300	135,800	125,800
22	31	20	12	.04	15	4.7	6.6	.0	57	9.9	.20	1.0	80	559,500	120,900	42,300
June 1	June 10	15	14	.05	16	4.8	6.0	.0	60	11	.50	.8	84	523,800	118,500	50,800
11	20	9	14	.01	14	4.4	6.0	.0	66	9.4	.00	.6	82	445,100	98,500	15,600
21	30	5	4.3	.01	16	4.2	4.1	[b] 17	32	11	.20	1.3	71	372,600	71,300	8,460
July 1	July 10	13	9.4	.02	17	5.6	6.1	.0	70	8.7	.20	.8	81	302,200	66,100	13,900
11	20	10	8.8	.01	17	5.2	5.7	.0	70	12	.20	1.0	99	238,100	63,600	7,080
21	30	18	11	.02	16	4.5	4.7	.0	70	9.7	.25	1.3	83	216,000	48,400	12,200
31	Aug. 9	10	8.8	.02	18	4.4	5.2	.0	68	13	.20	2.5	88	191,800	45,500	10,400
Aug. 10	19	5	7.8	.01	18	4.9	6.6	.0	71	11	.20	1.3	82	161,500	35,700	4,800
20	29	20	9.2	.01	17	4.3	5.0	.0	71	9.1	.20	2.3	85	140,700	32,300	42,200
30	Sept. 8	28	6.2	Tr.	19	4.0	5.0	.0	73	8.2	1.10	1.4	83	113,800	25,500	4,750
Sept. 9	18	8	12	.13	19	3.4	7.1	.0	73	12	.40	2.3	94	92,850	23,600	5,020
19	28	5	13	.03	19	4.2	11	.0	78	17	1.80	3.0	106	85,430	24,400	1,110
29	Oct. 8	21	11	.12	19	4.6	11	.0	79	18	1.0	3.5	104	89,390	25,100	19,300
Oct. 9	18	12	8.8	.01	18	4.3	10	.0	70	14	.00	4.3	92	102,000	25,300	8,540
19	28	22	10	.04	17	5.2	7.6	.0	68	14	.98	4.0	94	109,700	27,600	11,300
29	Nov. 7	15	10	.01	18	4.8	7.6	.0	76	19	.60	2.0	94	110,900	28,100	15,000
Nov. 8	17	12	12	Tr.	17	4.4	7.7	.0	71	20	45	2.2	97	121,700	31,800	11,200
18	27	30	14	Tr.	16	4.7	8.0	.0	70	15	65	2.0	94	132,500	33,600	21,100
28	Dec. 7	12	11	Tr.	16	4.0	7.2	.0	67	13	.30	2.0	90	134,700	32,700	9,100
Dec. 8	17	20	17	.01	16	3.9	5.7	.0	68	9.4	.20	3.0	97	124,800	32,600	14,500
18	27	40	17	Tr.	19	4.0	7.7	.0	72	19	.64	3.0	102	97,670	26,900	14,000
28	31	25	17	Tr.	17	4.8	6.8	.0	76	14	Tr.	3.0	80	98,930	21,300	12,300
Mean		26	13	.04	16	4.2	7.1	.0	67	13	.43	2.0	89		[d] 21,510,000	[d] 14,022,000

[a] Estimated denudation during period Jan. 1 to Mar 12, 1910, inclusive.
[b] Abnormal; computed as HCO_3 in average.
[c] Estimated.
[d] Annual denudation.

Analyses of water from Columbia River at Cascade Locks, Wash.

[Parts per million unless otherwise stated.]

Date (1911-12).		Turbidity.	Silica (SiO₂).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+ ¾K).	Carbonate radicle (CO₃).	Bicarbonate radicle (HCO₃).	Sulphate radicle (SO₄).	Nitrate radicle (NO₃).	Chlorine (Cl).	Dissolved solids.	Mean discharge (second-feet).	Suspended matter (tons per day).	Dissolved matter (tons per day).
From—	To—															
Aug. 11	Aug. 20	12	23	0.06	19	4.5	9.3	0.0	76	10	1.4	1.0	103	187,419	9,614	52,120
21	30	5	9.4	.03	18	3.3	9.5	.0	73	13	.56	1.7	88	147,235	4,380	35,050
31	Sept. 9	12	10	1.1	20	5.0	6.0	.0	70	13	.56	1.8	91	129,529	6,300	30,780
Sept. 10	19	10	10	.01	17	5.8	6.3	.0	71	9.5	.36	2.0	89	125,161	9,820	30,100
20	29	5	10	.05	20	4.9	8.2	.0	74	15	.44	2.3	95	108,720	9,380	27,800
30	Oct. 9	5	12	Tr.	20	6.4	9.5	.0	79	17	.52	3.0	113	93,170	2,760	28,400
Oct. 10	19	12	16	.01	16	5.0	9.6	.0	67	13	.44	2.8	87	85,571	7,850	20,100
20	29	10	14	Tr.	21	5.6	11	.0	88	7.3	.56	5.0	114	81,808	8,400	25,200
30	Nov. 8	25	9.2	.02	21	6.4	7.9	.0	84	13	.60	4.8	115	74,710	7,860	23,200
Nov. 9	18	40	13	Tr.	19	5.3	11	.0	81	15	.66	4.4	111	78,765	25,500	23,600
19	28	20	14	.02	19	5.0	10	.0	77	14	1.2	4.9	108	86,640	9,360	25,200
29	Dec. 8	10	13	Tr.	19	6.7	8.4	.0	71	17	.78	4.0	109	75,587	13,100	22,300
Dec. 9	18	4	15	.01	18	4.6	10	.0	79	13	.60	4.0	107	71,902	11,050	20,750
19	28	4	16	.02	19	4.4	11	.0	84	16	.32	4.3	116	70,255	5,300	21,900
29	Jan. 3	5	15	.03	22	4.4	12	.0	82	16	.14	5.2	119	60,603	1,800	19,450
Jan. 4	17													72,633	[a] 1,950	[a] 21,500
18	27	80	18	.06	17	4.4	10	.0	71	11	.56	4.0	102	93,329	1,960	25,610
28	Feb. 6	100	19	.11	14	3.6	11	.0	61	9.4	.52	3.3	129	196,789	82,500	68,600
Feb. 7	16	45	20	.01	15	6.2	6.1	.0	64	10	.48	3.8	99	110,293	19,050	29,620
17	26	60	21	Tr.	13	4.0	9.8	.0	60	9.1	.69	3.8	104	133,810	20,900	37,550
27	Mar. 7	30	20	.06	15	3.6	11	.0	70	13	.90	3.5	107	91,251	16,250	26,300
Mar. 8	17	20	20	.03	18	3.9	13	.0	79	14	.45	4.5	117	78,761	8,060	24,800
18	27	20	19	.05	19	4.0	12	[b] 2.4	74	11	.30	9.8	115	80,570	4,790	25,000
28	Apr. 6	50	22	.35	17	3.8	11	[b] Tr.	74	11	.94	5.0	116	118,150	16,600	37,100
Apr. 7	16	80	18	.18	14	2.6	8.5	[b] 7.2	44	8.2	.30	3.0	90	190,495	33,400	46,200
17	26	40	15	.16	14	2.4	8.2	.0	57	8.9	.24	2.3	89	200,755	22,200	48,100
27	May 6	45	15	.12	14	2.4	6.3	.0	51	5.4	.27	2.3	80	246,561	29,300	53,300
May 7	16	50	9.2	.10	16	3.0	9.1	[b] 6.5	42	11	.24	2.4	79	324,073	29,800	69,200
17	26	25	12	.12	15	2.4	6.9	.0	50	8.6	.26	1.9	75	517,870	43,400	104,900
27	June 5	20	14	.07	15	2.5	7.9	.0	53	9.9	.27	2.0	76	610,266	36,200	125,000
June 6	15	32	10	.10	14	1.8	4.7	.0	50	7.6	.28	1.0	68	624,854	53,900	114,000
16	25	26	11	.13	17	1.3	4.4	[b] Tr.	57	8.6	.32	1.4	74	573,314	38,600	114,200
26	July 5	11	7.8	.05	17	2.8	6.5	[b] 2.9	54	7.9	.30	1.2	72	519,810	28,000	103,500
July 6	15	10	8.0	.06	18	2.3	6.9	.0	65	12	.20	1.6	83	374,009	26,200	83,800
16	25	10	13	.05	19	2.2	6.3	.0	65	9.4	.28	1.6	82	275,672	14,300	58,600
26	Aug. 4	25	4.8	.03	18	2.0	6.9	.0	65	10	.24	2.5	80	223,503	175,000	48,200
Aug. 5	14	50	7.2	.04	19	2.6	13	.0	72	17	.16	2.3	93	196,649	30,300	49,400
Mean		27	14	.06	17	3.9	[c] 8.9	.0	69	12	.48	3.2	97		[d] 7,000,000	[d] 17,000,000

[a] Estimated. [b] Abnormal; computed as HCO_3 in average.
[c] Alkalies separated in composite residue, giving Na=7.5 and K=1.8, which in percentage of anhydrous residue gives Na=8.0 and K=1.9 per cent.
[d] Annual denudation.

A single analysis of water from the Columbia, taken at Mayger, Oreg., about 30 miles above the mouth of the river, is cited by Van Winkle,[50] but is of doubtful value and may be neglected here. The average of the four tables just given, reduced to percentage form are as follows:

Reduced analyses of water from Columbia River.

1. At Northport, Wash., near the Canada line. 37 composite analyses.
2. At Pasco, Wash., above the mouth of Snake River. 37 composites.
3. At Cascade Locks, Wash., 1910. 30 composites.
4. The same, 1911-12. 37 composites.

	1	2	3	4
CO_3	42.01	42.75	37.09	36.10
SO_4	14.00	13.10	14.66	12.78
Cl	.70	.83	2.25	3.41
NO_3	.23	.16	.45	.53
Ca	21.00	21.44	18.04	18.10
Mg	5.49	5.35	4.74	4.15
Na	5.49	7.14	8.01	7.99
K				1.92
Fe_2O_3	.12	.06	.10	.11
SiO_2	10.96	9.17	14.66	14.91
	100.00	100.00	100.00	100.00
Salinity, parts per million	85	84	89	94

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[50] U. S. Geol. Survey Water-Supply Paper 339, p. 91, 1914.

The progressive change from the upper to the lower waters of the Columbia is very marked, although the waters are all of the same general type. The changes are due to the influx of tributaries.

NORTHERN TRIBUTARIES OF THE COLUMBIA.

Numerous tributaries enter the Columbia from the north, and five of these have been studied by Van Winkle.[51] Spokane, Okanogon, Wenatchee, and Yakima rivers join the Columbia above Snake River; Klickitat River is lower and far west of the others. There are seven tables of analyses of these waters by Van Winkle, as follows:

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[51] U. S. Geol. Survey Water-Supply Paper 339, 1914.

Analyses of water from Spokane River at Spokane, Wash.

[Parts per million unless otherwise stated.]

Date (1910-11). From—	Date (1910-11). To—	Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Dissolved solids.	Mean gage height (feet).	Mean discharge (second-feet).	Dissolved solids (tons per day).	Suspended matter (tons per day).
Feb. 1	Feb. 10	4	12	0.12	9.6	3.3	6.3	0.0	38	--------	0.15	0.8	60	19.45	4,744	765	15
11	20	8	--------	--------	--------	--------	--------	--------	--------	--------	.10	.6	76	19.45	4,748	970	82
21	Mar. 2	8	14	.02	9.4	--------	7.9	[a] 17	6.1	18	--------	.4	64	18.85	3,988	690	88
Mar. 3	12	3	8.8	.02	7.6	--------	4.1	[a] 9.6	15	9.9	.00	.10	48	23.30	12,512	1,620	81
Apr. 2	Apr. 11	15	9.0	.04	8.0	2.6	8.3	.0	38	19	--------	1.2	54	26.70	20,980	3,060	907
12	21	25	18	.05	8.0	3.1	9.4	.0	44	22	--------	--------	70	27.85	24,180	4,560	1,630
22	May 1	10	12	.04	--------	2.4	--------	.0	31	--------	--------	.2	59	28.15	25,090	3,930	434
May 2	11	5	15	.03	6.2	1.7	4.6	.0	28	5.4	--------	.5	51	26.85	21,500	2,960	273
12	21	6	15	.03	5.5	1.9	4.9	.0	33	6.6	--------	.6	51	26.10	19,380	2,760	336
22	31	5	13	.02	9.6	1.8	5.2	.0	42	6.2	.00	.2	59	24.35	14,910	2,380	129
June 1	June 10	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------
11	20	5	17	.01	12	2.6	5.3	.0	52	6.2	.00	.4	72	19.50	4,799	930	--------
21	30	3	17	.01	11	1.9	3.7	.0	48	6.9	.00	.3	60	18.75	3,691	600	16
July 1	July 10	5	13	.01	12	4.2	5.0	.0	57	8.6	.00	.1	71	18.40	3,165	606	29
11	20	3	13	Tr.	11	3.8	4.7	.0	50	4.0	.00	.2	65	18.45	3,273	574	18
21	30	10	10	Tr.	10	4.0	5.7	.0	50	5.1	.00	.3	61	18.30	3,083	510	71
31	Aug. 9	10	9.6	Tr.	14	5.2	5.0	.0	66	6.9	.00	.1	69	17.85	2,485	464	23
Aug. 10	19	10	11	.01	13	5.0	5.7	.0	67	5.1	.00	.1	75	17.55	2,160	437	7
20	29	15	6.2	.01	13	5.2	5.4	.0	66	5.8	.00	.7	73	17.55	2,118	416	40
30	Sept. 8	2	6.8	.01	12	5.0	5.4	.0	63	11	.10	.3	72	17.55	2,146	417	7
Sept. 9	18	2	3.8	.01	14	4.4	5.2	.0	72	9.5	.44	.3	82	17.35	1,928	426	8
19	28	3	5.2	.01	14	5.2	7.9	.0	63	11	.05	.9	69	17.40	1,953	364	7
29	Oct. 8	4	11	.03	14	5.2	5.2	.0	62	10	1.2	.5	75	17.55	2,163	439	1.2
Oct. 9	18	1	8.0	.01	15	5.2	6.9	.0	68	9.2	.40	.8	76	17.55	2,136	438	0
19	28	4	11	.02	15	4.6	5.1	.01	57	13	.50	.5	74	17.60	2,170	434	15
29	Nov. 7	3	11	.01	14	4.0	6.0	.0	55	8.9	.50	1.5	71	17.60	2,220	425	6.0
Nov. 8	17	2	9.0	.01	11	4.0	4.6	.0	52	4.6	.65	1.5	64	17.75	2,402	415	5.2
18	27	5	8.0	.06	7.8	24	3.6	.0	33	9.7	.00	.5	48	19.80	5,327	690	0
28	Dec. 7	1	9.2	.01	6.8	2.0	3.2	.0	28	7.9	2.0	.5	45	20.60	6,634	805	34
Dec. 8	17	1	11	.01	7.7	2.6	2.8	.0	30	8.3	.20	.3	47	20.30	6,115	742	35
18	27	2	11	Tr.	8.4	3.5	3.0	.0	39	6.4	.25	.1	53	19.40	4,683	670	15
28	Jan. 6	5	9.3	Tr.	9.0	3.2	4.9	.0	41	9.4	Tr.	.4	56	18.80	3,760	569	59
Jan. 7	16	3	10	Tr.	9.5	3.2	4.5	.0	43	8.9	Tr.	.4	58	18.50	3,345	524	23
17	26	2	22	Tr.	9.6	3.6	6.5	.0	43	11	Tr.	4.5	66	18.50	3,302	589	19
27	31	1	10	Tr.	9.1	3.2	3.2	.0	45	11	Tr.	.3	59	18.25	2,996	426	13
Mean		5	11	.02	11	3.6	5.3	.0	48	9.2	.23	.6	63	--------	--------	[b] 404,900	[b] 45,900

[a] Abnormal; computed as HCO_3 in average.

[b] Annual denudation.

Analyses of water from Okanogan River at Okanogan, Wash.

[Parts per million.]

Date (1910-11). From—	Date (1910-11). To—	Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Dissolved solids.
Mar. 3	Mar. 12	20	18	0.02	27	7.8	10	0.0	92	25	0.20	0.7	145
13	22	20	20	.03	28	7.5	7.9	.0	115	22	.00	.3	148
23	Apr. 1	50	16	.05	20	5.5	11	.0	96	16	.40	.6	116
Apr. 2	11	18	23	.03	17	5.7	9.6	.0	73	17	.25	.8	115
12	21	45	4.9	.03	15	5.0	8.0	.0	68	17	.50	.3	86
22	May 1	250	14	.04	16	1.9	7.9	.0	60	8.5	----------	.8	89
May 2	11	40	15	.04	16	3.6	7.9	.0	66	8.8	.20	.8	90
12	21	50	12	.05	13	2.9	7.7	.0	58	8.4	.35	.3	76
22	31	60	9.8	.01	12	2.4	6.1	.0	54	8.2	----------	Tr.	72
June 1	June 10	13	10	.01	13	3.5	6.1	.0	57	5.1	----------	.1	67
11	20	30	6.4	.01	12	2.9	5.0	.0	51	6.1	.00	.1	65
21	30	30	6.8	.01	17	2.5	8.4	.0	72	7.0	.00	Tr.	90
July 1	July 10	20	87	.02	13	2.7	9.8	.0	60	8.6	.00	1.6	182
11	20	55	15	.02	16	2.7	9.5	.0	70	8.4	.00	1.3	93
21	30	12	9.0	.02	17	4.0	12	.0	78	12	Tr.	.8	96
31	Aug. 9	3	12	.01	24	4.7	9.0	.0	92	13	----------	.5	117
Aug. 10	19	5	16	.01	24	4.5	12	.0	98	14	.20	1.5	124
20	29	10	12	Tr.	26	5.8	9.6	.0	95	18	Tr.	.5	128
30	Sept. 8	15	6.4	.04	16	5.8	11	.0	67	18	.50	.8	96
Sept. 9	18	8	11	Tr.	29	5.8	7.2	.0	109	18	.00	.4	130
19	28	5	7.4	.02	28	5.2	8.5	.0	98	21	.80	.5	136
29	Oct. 8	7	12	.02	27	5.4	11	.0	101	24	.39	1.0	129
Oct. 9	18	5	8.6	.02	21	3.8	9.1	.0	74	19	.42	1.2	99
19	28	1	12	.01	23	4.0	9.6	.0	77	15	2.5	2.8	101
29	Nov. 7	7	11	.02	18	4.0	6.9	.0	70	13	.50	1.8	95
Nov. 8	17	6	14	.01	20	4.5	7.4	.0	77	20	.60	.5	104
18	27	5	6.4	.01	21	4.6	6.6	.0	78	20	Tr.	.5	100
28	Dec. 7	5	11	Tr.	22	5.0	6.0	.0	78	23	.00	2.3	109
Dec. 8	17	3	5.4	.01	24	5.2	8.7	.0	90	20	Tr.	.5	115
18	27	5	10	.01	31	6.4	6.1	.0	102	24	Tr.	.6	130
28	Jan. 6	4	13	Tr.	27	6.2	5.3	.0	95	20	Tr.	.8	126
Jan. 7	16	5	14	Tr.	30	6.8	10	.0	113	22	Tr.	1.3	143
Mean		25	14	.02	21	4.6	8.5	.0	81	16	.28	.8	110

Analyses of water from Wenatchee River at Cashmere, Wash.

[Parts per million unless otherwise stated.]

Date (1910-11). From—	Date (1910-11). To—	Turbidity.	Silica (SiO_2.)	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Dissolved solids.	Mean gage height (feet).	Mean discharge (second-feet).	Suspended matter (tons per day).	Dissolved matter (tons per day).
Feb. 1	Feb. 10	3	20	0.20	7.3	4.3	7.6	0.0	45	8.1	0.34	1.2	70	1.50	1,476	64	279
11	20	2	22	.15	8.0	4.1	8.2	.0	50	8.4	.33	.5	75	1.40	1,382	60	282
21	Mar. 2	2	25	.16	9.5	5.2	7.2	.0	59	13	.20	1.0	85	1.40	1,421	15	327
Mar. 3	12	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	2.25	2,626	[a] 407	[a] 599
13	22	35	15	.07	7.6	4.2	5.0	[b] 19	11	4.1	.15	.5	58	3.60	5,558	800	871
23	Apr. 1	10	19	.01	7.4	2.9	4.6	.0	37	6.4	.41	1.2	63	3.80	5,957	160	1,010
Apr. 2	11	20	37	.14	10	4.5	10	.0	54	15	Tr.	.5	111	2.90	3,869	115	1,160
12	21	8	15	.04	6.0	4.2	6.3	.0	32	7.5	Tr.	.8	51	3.45	5,489	162	755
22	May 1	40	8.3	.02	5.2	1.9	3.5	[b] 9.7	4.9	4.5	.30	1.5	40	5.80	13,197	1,350	1,420
May 2	11	18	16	.01	4.6	1.9	3.9	[b] 8.4	9.8	4.1	.15	1.0	46	5.65	12,808	467	1,350
12	21	10	8.7	Tr.	4.2	1.4	4.4	.0	22	7.2	Tr.	1.1	41	5.65	12,440	404	1,380
22	31	25	18	.01	4.2	1.5	4.4	.0	20	13	Tr.	1.2	51	6.05	14,280	579	1,960
June 1	June 10	8	10	Tr.	4.7	1.4	3.4	.0	20	6.5	.00	1.0	38	4.75	8,896	89	912
11	20	18	9.2	Tr.	4.4	1.6	2.8	[b] 6.0	7.3	5.0	Tr.	1.3	34	4.65	8,624	256	791
21	30	8	15	Tr.	4.3	1.7	3.1	[b] 2.4	12	10	.00	1.0	45	3.70	5,571	89	676
July 1	July 10	8	-------	.01	3.9	1.7	5.0	.0	23	7.6	Tr.	.5	-------	3.85	6,018	195	[a] 568
11	20	10	6.8	.03	3.4	1.1	3.4	.0	13	11	Tr.	.8	33	3.50	5,154	22	460
21	30	12	6.4	.01	4.2	1.6	3.8	.0	22	7.2	.00	.7	35	2.55	3,176	21	300
31	Aug. 9	8	5.2	.02	5.0	2.0	4.0	.0	23	8.0	.00	1.3	37	2.05	2,247	21	224
Aug. 10	19	17	7.9	Tr.	4.8	1.8	2.7	.0	23	5.4	Tr.	1.0	37	1.75	1,839	32	184
20	29	1	12	.01	6.8	2.4	3.0	.0	31	6.2	Tr.	1.0	47	1.20	1,191	2	129
30	Sept. 8	7	5.6	.01	6.0	2.8	4.3	.0	32	6.7	Tr.	1.2	43	.95	960	4	111
Sept. 9	18	3	9.5	.01	6.4	3.0	4.9	.0	34	5.7	.70	1.3	47	.70	795	5	101
19	28	1	8.5	Tr.	5.8	2.4	3.6	.0	29	5.2	1.00	1.0	42	.90	892	2	101
29	Oct. 8	5	6.7	.02	5.0	2.0	3.9	.0	26	8.3	.20	1.0	38	2.05	2,539	25	260
Oct. 9	18	4	6.6	.01	4.2	1.5	3.5	.0	20	4.7	.05	1.0	31	2.50	3,053	31	255
19	28	5	6.6	.02	5.3	1.6	2.8	.0	20	7.7	.32	1.8	33	2.35	2,830	2	252
29	Nov. 7	2	7.5	.06	4.3	1.3	3.1	.0	19	5.8	.00	1.3	35	2.00	2,176	8	206
Nov. 8	17	5	6.2	.01	4.2	1.4	2.7	.0	17	5.8	.90	1.1	31	2.00	3,833	18	320
18	27	4	6.1	.01	5.3	1.8	3.4	.0	18	11	4.0	.8	36	3.60	5,958	105	580
28	Dec. 7	2	8.2	.01	4.9	1.8	3.4	.0	18	12	2.0	1.5	40	2.25	2,651	8	286
Dec. 8	17	2	9.0	.01	5.0	2.2	3.0	.0	26	6.3	.05	.3	39	1.70	1,750	3	184
18	27	5	9.4	Tr.	5.4	2.4	3.1	.0	31	6.1	Tr.	.8	41	1.45	1,437	.4	159
28	Jan. 6	2	9.6	Tr.	5.8	2.0	3.8	.0	28	4.1	Tr.	.8	44	1.35	1,343	3.6	159
Jan. 7	16	1	10	.01	5.4	2.5	3.9	.0	28	5.2	Tr.	.8	44	1.35	1,367	5.2	162
17	26	1	11	.02	5.4	2.2	3.2	.0	31	5.7	Tr.	.5	43	1.30	1,259	6.1	146
27	31	1	11	.01	5.6	1.4	3.5	.0	29	6.5	Tr.	.7	44	1.10	1,070	2.9	127
Mean		9	12	.03	5.5	2.3	4.2	.0	28	7.4	.31	1.0	46	--------	--------	[c] 55,400	[c] 189,830

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[a] Estimated.
[b] Abnormal; computed as HCO_3 in average.
[c] Annual denudation.

Analyses of water from Yakima River at Cle Elum, Wash.

[Parts per million unless otherwise stated.]

Date (1910–11).		Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na + $\frac{3}{4}$ K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Dissolved solids.	Mean gage height (feet).	Mean discharge (second-feet).	Dissolved solids (tons per day).	Suspended matter (tons per day).
From—	To—																
Feb. 1	Feb. 10	3	10	0.12	6.4	2.5	-------	0.0	32	7.2	0.06	0.5	52	2.90	1,199	168	[a] 7.3
11	20	3	17	.18	-------	2.4	-------	.0	44	9.9	Tr.	.5	60	2.70	1,005	163	6.5
21	Mar. 2	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	2.85	1,170	[a] 218	[a] 21
Mar. 3	12	10	12	.06	6.3	3.1	2.2	.0	28	9.1	.00	.8	45	2.85	2,249	273	36
13	22	19	11	.01	-------	3.8	4.1	[b] 9.6	9.8	7.4	.35	1.5	55	5.35	5,102	758	304
23	Apr. 1	12	12	.03	5.6	2.7	3.7	[b] 9.6	13	8.4	.50	.8	56	5.10	4.434	668	143
Apr. 2	11	6	16	.01	5.5	2.7	3.3	[b] 9.8	12	6.7	.00	.5	53	4.30	2,919	416	118
12	21	15	15	.01	6.0	2.7	3.5	[b] 1.2	31	9.1	.20	1.5	54	5.00	4,189	610	147
22	May 1	10	3.2	.01	7.6	2.0	5.0	Tr.	28	3.6	Tr.	2.5	39	6.55	7,923	833	278
May 2	11	20	7.3	Tr.	6.3	2.0	4.5	.0	31	6.0	Tr.	1.7	43	5.80	6,056	704	212
12	21	10	11	.01	5.8	1.6	4.6	.0	28	5.6	Tr.	1.4	47	5.80	5,918	750	131
22	31	3	15	.01	5.8	2.2	4.2	.0	33	5.2	Tr.	1.7	52	5.40	4,918	690	17
June 1	June 10	15	22	Tr.	7.4	1.6	5.7	.0	41	5.4	Tr.	2.2	71	4.55	3,370	646	7.2
11	20	Tr.	9.9	Tr.	5.6	1.7	3.8	.0	31	5.5	Tr.	1.1	44	4.15	2,693	320	-------
21	30	15	9.2	.01	6.0	1.8	3.5	.0	24	5.2	Tr.	3.8	44	3.20	1,501	178	36
July 1	July 10	2	15	.01	6.0	1.7	4.1	.0	28	2.8	Tr.	3.6	54	2.95	1,266	185	6.3
11	20	10	9.9	.01	5.3	2.2	5.4	.0	35	3.6	Tr.	2.0	50	2.80	1,136	153	24
21	30	6	6.2	.01	6.7	2.1	5.4	.0	33	7.2	Tr.	2.3	43	2.50	871	101	12
31	Aug. 9	10	5.8	.01	7.8	2.1	4.7	.0	37	4.4	Tr.	.9	42	2.55	907	103	43
Aug. 10	19	4	9.7	.01	7.6	2.5	5.2	.0	40	4.2	Tr.	1.2	48	2.85	1,144	148	23
20	29	5	8.0	Tr.	7.8	2.8	4.0	.0	39	4.4	Tr.	1.9	49	2.80	1,134	150	10
30	Sept. 8	2	14	Tr.	12	3.9	3.3	.0	60	6.9	Tr.	1.7	68	2.25	690	127	3.0
Sept. 9	18	5	9.0	Tr.	6.7	-------	2.7	.0	31	6.9	Tr.	1.7	39	2.00	508	54	[a] 13
19	28	1	8.0	.01	6.4	2.1	3.2	.0	31	6.9	.20	1.1	42	1.60	336	38	.5
29	Oct. 8	1	7.8	.01	6.2	2.0	4.1	.0	29	8.6	.36	2.3	40	2.60	1,123	121	7.2
Oct. 9	18	5	7.4	.01	5.8	2.2	5.0	.0	31	5.0	1.5	3.1	43	3.50	1,856	216	12
19	28	3	7.9	.01	6.2	2.1	2.7	.0	28	4.7	.05	2.2	40	3.45	1,777	192	6.3
29	Nov. 7	4	7.7	.01	5.6	2.0	2.7	.0	24	3.8	.40	1.1	38	3.20	1,501	154	9.3
Nov. 8	17	2	7.6	.01	5.6	2.1	2.4	.0	24	4.3	.75	1.3	37	4.05	2,564	256	[a] 50
18	27	5	7.8	.04	5.9	1.8	2.8	.0	25	4.0	3.5	1.7	41	5.05	4,595	516	92
28	Dec. 7	2	6.7	Tr.	5.8	2.3	3.2	.0	23	10	Tr.	1.2	37	3.90	2,320	232	24
Dec. 8	17	1	8.7	.01	6.2	2.1	2.5	.0	29	11	Tr.	.8	43	3.30	1,604	186	6.9
18	27	1	6.8	Tr.	7.1	1.9	2.4	.0	32	4.6	Tr.	1.0	39	2.85	1,153	121	2.2
28	Jan. 6	2	10	.01	8.4	2.3	3.3	.0	31	8.1	.50	1.4	47	2.75	1,087	138	4.9
Jan. 7	16	1	8.5	Tr.	8.9	2.1	3.4	.0	32	8.1	.60	1.7	46	2.75	1,050	130	12
17	26	1	7.4	.01	7.3	2.1	2.8	.0	28	5.3	Tr.	1.4	40	2.45	844	91	3.9
27	31	3	7.5	Tr.	7.1	2.2	3.8	.0	32	5.1	Tr.	1.4	43	2.20	659	77	8.2
Mean-------		6	9.9	.02	6.7	2.3	3.7	.0	32	6.2	.25	1.6	47	-------	-------	[c] 108,460	[c] 18,336

[a] Estimated.

[b] Abnormal; computed as HCO_3 in average.

[c] Annual denudation.

Analyses of water from Yakima River at Prosser, Wash.

[Parts per million unless otherwise stated.]

Date (1910–11).		Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Dissolved solids.	Mean discharge (cubic feet per second).	Suspended matter (tons per day).	Dissolved matter (tons per day).
From—	To—															
Feb. 1	Feb. 10	30	25	0.24	17	6.8	13	0.0	78	20	0.95	4.5	121	4,401	237	1,437
11	20	10	50	.25	16	5.8	22	[a] 5.8	78	23	.46	6.7	169	3,271	203	1,495
21	Mar. 2	125	27	.40	15	6.5	17	.0	94	18	.15	4.3	130	4,313	455	1,514
Mar. 3	12	35	31	.42	13	4.5	13	.0	73	16	Tr.	1.9	115	12,158	525	3,776
13	22	20	24	.29	11	6.0	9.5	.0	67	12	Tr.	1.6	98	17,010	1,195	4,510
23	Apr. 1	25	23	.08	11	5.0	9.1	.0	65	6.9	.20	1.5	88	17,610	667	4,180
Apr. 2	11	18	15	.15	13	6.5	9.9	.0	72	10	.40	1.9	89	9,369	656	2,250
12	21	50	20	.02	12	4.8	8.5	.0	63	7.6	.00	2.0	90	10,486	2,520	2,548
22	May 1	15	14	.09	10	3.4	6.1	.0	50	7.9	.00	1.4	69	17,120	924	3,189
May 2	11	15	10	.20	13	3.5	6.3	.0	57	6.6	.20	1.5	73	11,620	376	2,289
12	21	25	13	.15	11	3.4	6.6	.0	49	13	.35	1.2	71	12,880	904	2,470
22	31	25	13	.12	12	3.1	9.0	.0	54	10	.10	1.3	80	9,858	878	2,160
June 1	June 10	10	16	.15	10	3.4	7.4	.0	56	8.7	.00	1.8	78	6,999	227	1,473
11	20	20	9.6	.20	12	3.4	7.2	.0	55	16	.10	1.9	75	5,136	153	1,040
21	30	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	[b] 96	2,718	[b] 81	[b] 700
July 1	July 10	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	[b] 118	1,589	[b] 47	[b] 506
11	20	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	[b] 139	1,174	[b] 32	[b] 440
21	30	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	[b] 160	528	[b] 14	[b] 228
31	Aug. [a] 9	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	[b] 182	328	[b] 6.9	[b] 162
Aug. 10	19	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	[b] 203	529	[b] 14	[b] 288
20	29	10	20	.01	29	11	30	.0	143	43	.60	12	225	408	11	223
30	Sept. 8	10	19	Tr.	19	12	27	.0	116	46	.00	14	202	400	2.6	218
Sept. 9	18	15	27	.02	37	14	35	.0	174	62	.00	16	284	373	8.1	286
19	28	12	23	.02	30	11	28	.0	140	50	.50	13	232	421	13.6	264
29	Oct. 8	4	25	.02	30	11	28	.0	138	49	1.9	13	230	970	15.7	602
Oct. 9	18	5	16	.01	24	7.4	15	.0	106	22	3.0	6.0	144	2,578	39	1,036
19	28	4	17	Tr.	16	5.4	13	.0	73	21	.10	6.0	119	1,941	31.4	624
29	Nov. 7	5	11	.05	15	4.4	12	.0	73	20	.85	4.8	129	2,204	6.0	768
Nov. 8	17	13	6.4	Tr.	16	4.8	5.4	.0	49	14	-------	4.5	85	4,937	240	1,133
18	27	38	16	.10	11	4.2	7.6	.0	52	13	Tr.	4.3	80	7,729	1,231	1,669
28	Dec. 7	10	17	.01	13	4.4	11	.0	59	19	.50	3.1	87	5,561	225	1,306
Dec. 8	17	4	16	.03	13	4.2	11	.0	65	18	Tr.	4.5	99	3,947	29.9	1,055
18	27	3	17	Tr.	15	5.2	12	.0	73	18	Tr.	5.5	111	2,867	9.3	858
28	Jan. 6	4	15	.01	16	5.2	11	.0	73	17	Tr.	5.8	110	2,656	20.1	789
Jan. 7	16	3	13	Tr.	16	5.2	11	.0	74	17	Tr.	4.8	109	2,539	6.8	747
17	26	3	16	Tr.	15	5.2	10	.0	73	14	Tr.	4.3	107	2,288	9.9	661
27	31	3	17	Tr.	18	7.2	11	.0	79	23	Tr.	4.8	125	2,046	9.9	758
Mean-------		18	19	.10	16	6.1	14	.0	80	21	.34	5.2	123	-------	[c] 120,193	[c] 492,730

[a] Abnormal; computed as HCO_3 in average.

[b] Estimated.

[c] Annual denudation.

Analyses of water from Naches River at Naches, Wash.

[Parts per million]

Date (1910). From—	To—	Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium ($Na+\frac{3}{4}K$).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Dissolved solids.
Feb. 1	Feb. 10	5	26	0.10	8.8	2.4	7.4	0.0	45	8.6	0.22	0.4	80
11	20	5	31	.13	10	2.4	7.2	.0	52	8.9	.50	.6	89
21	Mar. 2	100	25	.20	9.4	[a] 2.5	8.5	.0	47	12	Tr.	.7	82
Mar. 3	12	20	24	.15	8.8	3.1	5.7	[b] 4.3	37	8.9	Tr.	.4	74
13	22	30	20	.25	8.1	2.7	6.8	[b] 11	22	8.1	Tr.	.4	74
23	Apr. 1	40	20	.02	9.5	3.1	7.7	.0	48	3.5	.20	.2	67
Apr. 2	11	25	26	.08	9.6	3.2	6.9	.0	48	5.8	.00	.4	76
12	21	60	17	.05	8.4	3.1	7.0	.0	52	3.1	Tr.	.5	66
22	May 1	28	30	.01	7.5	2.2	5.5	.0	44	6.3	Tr.	.5	79
May 2	11	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------
12	21	25	32	.02	6.7	2.4	6.3	.0	39	2.6	.00	.3	76
22	31	15	18	.01	6.5	2.0	4.5	.0	34	2.5	.00	.3	52
June 1	June 10	10	16	.01	6.7	1.9	2.4	.0	31	3.9	--------	.3	59
11	20	10	16	.01	--------	--------	5.8	.0	29	--------	--------	.3	61
21	30	21	22	.01	6.8	2.2	4.3	.0	37	2.8	.00	.3	65
Mean		27	23	.08	8.2	2.5	6.1	.0	43	5.9	.08	.4	71

[a] Estimated.

[b] Abnormal; computed as HCO_3 in average.

Analyses of water from Klickitat River at Klickitat, Wash.

[Parts per million unless otherwise stated.]

Date (1910-11). From—	To—	Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Dissolved solids.	Mean gage height (feet).	Mean discharge (second feet).	Dissolved solids (tons per day).	Suspended matter (tons per day).
Feb. 1	Feb. 10	25	33	0.65	7.4	3.8	9.3	0.0	45	7.7	0.71	4.7	103	3.50	2,859	795	68
11	20	20	38	.40	7.0	3.4	11	.0	51	8.6	.43	1.5	97	3.00	2,193	574	71
21	Mar. 2	25	32	.15	7.6	4.5	8.8	.0	50	9.5	Tr.	1.2	92	4.55	4,509	1,120	231
Mar. 3	12	25	28	.19	--------	4.0	6.3	.0	48	5.8	Tr.	1.5	87	6.00	6,591	1,540	373
13	22	15	32	.17	7.6	3.5	7.1	.0	52	7.1	Tr.	1.1	90	5.90	6.428	1,560	312
23	Apr. 1	15	30	.07	6.3	2.6	6.8	.0	44	7.6	--------	.5	78	4.55	4,424	931	248
Apr. 2	11	15	27	.07	8.4	2.7	6.3	.0	45	11	--------	.1	80	3.80	3,330	718	108
12	21	50	37	.06	6.3	2.9	7.6	.0	43	5.7	.10	.9	86	4.00	3,578	830	251
22	May 1	20	20	.02	5.6	3.9	8.0	.0	37	14	.10	.8	68	4.20	3,961	728	321
May 2	11	40	11	.02	5.3	3.2	7.1	.0	35	11	.10	.1	54	3.95	3,542	515	564
12	21	7	28	.04	5.2	2.4	5.3	.0	37	3.5	Tr.	1.2	70	3.65	3,094	585	68
22	31	10	26	.04	5.5	2.1	5.4	.0	37	3.5	.00	1.2	67	3.40	2,771	502	61
June 1	June 10	10	30	.01	6.8	2.9	5.6	.0	43	7.3	Tr.	1.1	75	3.00	2,230	451	49
11	20	25	22	.04	5.6	3.2	5.4	.0	44	5.5	--------	.5	63	2.80	1,943	330	126
21	30	8	38	.05	7.9	3.0	6.0	.0	48	7.2	.00	1.2	93	2.50	1,586	398	64
July 1	July 10	18	24	.03	7.4	3.0	8.4	.0	49	9.1	.00	1.2	76	2.40	1,454	298	71
11	20	22	29	.23	6.0	3.4	5.2	.0	44	--------	--------	1.0	75	2.30	1,368	277	89
21	30	9	25	.13	7.6	2.8	6.1	.0	40	7.7	--------	1.2	72	2.15	1,167	227	38
31	Aug. 9	15	21	.07	6.3	2.8	6.2	.0	40	5.1	--------	1.1	69	2.05	1,090	203	35
Aug. 10	19	10	26	.05	5.8	3.1	5.4	.0	41	4.8	.05	.8	71	2.00	1,025	197	36
20	29	20	25	.16	6.1	3.4	6.4	.0	40	7.0	.45	1.2	75	1.90	945	192	59
30	Sept. 8	10	30	.06	6.4	3.3	5.2	.0	48	5.3	.00	.1	73	1.85	887	175	39
Sept. 9	18	5	30	.02	9.2	4.6	6.3	.0	64	6.0	.13	.8	85	1.80	849	195	11
19	28	15	24	.24	6.9	3.2	5.2	.0	41	8.9	.05	1.1	77	1.85	892	185	38
29	Oct. 8	30	25	.07	6.2	3.0	6.9	.0	42	9.3	.70	1.7	76	2.05	1,097	225	89
Oct. 9	18	4	27	.02	7.6	3.4	7.3	.0	49	--------	.35	2.0	83	1 95	980	220	11
19	28	3	27	.15	7.3	3.0	6.1	.0	46	5.5	.05	1.5	76	1 95	980	201	9
29	Nov. 7	3	21	.04	7.6	3.5	6.5	.0	48	--------	.36	2.0	84	1.85	868	197	4
Nov. 8	17	10	--------	.03	5.9	2.7	5.3	.0	39	4.4	.80	1.0	68	2.30	1,368	251	32
18	27	4	21	.02	8.2	3.0	5.7	.0	38	5.6	.20	1.1	72	2.50	1,628	316	57
28	Dec. 7	10	26	.30	9.2	3.2	5.4	.0	43	11	Tr.	1.0	81	2.60	1,711	375	55
Dec. 8	17	10	27	.50	6.2	2.2	6.1	.0	41	3.6	Tr.	.7	83	2.50	1,585	354	21
18	27	3	28	.12	8.1	3.0	5.2	.0	44	3.8	Tr.	1.0	81	2.25	1,301	284	8
28	Jan. 6	5	28	.05	9.1	3.2	6.9	.0	45	8.5	Tr.	1.1	80	2.15	1,185	256	15
Jan. 7	16	3	--------	.07	8.0	3.0	6.9	.0	47	5.1	Tr	.9	80	2.00	1,045	226	10
17	26	8	28	.25	9.0	3.6	7.2	.0	45	11	Tr.	1.2	86	2.40	1,463	340	25
27	31	12	29	.35	8.1	3.6	7.4	.0	46	6.7	Tr.	1.4	85	2.20	1,218	279	49
Mean		15	27	.13	7.1	3.2	6.6	.0	44	7.2	.15	1.2	79	--------	--------	[a] 169,100	[a] 36,920

[a] Annual denudation.

Reduced to percentage form, the averages of the seven tables are as follows:

Reduced analyses of water from upper tributaries of the Columbia in Washington.

1. Spokane River at Spokane. 35 composite analyses.
2. Okanogan River at Okanogan. 32 composites.
3. Wenatchee River at Cashmere. 37 composites.
4. Yakima River at Cle Elum. 36 composites.
5. Yakima River, at Prosser. 37 composites.
6. Naches River at Naches. A tributary of the Yakima. 15 composites.
7. Klickitat River at Klickitat. 37 composites.

	1	2	3	4	5	6	7
CO_3	36.57	37.95	29.79	34.24	32.52	31.31	29.09
SO_4	14.25	15.22	15.85	13.27	17.34	8.95	9.70
Cl	.93	.76	2.14	3.42	4.29	.59	1.62
NO_3	.31	.28	.70	.64	.25	.15	.20
Ca	17.05	19.97	11.79	14.34	13.21	12.17	9.56
Mg	5.58	4.38	4.92	4.93	5.04	3.71	4.31
Na,K	8.21	8.09	9.00	7.92	11.55	9.05	8.89
Fe_2O_3	.05	.03	.10	.06	.12	.15	.27
SiO_2	17.05	13.32	25.71	21.18	15.68	34.12	36.36
	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Salinity, parts per million	64.5	105	46.6	46.7	121	67.4	74

SNAKE RIVER.

Snake River, which drains an area of 109,000 square miles, is the largest tributary or branch of the Columbia. Its headwaters are near the Continental Divide in the Yellowstone National Park, western Wyoming, and northeastern Idaho. Much of its course is through the Columbia River basalt. In addition to the analyses given here, Van Winkle cites other partial analyses of water from Malheur and Powder rivers,[52] but they are too incomplete for present use.

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[52] U. S. Geol. Survey Water-Supply Paper 363, pp. 57, 58, 59, 1914.

Analyses of water from Snake River near Weiser, Idaho.

[Parts per million except as otherwise designated.]

Date (1911–12).		Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Dissolved solids.	Mean gage height (feet).	Mean discharge (second-feet).	Suspended matter (tons per day).	Dissolved matter (tons per day).
From—	To—																
Aug. 11	Aug. 20	6	34	0.08	33	14	31	0.0	142	43	1.2	20	247	5.1	6,830	159	4,555
21	30	9	29	.02	37	15	30	.0	149	48	1.4	22	253	5.0	6,620	232	4,520
31	Sept. 9	18	31	.08	35	15	29	Tr.	153	45	1.05	22	253	4.9	6,164	216	4,205
Sept. 10	19	12	28	.10	38	15	30	Tr.	150	49	--------	23	254	5.0	6,620	------------	4,535
20	29	5	31	.04	36	14	33	.0	150	46	.80	23	258	5.2	7,510	324	5,245
30	Oct. 9	10	31	Tr.	35	15	30	Tr.	156	47	.80	23	259	5.5	8,686	351	6,070
Oct. 10	19	20	26	.01	37	13	31	Tr.	154	47	.82	23	256	6.7	14,968	4,640	10,340
20	29	30	28	.01	38	13	27	.0	155	45	.44	21	253	6.7	15,050	1,032	10,400
30	Nov. 8	8	26	.01	38	13	25	.0	155	44	.70	21	257	6.4	13,310	467	9,230
Nov. 9	18	25	18	.01	40	12	30	Tr.	160	43	--------	21	258	6.8	15,370	787	11,150
19	28	7	21	.04	37	12	27	Tr.	156	44	.80	21	253	6.5	14,160	283	9,665
29	Dec. 8	10	22	.02	35	12	27	.0	156	39	.60	24	241	6.1	11,950	238	7,765
Dec. 9	18	3	29	.11	41	11	30	2.4	155	44	.54	22	256	6.6	14,300	116	9,878
19	28	5	28	.02	42	12	28	Tr.	163	42	.50	22	260	6.6	14,210	422	9,970
29	Jan. 7	5	29	.01	42	12	28	.0	159	43	.60	21	259	6.2	12,000	104	8,380
Jan. 8	17	10	29	.02	39	11	27	.0	154	43	1.1	20	250	6.8	15,540	277	10,480
18	27	80	27	.01	38	8.6	27	.0	154	40	.76	21	242	7.2	17,600	5,126	11,500
28	Feb. 6	80	29	Tr.	36	4.8	30	.0	146	38	.60	20	238	7.1	17,260	2,655	11,085
Feb. 7	16	100	26	.01	31	12	29	.0	138	37	.40	19	263	7.5	19,600	6,665	13,910
17	26	120	34	.06	29	5.2	26	.0	125	33	.63	17	212	7.8	21,320	8,220	12,200
27	Mar. 7	20	32	.05	31	9.0	27	4.6	136	36	.72	20	245	6.9	15,840	1,495	10,465
Mar. 8	17	90	24	.05	34	6.4	30	4.3	129	39	.66	18	223	7.3	18,080	4,435	10,875
18	27	60	23	.02	32	7.6	28	9.6	114	37	.30	18	217	7.2	17,840	2,455	10,447
28	Apr. 6	110	28	.04	26	7.2	21	14	101	25	.21	12	175	8.6	26,100	14,930	12,315
Apr. 7	16	155	20	.05	21	3.2	15	Tr.	83	21	.30	9.0	138	9.9	35,450	21,450	13,202
17	26	225	22	.09	25	6.4	19	.0	96	24	.27	11	161	9.4	31,660	23,250	13,770
27	May 6	100	18	.12	20	5.4	17	11	63	19	1.4	8.5	132	10.4	39,240	24,120	13,970
May 7	16	85	19	.03	22	7.4	17	9.6	73	21	Tr.	10	143	10.6	40,790	16,010	15,735
17	26	70	22	.06	28	7.6	16	Tr.	94	23	Tr.	9.8	154	12.3	54,760	26,590	22,760
27	June 5	90	20	.05	26	7.3	15	.0	94	17	.13	7.0	144	12.6	57,810	19,630	22,470
June 6	15	110	20	.08	25	3.8	9.8	.0	93	17	.24	7.5	152	13.7	67,360	48,300	27,640
16	25	80	16	.02	25	5.0	8.8	17	72	17	.36	6.9	134	12.7	58,450	22,690	21,135
26	July 5	50	18	.01	31	6.2	13	Tr.	117	24	.28	10	174	10.4	38,900	6,026	18,270
July 6	15	85	26	.02	30	6.0	22	.0	123	27	.66	11	186	8.5	25,810	6,540	12,950
16	25	100	33	.01	32	8.2	27	.0	131	38	.48	15	226	6.7	14,660	4,154	8,930
26	Aug. 4	280	42	Tr.	26	10	28	2.6	135	25	.16	19	238	6.0	11,260	8,810	7,225
Aug. 5	14	600	39	Tr.	34	10	30	Tr.	139	39	1.2	22	268	6.3	12,907	16,875	9,340
Mean		80	26	.04	33	9.6	[a] 22 [a] 3.5	2.0	130	35	.6	17	220	--------	--------	[b] 3,042,000	[b] 4,208,000

[a] Sodium and potassium, determined on combined alkali residues.

[b] Total annual denudation.

Analyses of water from Snake River at Burbank, Wash.

[Parts per million unless otherwise stated.]

Date (1910-11).		Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Dissolved solids.	Mean gage height (feet).	Mean discharge (second-feet).	Dissolved matter (tons per day).	Suspended matter (tons per day).
From—	To—																
Mar. 13	Mar. 22	240	24	0.20	14	5.1	12	[a] 4.8	56	15	Tr.	3.5	124	344.70	163,700	54,800	88,800
23	Apr. 1	185	26	.10	13	2.3	10	.0	59	14	0.28	3.8	102	45.66	185,000	50,900	104,900
Apr. 2	11	60	32	.05	17	3.7	9.4	.0	74	15	.25	4.5	120	43.10	127,900	41,400	33,200
12	21	60	14	.20	12	2.7	8.0	.0	52	15	.23	3.2	79	45.38	178,000	38,000	43,700
22	May 1	40	6.6	.01	10	3.5	8.5	.0	50	12	--------	3.8	69	46.93	214,500	39,900	52,100
May 2	11	10	15	.01	13	4.3	9.1	.0	57	21	.00	3.5	90	45.28	175,400	42,600	14,700
12	21	15	20	.02	13	3.2	9.3	.0	55	18	.00	2.2	93	45.49	180,600	45,300	23,500
22	31	12	16	.02	12	3.2	9.0	.0	54	14	.00	2.2	84	43.66	139,400	31,600	15,810
June 1	June 10	20	19	.02	13	3.9	9.0	.0	60	12	.10	3.1	88	42.75	120,800	28,700	16,310
11	20	12	13	.01	14	3.9	8.4	.0	57	15	.10	4.1	80	40.45	77,840	16,600	11,000
21	30	25	13	.01	14	3.3	8.2	.0	59	15	1.3	4.7	89	38.47	47,640	11,400	3,340
July 1	July 10	20	18	.02	16	4.7	10	.0	71	17	Tr.	5.6	105	37.21	32,330	9,170	6,020
11	20	15	20	.01	19	5.4	15	.0	82	17	Tr.	5.8	121	36.35	24,350	7,960	1,310
21	30	15	21	.01	22	5.4	15	.0	93	20	.95	7.3	138	35.79	20,600	7,680	723
31	Aug. 9	15	19	.02	22	6.5	16	.0	96	19	2.5	7.8	137	35.17	17,390	6,430	338
Aug. 10	19	65	13	.09	18	6.5	17	.0	99	20	Tr.	8.5	141	34.79	15,760	6,030	4,700
20	29	19	20	.05	22	7.1	18	.0	100	22	1.7	10	154	34.44	14,450	6,010	780
30	Sept. 8	20	17	.01	23	7.4	15	.0	101	22	.00	10	149	34.78	15,720	6,330	1,060
Sept. 9	18	18	19	.05	24	7.7	19	.0	104	25	1.0	11	158	34.69	15,300	6,180	580
19	28	135	19	.28	25	7.0	20	.0	104	31	1.7	11	171	35.51	19,050	7,090	4,310
29	Oct. 8	100	24	.20	24	7.7	21	.0	109	28	.50	13	177	35.80	21,290	10,200	4,430
Oct. 9	18	20	21	.02	22	7.2	18	.0	95	24	2.5	13	159	36.17	22,990	9,870	1,240
19	28	15	19	.03	24	7.6	17	.0	101	24	1.1	13	160	36.29	23,950	10,300	1,034
29	Nov. 7	20	19	.03	23	7.6	17	.0	101	26	.75	13	160	36.26	23,660	10,200	1,400
Nov. 8	17	10	17	Tr.	21	7.0	15	.0	89	32	Tr.	8.6	143	37.79	39,630	15,200	3,080
18	27	18	19	.01	20	5.8	13	.0	83	23	Tr.	8.0	135	37.99	41,660	15,300	6,100
28	Dec. 7	35	19	.10	21	6.4	15	.0	90	27	Tr.	8.8	146	38.14	43,340	17,000	4,680
Dec. 8	17	90	24	.05	20	5.6	14	.0	92	19	.40	10	146	37.85	39,650	15,600	7,170
18	27	60	23	.02	23	5.6	15	.0	85	23	Tr.	10	160	36.93	29,410	12,700	3,580
28	Jan. 6	11	22	Tr.	25	6.4	16	.0	102	24	.50	13	162	36.56	26,110	10,900	1,620
Jan. 7	16	2	21	.01	24	6.3	15	.0	98	23	.50	13	155	36.55	26,010	10,500	337
17	26	3	20	Tr.	26	6.4	14	.0	100	22	Tr.	14	161	36.93	29,530	12,800	621
27	31	6	22	Tr.	28	7.8	18	.0	109	35	.50	14	168	36.44	25,100	11,400	393
Mean		42	19	.05	19	5.6	14	.0	83	21	.53	8.1	131	--------	--------	[b] 6,824,000	[b] 5,049,000

[a] Abnormal; computed as HCO_3 in average.

[b] Annual denudation.

Analyses of water from Owyhee River near Owyhee, Oreg.

[Parts per million except as otherwise designated.]

Date (1911-12).		Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Dissolved solids.	Mean gage height (feet).	Mean discharge (second-feet).	Suspended matter (tons per day).	Dissolved matter (tons per day).
From—	To—																
Aug. 11	Aug. 20	40	38	0.08	58	20	76	[a] Tr.	262	95	2.0	32	445	2.03	4.4	0.38	5.3
21	30	30	40	.01	58	19	79	[a] Tr.	289	97	1.3	32	472	2.05	5.0	.38	6.4
31	Sept. 9	50	40	.01	55	14	69	0.0	290	96	.60	34	472	2.05	5.0	.38	6.4
Sept. 10	19	50	36	.11	47	17	78	.0	258	87	.64	33	438	2.09	7.0	.79	8.3
20	29	30	35	.11	52	18	78	[a] Tr.	266	90	.88	33	451	2.15	10.0	.57	12.2
30	Oct. 9	25	31	.10	37	12	61	.0	204	65	.72	24	334	2.24	21.4	1.1	19.4
Oct. 10	19	60	35	.12	29	11	61	.0	186	51	1.0	21	334	2.43	59	11.9	53
20	29	65	35	.11	24	6.4	52	.0	158	39	.60	16	264	2.38	46	3.1	33
30	Nov. 8	25	38	.22	26	6.2	51	.0	160	43	.56	16	275	2.35	38	1.9	28
Nov. 9	18	35	33	.42	26	6.4	49	.0	148	43	.54	15	261	2.42	56	.7	39
19	28	20	33	.22	21	4.8	49	.0	146	34	.36	16	243	2.54	95	2.6	62
29	Dec. 8	11	28	.05	22	5.2	45	.0	139	36	.58	15	230	2.57	105	5.4	65
Dec. 9	18	5	36	.10	21	5.0	46	.0	134	34	.26	12	224	2.67	147	.0	89
19	28	20	35	.11	22	4.2	47	.0	142	33	.40	15	237	2.80	206	8.3	131
20	Jan. 7	20	34	.12	24	6.4	51	.0	155	46	.44	16	260	3.20	210	16.5	147
Jan. 8	17	140	33	.01	23	4.8	47	.0	144	32	.66	13	231	3.8	410	118	255
18	27	400	24	.01	22	4.6	38	.0	122	26	.56	12	197	4.0	695	710	370
28	Feb. 6	100	29	.02	18	3.8	32	.0	109	23	.40	9.0	172	3.6	611	119	283
Feb. 7	16	100	27	.02	16	4.0	29	.0	104	24	.52	8.5	164	3.9	932	211	412
17	26	175	22	.11	12	3.1	19	.0	68	12	1.1	5.3	120	4.8	1,928	988	625
27	Mar. 7	75	25	.08	16	1.0	20	.0	76	14	1.5	2.0	123	3.6	742	88	245
Mar. 8	17	170	14	.05	15	2.0	20	[a] 14	53	13	.12	4.2	121	4.4	1,478	574	483
18	27	100	31	.35	16	4.0	21	[a] Tr.	88	17	.66	6.0	152	3.9	949	167	389
28	Apr. 6	125	24	.45	12	2.8	13	.0	54	13	1.2	2.8	104	6.4	4,188	3,020	1,175
Apr. 7	16	100	21	.23	10	2.8	9.1	.0	43	12	.22	2.0	88	7.3	6,466	3,070	1,533
17	26	340	27	.35	11	2.9	14	.0	59	12	.36	3.0	110	7.4	7,120	6,935	2,110
27	May 6	120	22	.07	14	2.0	12	[a] 26	1.2	7.2	.44	2.5	98	7.8	7,892	4,620	2,080
May 7	16	90	27	.06	18	1.8	12	.0	67	11	.36	2.8	117	7.3	6,387	1,657	2,015
17	26	90	27	.10	18	2.4	12	.0	74	8.7	--------	3.0	125	7.2	6,152	1,643	2,073
27	June 5	60	70	.15	22	2.8	19	.0	110	10	.32	5.5	210	6.3	4,202	1,179	2,380
June 6	15	750	21	.01	23	2.9	16	.0	98	13	.42	3.5	142	5.6	2,959	14,099	1,135
16	25	40	18	.10	22	4.1	20	.0	104	11	.30	5.5	139	4.7	1,792	377	670
26	July 5	30	32	.08	28	5.9	25	.0	128	18	.30	8.8	198	3.6	754	77	403
July 6	15	25	30	.10	23	3.8	24	.0	128	18	1.0	8.0	181	3.1	396	26	193
16	25	1,200	38	.08	28	6.8	42	[a] Tr.	156	38	1.2	12	249	2.8	243	426	164
26	Aug. 4	675	31	.02	29	7.2	42	[a] 4.8	156	35	.36	14	250	2.4	62	52	42
Aug. 5	14	800	39	.20	28	7.4	50	.0	170	40	.20	14	276	2.5	89	110	66
Mean		167	31	.12	26	6.4	[b] 35 [b] 4.6	.0	139	35	.64	13	230	--------	--------	[c] 397,800	[c] 195,400

[a] Abnormal, computed as HCO_3 in average.

[b] Sodium and potassium, determined on the combined alkali residues.

[c] Total annual denudation.

Analyses of water from Powder River near North Powder, Oreg.

[Parts per million except as otherwise designated.]

Date (1911-12). From—	Date (1911-12). To—	Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Dissolved solids.	Mean gage height (feet).	Mean discharge (second-feet).	Suspended matter (tons per day).	Dissolved matter (tons per day).
Aug. 11	Aug. 20	3	32	0.06	20	8.8	48	0.0	157	36	1.70	12	231	0.71	3.4	0.05	2.1
21	30	10	25	.05	21	8.8	39	.0	151	30	1.50	11	213	.69	3.1	.04	1.8
31	Sept. 9	5	26	.11	22	8.9	39	.0	160	27	.56	9.8	216	.67	2.8	.05	1.6
Sept. 10	19	5	25	.05	24	9.2	36	[a] Tr.	162	35	.16	13	231	.79	5.2	.06	3.2
29	29	1	21	.04	27	9.0	42	.0	160	36	.40	12	230	.89	7.7	.12	4.8
30	Oct. 9	2	23	Tr.	29	9.8	43	.0	177	40	.32	13	247	1.00	11.3	.13	7.5
Oct. 10	19	4	27	.05	30	10	39	.0	166	36	.50	11	234	1.14	16.5	.32	10.4
20	29	5	26	.22	28	9.6	37	.0	155	32	.44	9.5	222	1.17	18	.31	10.8
30	Nov. 8	1	25	.02	25	6.2	29	.0	140	25	.50	7.2	196	1.4	31	.22	16.4
Nov. 9	18	80	25	.11	27	6.4	45	.0	166	38	.80	11	249	1.8	80	52	54
19	28	30	26	.02	23	5.8	32	.0	137	28	.88	6.8	197	1.6	45	1.6	24
29	Dec. 8	3	22	.02	24	5.2	24	.0	126	18	.50	5.8	173	1.7	[b] 35	.4	16
Dec. 9	18	1	27	.02	22	5.2	27	.0	132	18	.20	5.8	178	1.6	[b] 30	.4	14
19	28	1	26	.10	22	5.2	27	.0	131	22	.22	6.2	177	1.8	[b] 30	.0	14
29	Jan. 7	1	23	.01	25	5.2	24	.0	132	18	.40	6.0	171	1.9	[b] 45	.15	21
Jan. 8	17	3	22	.06	22	4.4	24	.0	118	15	.48	5.8	154	2.4	[b] 50	.15	21
18	27	2	24	.10	23	3.8	28	.0	137	19	.40	1.0	176	2.3	[b] 50	.5	24
28	Feb. 6	90	21	.05	21	3.2	29	.0	137	17	.44	5.8	214	2.1	[b] 50	21.5	29
Feb. 7	16	210	27	.06	20	6.3	38	.0	148	27	1.00	6.8	205	2.8	212	153	117
17	26	55	33	.07	26	6.6	41	.0	178	33	.96	6.8	244	2.9	352	56	232
27	Mar. 7	50	28	.08	26	7.8	33	.0	151	31	1.30	6.3	220	2.3	192	32	114
Mar. 8	17	90	31	.12	30	7.4	42	.0	177	28	.99	7.3	296	2.7	281	79	164
18	27	100	30	.10	23	7.8	32	.0	139	23	1.5	4.8	190	2.9	354	127	182
28	Apr. 6	80	25	.11	18	4.8	21	[a] 7.2	92	19	.42	2.8	150	3.5	634	53	256
Apr. 7	16	100	31	.12	19	5.4	18	.0	92	15	.75	2.0	146	4.3	779	330	307
17	26	30	22	.16	20	5.8	15	[a] 9.6	84	16	.34	2.0	144	3.5	520	122	202
27	May 6	20	29	.25	19	5.3	15	[a] 4.8	95	14	.40	3.9	147	3.4	487	42	193
May 7	16	35	33	.26	17	4.9	15	.0	90	16	.44	1.3	141	3.4	477	71	181
17	26	80	32	.04	18	5.5	22	.0	109	11	.60	3.3	160	5.0	1,001	748	432
27	June 5	10	22	.03	18	5.6	18	.0	93	15	.30	2.8	142	6.0	1,344	83	511
June 6	15	15	23	.07	16	5.5	17	.0	94	12	.40	2.3	143	6.7	1,587	77	612
16	25	11	23	.06	16	4.6	14	[a] Tr.	83	9.7	.22	2.5	128	5.6	1,225	66	423
26	July 5	10	24	.05	18	5.5	19	.0	104	14	.10	4.6	151	--------	[b] 1,023	44	417
July 6	15	15	19	.04	19	6.1	27	.0	126	19	.32	6.0	160	--------	[b] 821	31	355
16	25	25	20	.03	24	6.4	39	[a] 10	132	30	.30	7.5	206	--------	[b] 619	20	344
26	Aug. 4	50	32	.04	26	6.9	43	[a] Tr.	179	26	.20	7.3	243	--------	[b] 417	13	274
Aug. 5	14	80	30	.02	28	7.8	30	.0	148	23	.40	7.8	220	--------	[b] 215	16	128
Mean		35	26	.08	23	6.5	[c] 27 [c] 4.1	.0	136	24	.58	6.5	193	--------	--------	[d] 22,100	[d] 56,400

[a] Abnormal; computed as HCO_3 for average. [b] Estimated. [c] Sodium and potassium, determined on combined alkali residues. [d] Total annual denudation.

Analyses of water from Grande Ronde River at Elgin, Oreg.

[Parts per million except as otherwise designated.]

Date (1911-12). From—	Date (1911-12). To—	Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Dissolved solids.	Mean gage height (feet).	Mean discharge (second-feet).	Suspended matter (tons per day).	Dissolved matter (tons per day).
Aug. 11	Aug. 20	10	41	0.25	13	3.7	11	0.0	66	4.1	1.6	1.5	114	1.2	24	0.71	7.4
21	30	19	39	.42	14	4.7	6.8	.0	66	5.6	.52	.50	114	1.1	19	1.18	5.8
31	Sept. 9	20	35	.20	13	4.4	8.2	.0	64	7.6	1.60	.75	110	1.2	24	1.17	7.1
Sept. 10	19	20	32	.12	15	7.0	11	.0	93	4.8	.88	2.0	125	1.3	33	1.42	11.1
20	29	20	39	.25	15	3.2	14	.0	92	10	.52	3.0	135	1.4	35	2.08	12.6
30	Oct. 9	10	31	.05	12	5.2	13	.0	76	5.6	.48	2.3	106	1.5	48	1.68	14
Oct. 10	19	10	38	.10	11	4.4	11	.0	67	5.4	1.0	2.0	97	1.6	72	1.59	19
20	29	3	31	.11	13	3.8	13	.0	71	5.9	.48	2.3	108	1.6	63	.68	18
30	Nov. 8	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	[a] 1.60	[a] 22
Nov. 9	18	5	29	.08	12	2.6	12	.0	68	3.8	.40	1.5	100	1.7	97	2.62	26
19	28	10	32	.22	11	3.4	12	.0	64	3.8	.60	2.0	104	1.8	115	2.73	32
29	Dec. 8	4	25	.24	16	3.2	11	.0	67	14	.36	1.6	109	1.7	99	2.03	29
Dec. 9	18	3	26	.20	12	3.5	9.0	.0	60	8.1	Tr.	1.9	94	1.7	96	1.19	24
19	28	4	32	.15	11	2.8	11	.0	59	4.6	1.4	5.3	106	1.7	90	.78	26
29	Jan. 7	7	28	.15	9.7	3.0	12	.0	56	6.6	--------	3.0	104	1.8	73	1.18	21
Jan. 8	17	20	25	.15	9.0	1.4	8.2	.0	43	5.8	1.3	.85	85	2.6	549	47.26	126
18	27	60	20	.35	8.8	2.0	8.8	.0	39	5.4	2.4	1.8	78	3.2	980	193	230
28	Feb. 6	22	33	.16	8.6	3.8	6.3	.0	46	3.6	1.8	1.8	105	3.1	866	75	245
Feb. 7	16	60	29	.14	7.8	3.0	5.2	.0	40	3.1	1.2	1.8	84	3.8	1,716	380	389
17	26	50	34	.35	7.3	.80	9.5	.0	45	6.3	2.2	.25	100	4.1	2,236	307	604
27	Mar. 7	20	23	.70	10	1.4	14	[b] 4.1	45	5.6	.30	1.8	110	3.0	636	20.6	189
Mar. 8	17	40	29	.38	10	4.0	11	.0	56	7.1	.75	2.5	110	3.1	822	53	242
18	27	45	33	.58	9.4	1.6	10	.0	47	4.4	.54	1.5	107	3.2	981	100	281
28	Apr. 6	55	30	.60	7.6	1.2	9.0	.0	38	4.3	.45	.50	95	4.9	3,545	727	957
Apr. 7	16	75	25	.60	6.4	.80	7.9	.0	34	2.5	.90	.25	88	6.4	6,088	1,165	1,446
17	26	30	31	.55	6.2	--------	11	.0	38	2.6	.18	.50	96	5.1	3,856	364	998
27	May 6	35	26	.55	6.4	--------	8.5	.0	35	2.6	.27	.25	93	6.0	5,430	498	1,363
May 7	16	25	22	.25	6.2	.96	7.9	.0	33	4.6	.42	.40	78	6.5	6,430	503	1,353
17	26	15	26	.20	6.6	.56	4.7	.0	30	3.1	.32	.45	76	6.3	6,070	491	1,245
27	June 5	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	6.3	5,890	[a] 399	[a] 1,070
June 6	15	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	5.4	4,288	[a] 307	[a] 894
16	25	15	27	.18	7.8	.20	6.0	.0	40	3.5	.36	1.1	84	4.7	3,171	214	718
26	July 5	10	26	.28	8.2	.20	7.2	.0	44	3.5	.30	.85	81	3.7	1,512	122	331
July 6	15	50	24	.01	8.4	3.0	6.3	.0	48	4.0	.22	1.5	77	2.6	4,874	421	1,013
16	25	50	25	.01	10	3.4	7.2	[b] 11	30	8.9	.40	1.5	88	2.2	2,656	229	631
26	Aug. 4	40	32	.01	12	4.2	5.4	.0	58	5.9	.24	1.8	103	2.0	1,853	150	515
Aug. 5	14	40	30	.01	12	4.0	7.7	.0	64	4.1	.34	2.0	101	2.0	1,846	110	503
Mean		27	30	.25	10	2.8	[c] 7.8 [c] 2.0	.0	54	5.3	.75	1.6	99	--------	--------	[d] 68,000	[d] 154,100

[a] Estimated.
[b] Abnormal; computed as HCO_3 in average.
[c] Sodium and potassium, determined on combined alkali residues.
[d] Total annual denudation.

Analyses of water from Wallowa River near Joseph, Oreg.

[Parts per million except as otherwise designated.]

Date (1911-12).		Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Dissolved solids.	Mean gage height (feet).	Mean discharge (second-feet).	Suspended matter (tons per day).	Dissolved matter (tons per day).
From—	To—																
Aug. 18	Aug. 31	1	14	0.01	16	1.3	0.8	0.0	45	7.9	Tr.	0.25	68	2.35	148	0.48	.27
Sept. 1	Sept. 30	1	4.1	.11	15	1.3	3.8	.0	53	8.7	0.32	.50	72	2.14	90	.49	17
Oct. 1	Oct. 31	3	12	Tr.	14	.90	4.5	.0	48	7.1	.42	.60	64	2.09	78	.23	13
Nov. 1	Nov. 30	1	8.6	Tr.	15	.88	3.5	.0	44	7.6	.46	.65	60	2.02	63	.05	10
Dec. 1	Dec. 31	2	7.7	.01	16	1.2	4.6	.0	50	8.7	.12	.20	65	2.0	65	.00	11
Jan. 1	Jan. 31	1	18	.10	16	.70	4.2	.0	46	7.2	.16	.65	62	2.0	57	.09	9.5
Feb. 1	Feb. 29	Tr.	9.6	Tr.	17	.70	3.5	.0	49	8.4	.30	.75	66	2.0	60	Tr.	10.7
Mar. 1	Mar. 31	Tr.	7.3	.01	14	.50	5.5	.0	46	9.5	.12	.25	63	1.9	51	Tr.	8.7
Apr. 1	Apr. 30	Tr.	9.6	.03	15	.04	4.3	[a] Tr.	46	7.2	.22	.50	63	2.1	70	Tr.	12
May 1	May 31	Tr.	8.9	Tr.	16	.04	4.9	.0	48	9.8	.20	.50	66	2.4	180	Tr.	32
June 1	June 30	Tr.	9.0	Tr.	14	.06	6.3	[a] 6.7	31	11	.06	.75	63	3.2	549	Tr.	93
July 1	July 31	Tr.	11	Tr.	14	.10	6.8	.0	46	9.4	.10	.75	63	2.9	385	Tr.	65
Aug. 1	Aug. 15	Tr.	11	Tr.	13	.10	6.1	.0	44	7.4	.20	1.0	62	2.8	316	Tr.	53
Mean		1	10	.02	15	.6	[b]3.8 [b]1.0	.0	47	8.5	.21	.55	64	....	....	[c] 33.5	[c] 9,790

[a] Abnormal; computed as HCO_3 in average.

[b] Sodium and potassium, determined on combined alkali residues.

[c] Total annual denudation.

These six tables of analyses, reduced to standard form and expressed in percentages, compare as follows:

Reduced analyses of waters in Snake River basin.

1. Snake River at Weiser, Idaho. 37 composite analyses.
2. Snake River at Burbank, Wash. 33 composites.
3. Owyhee River near Owyhee, Oreg. 37 composites.
4. Powder River near North Powder, Oreg. 37 composites.
5. Grande Ronde River at Elgin, Oreg. 37 composites.
6. Wallowa River near Joseph, Oreg. A tributary of the Grande Ronde. 13 composites.

	1	2	3	4	5	6
CO_3	30.99	31.85	31.06	36.22	30.50	36.81
SO_4	16.46	16.40	15.90	12.99	6.08	13.54
Cl	7.99	6.32	5.91	3.52	1.84	.87
NO_3	.28	.39	.27	.32	.92	.33
Ca	15.52	14.83	11.80	12.46	11.47	23.89
Mg	4.51	4.37	2.91	3.52	3.21	.96
Na	10.34	10.93	15.90	14.62	8.95	6.05
K	1.65	....	2.09	2.22	2.29	1.59
Fe_2O_3	.04	.08	.09	.05	.34	.03
SiO_2	12.22	14.83	14.07	14.08	34.40	15.93
	100.00	100.00	100.00	100.00	100.00	100.00
Salinity, parts per million	213	128	220	185	87	63

The first four of these analyses are much alike and show the influence upon the waters of volcanic rocks, and especially of the Columbia River basalt. Grande Ronde River is quite different, and so too is Wallowa River, which drains an area of sedimentary rocks. Its low proportion of magnesium is very unusual.

SOUTHERN TRIBUTARIES OF THE COLUMBIA.

In Water-Supply Paper 363 Van Winkle gives tables of analyses of the following southern tributaries of the Columbia: Umatilla River, John Day River, Deschutes River and its tributary Crooked River, Sandy River and its tributary Bull Run River, Willamette River and its tributaries McKenzie, Santiam, and Clackamas rivers. The courses of these streams are all in Oregon.

Analyses of water from Umatilla River, Oreg.

[Parts per million except as otherwise designated.]

Date.		Turbidity.	Silica (SiO2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO3).	Bicarbonate radicle (HCO3).	Sulphate radicle (SO4).	Nitrate radicle (NO3).	Chlorine (Cl).	Dissolved solids.	Mean gage height (feet).	Mean discharge (second-feet).	Suspended matter (tons per day).	Dissolved matter (tons per day).
From—	To—																
Near Gibbon.																	
1911.	1911.																
Aug. 1	Aug. 10	1	41	0.04	10	1.0	13	0.0	48	7.2	Tr.	4.0	108	0.10	50	0.57	14.6
11	20	2	41	.02	7.4	3.0	12	.0	41	4.1	0.56	4.0	90	.06	44	.29	10.7
21	30	5	40	.10	9.2	2.9	10	.0	45	6.7	.52	4.1	100	.05	42	.18	11.3
Mean		3	41	.05	8.9	2.3	12	.0	45	6.0	.36	4.0	99	--------	--------	--------	--------
Near Yoakum.																	
1911.	1911.																
Aug. 31	Sept. 9	5	40	0.08	25	6.4	18	0.0	104	11	1.1	7.8	161	3.1	36	1.0	16
Sept. 10	19	5	38	.04	15	5.6	16	.0	82	12	.52	6.8	134	3.3	61	.9	22
20	29	2	32	.12	15	5.0	13	.0	71	7.6	.40	6.0	116	3.2	53	1.1	17
30	Oct. 9	12	30	.02	12	4.8	9.9	.0	63	9.5	.52	5.3	103	3.3	56	1.5	16
Oct. 10	19	10	31	.01	11	4.8	12	.0	65	7.9	.52	5.0	101	3.4	71	2.1	19
20	29	3	30	.10	18	4.8	17	.0	100	14	.90	8.1	161	3.4	81	1.3	35
30	Nov. 8	2	32	Tr.	21	6.7	21	.0	110	15	.76	9.3	166	3.4	75	1.6	34
Nov. 9	18	1	32	.01	10	3.4	12	.0	59	7.0	.60	4.2	101	3.7	128	2.5	35
19	28	5	16	Tr.	5.9	2.3	7.6	.0	45	2.8	.60	3.5	92	4.1	267	6.1	66
29	Dec. 8	5	31	.02	10	2.5	11	.0	54	6.9	.40	4.0	98	3.8	162	1.1	43
Dec. 9	18	1	28	.03	9.8	2.0	9.9	.0	54	5.9	Tr.	3.5	87	3.8	165	1.8	39
19	28	5	27	.05	8.8	2.6	11	.0	50	6.1	.36	3.3	93	4.0	208	.8	52
	1912.																
29	Jan. 7	7	28	.01	11	2.8	9.3	.0	50	7.6	.20	2.5	90	3.9	197	1.9	48
1912.																	
Jan. 8	17	40	30	.12	8.6	2.8	9.5	.0	44	3.8	.40	2.3	95	5.6	1,644	266	422
18	27	30	23	.10	8.5	2.2	8.8	.0	39	4.0	.52	2.3	85	6.1	1,600	168	317
28	Feb. 6	10	28	.05	6.2	3.6	6.6	.0	36	4.4	1.5	1.8	81	6.4	1,782	101	389
Feb. 7	16	15	28	.03	6.4	3.6	6.3	.0	40	5.4	.90	1.8	85	6.4	1,912	211	516
17	26	50	29	.01	6.6	.4	8.4	.0	35	4.4	.36	.50	81	6.8	2,240	350	490
27	Mar. 7	7	33	.25	7.4	1.2	8.7	.0	46	7.1	.51	.50	93	5.3	872	23.5	219
Mar. 8	17	3	27	.16	9.0	2.8	9.5	.0	42	5.9	.69	1.5	92	5.6	1,045	11.3	259
18	27	10	27	.21	8.4	1.8	7.7	.0	42	5.1	.78	1.0	91	5.7	1,168	23.3	288
28	Apr. 6	35	25	.28	6.6	1.8	8.6	.0	37	4.1	1.0	.50	85	7.2	2,669	180	612
Apr. 7	16	40	26	.19	6.0	2.0	8.5	.0	35	4.3	.69	1.8	82	7.9	3,729	634	825
17	26	20	26	.02	5.4	.6	10	.0	35	5.3	.60	.95	78	7.0	2,438	263	513
27	May 6	60	34	.01	6.8	.3	7.9	.0	35	3.0	.54	.85	82	8.1	3,964	900	878
May 7	16	35	16	.24	5.2	1.2	7.7	.0	31	3.0	.45	.25	72	7.8	3,457	438	672
17	26	30	21	.20	5.6	1.4	7.4	.0	33	3.0	.27	.75	76	6.6	1,935	193	393
27	June 5	60	33	.03	8.0	2.0	6.2	.0	42	2.8	.40	.25	83	6.6	1,955	274	438
June 6	15	80	29	.11	9.6	1.4	7.6	.0	48	3.8	.32	.90	90	5.3	852	133	207
16	25	50	31	.02	10	2.6	11	.0	53	10	.32	.80	105	4.7	530	54	152
26	July 5	30	36	.02	10	2.8	9.8	.0	57	4.6	.60	2.0	102	3.9	197	5.8	54.2
July 6	15	15	30	.01	12	1.8	9.8	[a]4.3	53	2.5	.40	1.3	99	3.6	116	5.0	31.0
16	25	90	29	.01	12	4.0	13	[a]6.2	63	4.1	.22	3.5	104	3.6	115	26.7	32.3
26	Aug. 4	200	29	.01	14	5.2	15	[a]3.1	77	7.6	.24	3.8	124	3.3	65	15.1	21.7
Aug. 5	14	60	33	.25	15	6.0	14	.0	86	7.2	.18	3.9	126	3.4	81	9.9	27.6
Mean		30	29	.08	10	3.0	[b]9.7 [b]1.7	.0	55	6.2	.54	2.9	100	--------	--------	[c]44,900	[c]85,500
Near Umatilla.																	
1911.	1911.																
Aug. 11	Aug. 20	4	39	0.04	38	11	45	[a]2.4	170	41	1.8	15	266	2.5	90	1.3	65
21	30	10	42	.02	30	9.8	43	.0	163	43	2.0	17	273	2.5	90	2.2	66
31	Sept. 9	4	40	.02	36	14	42	.0	189	42	--------	--------	294	2.5	97	2.1	77
Sept. 10	19	5	36	.01	35	14	43	.0	195	35	1.7	16	281	2.5	102	1.7	77
20	29	1	43	.07	34	12	36	.0	174	33	1.4	15	267	2.5	83	1.0	60
30	Oct. 9	2	39	Tr.	33	12	35	.0	176	36	1.1	15	260	2.5	82	1.2	57
														2.5	92	[d]1.4	[d]60
Oct. 20	29	1	35	.01	32	11	33	.0	164	32	1.2	14	243	2.5	95	1.6	62
30	Nov. 8	Tr.	32	.03	42	9.6	33	[a]Tr.	168	70	1.6	14	261	2.5	95	1.3	67
Nov. 9	18	Tr.	33	.02	34	7.2	27	.0	165	30	1.6	13	240	2.6	131	1.8	85
19	28	3	39	.01	30	7.5	31	[a]1.2	149	26	1.0	11	225	2.7	173	4.7	105
29	Dec. 8	8	32	.02	29	7.8	27	.0	145	27	1.2	12	218	2.6	115	2.7	68
Dec. 9	18	1	36	.01	31	10	30	.0	154	29	.70	12	229	2.6	111	3.6	69
19	28	3	37	.02	30	8.4	31	.0	161	27	.90	13	231	2.5	90	1.3	56
29																	
	1912																
1912	Jan. 7	10	35	.01	32	7.2	27	.0	142	27	1.1	13	217	2.6	112	3.9	66
Jan. 8	17	90	32	.02	17	1.6	21	.0	72	11	12	9.5	138	3.6	1,255	393	468
18	27	40	30	.18	12	2.9	13	.0	54	8.9	.60	2.5	101	4.0	1,450	215	395
28	Feb. 6	10	33	.10	8.6	1.0	10	.0	48	5.8	.63	.75	98	4.1	1,597	129	422
Feb. 7	16	30	32	.09	8.6	3.6	10	.0	51	6.7	.60	1.0	99	4.1	1,637	274	437
8	26	60	28	.06	7.2	2.4	9.0	.0	43	8.4	.54	1.5	88	4.4	2,021	420	476
27	Mar. 7	10	39	.15	15	1.4	15	.0	67	11	.60	1.5	123	3.3	594	18	197
Mar. 8	17	10	33	.20	11	2.7	14	.0	62	10	.69	3.0	117	3.5	737	30	231
18	27	15	34	.15	12	2.2	12	.0	57	8.6	.30	3.5	110	3.5	786	49	232
28	Apr. 6	20	26	.24	7.6	1.4	8.7	.0	38	6.6	.45	1.8	87	4.5	2,195	403	514
Apr. 7	16	90	29	.15	7.2	1.6	9.6	.0	46	7.6	.51	2.3	86	5.2	3,344	535	776
17	26	20	29	.01	8.6	1.5	9.8	.0	46	6.3	.56	3.3	95	4.4	2,023	322	520
27	May 6	80	23	.16	9.4	2.6	7.7	[a]7.7	30	2.8	.22	2.1	89	5.1	3,261	995	784
May 7	16	40	35	.14	12	2.6	13	.0	59	4.9	.30	3.4	116	5.2	3,264	581	1,024
17	26	20	30	.09	11	3.4	12	.0	50	4.9	--------	3.4	101	4.3	1,871	81	510
27	June 5	30	35	.09	11	3.6	16	.0	58	6.3	--------	2.5	114	4.3	1,882	76	579
June 6	15	95	38	.06	18	2.0	19	.0	84	10	.30	7.8	143	3.4	700	327	270
16	25	35	32	.04	24	5.8	28	.0	116	20	.32	11	188	3.0	418	79	212
26	July 5	5	29	.06	27	10	44	.0	163	38	.40	18	250	2.6	130	6.7	88
July 6	15	7	36	.04	32	9.0	44	.0	167	38	.60	18	268	2.6	119	7.1	86
16	25	1,800	43	.03	33	9.6	44	[a]8.4	153	34	.60	17	273	2.7	159	331	117
26	Aug. 4	290	41	.10	35	12	39	[a]Tr.	181	38	1.2	18	287	2.6	122	61	94
Aug. 5	14	5	34	.08	34	13	38	[a]Tr.	182	39	.36	17	274	2.6	117	3.2	87
Mean		79	34	.07	23	6.6	[b]22 [b]4.8	.0	116	23	1.2	9.4	188	--------	--------	[c]53,000	[c]94,300

[a] Abnormal; computed as HCO_3 in average.

[b] Sodium and potassium, determined on combined alkali residues.

[c] Total annual denudation.

[d] Estimated.

Analyses of water from John Day River, Oreg.

Near Dayville.

[Parts per million except as otherwise designated.]

Date (1911-12).		Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Dissolved solids.	Mean gage height (feet).	Mean discharge (second-feet).	Suspended matter (tons per day).	Dissolved matter (tons per day).
From—	To—																
Aug. 1	Aug. 31	4	38	0.05	40	17	31	0.0	229	17	1.8	3.5	250	−0.36	19	19	13
Sept. 1	Sept. 30	100	40	.14	30	18	26	.0	220	14	.84	3.0	235	−.17	50	19	31.7
Oct. 1	Oct. 31	60	38	.04	22	13	17	.0	156	12	--------	1.8	182	+.03	62	12	30.5
Nov. 1	Nov. 30	70	32	.02	19	9.4	15	.0	142	7.9	.48	2.3	163	--------	[a] 90	20.9	39.4
Dec. 1	Dec. 31	20	33	.05	19	10	16	.0	137	7.6	.20	2.3	155	--------	[a] 90	4.1	37.7
Jan. 1	Jan. 31	240	24	.01	21	6.6	15	.0	125	8.7	1.4	1.8	148	1.44	398	351	159
Feb. 1	Feb. 29	100	35	.15	19	10	13	.0	121	8.7	1.6	.75	145	2.5	683	402	267
Mar. 1	Mar. 31	80	34	.03	19	9.4	8.2	[b] Tr.	121	6.3	.56	6.0	144	2.03	517	198	201
Apr. 1	Apr. 30	200	25	.05	18	7.6	8.0	[b] 8.6	84	3.8	.24	1.3	121	3.75	1,184	1,260	387
May 1	May 31	300	32	.05	18	8.8	6.6	.0	100	6.1	80	.25	130	4.8	1,824	2,730	639
June 1	June 30	300	30	.09	16	5.3	8.5	[b] Tr.	93	4.0	.52	.25	121	3.4	1,067	1,533	349
July 1	July 31	120	39	.05	24	15	14	.0	163	9.9	.50	3.0	191	.95	242	.78	125
Aug. 1	Aug. 15	500	33	.10	22	14	14	.0	155	10	.22	2.3	169	.84	214	311	98
Mean........		160	33	.06	22	11	[c] 13 [c] 2.1	.0	143	8.9	.76	2.2	166	--------	--------	[d] 198,000	[d] 68,000

At McDonald.

Date (1911-12).		Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Dissolved solids.	Mean gage height (feet).	Mean discharge (second-feet).	Suspended matter (tons per day).	Dissolved matter (tons per day).
From—	To—																
Aug. 11	Aug. 20	4	31	0.08	24	14	14	0.0	134	12	1.4	2.8	153	1.14	101	1.3	42
21	30	10	20	.01	22	11	14	.0	135	14	.92	2.7	153	1.10	87	.8	36
31	Sept. 9	4	19	.05	27	12	20	.0	144	12	--------	2.8	162	1.22	133	3.9	58
Sept. 10	19	1,400	25	.14	30	11	35	.0	176	37	4.4	6.0	239	1.47	238	551	154
20	29	500	27	.25	31	11	25	.0	167	20	2.0	4.8	210	1.38	191	152	108
30	Oct. 9	430	30	.22	26	13	25	.0	170	21	1.9	3.8	204	1.60	314	241	173
Oct. 10	19	220	28	.10	29	12	21	.0	161	15	1.6	3.3	187	1.64	336	148	170
20	29	90	24	.04	25	10	17	.0	140	13	1.2	3.0	170	1.64	336	54	154
30	Nov. 8	50	27	.02	22	10	18	.0	145	12	.90	3.5	167	1.60	310	33	140
Nov. 9	18	80	27	.22	26	10	17	.0	138	20	1.4	3.3	170	1.77	427	65	196
19	28	380	25	.03	21	.7	14	.0	113	11	.82	2.6	146	1.99	609	402	240
29	Dec. 8	85	28	.20	23	8.4	15	.0	126	14	.90	3.1	162	1.78	433	65	189
Dec. 9	18	65	27	.03	23	5.8	16	.0	127	14	.26	2.5	151	1.80	447	13	182
19	28	20	30	.04	23	8.4	17	.0	129	14	.26	2.7	153	1.78	431	44	178
29	Jan. 7	75	27	.05	24	9.4	18	.0	147	15	.56	2.8	170	1.91	539	74	247
Jan. 8	17	900	20	.01	21	7.2	19	.0	124	13	--------	3.3	153	3.4	2,852	3,130	1,178
18	27	700	22	.02	20	5.6	14	.0	106	11	3.8	2.1	136	3.9	3,494	3,985	1,280
28	Feb. 6	225	29	.03	19	4.4	12	.0	99	7.7	1.7	--------	127	4.0	3,586	1,587	1,132
Feb. 7	16	300	29	.02	16	4.8	11	.0	94	5.6	.80	1.8	122	4.4	4,336	3,135	1,427
17	26	200	34	.18	17	6.0	11	.0	99	6.6	1.4	.5	130	4.6	4,898	1,903	1,719
27	Mar. 7	95	30	.05	19	7.6	13	.0	118	8.1	2.0	2.3	149	3.3	2,264	544	911
Mar. 8	17	100	32	.03	21	8.0	13	.0	123	8.2	1.3	.5	144	3.4	2,332	578	906
18	27	100	29	.05	22	8.2	13	.0	116	9.4	.27	2.0	145	3.4	2,397	1,100	939
28	Apr. 6	250	24	.05	15	5.6	9.8	.0	77	8.7	1.1	2.0	112	5.7	7,630	5,470	2,306
Apr. 7	16	110	20	.08	13	4.9	8.8	.0	63	8.4	1.7	1.5	99	6.7	10,512	3,660	2,810
17	26	100	24	.07	16	5.9	9.5	.0	81	7.7	.30	1.5	113	5.7	7,587	1,967	2,315
27	May 6	170	27	.09	16	5.8	6.1	.0	78	5.9	.32	2.5	116	6.5	10,057	5,720	3,133
May 7	16	210	22	.08	16	5.2	13	.0	65	4.0	--------	1.5	100	7.3	12,564	9,890	3,389
17	26	175	18	.06	17	5.2	10	.0	57	3.0	.13	.50	100	6.9	11,201	8,465	3,027
27	June 5	240	21	Tr.	11	3.0	15	.0	66	13	.54	3.0	93	6.7	10,572	5,170	2,652
June 6	15	800	24	.01	13	3.6	6.5	.0	65	8.2	.60	.50	98	5.8	7,810	3,135	2,066
16	25	175	23	.03	14	4.8	5.7	.0	68	10	.30	3.8	101	4.7	5,056	4,260	1,378
26	July 5	90	23	.04	13	2.8	15	[b] 8.2	61	9.7	.40	1.1	109	3.7	2,838	674	835
July 6	15	35	22	.01	20	5.6	18	[b] 3.6	104	12	.30	3.3	129	2.9	1,593	103	554
16	25	390	30	.02	22	7.2	19	.0	123	11	.40	3.1	151	2.2	777	310	317
26	Aug. 4	90	20	.01	15	8.6	19	[b] 12	84	11	.16	5.5	126	1.9	564	134	192
Aug. 5	14	200	32	.02	23	9.6	18	[b] 6.7	121	13	.20	4.0	163	2.0	660	223	291
Mean........		245	26	.07	20	7.6	[c] 13 [c] 2.4	.0	114	12	1.1	2.7	144	--------	--------	[d] 759,500	[d] 365,000

[a] Estimated. [b] Abnormal; computed as HCO_3 in average. [c] Sodium and potassium, determined on combined alkali residues. [d] Total annual denudation.

Analyses of water from Deschutes River, Oreg.

[Parts per million except as otherwise designated.]

At Bend.

Date (1911–12). From—	To—	Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4)	Nitrate radicle (NO_3).	Chlorine (Cl).	Dissolved solids.	Mean gage height (feet).	Mean discharge (second-feet).	Suspended matter (tons per day).	Dissolved matter (tons per day).
Aug. 1	Aug. 31	3	29	0.06	6.2	3.4	8.7	0.0	39	2.5	0.32	1.3	75	1.1	918	5.5	186
Sept. 1	Sept. 30	1	27	.05	5.6	2.8	6.5	.0	33	5.4	.24	1.0	66	1.2	1,050	6.0	187
Oct. 1	Oct. 31	2	21	.01	6.0	2.3	7.9	.0	37	4.9	.40	1.4	67	1.3	1,130	9.0	205
Nov. 1	Nov. 30	2	24	.01	4.2	1.2	8.8	.0	34	2.5	.36	1.3	65	1.5	1,310	8.5	230
Dec. 1	Dec. 31	2	26	.09	5.9	1.4	8.1	.0	38	1.7	.10	.90	64	1.5	1,260	3.6	218
Jan. 1	Jan. 31	1	18	.06	4.4	1.4	7.6	.0	33	3.3	.12	1.2	64	1.2	1,380	3.7	238
Feb. 1	Feb. 29	Tr.	25	.05	5.2	1.8	7.1	.0	35	3.2	.27	1.3	63	1.5	1,510	Tr.	258
Mar. 1	Mar. 31	Tr.	24	.02	3.9	1.2	7.4	.0	32	3.7	.09	1.0	64	1.2	1,360	Tr.	235
Apr. 1	Apr. 30	3	23	.07	3.8	1.1	8.4	.0	32	4.2	.20	1.2	64	1.3	1,430	20.5	247
May 1	May 31	Tr.	24	.02	5.0	.7	8.2	[a] 2.4	24	4.6	.25	1.0	64	1.5	1,580	Tr.	273
June 1	June 30	3	30	.02	5.1	.6	6.9	[a] 1.4	33	2.5	.24	.40	72	1.6	1,690	24.7	328
July 1	July 31	Tr.	22	Tr.	3.6	1.5	7.4	[a] Tr.	33	2.5	.10	1.5	58	1.2	1,310	Tr.	205
Aug. 1	Aug. 15	5	21	.10	7.2	---------	12	.0	34	6.6	.10	1.5	76	1.1	1,194	37.2	245
Mean-------		2	24	.04	5.1	1.6	[b] 6.7 [b] 1.6	.0	34	3.6	.22	1.2	66	---------	---------	[c] 2,850	[c] 85,600

At Moody.

Date (1911–12). From—	To—	Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4)	Nitrate radicle (NO_3).	Chlorine (Cl).	Dissolved solids.	Mean gage height (feet).	Mean discharge (second-feet).	Suspended matter (tons per day).	Dissolved matter (tons per day).
Aug. 21	Aug. 30	25	36	0.01	14	4.0	12	0.0	60	8.4	0.24	1.8	100	2.2	4,898	542	1,322
31	Sept. 9	60	37	.10	9.3	3.6	12	.0	55	6.9	.40	1.0	92	2.2	4,924	1,236	1,223
Sept. 10	19	5	33	.05	9.4	4.0	12	.0	55	6.6	.44	2.0	92	2.2	4,950	495	1,228
20	29	3	27	Tr.	6.9	4.2	6.9	.0	56	6.4	.64	2.3	88	2.2	4,898	161	1,044
30	Oct. 9	6	27	.02	6.8	4.0	12	.0	55	4.8	.74	1.8	85	2.3	5,080	206	1,166
Oct. 10	19	1	30	.01	7.1	4.6	13	.0	58	4.6	.54	2.1	91	2.3	5,080	96	1,249
20	29	4	28	.01	10	3.6	6.8	.0	59	3.3	.40	1.9	88	2.2	4,846	73	1,151
30	Nov. 8	4	23	Tr.	7.0	2.8	12	.0	57	2.3	.30	1.8	88	2.2	4,872	58	1,158
Nov. 9	18	10	24	.07	6.2	2.6	12	.0	54	4.6	.50	2.0	90	2.5	5,552	420	1,349
19	28	20	25	.01	6.6	3.0	11	.0	53	5.6	.60	2.0	87	2.5	5,782	469	1,359
29	Dec. 8	Tr.	28	.08	7.6	3.1	10	.0	57	5.8	Tr.	1.3	87	2.5	5,540	117	1,286
Dec. 9	18	1	26	.08	7.8	3.6	13	.0	55	6.6	.30	1.8	90	2.4	5,280	108	1,283
19	28	1	29	.06	7.4	3.2	12	.0	56	6.7	.36	2.3	89	2.4	5,250	79	1,261
29	Jan. 7	1	31	.04	6.7	3.0	12	.0	56	3.8	.30	2.0	86	2.2	4,732	102	1,100
Jan. 8	17	45	24	.06	6.8	2.6	11	.0	50	2.0	1.1	1.9	78	3.4	9,494	691	1,996
18	27	280	31	.02	11	5.4	9.5	.0	69	5.9	1.5	3.0	105	3.2	8,034	3,166	2,278
28	Feb. 6	60	26	.02	8.1	4.8	8.7	.0	55	3.6	.90	2.3	87	3.3	8,704	2,289	2,040
Feb. 7	16	80	29	.01	9.4	4.5	9.6	.0	60	2.0	1.3	3.3	92	3.5	9,400	2,565	2,332
17	26	60	29	.01	9.8	2.6	12	.0	56	5.3	1.3	2.5	96	3.9	11,568	3,438	2,999
27	Mar. 7	8	31	.12	11	.6	11	.0	57	5.1	.39	2.3	95	3.0	7,576	532	1,943
Mar. 8	17	15	33	.15	8.2	.6	15	.0	56	6.4	.28	1.8	98	2.8	6,862	222	1,816
18	27	5	32	.05	8.2	1.0	14	.0	54	5.8	.64	1.3	95	2.8	6,608	219	1,693
28	Apr. 6	40	30	.04	8.5	.6	15	.0	61	7.6	1.0	1.3	96	3.2	8,194	1,592	2,121
Apr. 7	16	80	28	.03	8.4	.4	14	.0	57	5.6	.84	2.0	92	3.8	10,916	4,271	2,710
17	26	15	28	.14	9.2	.8	12	.0	59	2.8	.16	1.5	97	3.4	8,852	694	2,319
27	May 6	80	23	.04	9.6	1.2	14	[a] 11	45	5.1	.10	1.8	96	3.4	9,046	2,123	2,344
May 7	16	45	30	.16	10	2.6	7.6	.0	59	4.9	2.9	2.3	117	3.6	9,800	2,301	3,097
17	26	15	26	.10	8.0	1.8	12	.0	53	4.4	1.6	1.8	92	3.6	9,910	1,204	2,461
27	June 5	15	14	.02	8.8	.8	11	.0	56	6.1	.34	2.3	79	3.6	9,948	1,101	2,121
June 6	15	30	26	.04	8.6	1.9	11	.0	51	4.6	.30	2.3	93	3.3	8,566	1,526	2,151
16	25	20	22	.10	8.6	1.4	10	.0	52	4.8	.58	2.1	91	3.0	7,500	870	1,842
26	July 5	5	27	.02	7.2	1.4	10	.0	49	4.8	1.10	2.4	85	2.6	6,086	99	1,397
July 6	15	Tr.	31	.01	7.4	1.7	14	.0	61	4.3	.36	2.5	96	2.6	5,982	---------	1,551
16	25	50	34	.20	7.8	4.2	13	.0	54	3.6	.16	2.9	93	2.6	5,856	1,436	1,494
Mean--------		32	28	.05	8.5	2.7	[b] 11 2.0	.0	57	5.0	.66	2.1	92	---------	---------	[c] 370,400	[c] 642,900

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[a] Abnormal; computed as HCO_3 in average.

[b] Sodium and potassium, determined on combined alkali residues.

[c] Total annual denudation.

Analyses of water from Crooked River near Prineville, Oreg.

[Parts per million except as otherwise designated.]

Date (1911-12).		Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Dissolved solids.	Mean gage height (feet).	Mean discharge (second-feet).	Suspended matter (tons per day).	Dissolved matter (tons per day).
From—	To—																
Aug. 1	Aug. 31	4	35	0.05	29	16	73	9.6	287	29	0.56	18	358	0.26	9.3	0.27	9.0
Sept. 1	Sept. 30	30	28	.30	29	17	65	7.2	261	25	.56	18	324	.40	18.1	.98	15.7
Oct. 1	Oct. 31	20	33	.05	31	16	63	Tr.	280	23	.74	20	331	.72	50.8	3.72	46
Nov. 1	Nov. 30	30	36	.15	29	12	52	.0	243	20	.40	15	297	.82	66.7	2.70	53
Dec. 1	Dec. 8	18	36	.11	28	13	48	.0	234	19	.20	14	279	.79	62	1.35	50
9	18	10	41	.11	30	13	47	.0	222	16	.18	13	268	1.04	116	8.14	84
19	28	25	45	.12	31	12	48	.0	240	17	.30	14	287	.76	58	2.66	45
29	Jan. 7	3	48	.04	32	13	49	1.2	235	20	.20	14	288	.89	80	1.82	62
Jan. 8	17	200	38	.05	27	10	37	.0	193	15	---------	23	228	1.47	244	83.0	150
18	27	550	18	.01	23	7.1	26	.0	131	8.2	.60	6.0	172	2.14	514	829	239
28	Feb. 6	100	32	.03	22	10	34	.0	159	16	.40	9.8	202	2.17	475	101	259
Feb. 7	16	463	28	.5	20	7.6	27	.0	133	9.2	.44	5.8	169	2.94	819	1,148	374
17	26	190	29	Tr.	16	4.8	23	4.8	110	12	.12	5.3	158	2.97	787	408	336
27	Mar. 7	90	36	Tr.	22	9.1	26	.0	160	13	.27	7.0	198	1.88	750	92	401
Mar. 8	17	100	34	.13	21	7.8	27	.0	150	11	.15	5.8	182	1.91	285	46.2	140
18	27	100	35	.04	22	7.4	27	.0	149	9.2	.20	5.5	179	1.95	305	92.3	147
28	Apr. 6	330	31	.15	16	5.4	14	.0	92	6.7	.40	1.0	122	3.94	1,236	1,594	407
Apr. 7	16	172	28	.02	13	3.6	8.5	.0	73	4.3	.24	.75	103	4.57	1,612	1,264	448
17	26	190	31	.12	17	5.3	15	.0	100	8.7	.32	1.5	130	3.87	1,184	646	415
27	May 6	125	30	.10	20	4.8	14	.0	93	4.9	.32	.85	124	4.53	1,578	1,274	528
May 7	16	130	29	.02	13	3.2	10	.0	73	6.6	.62	1.0	107	4.71	1,686	1,256	487
17	26	50	31	.15	18	4.7	14	Tr.	92	11	.29	1.1	127	3.33	893	147	306
27	June 5	35	39	.04	22	6.8	17	.0	127	8.7	.36	3.0	170	2.99	730	116	335
June 6	15	600	40	.01	28	7.6	25	.0	169	15	.34	4.3	218	1.95	297	425	175
16	25	40	42	Tr.	27	12	31	14	177	19	.28	6.5	241	1.28	124	14.7	81
26	July 5	15	30	.05	34	14	44	12	221	24	.50	10	282	.90	51	3.06	39
July 6	15	6	36	.08	34	14	57	4.3	257	22	.80	12	308	.89	45	.78	37
16	25	120	30	.04	26	13	49	Tr.	240	26	.74	12	287	.66	20	---------	15
Aug. 5	Aug. 14	150	36	.18	35	15	62	Tr.	282	21	.24	15	338	.61	16	5.1	15
Mean		110	34	.09	26	11	[a] 38 [a] 5.2	1.1	199	17	.42	11	246	---------	---------	[b] 96,600	[b] 58,400

[a] Sodium and potassium, determined on combined alkali residues.

[b] Total annual denudation.

Another analysis of water from Crooked River is reported by Van Winkle, together with one from White River, also a tributary of the Deschutes. Both are reduced to standard form.

Analyses of water from Deschutes basin, Oreg.

1. Crooked River near Paulina.
2. White River at Tygh Valley dam site.

	Parts per million.		Percentage composition.	
	1	2	1	2
CO_3	95.0	15.3	41.01	28.70
SO_4	16.	5.9	6.90	11.07
Cl	4.5	1.0	1.94	1.88
NO_3	.1	Tr.	.04	Tr.
Ca	32.0	5.8	13.82	10.88
Mg	11.0	1.8	4.75	3.38
Na, K	28.0	5.4	12.09	10.13
Fe_2O_3	.04	.1	.02	.19
SiO_2	45.0	18.0	19.43	33.77
	231.64	53.3	100.00	100.00

Analyses of water from Sandy River near Brightwood, Oreg.

[Parts per million except as otherwise designated.]

Below mouth of Salmon River.

Date. From—	Date. To—	Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Dissolved solids.	Mean gage height (feet).	Mean discharge (second-feet)	Suspended matter (tons per day).	Dissolved matter (tons per day).
1911.	1911.																
Aug. 11	Aug. 20	85	22	0.10	5.1	2.1	6.0	0.0	25	12	Tr.	2.3	62	3.19	362	133	60
21	30	90	23	.10	4.7	2.7	6.8	.0	23	13	Tr.	2.0	67	3.07	322	150	56
31	Sept. 9	140	17	.11	8.4	3.1	6.9	.0	23	9.4	---------	1.8	65	3.49	402	57.9	71
Sept. 10	19	35	21	.12	8.6	2.3	6.9	.0	23	12	0.12	2.8	62	3.83	504	107	84
20	29	1	20	.13	5.8	2.0	5.4	.0	27	8.6	Tr.	2.5	64	3.67	389	13	67
30	Oct. 9	5	18	.04	5.2	3.5	5.8	.0	24	8.6	.48	2.0	57	4.61	720	93	111
Oct.--10	19	3	20	.04	5.0	2.8	6.5	.0	24	9.5	.22	1.8	61	4.21	502	11	83
20	29	4	20	.06	6.0	2.8	8.2	.0	28	10	.54	2.3	66	3.60	376	5.9	63
30	Nov. 8	15	19	.10	5.9	1.7	5.0	.0	23	8.0	.50	2.0	60	3.90	660	---------	107
Nov. 9	18	5	12	.05	3.1	1.2	2.8	.0	13	5.3	.48	1.0	38	5.30	1,720	279	177
19	28	10	12	.01	5.8	.6	3.9	.0	12	3.5	---------	.5	37	4.98	1,816	176	186
Above mouth of Salmon River.																	
Dec. 11	Dec. 18	1	16	0.12	3.8	---------	5.4	0.0	17	5.4	0.12	1.3	45	2.37	816	0.0	99
19	28	1	15	.13	5.6	0.7	6.6	.0	18	5.8	Tr.	.75	49	2.18	680	4.0	90
	1912.																
29	Jan. 7	3	17	.02	4.6	.3	4.9	.0	17	8.0	.40	1.0	53	1.74	439	.7	63
1912.																	
Jan. 8	17	5	14	.08	3.4	.1	3.7	.0	16	5.6	.20	1.4	37	3.50	2,234	175	222
18	27	1	13	.04	3.8	.2	3.7	.0	17	7.2	.16	1.3	40	2.91	1,363	14.7	147
28	Feb. 6	2	13	.17	3.2	.2	3.8	.0	13	4.4	.08	.95	37	3.10	1,465	22.5	147
Feb. 7	16	3	11	.05	3.2	.6	3.3	.0	13	4.3	.12	1.50	33	3.37	1,739	27.7	155
17	26	Tr.	13	.05	4.7	1.1	3.6	.0	15	5.7	.15	1.50	38	3.17	1,672	7.7	172
27	Mar. 7	Tr.	17	.05	5.1	1.2	5.1	.0	18	6.1	.21	1.8	47	2.05	747	Tr.	95
Mar. 8	17	2	18	.06	3.9	.8	4.2	.0	18	6.9	.30	1.8	52	1.69	545	1.5	77
18	27	Tr.	15	.05	3.9	.6	4.9	.0	18	4.8	.30	1.7	46	1.77	587	Tr.	73
28	Apr. 6	1	13	.05	3.3	.5	3.7	.0	16	5.4	.18	1.6	44	2.10	775	4.6	92
Apr. 7	16	Tr.	11	.05	3.1	.7	3.8	1.7	11	5.5	.12	1.4	40	2.29	897	Tr.	97
17	26	Tr.	14	.05	3.9	.7	5.0	.0	18	6.3	.27	1.5	50	2.01	721	Tr.	98
27	May 6	Tr.	15	.02	3.8	1.0	3.9	.0	16	3.8	.16	1.5	39	2.43	986	Tr.	104
May 7	16	Tr.	13	.03	3.2	.8	4.1	.0	13	6.4	.28	1.5	38	2.86	1,318	Tr.	135
17	26	Tr.	14	.04	3.1	.6	3.5	.0	13	5.4	.34	1.8	40	2.56	1,077	Tr.	116
27	June 5	4	14	.04	4.0	.8	5.9	.0	15	3.5	.25	1.5	40	2.55	1,076	Tr.	116
June 6	15	3	13	.04	4.1	.8	4.0	.0	16	5.3	.26	1.5	44	2.23	856	32	101
16	25	25	14	.06	3.9	1.4	5.5	.0	18	9.5	.18	1.6	47	2.15	805	82	101
26	July 5	18	18	.05	4.2	1.5	5.0	.0	19	5.8	.20	3.3	49	1.90	658	75	87
July 6	15	6	17	.03	4.5	1.4	4.1	.0	18	8.3	.26	2.4	53	1.74	570	18	82
16	25	8	21	.06	4.7	1.4	3.5	.0	19	7.0	.44	3.1	57	1.59	497	62	71
26	Aug. 4	23	17	.15	5.7	1.5	3.8	.0	20	8.4	.20	1.3	58	1.43	425	54	67
Aug. 5	14	25	19	.25	5.7	1.7	5.4	.0	20	13	.16	2.0	61	1.30	372	35	61
Mean--------		15	16	.07	4.6	1.3	[a]4.2 [a].8	.0	18	7.2	.23	1.7	49	---------	---------	---------	---------

[a] Sodium and potassium, determined on combined alkali residues.

Analyses of water from Bull Run River near Bull Run, Oreg.

[Parts per million, except as otherwise designated.]

Date (1911–12). From—	Date (1911–12). To—	Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Dissolved solids.	Mean gage height (feet).	Mean discharge (second-feet).	Suspended matter (tons per day).	Dissolved matter (tons per day)
Aug. 1	Aug. 10	2	15	0.02	6.1	1.7	---------	---------	---------	4.1	---------	0.40	45	2.9	134	0.5	16
11	20	1	13	.05	4.7	1.7	6.4	0.0	20	4.6	Tr.	1.3	41	2.8	122	.03	13
21	30	Tr.	15	.02	3.7	1.6	3.9	.0	20	3.9	Tr.	.75	40	2.7	97	.03	11
31	Sept. 9	1	14	.10	4.4	1.6	4.2	.0	19	3.5	Tr.	.75	40	3.0	184	1.34	20
Sept. 10	19	3	9.8	.10	3.5	1.0	3.3	.0	16	4.8	0.04	1.30	33	3.6	377	.6	34
20	29	Tr.	12	.05	3.2	1.3	3.0	.0	16	3.1	.20	1.30	38	3.2	211	.3	22
30	Oct. 9	Tr.	7.7	.01	2.9	.76	2.7	.0	11	2.6	.40	1.30	27	3.7	423	1.3	31
Oct. 10	19	Tr.	10	Tr.	2.9	.80	3.5	.0	13	3.4	3.8	1.30	29	3.7	402	.0	31
20	29	Tr.	12	.03	2.8	1.0	2.4	.0	12	2.5	1.1	1.4	32	3.1	198	.0	17
30	Nov. 8	2	9.4	Tr.	3.0	.70	4.3	.0	13	3.6	.42	1.30	32	4.0	867	2.3	75
Nov. 9	18	3	8.5	.02	2.1	.42	2.3	.0	9.0	3.5	.94	1.0	26	5.9	2,417	35.2	169
19	28	1	11	.02	2.5	.60	2.0	.0	11	4.3	.40	.65	29	5.1	1,450	.0	144
29	Dec. 8	Tr.	8.4	.01	2.3	.34	3.1	.0	11	2.0	.34	.85	25	4.1	616	.0	41
Dec. 9	18	Tr.	7.6	.01	2.2	.20	2.4	.0	8.8	4.0	.20	1.0	24	5.1	1,137	.0	77
19	28	Tr.	5.8	Tr.	2.3	.16	2.6	.0	8.5	3.1	.10	.85	22	4.5	845	.0	50
29	Jan. 7	Tr.	8.7	.01	2.2	.20	3.7	.0	12	2.6	.32	1.8	27	3.8	422	.0	31
Jan. 8	17	Tr.	6.2	.01	2.0	.10	3.5	.0	9.8	3.9	.08	1.3	24	---------	3,743	.0	243
18	27	Tr.	6.3	.06	1.7	.04	2.9	.0	9.8	1.7	.08	.75	21	4.8	1,183	.0	67
28	Feb. 6	Tr.	5.9	.13	1.7	.04	2.3	.0	8.5	2.7	.16	.50	22	5.3	1,848	.0	110
Feb. 7	16	Tr.	6.4	.02	2.1	.08	2.7	.0	8.1	1.1	.08	2.0	22	5.8	2,212	.0	131
17	26	Tr.	4.1	.01	1.9	.20	3.3	.0	8.5	2.1	.15	.25	23	5.3	1,799	.0	112
27	Mar. 7	Tr.	5.8	.01	2.2	.16	3.0	.0	10	3.3	.09	1.0	25	3.7	479	.0	32
Mar. 8	17	Tr.	7.6	.01	2.1	.16	3.9	.0	11	3.8	.06	1.3	27	3.4	335	.0	24
18	27	Tr.	5.1	Tr.	2.1	.14	4.3	.0	11	3.4	.09	1.7	28	3.6	439	.0	33
28	Apr. 6	1	8.0	.01	2.9	.40	6.3	.0	13	2.3	.90	3.9	560	8.2	560	8.2	50
Apr. 7	17	1	6.6	.01	2.7	.12	3.8	.0	11	2.1	.26	1.8	25	3.9	563	7.6	38
17	26	Tr.	5.2	.01	2.8	.40	3.8	.0	11	1.9	.20	1.0	22	3.8	502	.0	30
27	May 6	Tr.	5.8	Tr.	2.4	.10	4.1	.0	10	1.8	.60	2.0	23	4.4	906	.0	56
May 7	16	Tr.	5.6	.01	2.5	.10	5.0	.0	11	2.5	.26	2.5	26	4.4	900	.0	63
17	26	Tr.	16	.06	2.7	.16	3.0	.0	11	5.6	.42	.75	39	4.0	613	.0	65
27	June 5	Tr.	7.7	.02	2.6	.10	2.6	.0	11	2.3	.28	1.3	27	3.9	884	.0	64
June 6	15	Tr.	8.3	.02	2.7	.18	5.3	.0	14	2.1	.72	3.5	31	3.6	434	.0	36
16	25	1	8.6	Tr.	2.5	.70	3.2	.0	12	5.8	.60	1.8	34	3.8	501	2.0	46
26	July 5	5	12	.06	2.7	.60	1.8	.0	16	1.6	.28	.25	33	3.6	408	---------	36
July 6	15	6	12	.11	3.8	.40	3.2	.0	18	3.8	.68	1.8	42	3.2	273	---------	31
16	25	7	13	.09	2.9	.96	3.6	.0	20	2.8	Tr.	1.3	40	2.9	178	---------	19
Mean--------		Tr.	9.0	.03	2.7	.53	[a]3.1 [a].5	.0	12	3.1	.31	1.3	30.	---------	---------	[b]650	[b]21,000

[a] Sodium and potassium, determined on combined alkali residues.

[b] Total annual denudation.

Analyses of water from Willamette River at Salem, Oreg.

[Parts per million except as otherwise designated.]

Date.		Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Dissolved solids.	Mean discharge (second-feet).	Suspended matter (tons per day).	Dissolved matter (tons per day).
From—	To—															
1910.	1910.															
Aug. 10	Aug. 19	2	13	0.01	5.9	2.3	8.3	0.0	37	4.3	0.00	4.8	63	----------	----------	----------
20	29	3	8.9	.02	6.2	2.4	8.8	.0	37	4.0	1.20	5.3	53	----------	----------	----------
30	Sept. 8	18	12	.02	6.9	2.3	6.2	.0	36	3.0	.30	3.2	54	----------	----------	----------
Sept. 9	18	15	17	.02	5.6	2.1	6.5	.0	38	2.4	.90	2.8	58	----------	----------	----------
19	28	4	17	.02	6.3	1.9	6.3	.0	31	7.8	.30	4.4	62	----------	----------	----------
29	Oct. 8	4	18	.02	7.2	2.0	5.4	.0	32	9.3	.45	3.1	62	----------	----------	----------
Oct. 9	18	8	16	.02	5.7	2.1	6.2	.0	33	5.6	.20	4.0	58	----------	----------	----------
19	28	6	16	.01	5.8	2.1	8.4	.0	32	6.8	6.5	6.3	64	----------	----------	----------
29	Nov. 7	2	18	.02	6.6	1.8	7.2	.0	36	4.8	3.5	4.8	64	----------	----------	----------
Nov. 8	17	13	4.1	.01	5.6	2.0	6.0	.0	25	9.8	4.0	3.8	57	----------	----------	----------
18	27	20	16	.23	6.9	1.9	5.2	.0	28	4.6	3.6	3.5	59	----------	----------	----------
28	Dec. 7	45	18	.50	6.3	2.3	6.1	.0	33	8.2	.75	3.2	71	----------	----------	----------
Dec. 8	17	10	19	.14	7.8	2.6	6.1	.0	38	7.0	2.00	3.5	72	----------	----------	----------
18	27	10	16	.07	6.9	2.4	5.1	.0	33	4.1	Tr.	4.5	63	----------	----------	----------
28	31	1	10	Tr.	7.2	2.2	4.9	.0	31	3.3	.80	2.4	51	----------	----------	----------
Mean		11	15	.07	6.5	2.2	6.4	.0	33	5.7	1.6	4.0	61	----------	----------	----------
1911.	1911.															
Aug. 11	Aug. 20	3	18	.03	6.5	1.9	7.9	.0	33	4.0	1.1	3.0	58	4,350	22.3	681
21	30	3	17	.08	7.3	2.5	6.5	.0	34	6.5	1.5	3.3	60	3,580	23.2	580
31	Sept. 9	3	16	.02	6.2	2.8	5.5	.0	33	4.9	.16	1.3	56	5,550	150	840
Sept. 10	19	4	----------	.10	6.7	2.3	5.4	.0	37	5.6	.12	1.8	64	6,338	136	1,090
20	29	3	18	.11	6.2	2.4	4.4	.0	35	6.3	Tr.	2.0	60	5,863	120	950
30	Oct. 9	5	38	.04	4.7	2.2	6.4	.0	31	7.1	.32	2.3	83	7,626	162	1,705
Oct. 10	19	2	17	.04	5.9	1.8	5.5	.0	33	5.3	.32	2.3	55	6,932	90	1,029
20	29	4	19	.02	6.4	1.8	5.7	.0	31	4.8	.40	2.5	56	5,286	47	799
30	Nov. 8	2	16	.01	5.9	2.0	5.1	.0	32	5.1	.40	2.1	56	5,704	62	864
Nov. 9	18	30	15	.28	4.5	1.5	3.6	.0	19	5.7	.56	1.4	48	42,330	7,760	5,480
19	28	7	14	.11	4.1	1.4	3.2	.0	18	4.9	.48	1.7	46	34,420	1,489	4,280
29	Dec. 8	6	15	.12	5.1	1.6	3.6	.0	21	5.3	.32	1.5	50	15,420	275	2,080
Dec. 9	18	10	15	.14	5.0	1.5	4.3	.0	24	4.0	.26	2.0	47	16,670	256	2,115
19	28	5	17	.13	5.5	1.1	5.3	.0	23	2.8	.20	1.3	53	23,500	889	3,362
	1912.															
29	Jan. 7	35	16	.30	4.5	1.2	4.6	.0	24	1.7	.34	2.3	51	29,830	1,692	4,110
1912.	1912.															
Jan. 8	Jan. 17	50	9.8	.23	3.8	.8	3.9	.0	18	3.1	.20	1.6	48	122,060	29,000	15,820
18	27	15	16	.16	4.7	1.1	4.1	.0	24	2.0	.04	1.8	56	54,630	4,865	8,260
28	Feb. 6	12	14	.50	4.4	1.1	4.1	.0	21	3.0	.08	1.8	44	52,300	3,100	6,200
Feb. 7	16	12	12	.05	3.9	1.4	3.7	.0	22	4.0	.28	1.5	50	47,380	2,680	6,380
17	26	30	14	.09	3.7	1.0	3.6	.0	21	2.4	.12	1.5	41	73,190	10,650	8,100
27	Mar. 7	5	17	.25	4.1	.9	4.7	.0	23	2.1	.30	.50	51	33,630	895	3,260
Mar. 8	17	5	16	.12	5.5	1.5	2.7	[a]3.6	20	2.8	.30	1.5	49	23,310	1,450	3,080
18	27	5	14	.17	5.1	1.6	2.9	.0	24	1.6	.30	1.8	45	26,590	1,080	3,230
28	Apr. 6	3	14	.05	5.0	1.6	3.4	[a]6.7	13	2.6	.50	1.8	45	18,670	756	2,260
Apr. 7	16	5	15	.02	4.8	1.5	3.3	.0	24	1.6	.37	1.5	44	18,090	487	2,140
17	26	2	12	.01	5.3	1.6	2.3	.0	27	1.7	.25	1.8	45	15,610	465	1,890
27	May 6	10	12	.11	4.8	1.2	2.0	.0	23	2.0	.35	1.5	46	28,530	1,694	3,540
May 7	16	2	11	.02	4.6	1.2	3.2	[a]3.6	17	1.7	.37	1.5	44	25,690	973	3,060
17	26	1	12	.01	4.4	1.2	2.5	.0	22	1.3	.36	1.3	41	19,250	354	2,138
27	June 5	3	11	.04	4.6	.2	5.2	.0	20	3.4	.36	1.0	44	26,520	1,070	3,150
June 6	15	1	16	.02	4.0	.5	4.5	.0	21	3.4	.36	1.4	45	18,790	660	2,280
16	25	2	13	.03	4.9	.8	4.4	.0	21	4.4	.30	1.4	46	20,840	790	2,600
26	July 5	3	16	.02	5.0	.3	5.7	.0	24	4.8	.56	1.3	48	15,510	420	2,050
July 6	15	3	16	.02	8.0	.1	6.3	.0	31	5.3	.30	4.5	55	11,286	146	1,670
16	25	Tr.	16	.02	5.7	1.2	4.6	.0	29	3.3	.28	4.5	52	8,526	0	1,195
26	Aug. 4	Tr.	14	.08	7.2	1.9	4.9	.0	32	5.8	.40	2.0	53	7,184	0	1,025
Aug. 5	14	Tr.	14	.06	6.5	1.9	4.2	.0	32	2.4	.30	2.3	51	6,142	0	845
Mean		8	15	.10	5.3	1.4	[b]3.8 [b].8	.0	26	3.7	.36	1.9	51	----------	[c]737,000	[c]1,126,000

[a] Abnormal; computed as HCO_3 in average.

[b] Sodium and potassium, determined on combined alkali residues.

[c] Total annual denudation.

Analyses of water from McKenzie River near Springfield, Oreg.

[Parts per million except as otherwise designated.]

Date (1911-12).		Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Dissolved solids.	Mean gage height (feet).	Mean discharge (second-feet).	Suspended matter (tons per day).	Dissolved matter (tons per day).
From—	To—																
Aug. 11	Aug. 20	5	22	0.06	6.0	2.0	8.0	0.0	28	8.7	0.28	1.2	59	1.21	1,690	12.8	269
21	30	2	23	.02	6.8	2.3	6.9	.0	32	4.8	Tr.	1.8	64	1.11	1,592	6.9	275
31	Sept. 9	4	22	.10	6.6	2.5	6.0	.0	32	4.2	Tr.	1.5	60	1.53	2,079	32.5	336
Sept. 10	19	2	22	.07	9.6	1.0	7.2	.0	30	7.7	.12	2.3	56	1.38	1,873	16.2	283
20	29	2	19	.03	5.2	2.3	5.9	.0	35	6.7	Tr.	2.3	60	1.59	2,121	40.6	344
30	Oct. 9	3	20	.02	5.1	2.1	6.1	.0	33	2.6	Tr.	1.8	55	1.57	2,095	35.0	311
Oct. 10	19	1	18	Tr.	5.5	1.5	5.7	.0	29	3.8	.40	1.8	53	1.42	1,920	7.8	274
20	29	1	21	.02	4.3	1.3	5.8	.0	31	4.9	.40	1.5	59	1.21	1,691	Tr.	256
30	Nov. 8	Tr.	20	.05	4.1	2.4	5.1	.0	29	5.2	.40	1.8	55	1.71	2,468	20.0	366
Nov. 9	18	1	16	.07	3.7	1.3	3.8	.0	20	2.9	.46	1.1	43	4.60	8,552	254	992
19	28	4	16	.20	5.6	.6	4.4	.0	21	4.3	.20	1.0	46	3.66	5,505		684
29	Dec. 8	1	17	.05	4.1	1.2	4.4	.0	23	4.3	Tr.	1.3	47	2.67	3,586	5.8	490
Dec. 9	18	1	17	.40	5.9	1.2	4.6	.0	23	3.3	Tr.	.85	48	2.76	3,783	6.1	491
19	28	Tr.	15	.05	5.0	1.2	4.7	.0	23	4.6	.08	.75	46	3.05	4,207	14.7	522
29	Jan. 7	4	16	.06	3.9	1.2	4.7	.0	23	4.3	.10	1.0	46	3.04	4,728	74	587
Jan. 8	17	5	12	.09	2.9	.9	3.9	.0	18	3.3	.20	.75	40	6.64	15,204	1,641	1,641
18	27	1	14	Tr.	3.9	.7	4.4	.0	20	4.1	.28	1.0	39	4.53	7,767	64.9	816
28	Feb. 6	Tr.	14	.17	3.5	.4	3.7	.0	20	2.8	.12	.75	40	4.18	6,866	Tr.	742
Feb. 7	16	3	13	.11	3.4	.8	3.4	.0	20	3.7	.16	1.3	39	4.54	7,966	99	816
17	26	1	14	.06	4.6	1.0	3.6	.0	21	2.1	.21	1.5	39	5.36	10,547	142	1,110
27	Mar. 7	1	16	.06	3.2	1.6	4.2	.0	21	2.6	.16	.50	45	3.55	5,422	33.6	657
Mar. 8	17	1	17	.04	3.4	.8	3.9	.0	24	2.6	.24	.75	46	2.96	4,283	30.1	532
18	27	Tr.	15	.02	3.5	.7	4.7	.0	21	1.9	.18	3.8	44	2.77	3,925	Tr.	466
28	Apr. 6	1	15	.02	3.7	.5	4.4	.0	20	3.5	.09	1.3	45	2.52	3,537	37.2	429
Apr. 7	16	1	12	.02	3.5	.6	4.2	.0	18	2.3	.15	.25	43	2.76	3,933	7.4	456
17	26	Tr.	15	.01	3.8	.7	4.3	.0	22	3.3	.12	1.0	47	2.41	3,376	Tr.	428
27	May 6	Tr.	14	.03	4.4	.2	4.6	[a] 1.9	16	1.6	.20	1.2	42	3.50	5,387	Tr.	610
May 7	16	1	17	.01	3.3	.2	5.5	.0	20	3.2	.22	1.0	46	3.71	5,735	52.6	711
17	26	Tr.	13	.02	3.1	.1	6.3	.0	19	4.1	.26	1.0	41	3.28	4,827	Tr.	534
27	June 5	Tr.	13	.02	3.3	.3	4.9	.0	19	2.8	.30	1.0	43	4.02	6,500	Tr.	755
June 6	15	1	15	.02	3.8	.5	3.5	.0	20	1.3	.32	1.0	43	3.46	5,228	8.5	606
16	25	Tr.	16	.04	4.1	1.0	4.6	.0	23	3.8	.20	1.3	45	3.09	4,442	Tr.	539
26	July 5	Tr.	17	Tr.	3.3	1.2	5.4	.0	24	1.4	.20	1.3	49	2.68	3,773	Tr.	499
July 6	15												[b] 51	2.07	2,925	[b] Tr.	[b] 403
16	25	Tr.	20	.01	3.4	1.3	5.6	.0	28	3.6	.28	1.3	53	1.74	2,525	Tr.	362
26	Aug. 4	Tr.	19	.08	5.1	1.4	5.2	[a] 2.6	22	3.8	.12	2.0	53	1.54	2,306	Tr.	330
Aug. 5	14	Tr.	19	.04	5.1	1.0	6.9	.0	28	5.8	.16	2.0	54	1.35	2,110	Tr.	308
Mean		Tr.	17	.06	4.4	1.1	[c] 4.1 [c] 1.2	.0	24	3.8	.18	1.3	50			[d] 26,800	[d] 199,600

[a] Abnormal; computed as HCO_3 in average.
[b] Estimated.
[c] Sodium and potassium, determined on combined alkali residues.
[d] Total annual denudation.

Analyses of water from Santiam River at Mehama, Oreg.

[Parts per million except as otherwise designated.]

Date (1911).		Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Dissolved solids.	Mean gage height (feet).	Mean discharge (second-feet).	Suspended matter (tons per day).	Dissolved matter (tons per day).
From—	To—																
Aug. 1	Aug. 10	1	21	0.10	5.7	0.8	7.6	0.0	28	4.3	0.48	1.5	55	2.4	830	3.1	123
11	20	3	23	.07	6.0	2.0	5.5	.0	24	5.6	.32	.75	54	2.3	749	4.4	109
21	30	3	21	.02	5.3	1.7	4.7	.0	26	4.4	Tr.	1.0	54	2.2	676	4.9	99
21	Sept. 9	3	21	.05	6.7	.8	5.8	.0	26	5.6		.80	49	2.4	899	5.3	119
Sept. 10	19	2		.01	7.2	1.0	5.3	.0	29	5.4	.28	1.8	59	2.7	1,136	0	181
20	29	1	23	.08	7.5	2.4	5.2	.0	31	5.9	Tr.	1.3	62	2.5	895	9.2	150
30	Oct. 9	1	16	.02	6.3	1.6	5.1	.0	31	6.1	Tr.	1.0	52	2.8	1,213	8.2	170
Oct. 10	19	Tr.	15	.02	4.6	1.0	4.5	.0	22	3.0	.26	1.5	43	2.7	1,112	5.7	129
20	29	1	21	.02	4.3	1.2	5.0	.0	26	2.1	.34	1.8	52	2.4	812	2.6	114
30	Nov. 8	5	16	.05	5.6	1.3	3.6	.0	22	3.0	.36	.90	46	3.4	2,504	29	311
Nov. 9	18	1	8.9	.03	3.4	.8	2.4	.0	10	2.3	.42	.65	28	5.9	8,346	186	630
19	28	2	8.2	.02	3.4	.9	2.4	.0	15	4.4	.40	.15	33	4.9	5,074	16.4	452
29	Dec. 8	2	11	.02	3.4	1.2	3.0	.0	17	5.1	.36	.40	37	3.8	2,572	4.9	257
Dec. 9	18	3	10	.02	3.3	.9	3.5	.0	17	5.3	Tr.	.85	33	4.3	3,414	9.2	304
Mean		2	17	.04	5.2	1.3	[a] 3.7 [a] 1.1	.0	23	4.5	.25	1.0	47				

[a] Sodium and potassium, determined on combined alkali residues.

Analyses of water from Clackamas River at Cazadero, Oreg.

[Parts per million except as otherwise designated.]

Date (1911-12).		Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Dissolved solids.	Mean gage height (feet).	Mean discharge (second-feet).	Suspended matter (tons per day).	Dissolved matter (tons per day).
From—	To—																
Aug. 11	Aug. 20	2	24	0.02	7.3	2.1	7.6	0.0	38	4.0	Tr.	2.2	64	26	870	0.0	150
21	30	2	19	.06	8.2	2.0	6.9	.0	38	4.9	Tr.	2.8	62	26	845	2.7	141
31	Sept. 9	1	31	.06	7.2	2.2	5.4	.0	32	6.3	.20	2.2	75	26	1,023	7.7	207
Sept. 10	19	1	19	.02	6.4	2.4	5.6	.0	34	4.9	.20	2.5	58	26	1,130	6.4	177
20	29	1	19	.05	6.0	2.7	6.8	.0	35	6.7	Tr.	2.8	63	26	950	5.1	162
30	Oct. 9	3	20	.06	5.8	1.8	5.1	.0	34	5.4	1.5	2.4	61	26	1,113	1.4	183
Oct. 10	19	1	20	.01	5.9	2.2	6.5	.0	35	5.4	.48	2.5	60	26	1,006	4.3	162
20	29	2	20	.02	6.4	1.8	5.7	.0	35	5.5	.28	2.7	61	26	855	4.6	141
30	Nov. 8	Tr.	16	.01	5.7	1.9	4.8	.0	31	3.9	.38	2.6	57	27	1,468	17.8	226
Nov. 9	18	1	16	.06	4.3	1.3	3.2	.0	21	1.8	.46	1.5	43	29	4,188	39.6	487
19	28	Tr.	16	.07	4.1	1.4	3.5	.0	22	5.6	.48	1.3	46	28	3,155	.0	392
29	Dec. 8	1	14	.02	4.9	1.4	4.6	.0	23	4.4	Tr.	1.3	46	27	1,925	.0	239
Dec. 9	18	1	15	.05	4.9	1.4	4.9	.0	22	3.8	Tr.	1.1	45	28	2,444	6.6	297
19	28	1	16	.06	5.7	.6	5.0	.0	26	5.2	.08	1.3	49	28	2,480	9.4	328
29	Jan. 7	6	16	.14	5.7	.9	4.9	.0	24	2.6	Tr.	1.5	49	27	2,064	30.6	273
Jan. 8	17	15	13	.12	3.9	1.2	3.8	.0	24	1.6	.08	.75	44	31	8,260	602	982
18	27	3	15	.06	4.3	.7	4.2	.0	20	2.5	.08	1.0	40	30	5,159	97.6	557
28	Feb. 6	3	14	.06	3.9	.7	4.0	.0	21	1.6	.07	.75	39	30	5,333	60.4	561
Feb. 7	16	8	13	.07	3.8	1.0	2.4	.0	18	4.0	.12	1.5	39	31	6,615	137	696
17	26	Tr.	13	.03	5.2	.9	4.3	.0	21	3.3	.30	1.0	41	30	5,815	Tr.	643
27	Mar. 7	Tr.	16	.04	4.2	1.6	4.3	.0	24	3.2	.15	1.0	47	28	2,660	Tr.	338
8	17	2	19	.05	4.8	1.4	3.9	.0	28	6.1	.15	.50	54	27	1,938	13.1	283
18	27	Tr.	15	.05	5.1	.9	6.0	.0	27	2.5	.14	1.0	52	27	2,020	Tr.	274
28	Apr. 6	1	15	.06	4.8	.9	5.3	Tr.	24	3.0	.12	1.3	48	28	2,379	24.4	308
Apr. 7	16	Tr.	18	.03	4.3	1.0	5.5	.0	22	3.0	.30	2.0	51	28	2,783	Tr.	384
17	26	1	14	.05	4.7	.9	6.0	.0	24	3.1	.14	2.3	49	28	2,309	11.9	307
27	May 6	1	14	.04	4.2	.8	4.4	.0	22	1.2	.24	1.3	43	28	3,162	23.9	367
May 7	16	1	14	.04	4.1	.7	3.5	.0	18	3.0	.26	1.0	40	29	4,379	50.8	473
17	26	Tr.	15	.04	4.1	.5	3.7	.0	18	3.5	.26	1.3	39	29	3,816	Tr.	402
27	June 5	Tr.	15	.06	4.8	.8	4.7	.0	18	4.3	.24	1.0	40	29	3,965	Tr.	428
June 6	15	Tr.	14	.02	4.4	1.0	4.3	.0	21	4.7	.40	1.5	41	28	2,944	Tr.	326
16	25	1	15	.01	4.3	1.2	4.7	.0	23	3.4	.34	1.9	44	28	2,558	15.2	304
26	July 5	1	18	.01	5.0	1.3	5.7	.0	26	2.1	.24	1.7	47	27	1,849	2.5	235
July 6	15	3	16	Tr.	5.9	1.6	2.4	.0	25	3.9	.30	2.4	54	27	1,493	16.9	218
16	25	Tr.	18	.01	6.3	1.6	4.1	.0	31	4.9	.28	2.3	58	26	1,272	Tr.	199
26	Aug. 4	Tr.	17	.04	6.9	1.9	5.2	.0	33	4.9	.10	1.8	55	26	1,136	Tr.	169
Aug. 5	14	Tr.	18	.07	7.3	1.8	5.0	.0	33	4.0	.24	3.0	58	26	1,042	Tr.	163
Mean		2	17	.05	5.3	1.4	[a]4.2 [a].8	.0	26	3.9	.23	1.7	50			[b]11,750	[b]120,300

[a] Sodium and potassium, determined on combined alkali residues.
[b] Total annual denudation.

Reduced to standard form and percentages the foregoing tables of analyses of water from southern tributaries of the Columbia compare as follows:

Analyses of water from southern tributaries of the Columbia in Oregon.

1. Umatilla River near Gibbon. 3 composite analyses.
2. Umatilla River near Yoakum. 35 composites.
3. Umatilla River near Umatilla. 36 composites.
4. John Day River near Dayville. 13 composites.
5. John Day River near McDonald. 37 composites.
6. Deschutes River at Bond. 13 composites.
7. Deschutes River at Moody. 34 composites.
8. Crooked River near Prineville. 29 composites.
9. Sandy River near Brightwood. 36 composites.
10. Bull Run River near Bull Run. 36 composites.
11. Willamette River at Salem, 1910. 15 composites.
12. The same, 1911-12. 37 composites.
13. McKenzie River near Springfield. 37 composites.
14. Santiam River at Mehama. 14 composites.
15. Clackamas River at Cazadero. 37 composites.

	1	2	3	4	5	6	7	8
CO_3	22.84	30.04	31.48	43.02	39.79	27.71	31.79	40.95
SO_4	6.20	6.88	12.70	5.45	8.51	5.91	5.68	7.04
Cl	4.13	3.22	5.19	1.34	1.91	1.97	2.39	4.55
NO_3	.41	.55	.66	.49	.78	.36	.79	.17
Ca	9.18	11.09	12.70	13.47	14.18	8.36	9.65	10.75
Mg	2.38	3.32	3.64.	6.73	5.39	2.62	3.07	4.56
Na	12.41	10.75	12.15	7.96	9.22	10.99	12.49	15.72
K		1.89	2.65	1.29	1.70	2.62	2.27	2.15
Fe_2O_3	.08	.11	.06	.05	.08	.10	.08	.04
SiO_2	42.37	32.15	18.77	20.20	18.44	39.36	31.79	14.07
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Salinity [a]	97	90	181	163	141	61	88	242

[a] Parts per million.

Analyses of water from southern tributaries of the Columbia in Oregon—Continued.

	9	10	11	12	13	14	15
CO_3	19.95	22.28	28.08	28.32	26.25	24.88	27.00
SO_4	15.96	11.71	9.88	8.19	8.45	9.91	8.23
Cl	3.76	4.91	6.93	4.20	2.89	2.20	3.59
NO_3	.52	1.17	2.77	.80	.40	.55	.49
Ca	10.20	10.20	11.26	11.72	9.79	11.45	11.18
Mg	2.88	2.00	3.82	3.09	2.44	2.86	2.96
Na	9.30	11.71	11.09	8.40	9.12	8.15	8.86
K	1.75	1.89		1.80	2.67	2.43	1.69
Fe_2O_3	.23	.15	.17	.30	.18	.13	.14
SiO_2	35.45	33.98	26.00	33.18	37.81	37.44	35.86
	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Salinity [a]	45	26.5	58	45.2	45	45.4	47.4

[a] Parts per million.

With a few exceptions these waters much resemble those of the south Atlantic slope. Their low salinity and high percentage of silica and alkalies indicate the derivation of their solid contents from igneous rocks in which persilicic varieties are most abundant. The three average analyses of waters from Umatilla River show a progressive change of composition from Gibbon, near the head of the stream, to Umatilla, near its mouth. The five averages for the Willamette and its tributaries are almost identical.[53]

Three additional analyses of water from the Willamette basin have been received from the Southern Pacific Co., as follows:

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[53] An analysis of water from the Willamette at Corvallis by B. Pilkinton, reported by C. E. Bradley in Jour. Ind. and Eng. Chemistry, vol. 2, p. 294, 1910, is so unlike the others as to render it of very doubtful value. It is therefore not used here.

Analyses of water from the Willamette basin, Oreg.

1. Willamette River at Eugene.
2. Lacreole Creek at Derry.
3. Tualatin River at Gaston.

	Parts per million.			Percentage composition.		
	1	2	3	1	2	3
CO_3	15.0	20.6	17.8	27.99	27.17	24.83
SO_4	1.4	3.5	2.2	2.61	4.62	3.07
Cl	6.4	8.0	10.7	11.94	10.56	14.92
Ca	7.8	10.9	6.7	14.55	14.38	9.34
Mg	2.4	4.7	5.4	4.48	6.20	7.53
Na, K	2.7	1.1	3.9	5.04	1.45	5.44
Oxides [a]	17.9	27.0	25.0	33.39	35.62	34.87
	53.6	75.8	71.7	100.00	100.00	100.00

[a] Silica plus sesquioxides.

The high proportion of chlorine in these analyses is suggestive of contamination.

SALINE AND ALKALINE LAKES OF NORTHEASTERN WASHINGTON.

In northeastern Washington between Snake River and the Columbia there are several saline or alkaline lakes. As these isolated bodies of water lie within the general drainage area of the Columbia it is convenient to consider them here. For four of these lakes analyses are on record as shown in the following table:

Analyses of water from four lakes in Washington.

1. Omak Lake, Colville Indian Reservation. Analysis by G. Steiger in chemical laboratory of U. S. Geological Survey.
2. Soap Lake, 6 miles north of Ephrata, Grant County. Analysis by Steiger.
3. The same. Analysis by H. G. Knight, Washington Geol. Survey Ann. Rept., vol. 1, p. 295, 1901.
4. Medical Lake, Spokane County. Analysis by G. A. Mariner, Washington Geol. Survey Ann. Rept., vol. 1, p. 292, 1901.
5. Moses Lake, Grant County. Analysis by Knight, op. cit., p. 294.

I. Parts per million.

	1	2	3	4	5
CO_3	2,095	8,522	8,147	66.5	1,531
SO_4	1,205	4,636	4,600	--------	85
Cl	169	3,745	3,527	251.1	115
PO_4	--------	--------	134	Tr.	--------
Ca	13	Tr.	Tr.	1.2	252
Mg	105	12	79	1.1	215
Na	1,859	} 11,167	10,450	160.0	590
K	258		335	84.6	--------
$(Al, Fe)_2O_3$	--------	--------	Tr.	12.0	.32
SiO_2	--------	118	128	182.5	1.50
Li, B_4O_7	--------	--------	--------	Tr.	--------
	5,704	28,200	27,400	759.0	2,970

Analyses of waters from four lakes in Washington—Continued.

II. Percentage composition of dissolved solids.

	1	2	3	4	5
CO_3	36.75	30.22	29.73	8.76	51.56
SO_4	21.12	16.44	16.79	--------	2.87
Cl	2.96	13.28	12.87	33.08	3.88
PO_4	--------	--------	.49	Tr.	--------
Ca	.23	Tr.	Tr.	.16	8.41
Mg	1.82	.04	.29	.15	7.25
Na	32.60	} 39.60	38.14	21.08	} 19.86
K	4.52		1.22	11.15	
$(Al, Fe)_2O_3$	--------	--------	Tr.	1.58	1.11
SiO_2	--------	.42	.47	24.04	5.06
Li, B_4O_7	--------	--------	--------	Tr.	--------
	100.00	100.00	100.00	100.00	100.00

All these waters, except that of Medical Lake, contain alkaline bicarbonates, but the analyses as reported do not show the fact.

PUGET SOUND DRAINAGE BASIN.

A number of rivers in Washington empty into Puget Sound and several of them have been studied by Van Winkle.[54] They are Skagit River, Wood Creek (a tributary of Snohomish River), Cedar River, Green River (a tributary of White River, which joins Cedar River to form Duwamish River), and Chehalis River and its tributary Wynoochee River. The tables of analyses follow:

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[54] U. S. Geol. Survey Water-Supply Paper 339, 1914.

Analyses of water from Skagit River at Sedro Woolley, Wash.

[Parts per million unless otherwise stated.]

Date (1910-11).		Turbidity.	Silica (SiO₂).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO₃).	Bicarbonate radicle (HCO₃).	Sulphate radicle (SO₄).	Nitrate radicle (NO₃).	Chlorine (Cl).	Dissolved solids.	Mean gage height (feet).	Mean discharge (second-feet).	Suspended matter (tons per day).	Dissolved matter (tons per day).
From—	To—																
Feb. 1	Feb. 10	4	15	0.30	9.4	2.7	3.2	0.0	39	11	0.63	0.5	65	38.64	10,386	118	1,820
11	20	3	15	.90	11	2.2	5.7	.0	41	12	.12	1.5	68	37.72	7,997	69	1,470
21	Mar. 2	15	15	.10	12	3.0	6.5	.0	49	8.3	.12	.7	69	38.48	10,085	490	1,880
Mar. 3	12	10	8.7	.05	8.4	2.6	3.1	.0	26	14	.50	.5	59	39.97	14,430	585	2,300
13	22	15	13	.08	7.4	2.4	3.6	.0	31	7.2	.30	.3	54	41.41	19,310	1,560	2,820
23	Apr. 1	9	7.2	.03	8.3	2.0	4.4	.0	38	8.5	.30	.5	49	40.24	15,220	374	2,010
Apr. 2	11	20	14	Tr.	10	3.5	8.2	.0	48	6.9	--------	2.0	79	39.90	14,110	458	3,010
12	21	8	18	.30	9.2	2.0	4.9	.0	34	9.2	.30	.5	63	40.45	15,920	275	2,710
22	May 1	50	9.6	.01	7.6	3.0	4.7	.0	32	5.3	Tr.	.7	46	43.27	26,760	4,910	3,320
May 2	11	20	14	.06	7.6	1.5	5.8	.0	31	6.7	.00	.4	55	43.19	26,670	2,520	3,960
12	21	15	14	.05	7.6	1.6	3.9	.0	29	10	.00	.4	54	43.46	27,430	1,930	4,000
22	31	20	15	.05	6.8	1.4	4.1	.0	21	15	.00	.1	67	43.87	29,080	3,300	5,250
June 1	June 10	10	7.1	.04	7.5	1.2	3.5	.0	26	8.0	.00	1	41	42.13	21,940	830	2,430
11	20	10	14	.04	7.4	1.3	3.1	.0	27	5.2	.00	.5	47	42.24	22,560	1,340	2,860
21	30	5	7.6	.03	6.1	1.5	3.0	.0	21	6.8	.00	.5	38	40.58	16,260	847	1,670
July 1	July 10	5	6.7	.05	6.0	1.3	2.9	.0	20	4.9	.00	.4	33	40.95	17,540	355	1,560
11	20	18	6.2	.04	5.2	1.3	3.6	.0	21	5.2	.00	.8	32	41.33	19,010	975	1,640
21	30	10	3.9	.03	6.3	1.3	3.3	.0	22	5.8	--------	.9	34	39.85	13,860	374	1,270
31	Aug. 9	5	6.5	.04	7.7	1.4	2.9	.0	28	5.4	--------	1.4	41	39.20	11,880	135	1,310
Aug. 10	19	6	3.1	.02	5.9	1.4	3.8	.0	21	8.2	.75	1.1	32	38.89	10,050	206	870
20	29	5	6.0	.03	6.8	1.5	3.3	.0	24	6.5	.90	1.1	39	37.95	8,601	169	905
30	Sept. 8	5	10	.01	7.8	1.5	2.9	.0	28	9.5	.00	.9	47	37.46	7,375	63	935
Sept. 9	18	5	9.4	.02	8.3	2.0	3.0	.0	30	12	.31	.9	49	37.04	6,401	61	845
19	28	19	8.6	.10	8.3	1.5	3.1	.0	26	7.2	.10	1.8	47	37.56	7,636	475	970
29	Oct. 8	40	4.3	.18	5.9	1.6	3.3	.0	18	10	.70	1.2	40	41.79	21,720	4,050	2,340
Oct. 9	18	13	6.8	.11	7.0	1.3	3.6	.0	23	6.5	1.0	1.1	41	41.06	18,320	940	2,030
19	28	11	7.5	.13	7.1	1.4	3.2	.0	26	6.8	.85	1.5	41	40.87	18,278	887	2,020
29	Nov. 7	7	7.1	.06	7.2	.7	2.9	.0	26	--------	.70	1.7	41	39.70	13,630	214	1,510
Nov. 8	17	18	6.9	.05	7.5	.7	2.7	.0	25	8.3	.50	1.0	43	42.81	25,380	253	2,940
18	27	50	6.3	.06	6.8	.9	2.2	.0	22	7.6	Tr.	.8	42	43.54	29,340	6,570	3,330
28	Dec. 7	5	7.2	.02	7.6	1.4	2.8	.0	26	8.5	Tr.	.3	44	40.36	15,530	327	1,850
Dec. 8	17	5	7.5	.01	8.1	1.8	2.8	.0	29	8.2	.10	.5	46	39,52	12,910	202	1,600
18	27	6	7.9	.01	8.2	1.1	2.8	.0	28	7.9	Tr.	.5	46	39.51	13,078	190	1,620
28	Jan. 6	3	9.5	.01	8.2	--------	3.6	.0	29	6.6	Tr.	1.0	51	38.85	10,928	118	1,510
Jan. 7	16	3	9.4	Tr.	9.6	1.9	2.4	.0	31	7.9	.10	1.3	47	39.17	11,860	112	1,500
17	26	1	10	.03	10	1.8	2.8	.0	32	9.5	Tr.	1.3	50	37.76	8,114	64	1,090
27	31	1	9.5	.03	11	2.0	2.9	.0	35	9.3	Tr.	1.8	52	37.08	6,486	17	910
Mean........		12	9.4	.08	7.9	1.7	3.6	.0	29	8.2	.24	.9	48	--------	15,840	a 363,550	a 756,100

a Annual denudation.

Anayses of water from Wood Creek near Everett, Wash.

[Parts per million.]

Date (1910-11).		Turbidity.	Silica (SiO₂).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO₃).	Bicarbonate radicle (HCO₃).	Sulphate radicle (SO₄).	Nitrate radicle (NO₃).	Chlorine (Cl).	Dissolved solids.
From—	To—												
Mar. 13	Mar. 22	10	26	Tr.	7.2	5.2	13	a 13	34	6.1	Tr.	2.5	86
23	Apr. 1	25	37	0.01	8.6	3.8	8.2	.0	54	14	Tr.	--------	106
Apr. 2	11	20	20	Tr.	8.5	4.4	7.6	.0	43	7.9	Tr.	2.5	75
12	21	25	26	Tr.	9.4	4.6	8.5	.0	56	8.9	0.40	3.3	94
22	May 1	5	26	Tr.	9.0	4.4	7.6	.0	51	9.8	.20	3.5	87
May 2	11	50	--------	.02	8.2	3.9	7.2	.0	51	11	.50	2.5	54
12	21	20	27	Tr.	8.2	4.2	7.9	.0	52	9.5	.00	2.8	91
22	31	5	27	Tr.	8.5	5.2	8.0	.0	51	7.9	Tr.	3.0	90
June 1	June 10	15	23	Tr.	9.0	5.2	8.8	.0	57	8.9	Tr.	3.0	91
11	20	15	35	Tr.	11	5.0	9.8	.0	61	7.2	Tr.	3.3	107
21	30	10	19	Tr.	9.8	5.6	8.8	.0	56	7.7	Tr.	2.8	81
July 1	July 10	50	41	.01	11	3.5	10	.0	55	8.9	.00	3.3	119
11	20	7	26	Tr.	8.8	--------	8.7	.0	52	12	--------	--------	90
21	30	5	23	Tr.	9.2	5.2	7.6	.0	55	6.9	.00	3.0	83
31	Aug. 9	7	27	Tr.	9.0	6.7	8.0	.0	57	6.9	.45	2.6	94
Aug. 10	19	15	21	Tr.	9.3	5.0	8.4	.0	49	7.1	Tr.	3.3	82
20	29	2	28	Tr.	9.6	5.2	7.6	.0	54	7.6	1.9	3.2	90
30	Sept. 8	15	25	.01	8.0	4.6	7.8	.0	57	5.1	.00	3.1	82
Sept. 9	18	5	21	.01	10	3.6	8.2	.0	54	6.9	Tr.	3.5	86
19	28	Tr.	21	.01	9.2	4.4	10	.0	63	5.3	.65	2.8	101
29	Oct. 8	5	18	.05	7.1	4.8	6.7	.0	50	6.6	Tr.	2.5	85
Oct. 9	18	3	30	.06	7.2	4.6	6.9	.0	50	5.0	.75	2.8	85
19	28	5	28	.06	8.6	4.8	7.2	.0	50	12	.63	3.3	89
29	Nov. 7	2	30	.07	7.2	4.4	6.1	.0	48	6.5	.75	3.0	86
Nov. 8	17	4	29	.03	7.7	4.4	6.5	.0	50	5.4	.70	2.5	83
18	27	1	26	.05	8.8	4.8	6.8	.0	48	9.7	2.0	2.8	87
28	Dec. 7	3	26	.01	7.6	5.0	5.7	.0	49	6.9	.50	2.5	84
Dec. 8	17	2	27	.01	7.6	4.4	4.9	.0	48	6.9	.10	2.8	80
18	27	3	15	.03	6.8	4.2	5.7	.0	48	7.6	Tr.	2.1	83
28	Jan. 6	2	22	Tr.	7.7	4.2	6.1	.0	45	6.9	.05	2.6	78
Jan. 7	16	3	24	.01	6.9	3.6	5.6	.0	42	5.6	Tr.	2.5	73
17	26	3	20	Tr.	9.6	3.5	6.8	.0	39	8.6	--------	--------	73
27	31	4	16	.01	8.2	2.8	5.7	.0	37	5.3	.10	2.8	65
Mean........		10	25	.01	8.6	4.5	7.6	.0	51	7.8	.31	2.9	86

a Abnormal; computed as HCO_3 in average.

Analyses of water from Cedar River at Ravensdale, Wash.

[Parts per million unless otherwise stated.]

Date (1910–11).		Turbidity.	Silica (SiO₂).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO₃).	Bicarbonate radicle (HCO₃).	Sulphate radicle (SO₄).	Nitrate radicle (NO₃).	Chlorine (Cl).	Dissolved solids.	Mean gage height (feet).	Mean discharge (second-feet).	Dissolved solids (tons per day).	Suspended matter (tons per day).
From—	To—																
Feb. 1	Feb. 10	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	1.25	708	[a] 108	[a] 7.7
11	20	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	1.10	606	[a] 161	[a] 11
21	Mar. 2	2	31	0.05	6.3	2.4	4.7	Tr.	34	7.4	Tr.	1.3	84	1.50	940	213	15
Mar. 3	12	5	16	.05	5.0	1.8	4.3	0.0	26	7.1	Tr.	1.3	50	2.25	1,644	222	9
13	22	8	26	.05	4.8	1.8	4.0	.0	28	3.8	0.00	.5	66	2.35	1,677	298	25
23	Apr. 1	10	12	.01	6.4	1.5	3.0	.0	24	6.7	.10	.8	47	1.70	1,056	213	43
Apr. 2	11	8	20	.01	6.1	1.4	3.8	.0	28	3.4	.20	1.3	58	1.60	972	149	18
12	21	10	19	.01	7.0	1.4	3.5	.0	31	6.3	Tr.	.8	59	1.60	963	152	19
22	May 1	30	13	.01	5.2	1.5	3.3	.0	24	5.1	Tr.	.9	48	1.85	1,186	154	11
May 2	11	10	17	.01	6.4	1.8	3.3	.0	29	5.3	.10	.8	53	1.40	815	116	18
12	21	5	15	.02	6.4	1.7	4.2	.0	33	5.3	--------	1.0	50	1.55	935	126	11
22	31	12	20	.01	6.7	1.5	4.6	.0	32	5.2	.10	.6	58	1.25	674	105	13
June 1	June 10	5	16	.01	6.7	1.3	3.0	.0	28	5.8	.20	.8	53	1.00	514	73	5
11	20	5	14	.01	8.4	1.9	4.1	.0	44	6.6	--------	1.1	57	.90	421	65	4
21	30	1	16	.01	9.6	2.1	3.5	.0	32	9.0	--------	.8	59	.80	382	61	.2
July 1	July 10	3	22	.01	7.2	2.1	3.8	.0	34	5.7	--------	.9	63	.75	351	60	2.9
11	20	1	11	.01	7.6	2.1	3.2	.0	34	3.6	--------	1.2	47	.60	249	32	.4
21	30	2	12	.01	8.0	2.0	3.8	.0	37	5.2	--------	.9	54	.50	213	31	.4
31	Aug. 9	2	9.5	.01	5.8	1.5	4.9	.0	27	3.5	.50	1.3	44	.50	200	24	1.1
Aug. 10	19	5	12	Tr.	8.2	1.3	3.2	.0	29	6.4	.00	4.0	49	.45	181	24	1.3
20	29	1	9.5	.01	7.2	1.4	4.1	.0	31	3.4	.10	1.8	44	.45	173	21	.5
30	Sept. 8	2	12	Tr.	7.8	1.6	2.8	.0	32	5.0	.00	.9	46	.50	205	25	.6
Sept. 9	18	7	11	.01	7.0	1.3	3.1	.0	31	5.0	.00	.9	45	.55	236	29	1.3
19	28	5	12	.01	7.7	1.2	4.0	.0	29	8.0	.70	1.3	48	.55	222	29	.6
29	Oct. 8	5	14	.02	6.4	1.4	4.8	.0	29	7.3	1.0	1.8	54	.80	390	57	4.1
Oct. 9	18	5	9.2	.01	6.3	1.5	4.0	.0	26	9.4	.76	1.0	45	.80	382	46	1.5
19	28	2	9.8	.08	6.0	.8	3.3	.0	22	5.6	.50	1.3	41	.85	406	45	1.1
29	Nov. 7	1	8.9	Tr.	5.9	.8	3.5	.0	21	5.7	.80	1.4	41	.95	480	53	[a] 13
Nov. 8	17	3	7.1	.01	4.4	.7	2.7	.0	17	4.6	.20	1.3	34	2.15	1,506	138	24
18	27	2	8.8	.02	5.5	1.0	2.7	.0	18	4.6	Tr.	1.2	37	2.15	1,572	157	14
28	Dec. 7	3	10	.02	5.6	1.1	3.3	.0	22	6.5	Tr.	1.0	40	1.40	807	87	8.5
Dec. 8	17	2	8.0	.01	6.2	1.1	2.9	.0	21	8.2	.20	1.0	37	1.40	791	79	3.6
18	27	3	7.5	.01	7.3	1.0	3.4	.0	23	5.3	.00	1.1	39	1.10	578	61	[a] 2.5
28	Jan. 6	1	9.5	.02	6.9	.6	2.5	.0	21	4.6	Tr.	1.2	40	1.25	691	80	[a] 1.6
Jan. 7	16	3	12	.02	7.4	.5	3.2	.0	23	4.9	Tr.	1.3	43	1.50	879	102	7.3
17	26	2	9.9	Tr.	8.3	.9	3.0	.0	23	5.9	Tr.	1.2	42	1.05	546	62	--------
27	31	1	9.0	--------	--------	--------	--------	.0	26	--------	--------	1.8	45	.95	456	55	[a] 4.0
Mean		5	13	.02	6.7	1.4	3.6	.0	28	5.7	.20	1.2	49	--------	685	[b] 34,855	[b] 2,960

[a] Estimated.

[b] Annual denudation.

Analyses of water from Green River at Hot Springs, Wash.

[Parts per million.]

Date (1910).		Turbidity.	Silica (SiO₂).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO₃).	Bicarbonate radicle (HCO₃).	Sulphate radicle (SO₄).	Nitrate radicle (NO₃).	Chlorine (Cl).	Dissolved solids.
From—	To—												
Feb. 1	Feb. 10	3	17	0.11	5.4	2.0	--------	0.0	25	12	0.45	2.5	58
11	20	3	18	.04	6.5	1.3	6.9	.0	29	10	.10	1.0	57
21	Mar. [a]2	10	35	.26	6.8	2.1	11	.0	51	8.6	.30	1.4	109
Mar. 3	12	4	6.6	.06	5.9	1.5	6.6	Tr.	24	8.9	.00	1.3	56
13	22	10	16	.05	4.8	1.9	8.2	.0	26	10	.00	1.0	51
23	Apr. 1	8	9.2	.06	4.1	1.0	3.5	.0	20	3.7	Tr.	1.3	39
Apr. 2	11	9	14	.02	5.4	1.7	7.1	.0	24	6.1	.10	1.0	50
12	21	10	13	.04	4.3	1.3	6.6	.0	29	5.3	.35	1.3	60
22	May 1	8	15	.01	5.3	1.0	5.4	.0	27	6.5	.50	1.5	44
May 2	11	10	20	.01	6.0	1.4	4.0	.0	25	3.2	.30	1.0	56
12	21	5	25	.01	5.4	1.2	3.3	.0	27	2.3	.50	1.0	56
22	31	5	20	.01	5.3	1.2	4.5	.0	23	5.2	.00	2.0	55
June 1	June 10	15	18	.01	5.6	1.3	5.6	.0	30	6.1	.00	1.0	55
11	20	10	12	.01	7.3	1.1	5.0	.0	29	3.6	.00	1.0	43
21	30	5	23	.01	6.0	1.4	6.0	.0	27	3.5	.00	.8	58
July 1	July 10	4	17	.01	7.2	1.3	5.1	.0	31	4.9	.00	1.3	54
11	20	5	17	.01	6.1	1.0	5.1	.0	28	6.4	.00	1.3	55
21	30	3	12	Tr.	8.5	.9	4.7	.0	34	3.4	.00	1.5	51
31	Aug. 9	1	11	Tr.	6.8	.8	3.5	.0	29	3.6	.00	1.8	45
Aug. 10	18	1	12	Tr.	7.1	.8	4.1	.0	28	5.2	.00	1.8	48
Mean		6	17	.04	6.0	1.3	5.6	.0	28	5.9	.13	1.3	55

Analyses of water from Chehalis River at Centralia, Wash.

[Parts per million except as otherwise stated.]

Date (1910-11).		Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Dissolved solids.	Mean gage height (feet).	Mean discharge (second-feet).	Suspended matter (tons per day).	Dissolved matter (tons per day).
From—	To—																
Feb. 1	Feb. 10	18	18	0.18	5.0	2.5	6.5	0.0	24	12	0.5	3.3	62	--------	--------	--------	--------
Mar. 3	Mar. 12	70	14	.05	4.4	2.3	5.4	.0	19	9.9	.05	2.5	45	--------	--------	--------	--------
13	22	40	20	.08	5.9	1.9	6.5	.0	36	5.4	.00	3.1	65	--------	--------	--------	--------
23	Apr. 1	20	15	.04	4.9	1.8	5.5	.0	28	7.6	.20	3.3	58	--------	--------	--------	--------
Apr. 2	11	50	17	.05	7.4	1.7	6.2	.0	34	5.4	.18	3.6	62	--------	--------	--------	--------
12	21	15	13	.01	5.9	1.3	6.5	.0	24	8.0	.10	3.3	53	--------	--------	--------	--------
22	May 1	15	18	.05	6.0	2.1	7.0	.0	33	4.9	.15	4.1	60	--------	--------	--------	--------
May 2	11	8	14	.04	6.6	1.4	5.4	.0	33	5.1	Tr.	7.3	56	--------	--------	--------	--------
12	21	5	20	.01	9.3	2.7	5.2	.0	38	5.2	--------	4.5	67	--------	--------	--------	--------
22	31	5	33	Tr.	9.2	2.2	10	.0	49	7.1	Tr.	5.8	100	--------	--------	--------	--------
June 1	June 10	10	24	Tr.	11	2.0	7.7	.0	40	6.8	.15	5.7	81	--------	--------	--------	--------
11	20	25	27	.05	11	3.2	14	.0	56	6.7	Tr.	6.5	114	--------	--------	--------	--------
21	30	5	19	.24	8.3	1.9	7.6	.0	33	6.7	.10	5.3	70	--------	--------	--------	--------
July 1	July 10	6	21	Tr.	9.5	2.0	8.7	.0	38	7.0	Tr.	5.8	76	--------	--------	--------	--------
11	20	7	16	.02	9.0	2.2	7.6	.0	39	10	Tr.	6.6	72	--------	--------	--------	--------
21	30	10	19	.01	9.1	1.9	7.8	.0	41	7.8	.00	7.2	76	--------	--------	--------	--------
31	Aug. 9	5	14	.05	9.2	2.5	5.9	.0	35	6.2	.00	8.6	67	--------	--------	--------	--------
Aug. 10	19	13	8.9	Tr.	8.1	2.2	6.6	.0	40	4.6	.12	8.5	61	--------	--------	--------	--------
20	29	4	14	.08	8.1	2.6	8.4	.0	40	4.9	.75	6.0	70	--------	--------	--------	--------
30	Sept. 8	12	13	.01	9.5	2.3	6.6	.0	40	7.0	Tr.	7.2	67	--------	--------	--------	--------
Sept. 9	18	7	19	.03	10	2.4	8.6	.0	48	6.9	.60	7.3	79	--------	--------	--------	--------
19	28	5	16	.05	8.1	2.6	7.8	.0	38	8.5	.40	8.3	71	--------	--------	--------	--------
29	Oct. 8	15	14	.18	6.4	1.9	6.4	.0	27	7.2	Tr.	5.0	61	--------	--------	--------	--------
Oct. 9	18	10	14	.10	6.4	2.0	5.8	.0	27	5.9	Tr.	4.0	55	3.780	1,833	24	272
19	28	10	15	.05	5.4	1.4	5.1	.0	26	4.9	Tr.	4.0	57	3.325	1,555	23	240
29	Nov. 7	10	15	.08	6.2	1.6	5.7	.0	29	6.5	Tr.	4.8	38	2.950	1,350	20	175
Nov. 8	17	35	13	.20	5.1	1.2	5.5	.0	23	5.1	Tr.	3.3	57	7.855	5,055	546	776
18	27	55	13	.30	4.6	1.2	--------	.0	17	4.6	Tr.	2.8	50	10.075	7,145	1,350	965
28	Dec. 7	25	15	.20	4.8	1.0	4.8	.0	17	6.7	Tr.	3.8	50	6.730	3,947	372	534
Dec. 8	17	12	13	.10	6.1	1.7	4.9	.0	21	4.5	.10	5.5	53	5.130	2,758	119	394
18	27	18	14	.13	5.4	1.5	4.8	.0	20	6.3	Tr.	4.8	51	4.980	2,652	172	365
28	Jan. 6	10	15	.15	5.6	1.4	4.4	.0	21	3.6	Tr.	4.5	51	5.175	2,748	111	378
Jan. 7	16	10	14	.10	6.1	1.4	4.3	.0	22	5.8	Tr.	5.0	50	4.300	2,153	55	291
17	26	35	15	.12	5.3	1.2	3.8	.0	20	4.8	Tr.	5.0	53	6.545	3,883	440	555
27	31	10	14	.15	4.5	1.2	4.2	.0	18	5.5	Tr.	5.0	48	5.430	2,914	87	377
Mean		17	16	.08	7.1	1.9	6.5	.0	31	6.4	.10	5.2	63	--------	--------	--------	--------

Analyses of water from Wynoochee River near Montesano, Wash.

[Parts per million.]

Date (1910).		Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Dissolved solids.
From—	To—												
July 17	July 20	1	11	0.02	8.6	2.4	5.8	0.0	37	9.7	0.50	2.0	55
21	30	1	16	.02	8.4	2.1	4.7	.0	39	--------	Tr.	1.9	59
31	Aug. 9	1	11	.01	8.1	2.2	3.6	.0	34	3.7	Tr.	2.0	50
Aug. 10	19	5	5.8	Tr.	7.7	2.2	5.2	.0	33	3.6	.65	2.4	47
Mean		2	.11	.01	8.2	2.2	4.8	.0	.36	5.7	.29	2.1	53

Reduced to standard form and expressed in percentages, the averages of the following tables are as follows:

Reduced analyses of waters in Puget Sound basin, Wash.

1. Skagit River at Sedro Woolley. 36 composite analyses.
2. Wood Creek near Everett. 33 composites.
3. Cedar River at Ravensdale. 35 composites.
4. Green River at Hot Springs. 20 composites.
5. Chehalis River at Centralia. 35 composites.
6. Wynoochee River, 20 miles above Montesano. 4 composites.

	1	2	3	4	5	6
CO_3	30.87	30.67	30.24	27.02	25.98	34.16
SO_4	17.70	9.55	12.49	11.52	10.94	10.94
Cl	1.94	3.54	2.63	2.55	8.89	4.03
NO_3	.52	.38	.44	.25	.18	.56
Ca	17.06	10.51	14.68	11.75	12.13	15.74
Mg	3.67	5.50	3.07	2.55	3.25	4.22
Na,K	7.77	9.28	7.90	10.96	11.10	9.21
Fe_2O_3	.18	.02	.06	.12	.18	.02
SiO_2	20.29	30.55	28.49	33.28	27.35	21.12
	100.00	100.00	100.00	100.00	100.00	100.00
Salinity, parts per million	46.3	81.8	45.6	51.1	58.5	52.1

These analyses indicate that the waters derive their solid contents mainly from the decomposition of igneous rocks in which lime and magnesia are in excess of the alkalies. The influence of sedimentary rocks is comparatively slight.

GREAT BASIN.

The Great Basin is that area west of the Rocky Mountains and east of the drainage of the Pacific slope which in early days was popularly known in part as the "Great American Desert." The greater portion of its territory is in Utah, Nevada, and Oregon and has no outlet to the ocean. Much of it is arid, containing many saline and alkaline lakes, each occupying a closed basin of greater or smaller extent. Some of these basins once coalesced into large lakes, of which there are now merely the surviving remnants. For two of these lakes the original boundaries have been determined, and their areas are now known as Lake

Bonneville and Lake Lahontan. These form the two largest divisions of the Great Basin; a third division is represented by a group of smaller basins in southern Oregon. The interior basin of California is sometimes treated as part of the Great Basin, but for present purposes its waters have been considered elsewhere (pp. 130–132).

LAKE BONNEVILLE.

Lake Bonneville, which is now represented by Great Salt Lake and several minor areas, occupied territory in which is now the State of Utah. For its history the exhaustive monograph by G. K. Gilbert[55] should be consulted. Analyses of the waters of Great Salt Lake are numerous, and the best of them, stated in percentage form, appear in the next table. Two analyses, one by L. D. Gale and one by H. Bassett, are not worth reproducing.

Analyses of water from Great Salt Lake.

1. By O. D. Allen, U. S. Geol. Expl. 40th Par. Rept., vol. 2, p. 433, 1877. Water collected in 1869. A trace of boric acid is also reported, in addition to the substances named in the table. Allen also gives analyses of a saline soil from a mud flat near Great Salt Lake. It contained 16.40 per cent of soluble matter much like that of the lake water.
2. By Charles Smart. Cited in Resources and attractions of the Territory of Utah, Omaha, 1879. Analysis made in 1877.
3. By E. von Cochenhausen, for C. Ochsenius, Deutsch. geol. Gesell. Zeitschr. vol. 34, p. 359, 1882. Sample collected by Ochsenius April 16, 1879. Ochsenius also gives an analysis of the salt manufactured from the water of Great Salt Lake.
4 By J. E. Talmage, Science, vol. 14, p. 445, 1889. Collected in 1889. An analysis of a sample taken in 1885 is also given,
5. By E. Waller, School of Mines Quart., vol. 14, p. 57, 1892. A trace of boric acid is also reported.
6. By W. Blum. Collected in 1904. Recalculated to 100 per cent. Reported by Talmage in Scottish Geog. Mag., vol. 20, p. 424, 1904. An earlier paper by Talmage on the lake is in the same journal, vol. 17, 1901, p. 617.
7. By W. C. Ebaugh and K. Williams, Chem. Zeitung, vol. 32, p. 409, 1908. Collected in October, 1907.
8. By R. K. Bailey, in the chemical laboratory of the U. S. Geological Survey. Sample collected by H. S. Gale, October 24, 1913.

	1	2	3	4	5	6	7	8
CO_3	------	0.07	------	------	------	------	------	0.09
SO_4	6.57	8.89	6.86	5.97	6.52	6.73	6.66	6.68
Cl	55.99	56.21	55.57	56.54	55.69	55.25	55.11	55.48
Br	Tr.	------	------	------	Tr.	Tr.	------	------
Ca	.17	.20	.21	.42	1.05	.16	.17	.16
Mg	2.52	3.18	2.60	2.60	2.10	.57	1.96	2.76
Li	Tr.	------	------	------	.01	Tr.	------	------
Na	33.15	33.45	33.17	33.39	32.92	34.65	32.97	33.17
K	1.60	(?)	1.59	1.08	1.70	2.64	3.13	1.66
Oxides [a]	------	------	------	------	.01	------	------	------
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Salinity, per cent	14.994	13.790	15.671	19.558	[b]23.036	27.72	22.99	20.349

[a] Silica plus sesquioxides.
[b] More correctly, 230.355 grams per liter.

Although the salinity of the lake is highly variable and from four to seven times as great as that of the ocean, its saline matter has nearly the same composition. The absence of carbonates, the higher sodium, and the lower magnesium are the most definite variations from the oceanic standard; but the general similarity, the identity of type, is unmistakable. Gilbert estimates the quantity of sodium chloride contained in the lake at about 400 millions of tons and the sulphate at 30 millions.

The next table contains analyses of waters from tributaries of Great Salt Lake.

Analyses of waters tributary to Great Salt Lake.

1. Bear River at Evanston, Wyo. Analysis by F. W. Clarke, U. S. Geol. Survey Bull. 9, 1884.
2. Bear River at Corinne, Utah, near its mouth. Received from Southern Pacific Co.
3. Weber River at Ogden, Utah. From Southern Pacific Co.
4. City Creek near Salt Lake City. Analysis by T. M. Chatard, U. S. Geol. Survey Bull. 9, 1884.
5. City Creek.
6. Red Butte Creek.
7. Emigration Creek.
8. Parleys Creek.
9. Cottonwood Creek.
10. Little Cottonwood Creek. Analyses 5 to 10 by J. T. Kingsbury, cited by G. B. Richardson in Water-Supply Paper U. S. Geol. Survey 157, p. 30, 1906. Analyses made in 1882 and 1884. These creeks are tributaries of Jordan River, which connects Utah Lake with Great Salt Lake.

I. Parts per million.

	1	2	3	4	5	6	7	8	9	10
CO_3	97.4	137.1	115.2	127.7	95.1	108.8	102.7	122.1	63.6	32.2
SO_4	10.6	52.0	8.3	7.0	7.3	100.6	126.2	56.5	42.1	12.3
Cl	5.0	206.1	15.3	13.1	19.5	22.9	28.6	19.7	7.9	2.8
Ca	43.8	64.5	55.5	58.8	55.3	88.8	101.0	85.1	48.1	17.5
Mg	12.7	30.3	17.3	17.4	18.9	31.3	31.6	22.5	18.9	8.2
Na	8.4	130.8	5.7	9.0	24.3	25.6	18.1	31.5	8.6	5.9
K					2.6	Tr.	9.9	2.6	Tr.	1.7
$(Al,Fe)_2O_3$	------	16.2	12.0	1.0	2.0	3.3	2.6	1.8	1.6	1.3
SiO_2	7.1			9.0	19.9	35.2	24.4	27.2	12.6	39.9
	185.0	637.0	229.3	243.0	244.9	416.5	445.1	369.0	203.4	121.8

II. Percentage composition of dissolved solids.

	1	2	3	4	5	6	7	8	9	10
CO_3	52.68	21.53	50.24	52.57	38.83	26.12	23.05	33.06	31.27	26.43
SO_4	5.76	8.16	3.62	2.87	2.98	24.15	28.36	15.32	20.70	10.10
Cl	2.68	32.36	6.67	5.38	7.96	5.50	6.42	5.34	3.89	2.30
Ca	23.69	10.12	24.20	24.19	22.58	21.32	22.70	23.07	23.64	14.37
Mg	6.86	4.76	7.55	7.15	7.72	7.52	7.10	6.10	9.29	6.73
Na	4.49	20.54	2.49	3.74	9.92	6.15	4.07	8.54	4.23	4.85
K					1.06	Tr.	2.20	.71	Tr.	1.40
$(Al,Fe)_2O_3$	------	2.53	5.23	.41	.82	.79	.58	.49	.78	1.07
SiO_2	3.84			3.69	8.13	8.45	5.52	7.37	6.20	32.75
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Utah Lake, at the head of Jordan River, has furnished material for a most instructive series of analyses. With them, for convenience, an analyses of water from Sevier Lake, an outlying remnant of Lake Bonneville, is tabulated.

Analyses of water from Utah and Sevier lakes, Utah.

1. Utah Lake. Analysis by F. W. Clarke, U. S. Geol. Survey Bull. 9, p. 20, 1884.
2. The same. Analysis by F. K. Cameron, 1899.
3. The same. Analysis by B. E. Brown, 1903.
4. The same. Mean of three analyses by A. Seidell, 1904. Sample taken in May.
5. The same. Analysis by B. E. Brown, 1904. Collected Aug. 21. For analyses 2 to 5, see Cameron, F. K., Am. Chem. Soc. Jour., vol. 27, p. 113, 1905.
6. Sevier Lake. Analysis by Oscar Loew, U. S. Geog. Survey W. 100th Mer. Rept., vol. 3, p. 114, 1875, Sample taken in 1872. All these analyses are stated in percentages, with the carbonates normal.

	1	2	3	4	5	6
CO_3	19.88	2.66	10.23	12.35	8.48	------
SO_4	42.68	26.53	28.49	28.25	30.14	10.88
Cl	4.04	35.48	26.23	24.75	26.87	52.66
Ca	18.24	7.58	6.25	5.90	5.34	.12
Sr	------	------	------	.15	------	------
Mg	6.08	1.55	7.18	6.18	6.85	3.01
Li	------	------	------	.06	------	------
Na	5.81	26.20	19.28	18.19	18.34	33.33
K			2.34	2.17	1.75	------
SiO_2	3.27	------	------	2.00	2.23	------
	100.00	100.00	100.00	100.00	100.00	100.00
Salinity, parts per million	306	892	1,281	1,165	1,254	86,400

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[55] U. S. Geol. Survey Mon. 1, 1890.

Although the foregoing analyses are, in one respect or another, incomplete, they tell an intelligible story. Bear River at Evanston is a normal river water, which upon evaporation will yield mainly calcium carbonate, and so too are Weber River and the several creeks. Bear River, near its mouth has changed its character almost completely and has evidently taken up large quantities of sodium chloride from the soil. Utah Lake, in the 20 years intervening between the earliest and latest analyses, has undergone a thorough transformation, and its salinity has more than quadrupled. From a fresh water of the sulphate type it has become distinctly saline, and this change is probably a result of irrigation. Its natural supplies of water have been diverted into irrigating ditches, and at the same time salts have been leached out from the soil and washed into the lake. To some extent these salts have been brought to the surface as a result of cultivation, so much so that considerable areas of land bordering upon the lake have ceased to be available for agriculture. Its outlet, Jordan River, exhibits the same peculiarities. As for Sevier Lake, which is now reduced to a mere pool in consequence of irrigation along its sources, its water resembles that of Great Salt Lake, except that at the time the analysis was made it was only about half as saline.

All the waters tributary to Great Salt Lake, so far as they have been examined, contain notable quantities of carbonates, which are absent from the lake itself. These salts have evidently been precipitated from solution, and evidence of this process is found in beds of oolitic sand, composed mainly of calcium carbonate, which exists at various points along the lake shore. The strong brine of the lake seems to be incapable of holding calcium carbonate in solution.[56]

LAKE LAHONTAN.

The Quaternary Lake Lahontan, which once covered an area of 8,400 square miles in northwestern Nevada, is now represented by a number of relatively small, scattered sheets of water and many alkaline or saline beds. Instead of one large basin there are now several basins, and each one is fed by independent sources of fresh water. Each lake, therefore, has its own individual peculiarities, as the various analyses show. Some of the lakes exist only during the humid season, when large areas are covered by a thin layer of water; others are permanent sheets of considerable depth. Our data relate only to the latter, with their sources of supply.

In the statement of some analyses precision, in a certain sense, has been sacrificed to uniformity. In strongly alkaline waters the radicle SiO_3 may possibly exist instead of the colloidal SiO_2. In no case, however, is the silica high enough to cause a serious error in this respect, and a fraction of 1 per cent will cover the uncertainty. A graver criticism might be based upon the representation of all the carbonates as normal, for bicarbonates are undoubtedly present in some of the waters, which on evaporation deposit trona in large quantities. If, however we regard the analyses as representing the percentage composition of ignited residues, the suggested objection no longer holds. We can compare our data upon the uniform basis adopted hitherto and leave the question of bicarbonates for separate consideration elsewhere. The divergent character of the analyses seems to render some such procedure necessary. It is only by eliminating variables that we can obtain comparable results.[57]

TRUCKEE BASIN.

Truckee River rises in California, its principal source being Lake Tahoe. Another branch issues from Donner Lake and Lake Angela. It empties into Pyramid and Winnemucca lakes, which have no outlets.

Analyses of waters in the Truckee River basin.

1. Lake Tahoe. Analysis by F. W. Clarke, U. S. Geol. Survey Bull. 9, 1884.
2. Lake Angela at Summit, Calif., drainage through Donner Lake.
3. Trout Creek at Truckee, Calif.
4. Alder Creek at Floriston, Calif.
5. Bells Creek at Calvada, Calif.
6. Truckee River at Hot Springs, Nev.
7. Truckee River at Wadsworth, Nev. Analyses 2 to 7 received from Southern Pacific Co.
8. Pyramid Lake, Nev. Mean of four concordant analyses.
9. Winnemucca Lake, Nev. Analyses 8 and 9 by Clarke, op. cit.

I. Parts per million.

	1	2	3	4	5	6	7	8	9
CO_3	28.3	9.25	15.5	17.1	17.6	49.8	51.1	498	286
SO_4	5.5	1.39	1.4	5.7	4.7	22.2	16.9	183	135
Cl	2.3	3.01	1.8	9.7	3.6	13.1	10.9	1,431	1,724
Ca	9.4	5.20	8.0	9.9	6.4	17.2	16.3	9	.20
Mg	3.0	.60	1.4	2.3	1.4	5.1	5.4	79	18
Na	7.4	2.61	1.8	6.2	8.1	27.1	25.9	1,179	1,321
K	3.3							74	70
(Al, Fe)$_2$O$_3$	------	4.96	15.9	21.9	22.9	19.0	25.0	------	------
SiO_2	13.8							33	28
	73.0	27.02	45.8	72.8	64.7	153.5	151.5	3,486	3,602

II. Percentage composition of dissolved solids.

	1	2	3	4	5	6	7	8	9
CO_3	38.73	34.23	33.84	23.49	27.20	32.44	33.73	14.28	7.93
SO_4	7.47	5.15	3.06	7.83	7.27	14.46	11.16	5.25	3.76
Cl	3.18	11.14	3.93	13.32	5.56	8.55	7.20	41.04	47.88
Ca	12.86	19.24	17.47	13.60	9.89	11.20	10.76	.25	.55
Mg	4.15	2.22	3.06	3.16	2.16	3.32	3.56	2.28	.49
Na	10.10	9.66	3.93	8.52	12.54	17.65	17.09	33.84	36.68
K	4.56							2.11	1.94
(Al, Fe)$_2$O$_3$	------	18.36	34.71	30.08	35.38	12.38	16.50	------	------
SiO_2	18.95							.95	.77
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

These analyses show very clearly the progressive change in salinity and composition from the dilute mountain waters to the two alkaline lakes. Ordinary fresh waters rich in carbonates and in calcium are

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[56] For other incomplete analyses of Utah waters see U. S. Dept. Agr., Div. Soils, Field Operations, 1900, p. 226, and 1903, p. 1138; U. S. Dept. Agr. Bur. Soils, Rept. 64, p. 108, 1900; Greaves, J. E., and Hirst, C. T., Utah Agr. Coll. Exper. Stat. Bull. 163, 1918. These analyses lack determinations of silica and sesquioxides.

[57] For details regarding Lake Lahontan see Russell, I. C., U. S. Geol. Survey Mon. 11, 1885.

concentrated, and the lime salts are finally thrown out in the form of tufa. The tufa, however, instead of being an oolitic or granular deposit, as in the Bonneville basin, is in the form of crystals—"thinolite," pseudomorphous after some unknown mineral. This peculiar variety of tufa is characteristic of the Lahontan basin, but the mode of its formation is uncertain.

WALKER AND HUMBOLDT BASINS.

Walker and Humboldt rivers, like the Truckee, end their courses in alkaline lakes that have no outlet. For their waters the following analyses have been made:

Analyses of water in Walker and Humboldt basins, Nev.

1. Walker River just below junction of two branches.
2. Walker Lake. Mean of two analyses. Analyses 1 and 2 by F. W. Clarke, U. S. Geol. Survey Bull. 9, 1884.
3. Creek at Golconda, Humboldt Basin. Received from Southern Pacific Co.
4. Humboldt River at Stone House. Analysis by T. M. Chatard, U. S. Geol. Survey Bull. 9, 1884.
5. Humboldt River at Humbridge, 1901. From Southern Pacific Co.
6. Humboldt Lake. Analysis by O. D. Allen, U. S. Geol. Expl. 40th Par. Rept., vol. 2, p. 743, 1877.

I. Parts per million.

	1	2	3	4	5	6
CO_3	54. 6	433. 5	71. 6	142. 8	120. 3	200. 7
SO_4	29. 1	532. 2	21. 4	50. 2	67. 3	30. 4
Cl	13. 5	594. 3	10. 3	7. 9	205. 7	296. 0
PO_4	--------	--------	--------	--------	--------	. 3
Ca	23. 3	22. 5	40. 7	51. 6	55. 1	12. 6
Mg	4. 0	39. 0	8. 0	13. 1	15. 1	17. 5
Na	132. 5	870. 7	9. 6	49. 2	165. 6	278. 8
K				10. 5		60. 9
$(Al, Fe)_2O_3$	--------	--------	14. 9	--------	33. 9	--------
Al_2O_3	--------	--------		1. 4		--------
SiO_2	23. 0	7. 8		34. 3		32. 8
	180. 0	2,500.0	176. 5	361. 0	663. 0	930. 0

II. Percentage composition of dissolved solids.

	1	2	3	4	5	6
CO_3	30. 34	17. 34	40. 56	39. 55	18. 14	21. 57
SO_4	16. 14	21. 29	12. 13	13. 92	10. 15	3. 27
Cl	7. 50	23. 77	5. 84	2. 19	31. 03	31. 82
PO_4	--------	--------	--------	--------	--------	. 07
Ca	12. 96	. 90	23. 06	14. 28	8. 31	1. 35
Mg	2. 21	1. 56	4. 53	3. 62	2. 28	1. 88
Na	18. 07	34. 83	5. 44	13. 63	24. 98	29. 97
K				2. 92		6. 54
$(Al, Fe)_2O_3$	--------	--------	8. 44	--------	5. 11	--------
Al_2O_3	--------	--------		. 38		--------
SiO_2	12. 78	. 31		9. 51		3. 53
	100. 00	100. 00	100. 00	100. 00	100. 00	100. 00

These analyses show the change from river to lake waters very clearly. With increased salinity there is a concentration of chlorides and a relative loss in silica, magnesium, and calcium.

RAGTOWN SODA LAKES.

At Ragtown, Nev., there are two isolated alkaline lakes, and for the larger of them analyses by T. M. Chatard [58] are available. There is also an earlier analysis by O. D. Allen,[59] which is less complete than Chatard's but otherwise not very different. The water contains bicarbonates, which are here reduced to standard form.

Analyses of water from Soda Lake, Ragtown, Nev.

[Specific gravity 1.101.]

1. Large Soda Lake at surface.
2. The same at a depth of 30.5 meters.

	1	2
CO_3	13. 78	15. 89
SO_4	10. 36	10. 50
Cl	36. 51	35. 38
B_4O_7	. 25	. 26
Ca	. 00	. 00
Mg	. 22	. 21
Na	36. 63	35. 38
K	2. 01	2. 13
SiO_2	. 24	. 25
	100. 00	100. 00
Salinity, parts per million	113, 700	113, 700

These analyses show that the water of Soda Lake is more than three times as concentrated as sea water and of an entirely different type. It has no visible supply of water except from springs near its margin, and at certain times it deposits trona and also gaylussite in notable quantities. Gaylussite is a carbonate of calcium and sodium, but no calcium is shown by Chatard's analyses. It must, therefore, be deposited by the lake about as rapidly as it is received. The tributary springs have not been investigated.

The Lahontan waters are distinctly alkaline, whereas the lakes of the Bonneville basin are salt. The cause of the difference must be sought in the sources from which the waters are derived, and one distinction is clear. Great Salt Lake is fed by streams and springs which flow in great part through sedimentary formations. Its saline matter is a concentration of old salts which were laid down long ago. The Lahontan lakes, on the other hand, are supplied with water from areas of igneous rocks, in which rhyolites and andesites are especially abundant and from which the alkalies were obtained. They represent, therefore, a primary concentration of leached material, as contrasted with the secondary origin of the Bonneville brine.

OREGON LAKES.

The extension of the Great Basin into southern Oregon contains a number of isolated depressions in which are saline or alkaline lakes. Of these the largest are the Harney, Warner, and Chewaucan basins. Christmas Lake and the three Alkali Lakes are of less importance.[60]

HARNEY BASIN.

Analyses are available for three lakes in the Harney Basin, namely, Harney, Malheur, and Silver lakes, with two tributary rivers. Van Winkle gives the following table for Silvies River, which discharges into Malheur Lake:

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[58] U. S. Geol. Survey Bull. 9, 1884.

[59] U. S. Geol. Survey 40th Par. Rept., vol. 2, p. 748, 1877.

[60] For details relative to these waters see Van Winkle, Walton, U. S. Geol. Survey Water-Supply Paper 363, pp. 104–123, 1914.

Analyses of water from Silvies River near Burns, Oreg.

[Parts per million except as otherwise designated].

Date (1911–12).		Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Dissolved solids.	Mean discharge (second-feet).	Suspended matter (tons per day).	Dissolved matter (tons per day).
From—	To—															
Oct. 12	Oct. 19	12	32	0.20	12	4.2	16	0.0	91	7.6	0.50	1.3	130	16.5	----------	5.8
20	29	25	38	.22	22	5.8	21	.0	124	11	1.9	4.3	175	20.1	1.4	9.5
30	Nov. 8	12	34	.18	18	5.5	16	.0	104	8.0	.66	1.8	145	20.7	.5	8.1
Nov. 9	18	10	34	.15	19	5.6	14	.0	103	13	.40	2.0	146	26.7	.9	10.5
19	28													29.9	1.0	11.7
29	Dec. 8	10	32	.15	24	7.4	19	.0	135	10	.66	3.3	175	22.1	.3	10.3
Dec. 9	18	10	40	.14	22	----------	18	.0	125	7.7	----------	1.5	164	19.3	.7	8.5
Mar. 8	Mar. 17	35	34	.16	18	----------	12	.0	98	5.6	.18	1.5	138	68.2	3.1	25.4
18	27	30	33	.03	32	6.8	20	Tr.	123	17	5.0	17.0	208	101.4	6.6	57
28	Apr. 6	85	26	.04	19	2.8	14	3.6	81	7.2	1.0	4.5	134	341.2	59	123
Apr. 7	16	80	28	.06	20	2.8	13	Tr.	93	10	.72	2.0	138	874.4	181	325
17	26	30	31	.05	25	4.4	15	2.9	106	9.7	.86	1.3	158	694.1	39	296
27	May 6	30	24	.03	23	4.0	15	.0	112	10	.24	3.0	153	1,434.5	142	465
May 7	16	25	37	.12	25	4.7	17	13	87	14	.38	4.1	166	1,123	89	644
17	26	7	47	.04	20	3.6	19	.0	114	12	1.8	4.8	188	1,187	38	602
27	June 5	8	49	.03	18	4.4	21	.0	114	9.9	3.0	5.3	185	974.1	12	450
June 6	15	1	56	.05	20	6.0	27	.0	126	14	2.2	6.8	212	564.9	12	323
16	25	4	58	.03	20	5.8	27	.0	128	15	2.0	7.5	215	329.5	8.1	192
26	July 6	5	58	.04	20	6.2	28	.0	127	15	2.6	7.5	213	127.8	2.8	73.5
July 7	16	7	69	.03	22	4.2	27	.0	131	15	1.4	3.3	200	55.1	2.4	30
17	26	Tr.	55	.02	20	6.6	27	1.9	126	16	2.5	7.3	213	27.2	Tr.	15.7
27	Aug. 4	Tr.	43	.05	22	5.6	27	6.2	115	18	1.9	8.0	202	20	Tr.	10.9
Aug. 5	14	Tr.	60	.04	20	5.6	28	.0	130	17	2.6	7.3	207	15	Tr.	8.4
Mean		19	41	.09	21	5.1	[a]17 [a]4.0	1.2	113	12	1.5	4.7	174	----------	----------	----------

[a] Sodium and potassium determined on combined alkali residues.

Analyses of waters in Harney Basin, Oreg.

The analyses as given in the following table are all reduced to standard form, with the carbonates normal. The figures therefore differ slightly from those given by Van Winkle.

1. Silvies River, which discharges into the swamp bordering Malheur Lake. Average from table of analyses by Van Winkle, op. cit.; 23 composite analyses.
2. Donner and Blitzen River, a tributary of Malheur Lake. Van Winkle, analyst.
3. Malheur Lake. Van Winkle. Collected Mar. 8, 1912.
4. Harney Lake, Aug. 5, 1902. Analysis by G. Steiger, in the chemical laboratory of the U. S. Geological Survey.
5. Harney Lake, Mar. 10, 1912. Van Winkle.
6. Silver Lake, Mar. 11, 1912. Van Winkle.

I. Parts per million.

	1	2	3	4	5	6
CO_3	57.9	25.1	215.9	2,710	4,424	682
SO_4	12.0	2.3	37.0	804	1,929	138
Cl	4.7	.75	22.0	2,881	6,804	456
NO_3	1.5	Tr.	2.4	----------	3	3
PO_4	----------	----------	1.6	----------	10	1
B_4O_7	----------	----------	0.0	97	(?)	(?)
Ca	21.0	8.2	27.0	00	8	10
Mg	5.1	4.0	20.0	7	1	1
Na	17.0	8.5	117.0	3,749	8,825	1,041
K	4.0		27.0	200	335	94
Fe_2O_3	.1	.17	.1	----------	1	10
Al_2O_3	----------	----------	Tr.	----------	23	1
SiO_2	41.0	29.0	14.0	29	31	85
	164.3	78.02	484.0	10,477	23,394	2,522

II. Percentage composition of dissolved solids.

	1	2	3	4	5	6
CO_3	35.24	32.17	44.60	25.87	19.75	27.04
SO_4	7.31	2.95	7.64	7.67	8.60	5.48
Cl	2.86	.96	4.54	27.50	30.38	18.08
NO_3	.91	Tr.	.50	----------	.01	.12
PO_4	----------	----------	.34	----------	.05	.04
B_4O_7	----------	----------	.00	.92	(?)	(?)
Ca	12.78	10.51	5.58	.00	.05	.40
Mg	3.10	5.12	4.13	.07	.01	.04
Na	10.35	10.90	24.18	3.78	39.40	41.27
K	2.44		5.58	1.91	1.50	3.73
Fe_2O_3	.06	.22	.01	.00	.01	.04
Al_2O_3	----------	----------	Tr.	.00	.10	.40
SiO_2	24.95	37.17	2.90	.28	.14	3.36
	100.00	100.00	100.00	100.00	100.00	100.00

The difference between the two analyses of Harney Lake is very striking. The samples of water were taken 10 years apart, and the later one is twice as concentrated as the other. Was one sample taken at low and the other at high water?

The two river waters are similar in type, and represent the decomposition of feldspars in which calcium and the alkaline radicles were present in nearly equal proportions.

WARNER BASIN.

The Warner Basin occupies an area of 2,100 square miles and contains a series of lakes which are remnants of what was formerly Warner Lake. These small lakes are indefinite in area, flooding their low banks in the wet season and becoming brackish sinks in the dry season. For five of them Van Winkle gives analyses, and these, reduced to standard form, appear in the next table. All the samples were taken in September, 1912.

Analyses of waters in Warner basin, Oreg.

1. Pelican Lake.
2. Crump Lake.
3. Hart Lake.
4. Flagstaff Lake.
5. Bluejoint Lake.

I. Parts per million.

	1	2	3	4	5
CO_3	611.6	46.7	103.3	177.0	1,407.5
SO_4	438.0	8.6	16.0	24.0	206.0
Cl	158.0	4.2	9.0	37.0	504.0
NO_3	1.0	1.7	.8	1.0	.8
PO_4	1.4	Tr.	.8	.8	2.0
B_4O_7	(?)	0.0	0.0	(?)	(?)
Ca	45.0	13.0	22.0	19.0	21.0
Mg	52.0	5.6	9.8	19.0	23.0
Na	580.0	21.0	55.0	102.0	1,372.0
K	71.0			15.0	82.0
Fe_2O_3	.4	.3	.8	.9	.7
SiO_2	24.0	3.0	19.0	28.0	20.0
	1,982.4	104.1	236.5	423.7	3,639.0

Analyses of waters in Warner basin, Oreg.—Continued.

II. Percentage composition of dissolved solids.

	1	2	3	4	5
CO_3	30.85	44.86	43.86	41.77	38.69
SO_4	22.10	8.27	6.77	5.67	5.66
Cl	7.97	4.03	3.81	8.73	13.85
NO_3	.05	1.63	.34	.24	.02
PO_4	.07	Tr.	.34	.19	.05
B_2O_7 [a]	(?)	.00	.00	(?)	(?)
Ca	2.27	12.49	9.30	4.48	.57
Mg	2.62	5.28	4.14	4.48	.64
Na	29.25	20.17	23.25	24.07	37.71
K	3.59			3.54	2.25
Fe_2O_3	.02	.29	.34	.22	.01
SiO_2	1.21	2.88	8.03	6.61	.55
	100.00	100.00	100.00	100.00	100.00

[a] The interrogation mark placed in the borate line indicates that borates were present in small amount, but not quantitatively determined.

Analyses 2, 3, and 4 are remarkably alike. Those of the more concentrated waters, 1 and 5, are very different. The proportion of calcium in these waters varies regularly, from highest in the most dilute to lowest in the most concentrated.

CHEWAUCAN BASIN.

The Chewaucan basin, northeast of the Warner basin, contains two lakes which are important as possible future sources of commercial soda. For these reasons their waters have been repeatedly analyzed. For Chewaucan River, a feeder of Abert Lake, Van Winkle gives the following table:

Analyses of water from Chewaucan River near Paisley, Oreg.

[Parts per million as otherwise designated.]

Date (1911-12). From—	Date (1911-12). To—	Turbidity.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Nitrate radicle (NO_3).	Chlorine (Cl).	Dissolved solids.	Mean gage height (feet).	Mean discharge (second-feet).	Suspended matter (tons per day).	Dissolved matter (tons per day).
Aug. 11	Aug. 20	6	46	0.12	8.5	2.9	5.0	0.0	50	3.1	0.48	0.25	98	3.9	35	0.66	9.3
21	30	3	34	.10	7.6	2.9	6.3	.0	43	3.8	.32	.60	81	3.9	35	.55	7.6
31	Sept. 9	5	15	.10	8.0	2.6	9.0	.0	44	5.6	.36	.75	87	3.9	39	.82	9.2
Sept. 10	19	3	33	.04	7.0	2.8	6.7	.0	43	5.3	.52	.50	81	4.0	40	.09	8.8
20	29	3	31	.11	9.7	3.2	7.2	.0	46	4.9	.20	.25	81	4.0	41	.89	9.0
30	Oct. 9	1	34	.11	7.2	3.2	9.8	.0	48	5.8	.30	.10	88	4.0	44	--------	10.5
Oct. 10	19	4	30	.04	7.3	3.2	8.3	.0	49	3.5	.60	.15	81	4.0	43	.97	9.4
20	29	Tr.	30	.01	7.8	2.4	10	.0	50	3.5	.40	.50	85	4.0	42	.70	9.6
30	Nov. 8	5	28	.02	12	.8	11	.0	49	4.3	--------	.30	82	4.0	44	.28	9.7
Nov. 9	18	20	29	.15	7.6	2.1	8.2	.0	46	5.1	.34	.25	81	4.0	59	2.23	12.9
19	28	25	28	.12	12	.8	9.5	.0	48	4.3	.34	.25	86	4.0	62	5.00	14.4
29	Dec. 8	20	32	.23	8.5	2.6	8.2	.0	46	6.6	.20	.25	86	3.9	55	7.40	12.8
Dec. 9	18	2	31	.11	9.1	1.4	7.6	.0	45	6.1	.06	.30	85	4.0	49	1.06	11.2
19	28	6	30	.10	8.8	1.6	12	.0	51	7.6	Tr.	.35	93	4.6	40	.30	10.1
29	Jan. 7	4	30	.52	9.0	1.0	14	.0	46	5.3	.32	.45	85	4.4	57	1.85	13.1
Jan. 8	17	10	30	.03	8.0	.5	11	.0	48	2.6	.27	1.8	103	4.5	65	2.98	18.1
18	27	20	24	.62	9.0	.5	9.8	.0	45	2.1	--------	--------	83	4.2	86	5.80	19.3
28	Feb. 6	15	34	.10	8.3	.4	11	.0	43	4.1	.33	1.3	106	4.0	66	1.96	19
Feb. 7	16	80	28	.22	7.6	1.2	12	.0	45	7.2	.24	1.3	91	4.2	92	22.4	23
17	26	145	35	.36	5.1	2.5	8.2	.0	45	4.3	.33	.25	92	4.2	105	51	26
27	Mar. 7	30	29	.22	9.8	.4	8,7	.0	43	5.6	.27	.25	90	4.0	62	5.2	15
Mar. 8	17	30	31	.15	7.0	2.8	8.0	[a] Tr.	48	2.8	.18	.25	88	3.9	59	3.8	14
18	27	90	30	.10	8.2	2.7	8.8	.0	49	2.0	.36	.25	92	4.0	71	17.6	18
28	Apr. 6	80	27	.35	6.8	2.6	7.7	.0	45	2.1	.48	.25	89	4.4	125	13.5	30
Apr. 7	16	90	27	.50	6.6	2.3	7.2	.0	40	1.3	.36	.50	83	4.9	227	92	51
17	26	30	25	.30	7.3	2.2	8.5	[a] 4.0	36	1.3	.30	.25	84	[b] 3.1	133	12.9	30
27	May 6	85	28	.55	6.4	2.0	8.5	.0	42	4.6	.45	.45	88	2.8	223	84	53
May 7	16	110	21	.48	6.5	1.9	6.6	.0	37	4.3	.48	.40	71	2.2	492	383	94
17	26	70	22	.35	5.9	.5	6.9	.0	32	4.3	.40	.45	71	1.9	630	167	121
27	June 5	35	22	.15	6.0	1.0	7.6	.0	35	3.8	.34	1.0	72	1.6	784	190	163
June 6	15	20	17	.15	4.6	1.5	6.9	[a] Tr.	28	6.7	.30	.40	64	1.9	613	94	106
16	25	10	34	.38	6.2	1.5	10	.0	37	5.4	.36	.50	90	2.7	263	3.4	64
26	July 5	10	15	.06	5.2	1.2	11	.0	35	8.6	.20	.75	66	3.0	156	3.2	28
July 6	15	8	35	.04	5.6	1.0	10	.0	39	7.4	.26	.50	78	3.2	85	1.7	18
16	25	50	25	.04	6.2	1.0	11	[a] 5.3	30	4.6	.20	.50	73	3.1	72	5.4	14
26	Aug. 4	50	32	.20	7.6	3.4	5.4	.0	46	3.8	.42	1.1	87	3.3	74	18.4	17
Aug. 5	14	5	31	.18	7.4	3.2	4.7	[a] Tr.	42	3.8	.90	.75	88	3.4	60	1.65	14
Mean		32	29	.20	7.6	1.9	[c]6.8 [c]2.5	.0	44	4.5	.34	.5	85	--------	--------	[d] 12,200	[d] 10,980

[a] Abnormal; computed as HCO_3 in average.
[b] Gage changed Apr. 15, 1912.
[c] Sodium and potassium, determined on combined alkali residues.
[d] Total annual denudation.

Analyses of waters in Chewaucan basin, Oreg.

1. Chewaucan River, average of 37 composite analyses by Van Winkle, reduced to standard form.
2. Ana River, a feeder of Summer Lake. Analysis by Van Winkle.
3. Abert Lake. Analysis by T. M. Chatard, U. S. Geol. Survey Bull. 60, p. 55, 1890.
4. Abert Lake. Analysis by Stillwell and Gladding, 1901. Cited by Van Winkle.
5. Abert Lake. Analysis by E. T. Dumble, 1902. Cited by Van Winkle.
6. Abert Lake, February, 1912. Analysis by Van Winkle.
7. Summer Lake. Analysis by Stillwell and Gladding, 1901. Cited by Van Winkle.
8. Summer Lake. Analysis by Dumble, 1902. Cited by Van Winkle.
9. Summer Lake, 1912. Analysis by Van Winkle.
10. Summer Lake. Analysis by J. G. Smith, U. S. Dept. Agr. Bull. 61, p. 80, 1914.

I. Parts per million.

	1	2	3	4	5	6	7	8	9	10
CO_3	21.6	50.9	8,098	15,742	15,966	6,149	13,294	10,712	5,916	1,667
SO_4	4.5	8.1	744	1,281	1,444	565	1,452	1,233	694	1,062
Cl	.5	11.0	14,118	22,359	27,483	10,711	6,280	5,559	3,038	838
NO_3	.34	.2				1			3.6	Tr.
PO_4										Tr.
B_4O_7										Tr.
Ca	7.6	4.9				Tr.			Tr.	130
Mg	1.9	4.4				6			.4	26
Na	6.8	39.0	15,406	26,570	30,032	11,470	14,529	12,105	6,567	2,171
K	2.5		563	1,043	1,233	502	727	560	265	1.06
Al_2O_3						64			.45	
Fe_2O_3	.3	.01				2			.25	
SiO_2	29.0	37.0	243	300	165	96	268	288	104	
	75.04	155.51	39,172	67,295	76,323	29,566	36,550	30,457	16,633.25	6,000

[a] Analyses 4 to 9 are stated in milligrams per kilogram.

II. Percentage composition of dissolved solids.

	1	2	3	4	5	6	7	8	9	10
CO_3	28.79	32.72	20.67	23.39	20.92	20.80	36.37	35.17	35.57	27.79
SO_4	5.99	5.20	1.90	1.91	1.86	1.91	3.98	4.05	4.17	17.70
Cl	.67	7.07	36.04	33.22	36.02	36.23	17.18	18.25	18.27	13.96
NO_3	.45	.12				Tr.			.02	Tr.
PO_4										Tr.
B_4O_7										Tr
Ca	10.13	3.15				Tr.			Tr.	2.16
Mg	2.53	2.83				.02			Tr.	.43
Na	9.06	25.07	39.33	39.48	39.32	38.80	39.75	39.74	39.48	36.19
K	3.33		1.44	1.55	1.66	1.70	1.99	1.84	1.59	1.77
Al_2O_3						.22			.27	
Fe_2O_3	.40	.05				Tr.			Tr.	
SiO_2	38.65	23.79	.62	.45	.22	.32	.73	.95	.63	
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

The specific gravity was determined as follows:

No. 3 (19.8° C.)	1.03117	No. 7 (15.5° C.)	1.0319
No. 4 (15.5° C.)	1.0515	No. 8	1.0354
No. 5	1.064	No. 9 (15° C.)	1.0162
No. 6 (15° C.)	1.0255		

The analyses of Abert Lake agree very well, except as regards concentration. So too do three of those of Summer Lake, but Smith's analysis is unlike the others. Was his sample of water a surface sample taken near the point of influx of Ana River?

MINOR BASINS.

North of the Chewaucan basin there are several small lakes for which analyses have been made. The available data are as follows:

Analyses of water from six small lakes north of Chewaucan basin, Oreg.

1. Silver Lake. Not to be confused with Silver Lake of the Harney Basin. Analysis by Van Winkle. Sample taken in 1912.
2. Fossil Lake.
3. Christmas Lake.
4. North Alkali Lake.
5. Middle Alkali Lake.
6. South Alkali Lake. Analyses 2 to 6 by J. G. Smith, U. S. Dept. Agr. Bull. 61, p. 80, 1914.

I. Parts per million.

	1	2	3	4	5	6
CO_3	180.0	3,766	1,353	20,437	22,235	5,005
SO_4	9.2	1,130	625	10,090	49,849	1,006
Cl	3.3	7,003	816	25,534	18,263	15,845
NO_3	.24	Tr.	Tr.	Tr.	Tr.	Tr.
PO_4		81	Tr.	162	409	103
B_4O_7		Tr.	Tr.	Tr.	Tr.	Tr.
Ca	42.0	245	96	105	15	30
Mg	25.0	20	63	19	45	41
Na	62.0	7,534	1,504	34,721	49,849	14,258
K		321	243	4,032	5,435	612
Fe_2O_3	.4					
SiO_2	57.0					
	379.14	20,100	4,700	95,100	146,100	36,900

II. Percentage composition of dissolved solids.

	1	2	3	4	5	6
CO_3	47.48	18.73	28.78	21.49	15.22	13.56
SO_4	2.42	5.62	13.29	10.61	34.12	2.73
Cl	.87	34.84	17.36	26.85	12.50	42.94
NO_3	.06	Tr.	Tr.	Tr.	Tr.	Tr.
PO_4		.41	Tr.	.17	.28	.28
B_4O_7		Tr.	Tr.	Tr.	Tr.	Tr.
Ca	11.08	1.22	2.04	.11	.01	.08
Mg	6.60	.10	1.35	.02	.03	.11
Na	16.35	37.48	32.00	36.51	34.12	38.64
K		1.60	5.18	4.24	3.72	1.66
Fe_2O_3	.11					
SiO_2	15.03					
	100.00	100.00	100.00	100.00	100.00	100.00

In five of these analyses the determination of silica was neglected. In waters of this type, however, the omission is not serious and may be disregarded.[61]

It is probable that at the time when desiccation began the water of Lake Lahontan was fairly uniform in composition, but such uniformity is not shown in its remainders. They differ one from another, apparently for two reasons. As the present lakes became separated, each one was affected by local conditions, which were not everywhere the same. In the first place the oceanic salts were unevenly distributed throughout the basin—that is, abundant at some points and relatively scarce at others. Secondly, the streams that fed the present lakes differed in composition, just as they do to-day. Hence some of the lakes are richer in chlorides than others, and some are more nearly

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[61] For additional information concerning the geology of the lake region of southeastern Oregon, see Russell, I. C., U. S. Geol. Survey Bull. 217, 1903, and Waring, G. A., U. S. Geol. Survey Water-Supply Paper 231, 1909.

carbonate waters. Their saline matter is a mixture of salts of quite dissimilar origins and in varying proportions.

The present lakes, however, tell only part of the story. They occupy only a small portion of the original lake basin. As the process of desiccation went on many small lakes or mere pools of water were left, which have evaporated, leaving their dissolved solids either in beds of some thickness or diffused in the soil of what was once the lake bottom. These are the desert salts such as in favorable localities find their way into flowing streams. Wherever such salts occur their origin was essentially the same. The less soluble constituents of the present waters have been deposited first, leaving the very soluble alkaline salts for possible re-solution later.[62]

In previous sections of this memoir attention has been called to the significance of desert salts as contributions to the salinity of river waters. The Colorado and the Rio Grande are striking examples of their importance. All such salts, disseminated in the soil or forming thick beds, originate in one way—namely, by the evaporation of isolated bodies of water, which may have been either oceanic, fluviatile, or supplied by springs. All three sources of salinity are represented in the Great Basin, an area that in past geologic time was covered by extensions of the ocean, which receded as the land was raised above sea level. As the bottom of the ancient sea was uncovered, it retained more or less saline matter—in beds where pools or lakes of water evaporated, as diffused salt in the more nearly level areas. The water of Great Salt Lake is distinctly of oceanic type, with a minimum of change due to the influx of fresh water. It represents a concentration of the salts left by the receding ocean.

In the Lahontan basin the conditions were different. Oceanic salts were there, but, as we have already seen, they were not the chief source of the salinity of the original Lake Lahontan. They probably supplied a large part of the chlorides now present in the Lahontan waters and also some of the sulphates; but a great volume of mountain waters formed the original lake, of which the present lakes are mere remnants. The oceanic salts were limited in quantity; the fresh waters have been pouring in ever since the oceanic water was withdrawn.

It is not possible, we believe, to frame any broad generalizations regarding the character of desert salts. Too much depends upon local conditions. In some localities hot springs must be taken into account, and other underground waters are sometimes brought to the surface by capillary attraction. From all such sources saline matter is derived and is added to the deposits of larger significance. In some regions, for purposes of irrigation, artesian wells are driven, and these help to complicate the general problem. Their waters are almost if not quite always distinctly saline. Furthermore, the dust from saline incrustations is taken up by the wind and scattered far and wide. Some of it falls into lakes, and some is deposited on other incrustations of possibly quite different character. The relative magnitude of these different influences can hardly be estimated. The conditions are too local and too variable.

The Lahontan basin has here been taken as a typical region in which saline residues occur, and one more feature of it is worth considering. When the ocean receded from this area the largest bodies of water were left in the deepest depressions. Pyramid and Winnemucca lakes are the deepest of the Lahontan remainders, and they contain by far the highest proportion of chlorides. The other Lahontan lakes are shallower and contain much lower percentages of chlorine. There is, however, no definite ratio between chlorine and depth, for a shallow lake may receive chlorides by drainage from the surrounding country. The significance of the oceanic remainders is, nevertheless, well illustrated by the two examples just cited.

Now, to sum up: Desert salts and all other saline residues are formed by the evaporation of waters of various dissimilar kinds. Some waters deposit carbonates, some sulphates, some chlorides; and between these classes of compounds all sorts of mixtures are possible. The first stage of deposition is differential, in which the dissolved solids of a water are separated into two parts—one containing an insoluble fraction, the other the soluble salts. Calcium carbonate is precipitated, because the excess of carbonic acid which held it in solution has been driven away; some of the slightly soluble calcium sulphate goes down with it, and also the silica. The soluble alkaline salts are the second product of the differential process. From ocean water and its immediate derivatives, the saline deposit is mainly sodium chloride with a much smaller amount of gypsum. From limestone waters the soluble portion is almost nil. The deposits from ordinary river waters are much more likely to be mixtures, in which, however, carbonates will predominate. The headwaters of the rivers that feed the Lahontan lakes receive carbonates derived from the decomposition of feldspars; in their lower courses the rivers take up other salts from the soil. The original source of the alkaline carbonates is in great part feldspathic, although in some places they may have been formed by reactions between sodium sulphate and calcium carbonate. Such reactions have been shown to be possible.[63]

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[62] For analyses of saline residues, including desert salts, see Clarke, F. W., The data of geochemistry, 4th ed.: U. S. Geol. Survey Bull. 695, chapter 7, 1920.

[63] For a summary of the literature relative to the origin of sodium carbonate see Clarke, F. W., The data of geochemistry, 4th ed.: U. S. Geol. Survey Bull. 695, pp. 231-237, 1920.

ALASKA.

The principal river of Alaska is the Yukon, which is formed by the union of Lewes and Pelly rivers in Yukon Territory, Canada. It is one of the largest rivers of North America, with a length, including the Lewes, of about 2,300 miles, and a drainage basin of 330,000 square miles. Its chief sources are in a group of lakes, and its upper course is in a mountainous region and through many deep gorges. It enters Alaska at Eagle, and a large part of its lower course, for hundreds of miles, is over tundra. From October to June the river is frozen over, and then navigation is suspended. It finally enters Norton Sound, Bering Sea.

Geochemically the water of the Yukon is of special interest. It is practically uncontaminated by human agencies, and it is a typical stream of what we may call subarctic character. A great part of its flow is mere surface run-off, and its low salinity is derived in great measure from the rocky region around its source. From the tundra, which is permanently frozen only a short distance below its surface, very little saline matter is received.

For the composition of the water we have first a table, hitherto unpublished, of analyses by R. B. Dole and A. A. Chambers, which is based upon weekly composites of samples taken daily during a period of 41 weeks, or nearly a year. The table follows.

Analyses of water from Yukon River at Anvik, Alaska.

[Parts per million. Analyzed by R. B. Dole and A. A. Chambers.]

Date (1915-16).		Sus-pended matter.	Total dissolved solids.	SiO_2.	Fe.	Ca.	Mg.	Na+K.	CO_3.	HCO_3.	SO_4.	Cl.
From—	To—											
Aug. 23	Aug. 29	366	151	15	0.02	36	6.0	10	3.6	133	17	1.5
30	Sept. 5	257	136	13	.01	31	5.8	6.5	2.9	110	16	1.1
Sept. 6	12	171	120	11	.02	28	5.6	6.1	2.9	98	14	1.4
13	19	139	114	7.7	Tr.	26	5.4	5.8	2.6	92	14	1.5
20	26	253	113	8.6	.03	23	5.0	6.7	2.2	81	12	2.2
27	Oct. 3	145	113	13	.09	23	5.0	5.5	2.4	78	13	1.6
Oct. 21	27	95	122	11	.08	25	5.6	7.4	3.8	86	14	2.7
28	Nov. 3	48	149	14	Tr.	34	7.1	7.0	2.4	118	16	2.4
Nov. 4	10	14	149	13	.12	33	7.4	[a] 4.2	.0	126	16	1.4
11	17	39	158	15	.16	37	8.0	7.1	.0	137	16	1.2
18	24	13	151	12	.19	36	7.6	6.1	.0	137	16	1.1
25	Dec. 1	7	160	14	.19	37	8.2	7.7	.0	139	18	1.6
Dec. 2	8	13	156	13	.15	37	7.9	6.1	.0	137	16	1.1
9	15	12	158	13	.19	38	7.8	6.5	.0	142	16	1.2
16	22	18	163	13	.07	39	8.0	7.6	.0	149	16	1.5
23	29	8	165	16	.08	39	8.2	7.2	.0	146	16	1.2
30	Jan. 5	8	166	14	.04	39	8.5	6.8	2.6	141	17	1.4
Jan. 6	12	8	165	8.4	Tr.	40	8.5	8.2	1.2	144	18	2.7
13	19	7	162	11	Tr.	40	8.5	6.0	1.7	145	16	1.2
20	26	7	169	14	.01	40	8.5	6.6	3.1	147	17	1.4
27	Feb. 2	5	165	8.4	.04	41	8.8	6.6	2.6	147	16	1.8
Feb. 3	9	6	172	13	.05	41	8.5	7.6	1.2	154	17	2.0
10	16	9	171	15	.02	42	8.8	7.0	2.9	148	17	1.6
17	23	5	180	16	Tr.	43	9.2	6.7	3.1	155	16	1.6
24	Mar. 1	6	185	20	.02	46	8.8	8.0	Tr.	176	15	1.4
Mar. 2	8	6	176	16	.02	43	8.7	6.9	.0	167	15	1.6
9	15	11	168	13	.01	42	8.6	7.5	2.6	154	15	1.6
16	22	5	178	16	.01	44	9.0	6.9	.0	167	16	1.4
23	29	4	175	14	Tr.	43	8.9	6.5	.0	168	16	1.4
30	Apr. 5	12	182	16	Tr.	44	9.1	8.0	.0	171	16	1.7
Apr. 6	12	12	181	12	Tr.	45	9.4	7.6	3.1	166	16	2.2
13	19	8	184	15	.02	45	9.4	8.0	2.4	168	16	1.5
June 14	June 20	135	92	6.2	.25	21	3.6	4.4	.0	72	8.3	.8
21	27	213	106	6.1	.02	24	4.0	7.6	.0	84	9.6	5.8
28	July 4	276	115	7.3	.04	28	4.6	5.4	.0	94	12	1.4
July 5	11	418	112	7.7	.05	28	4.6	5.4	.0	98	13	1.4
12	18	429	132	8.7	.10	34	4.7	4.9	Tr.	115	13	1.1
19	25	442	133	7.7	.08	33	5.3	4.5	Tr.	112	14	1.4
26	Aug. 1	551	147	9.1	.15	38	5.5	5.7	Tr.	131	16	2.0
Aug. 3	9	480	150	9.9	.08	38	5.4	5.3	.0	129	16	1.6
10	16	390	134	7.8	.01	33	6.0	5.6	.0	109	19	1.4
Average		123	151	12	.07	36	7.2	6.6	1.2	131	15	1.7
Composite ([b]) ([c])		----------	149	13	.05	36	7.0	[d] 7.0	2.2	130	16	1.8

[a] Computed.

[b] 100 cubic centimeters of each weekly composite Aug. 23, 1915, to Aug. 16, 1916, except that 70 cubic centimeters was taken of sample Jan. 26, and 130 cubic centimeters of sample Feb. 9. Filtered before analysis.

[c] Nitrate, 1.2 parts per million.

[d] Na, 4.4; K, 2.6 parts per million.

Additional analyses of water from the Yukon appear in the next table. All but one were made by Dole and Chambers and, except for the averages of the preceding table, were published in Water-Supply Paper 418, page 102, 1917. All are reduced to standard form, with carbonates normal. They are arranged in order, going downstream.

Analyses of water from Yukon River.

1. At Whitehorse, near the headwaters of the river.
2. 3 miles below mouth of Teslin River.
3. 1 mile below Fivefinger Rapids.
4. Near Selwyn.
5. Halfmile above mouth of Stewart River.
6. 10 miles below Stewart River.
7. 1 mile below Dawson. The localities of Nos. 1 to 7 are all in Yukon Territory, Canada. Those which follow represent localities in Alaska.
8. At Eagle.
9. At Eagle. Analysis by G. Steiger, reported by F. W. Clarke in Am. Chem. Soc. Jour., vol. 27, p. 111, 1905.
10. At Circle. Mean of two analyses.
11. About 15 miles below Fort Yukon, above mouth of Chandelar River.
12. 20 miles above Dall River.
13. 12 miles above Tanana.
14. 30 miles below Tanana.
15. 100 miles above Anvik.
16. At Anvik. The averages of the preceding table, of 41 composite analyses.
17. 20 miles below Andreafski.

I. In parts per million.

	1	2	3	4	5	6	7	8	9
CO_3	24.1	27.1	32.0	34.9	55.6	49.2	52.7	48.2	45.3
SO_4	6.0	6.0	6.5	9.6	17.0	18.0	16.0	16.0	10.5
Cl	Tr.	Tr.	Tr.	Tr.	Tr.	Tr.	Tr.	Tr.	.4
Ca	14.0	14.0	17.0	18.0	31.0	26.0	28.0	27.0	21.8
Mg	2.0	1.6	3.8	4.5	6.4	6.0	5.8	6.2	4.6
Na	3.4	4.2	3.7	3.9	6.8	4.8	5.5	6.2	6.0
K									Tr.
Al_2O_3	------	------	------	------	------	------	------	------	1.8
Fe_2O_3	Tr.	.1	Tr.	Tr.	.2	.2	.1	.2	------
SiO_2	8.0	10.0	10.0	11.0	15.0	9.7	8.6	9.6	7.6
	57.5	63.0	73.0	81.9	132.0	113.9	116.7	113.4	98.0

	10	11	12	13	14	15	16	17
CO_3	49.7	50.2	52.6	50.7	45.7	53.1	65.6	51.6
SO_4	16.0	17.0	14.0	14.0	17.0	16.0	15.0	18.0
Cl	Tr.	Tr.	Tr.	Tr.	.5	.8	1.7	.8
NO_3	------	------	------	------	------	------	1.2	------
Ca	27.0	27.0	29.0	31.0	23.0	29.0	36.0	30.0
Mg	6.1	6.7	5.6	6.0	5.4	5.4	7.2	6.3
Na	5.1	6.7	5.2	5.4	6.1	7.1	4.4	6.6
K							2.6	
Fe_2O_3	.1	.2	.1	.3	.2	.2	.1	.2
SiO_2	8.8	9.7	9.2	8.8	7.1	6.0	12.0	7.6
	112.8	117.5	115.7	116.2	105.0	117.6	145.8	121.1

II. Percentage composition of dissolved solids.

	1	2	3	4	5	6	7	8	9
CO_3	41.91	43.02	43.84	42.62	42.12	43.20	45.16	42.50	46.16
SO_4	10.43	9.52	8.90	11.72	12.88	15.80	13.72	14.10	10.75
Cl	Tr.	Tr.	Tr.	Tr.	Tr.	Tr.	Tr.	Tr.	.41
Ca	24.35	22.23	23.30	21.98	23.48	22.83	23.99	23.81	22.21
Mg	3.48	2.54	5.20	5.49	4.85	5.27	4.97	5.47	4.71
Na	5.91	6.66	5.06	4.76	5.15	4.21	4.71	5.47	6.14
K									Tr.
Al_2O_3	------	------	------	------	------	------	------	------	1.84
Fe_2O_3	Tr.	.16	Tr.	Tr.	.15	.17	.08	.18	------
SiO_2	13.92	15.87	13.70	13.43	11.37	8.52	7.37	8.47	7.78
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

	10	11	12	13	14	15	16	17
CO_3	44.06	42.72	45.46	43.63	32.52	45.15	45.00	42.62
SO_4	14.18	14.46	12.11	12.05	16.19	13.61	10.29	14.87
Cl	Tr.	Tr.	Tr.	Tr.	.48	.68	1.17	.66
NO_3	------	------	------	------	------	------	.82	------
Ca	23.93	22.98	25.06	26.68	21.90	24.66	24.69	24.75
Mg	5.41	5.71	4.84	5.16	5.15	4.59	4.94	5.20
Na	4.52	5.71	4.49	4.65	5.80	6.03	3.01	5.45
K							1.78	
Fe_2O_3	.19	.17	.09	.26	.19	.17	.07	.16
SiO_2	7.71	8.25	7.95	7.57	6.77	5.11	8.23	6.29
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

From these analyses it appears that the water of the Yukon is essentially a carbonate water, with a moderate amount of sulphates and a surprisingly small proportion of chlorine. The chlorine shown in analyses Nos. 14 to 16, of water taken in the lower course of the river, is probably of oceanic origin, brought down in rain. The salinity of the Yukon is fairly uniform, except for variations which may be due to the influx of tributaries. The proportion of silica is highest near the headwaters of the river and diminishes as we approach its mouth. The source of the silica is found in the igneous rocks around the upper course of the stream.

Dole and Chambers [64] estimate the annual discharge of the river as equivalent to 98,000,000 tons of suspended matter and 24,000,000 tons of dissolved solids.

The largest tributary of the Yukon is Tanana River, for which, including some of its affluents, the following analyses were made by S. C. Dinsmore.[65] An analysis of water from Illinois Creek, an independent tributary of the Yukon, is included in the table.

Analyses of waters from the Tanana basin, Alaska.

1. Tanana River 15 miles below Chena.
2. Tanana River below mouth of Kantishna River.
3. Tanana River 5 miles above its mouth.
4. North Fork of Chena River opposite Monument Creek.
5. Small affluent of Esther Creek opposite Eva Creek, about 7 miles west of Fairbanks.
6. Ready Bullion Creek about 8 miles west of Fairbanks.
7. St. Patricks Creek about 5 miles west of Fairbanks. Nos. 6 and 7 represent tributaries of Esther Creek.
8. Chatanika River above junction with Tolovana River.
9. Tolovana River 2 miles above junction with the Tanana.
10. Baker Creek above mouth of Eureka Creek.
11. Illinois Creek near its junction with the Yukon, west of the Tanana.

I. Parts per million.

	1	2	3	4	5	6	7	8	9	10	11
CO_3	52.6	53.6	52.2	14.26	43.3	21.6	41.8.	37.4	37.4	39.2	24.1
SO_4	13.0	17.0	21.0	2.8	.0	31.0	.0	10.0	5.7	4.9	5.3
Cl	3.0	4.0	1.6	1.0	4.0	2.0	8.0	2.0	2.5	1.5	1.0
NO_3	.8	1.0	.2	Tr.	.6	.5	.5	3.0	2.0	1.0	1.5
Ca	31.0	32.0	30.0	6.5	13.0	12.0	19.0	19.0	17.0	19.0	12.0
Mg	4.9	4.9	5.1	5.4	5.0	8.0	8.0	6.2	4.8	3.8	3.0
Na,K	4.0	6.2	7.7	7.3	12.0	4.0	.5	2.3	5.2	5.1	5.0
Fe_2O_3	Tr.	Tr.	.1	.07	.0	.0	.02	.1	Tr.	Tr.	Tr.
SiO_2	11.0	28.0	11.0	8.0	12.0	17.0	12.0	11.0	10.0	21.0	5.0
	120.3	146.7	128.9	45.33	89.9	96.1	88.02	91.0	84.6	95.5	56.9

II. Percentage composition of dissolved solids.

	1	2	3	4	5	6	7	8	9	10	11
CO_3	43.73	36.54	40.49	31.47	48.16	22.48	46.54	41.11	44.21	41.05	42.36
SO_4	10.79	11.59	16.29	6.18	.00	32.26	.00	10.99	6.74	5.13	9.32
Cl	2.49	2.73	1.24	2.20	4.45	2.08	8.90	2.20	2.96	1.57	1.75
NO_3	.67	.69	.16	Tr.	.67	.52	.55	3.28	2.36	1.05	2.63
Ca	25.77	21.81	23.27	14.34	14.46	12.49	21.16	20.88	20.09	19.89	21.09
Mg	4.07	3.34	3.96	11.91	5.56	8.32	8.90	6.82	5.67	3.98	5.27
Na,K	3.32	4.22	5.98	16.10	3.35	4.16	.55	2.53	6.15	5.34	8.79
Fe_2O_3	Tr.	Tr.	.08	.15	.00	.00	.03	.10	Tr.	Tr.	Tr.
SiO_2	9.16	19.08	8.53	17.65	13.35	17.69	13.37	12.09	11.82	21.99	8.79
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

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[64] Op. cit., p. 105.

[65] U. S. Geol. Survey see Water-Supply Paper 418. p. 107. 1917.

In general the water of Tanana River resembles that of the Yukon, except for its higher percentage of chlorine, which is unexplained. The second analysis differs from the other two in its higher silica, which may be derived from Kantishna River, for which no data are given. Analyses 4 to 7, of small streams near Fairbanks, exhibit peculiarities that are probably due to local influences. The water of Illinois Creek, which enters the Yukon from the north, is like that of the Yukon.

The foregoing analyses are all of waters from the Yukon basin. The three following analyses are of waters from other Alaskan rivers. They are reduced to standard form from the figures given in Water-Supply Paper 418. p. 109.

Analyses of three Alaskan waters.

1. Stikine River about 15 miles above Wrangell. Analysis by S. C. Dinsmore.
2 Copper River at Flag Point bridge. Analysis by A. A. Chambers.
3. Lowe River near Valdez. Dinsmore, analyst.

	Parts per million.			Percentage composition.		
	1	2	3	1	2	3
CO_3	30.9	54.1	29.0	34.84	40.71	37.91
SO_4	15.0	18.0	9.8	16.91	13.55	12.81
Cl	1.5	1.6	3.0	1.69	1.20	3.92
NO_3	Tr.	.5	2.0	Tr.	.38	2.61
Ca	21.0	32.0	11.0	23.67	24.08	14.38
Mg	3.6	7.3	3.0	4.06	5.49	3.92
Na,K	1.0	11.0	11.0	1.13	8.27	14.38
Fe_2O_3	.7	.4	.7	.79	.30	.92
SiO_2	15.0	8.0	7.0	16.91	6.02	9.15
	88.7	132.9	76.5	100.00	100.00	100.00

The water of Copper River resembles that of the Yukon. Stikine River, with its high silica, owes its character to igneous rocks around its source. The high proportion of alkalies in Lowe River may have been derived from the decomposition of feldspars.

INDEX TO ANALYSES.